

A Comprehensive Survey on the Impact of Renewable Energy Sources in Power System Operation and Control

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A COMPREHENSIVE SURVEY ON THE IMPACT OF RENEWABLE ENERGY SOURCES IN POWER SYSTEM OPERATION AND CONTROL

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Abstract

The concern for huge increasing electricity demand, fossil fuel depletion, developed infrastructure reliability, carbon footprint reduction insisted the power utility companies to uptake RES (Renewable Energy Sources). The improved adoption of RES like wind energy and solar energy into the prevailing transmission and distribution networks led to several problems. These problems could be rectified by optimizing the power system parameters like frequency response, inertia, stability, battery usage, efficiency and power loss. This review hence provide a comprehensive analysis on the impact of renewable energy sources like wind and solar energy on power system operation and control in accordance with the major findings of the existing works. This review highlights the difficulties in the installation of solar and wind power with adoptable solutions. The challenges of power systems regarding the encoding of non-linearized function could be rectified by AI (Artificial Intelligence). The paper also insists the importance of artificial intelligence algorithm in the optimization of power system parameters. Artificial intelligence methods is useful for resolving various issues in power systems such as control, scheduling, forecasting etc. Few artificial algorithms such as Atom search optimization, Particle swarm optimization, Salp swarm optimization were investigated in this review for improving the performance of the power system. In spite of optimization analysis, the paper investigate various storage system types for improving the power system in accordance with cost, application and operation characteristics. Proper understanding of these systems is necessary for the future designing and hence through revision of state of art characteristics has been performed in this paper.

Keywords: Renewable energy sources, power system, solar energy, wind energy, artificial intelligence.

1. INTRODUCTION

Electrical energy has been regarded as a major industrial source for transmitting and generating power over large distances. The industries are facing challenging issues particularly in the designing of future power systems that delivers huge amount of electricity[1]. The growing electricity demand draws the attention of recent research to focus on renewables. Such growth has been accelerated by the various power system parameters such as frequency response, inertia, battery usage, stability, power loss and efficiency. Further electricity demands and RES must be balanced for maintaining safe, stabilized and dependable operation[2]. Hence it is required to analyse and investigate the impacts of RES in power system operation and control on the basis of the following directions.

- It is significant to determine the factors associated with the transmitting and distributing operations[3].
- The importance of establishing a power reserve which balances the consumption and production must be focused.
- Determination of a maximum RES which could be integrated into the power source with optimized power control parameters.

Such kind of power system analysis by traditional methods seems to be more complex due to difficult, versatile and huge amount of information utilized in estimation and diagnosis.

Further accuracy and computational time period must be focused because of the vast and

extensive data handling[4]. Integrating several renewable energy sources in power-systems can decrease the amount of conventional generation units, which provides inertia response as well as frequency control. This kind of situation needs an optimized and conservative power system with the aid of AI (Artificial Intelligence)[5]. AI methods might not require any kind of significant knowledge of the power system control model. Moreover they possess the ability to handle inappropriate situations such as corrupted data, missing information etc [6]. These techniques are also fault tolerant, robust, adaptive, generalizable and fast. Hence the paper focused on the optimization the power control parameters such as inertia, power loss, frequency response, stability, efficiency and battery usage in the integrated environment with RES with various AI algorithms.

2. POWER SYSTEM

Electrical power systems referred as power systems could be described as a network of electric devices for generating, transmitting and distributing electrical power[7]. The main objective of power system control is the maintenance of constant electrical supply in an acceptable quality against several disturbances[8]. Such disturbances might be categorized into large scale and small scale disturbances[9]. Power quality issues are established as frequency deviation, distorted current and voltage waveforms that leads to destruction or failure of the customer equipment[10]. In addition, the power system must offer a reliable, secure and uninterrupted energy flow with sinusoidal voltage at the defined frequency and magnitude level[1]. In general poor quality of power might result in high power loss, undesirable equipment behaviour and intrudance with nearby communicating lines[11]. Hence the paper analyses the role of power system parameters in its operation and control[12]. The parameters of the power systems such as frequency response, inertia, stability, efficiency and power-loss are investigated[13].

Inertia

Generally, in power-systems, inertia play a significant role in the maintenance of reliability and stability of system by stabilizing the variations in frequency[14]. The conventional synchronous generation sources were displaced by the renewable energy sources that have no intrinsic inertia[15]. Further, several studies

examined the impacts of the reduced inertia on various aspects of dynamic stability of the power-systems like oscillatory modes, frequency response and stability[16]. Also, compared the outcomes obtained by inertia reduction technique of the RES with other techniques, where the inertia constant is decreased for all the synchronous generators. In such way, the following articles comprehensively describes about the inertia in power systems and its impacts.

This study [17] presented detailed review on the VI (virtual inertia) based inverters in the modern power systems. Further, the transition from SG (synchronous generator) based traditional power generation to the converter based RES (renewable energy sources) depreciates the frequency stability of power-systems because of intermittency of PV (photovoltaic) as well as wind generation. Moreover, unlike the traditional power generation, inadequate inertia will be the major drawback for interfacing the renewable energy sources with electrical grid through power-electronic converters. In recent years, several researchers have addressed about these problems by imitating the behaviour of synchronous generators through PWM (pulse width modulation) controller that are linked to the traditional inverter systems. Hence, these systems are called as the virtual inertia (VI) based inverters that incorporated VSM (virtual synchronous machine), synchronverter as well as VSG (virtual synchronous generator).

Due to the rapid increase in usage of power converter based RES (renewable energy sources), the system inertia in the interconnected power-systems will be substantially reduced, thereby increasing vulnerability of power-systems because of instability of the systems. In order to overcome these issues, this study [18] suggested a novel application of VI control for the improving the frequency stability of interconnected power-systems because of the higher penetration levels of renewable energy sources. Further, the derivative control method was introduced to high level applications of VI emulation. Therefore, the suggested VI control loop possess second order characteristics simultaneously enables inertia emulation as well as damping into interconnected power-systems, thereby enhancing the resiliency and frequency stability. Additionally, the study performed trajectory sensitivities for analysing

the impacts of VI control parameters on system stability.

The (renewable energy sources) RES are usually connected to power grid through the power-electronic converters. The higher penetration of RES into power grid might result in more instability in frequency and voltage. These problems are due to the avoidance of inherent characteristics of the SG (synchronous generators). In order to overcome these issues, this study[19] presented a power based control method on the basis of DSC (double synchronous controller) to interface the converter between power grid as well as RES that includes active reactive power-based dynamic equations. By the suggested method, this study performs decoupled controlled technique, from which a stable operation was guaranteed by the study while integrating large scale RES. Additionally, this study performed the analysis in MATLAB and verified the proficiency of the suggested method.

In recent years, due to the rapid increase of VRE (variable renewable energy) penetration in power systems, there is a decrement in the synchronous machines in the European power-systems. Further, the appropriate inertia levels for assuring the stability of systems, this study [20] examined the impacts of various levels of minimum inertia constraints in Europe as well as in every synchronous areas. The study simulated 2 scenarios with different decarbonisation aims for 2030 by utilizing economic dispatch as well as unit commitment model. Moreover, the findings of the study depicted that, increasing levels of inertia constrains increases the cost of total generation. And, when the inertia constrains applied to contrasting scenario, the study observed 49% of decrement on the emission of carbon dioxide.

Inertia of conventional power system

In conventional power systems, majority of the power is generated hydroelectric, coal and nuclear power. Further, the common element used in the power plants is synchronous generators. The kinetic energy which is stored in rotating parts of synchronous generators is the major property for the system stability as well as frequency dynamics[21]. Moreover, the inertia contribution is an impressive and feature of synchronous generators. In this manner, the synchronous generator maintains the synchronism as well as prevents the grid

collapse. The inertia of synchronous generator is given as the following,

$$J = \int r_{SG}^2 dm = r_{SG}^2 m \quad (1)$$

From the above equation, it is observed that r_{SG} is known as radius of rotating part of synchronous generators, whereas m is known as the mass.

The total inertia in conventional power systems could be described as the resistance as a form of the kinetic-energy for compensating the variations on frequency. Therefore, the short term energy under the load-fluctuations is known as inertia. Moreover, the kinetic energy required during the power-imbalance can be expressed as,

$$\Delta E_{KE} = \int (P_G - P_L) dt \quad (2)$$

From the above equation, it is observed that P_G is generated power and P_L is the load power.

Impact of renewable energy sources on the inertia of power system

The conventional power systems could contribute the inertia to power systems. Generally, inertia assists to limit the rate of change of frequency (ROCOF) and the contingency event. However, in the future of power systems, the loads as well as the Renewable energy sources are integrated to the grid via power-electronic converters. Therefore, the inertia of future power systems will be significantly reduced when compared to the conventional power systems. Consequently, the frequency as well as the rate of change of frequency will increase of contingency event arises[21]. Hence, the grid operators cannot maintain the stability of the system with only traditional synchronous generators. The instability problems occurs if the renewable energy system penetration level is equal of more than the synchronous generator's capacity. Additionally, the impact of the damping and lower inertia influences the performance of the grid, thereby leads to the frequency instability issues[22].

Frequency response

Conventionally, the network of power-systems rely on the heavy SGs (synchronous generators) that are fuelled with the fossils fuel for generating power. The rotating frequency of generator is directly coupled with the frequency

of power systems, thus this disturbance on power system network would have a significant influence in SG's rotor[23].

The frequency of the system serves as the primary indicator for power-balance between total load as well as total generation in power systems[24]. Further, when load/generation imbalance occurs, and the SG will absorb kinetic energy from power systems for normalising the imbalance issue, thereby resulting in frequency change[25]. When renewable energy sources replacing with the SGs (synchronous generators), the RES should participate in initial response for the low frequency events for combating the decline in the online SG[26]s.

The relevant integration of the wind power to power grid was involved as remarkable impact on the operation of power systems, specifically in terms of reliability as well as security because of inherent loss of inertia. The frequency control is most appropriate solution for improving the stability of the system. With respect to the grid stability as well as frequency response analysis, the study analysed the frequency response for the hypothetical imbalance between the range 5% to 20%. This study [27] suggested a realistic system for evaluating the frequency deviations by incorporating the integration of high wind power. From the experimental analysis, the study provided several influences from the wind FC (frequency control) depending upon the integration of wind-power and inertia reduction.

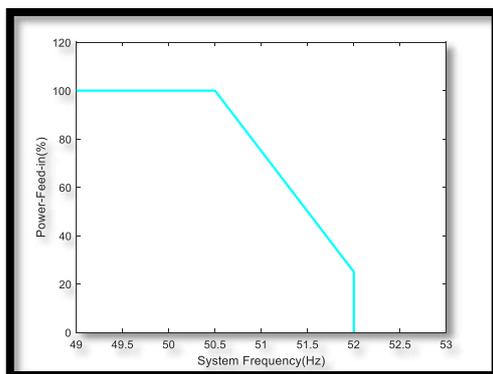


Figure 1. Power curtailment during the over-frequency for renewable power plants

When power system's frequency exceeds 51.5Hz more than four seconds, the renewable power plants are discontinued from power

systems. From the figure 1, it is understood that, during lower system frequency i.e. $f < 50\text{Hz}$, the renewable power plants produce about 100% of availability power. Thus, there is no power reserved for stabilizing drop in frequency during the low-frequency. Further, the SGs (synchronous generators) provides the inertial response for combating drop in frequency, thereby providing additive power from stored kinetic energy in rotating mass. When renewable energy sources replacing with the SGs (synchronous generators), the RES should participate in initial response for the low frequency events for combating the decline in the online SGs.

Stability

The major purpose to develop MGs (micro grids) is for facilitating integration of RES (renewable energy sources) in power systems. The renewable energy sources are connected to grid through power-electronic inverters. Since, there are several types of renewable energy sources integrated to electrical power systems, the future of power systems would have many IBGs (inverter based generators) rather than the synchronous machines. As the inverter based generators have substantial variations in the characteristics when compared to the SGs, specifically considering about the inertia as well as the capability for providing reactive power. This study [28] is conducted on stability of power-systems with incorporating inverter based generators. Further, this study examined the issues on the voltage stability of the micro grids in the power-systems. This study also presented a comprehensive review regarding the voltage stability of power-systems. The future analysis deals with developing more approaches in this particular field.

Power loss

The VRE (variable renewable energy) sources are adding more fluctuations to the power system. Further, the required types as well as the capacities of curtailment amount, balancing measures as well as the cost related to the system integration must be assessed to advise the policy makers. Several studies neglected storage from CSP (concentrated solar-power). This study [29] provided insights about the need for the backup capacity as well as grid by examining the integrated markets in Europe, thereby allowing for additive long term and short term storage and taking into account the concentrated solar power as dispatchable

backup. The renewable energy mix system model has been introduced and implemented for accessing the hourly dispatch and capacity expansion at different levels of wind power and photovoltaic penetration. Moreover, the model outcomes represented that the integration of temporal and spatial balancing measures, which enables the wind supply as well as net photovoltaic shares 70% and 60% of annual demand. Finally, the study stated that the utilization of storage as well as grid can keep the curtailments less than 20%. Additionally, the study determined that the variable renewable energy has huge impacts on the least-cost allocation of the power plants.

Efficiency

This study [30] described the benefits of RES throughout world in power generation. The renewable energy has significant scope in the power systems. Further, the RES acts as major powerhouse of the micro grids. The micro grids are small network of the power-systems with DG (distribution generation) units, that are connected in parallel. Also, the challenges involved in the integration of renewable energy sources in power systems are briefly described in the study. Moreover, the varied nature of the distribution generation produces the frequency as well as voltage deviations. Finally, the study examined the micro grid performance against various scenarios. Additionally, the micro grid's voltage is controlled by utilizing various controllers, and the outcomes were also examined. The study examined the controller performance by using Simulink/MATLAB.

3. RENEWABLE ENERGY SOURCES

In an interconnected power-system, the frequency stability is considered as the major issue for the system operators. Further, frequency oscillations within the power system is denoted as the unbalance between load demand and generation that needs to be in control. A higher penetration of RES (renewable energy sources) in power system increases the uncertainties to the parameters and brings numerous technical difficulties[5]. Initially, it was demonstrated that the QODA algorithm is improved optimization method when compared to non-conventional and conventional ways. The suggested control strategy was applied for tuning PID controller parameters in presence of renewable energy sources.

The demand for world-wide electricity is gradually raising, thereby making use of wind and solar energy sources that reduces the adverse environmental impacts. The variable energy source has a significant role in global energy, which includes the generating capacity. This study [31] presented the challenges of integrating VRE (variable renewable energy) in accordance to energy capacity as well as power capacity of the stationary storage technology. From the analysis, the study stated that the energy storage regulations as well as the market developments that motivates the increased utilization of energy storage system is significant for successful integration of wind and solar energy. Also, the study proves that, apart from energy capacity, the power capacity of the storage system is the major factor for efficient integration of VRES.

This article [32] observed the impacts of penetration as well as computed maximum penetration of VRE (variable renewable energy) power plants for the time period 2019 to 2023, specifically for solar power-plants. Further, the penetration of solar power-plant for JavaBali grid should be employed in certain areas because of the limited technical capabilities of the existing systems. The variables for determining the maximum penetration of variable renewable energy are the properties of the thermal generation units like mechanism of primary energy conversion, minimum load as well as ramping capability. From the analysis, the outcomes depicted that the penetration of variable renewable energy at 5000MWp capacity increases the requirement of grid remapping.

Solar energy

Renewable energy sources (RES) play a significant role in recent years for assisting traditional power systems. This study [33] presented a performance analysis of the integrated hybrid solar photovoltaic, diesel generator as well as fuel cell power system with BESS or SCESS (battery energy storage system) or (super-capacitor energy storage system). Further, this study utilized HOMER pro software for simulating HES (hybrid energy system) on the basis of energy consumption. The simulation outcomes depicted that, when utilizing SCESS as energy storage system increased the overall performance of the system. Additionally, the hybrid energy system with super-capacitor energy storage system has 68.1% of renewable fraction. Finally, the study

stated that the reduction of greenhouse gas for hybrid energy system with super-capacitor energy storage system was 83.2%.

Using both the solar as well as wind energy can cause a complementarity behaviour by diminishing the variable and inherent characteristics. Solar and wind energies are eminent RES (renewable energy sources), and several countries are investing in RES and also certain studies have investigated in this topic, in such way study [34] utilized wind as well as solar power for the grid integration in large scale. The integrated usage of solar and wind power in several regions results in well-balanced power supply that is critical for safety and operability of the electrical grids.

As there are numerous number installations of PV (photovoltaic) around the world, the photovoltaic impacts on the power systems were also rapidly increasing. In this study [35], implications of the high photovoltaic penetration on reliability as well as stability of the power systems' flexibility, stability, harmonics, protection, frequency and voltage were comprehensively reviewed. Further, the study also analysed the factors that contribute to the impacts, and timeframes and levels. The tools as well as models employed in the power systems were also elaborated by the study.

Basic concept of photovoltaic cell

The photovoltaic (PV) cell is an electric device, which generates electrical-power when it is exposed to the sunlight. Further, the generated electric power is then connected to the suitable load. This photovoltaic technology can become major renewable energy sources with a cost reduction in systems like AC/DC inverters, cables, fittings, PV modules and manpower. For the analysis of lower frequency domain, transfer-function model the photovoltaic system is shown as the below mentioned equation. Moreover, the hybrid power-system carries different autonomous generation-systems such as solar PV (photovoltaic), aqua electrolyzer, fuelcell and diesel engine.

$$G_{pv}(S) = \frac{P_{pv}}{P_0} = \frac{1}{1+T_{pv}} \quad (3)$$

From the above equation it is understood that, T_{pv} is known as time constant of photovoltaic.

Wind energy

The contribution of wind farms in improvisation of frequency control while integrating power grid was comprehensively discussed by [36], in which the study suggested an approach of quantifying wind penetration on the basis of power fluctuation amount, which could be filtered by the wind-turbine generators as well as thermal plants. The wind farm uses the droop control and energy control methods for improvisation of frequency regulation. Further, the study used PSO algorithm for obtaining optimum results.

The LFC (load frequency study) of power systems incorporating gas, hydro and thermal based generating units in the existence of wind-power plant under various penetrating levels as well as operating models was studied by [37]. Further, the wind-power integration shifted the electricity-grid in transition phase to newer model, in which the wind power-plants participated in every frequency regulation levels.

In order to improvise the frequency-stability in an inter-connected power-system incorporating RES (renewable energy sources), the control actions must be more efficient and robust. This study [38] suggested a novel optimized PID controller (proportional integral derivative) with RFBs (redox flow batteries) for enhancing the LFC (load frequency control) of the power system regarding huge penetration of wind-power generation.

In order to achieve clean energy, this study [39] integrated the renewable energy systems such as PV and STPG (solar photovoltaic and solar thermal power generation) in power system. Also, the study investigated the impacts of solar thermal system for load frequency control study of unequal thermal power system.

Solutions

Even though there are various challenges related to penetration of RES in power systems, there are several solutions, which can provide flexibility for handling these difficulties. Those include balancing the overall variable renewable energy output power via sufficient amount of geotropic diversity when utilizing these variable renewable energy generators. Further, expanding the transmission system will effectively move more power to the regions where the load is significantly required. Moreover, the increased geographic diversity of the variable renewable energy generators as well as the usage of transmission resources will

be achieved by coordinating with balancing authority as well as the faster interchange intervals.

Recent trends of Renewable energy sources

The Renewable energy sources (RES) are gaining huge popularity in the mainstream power-systems[13]. The native power systems generally needs some modifications for meeting strong requirements of rapid increase of the electricity consumption, uninterruptable power in urban and rural areas[40]. The renewable energy sources gradually replaces the one way power-transmission, and generally, the RES are small machines, low inertia driven by the sources like waves, hydro, solar as well as wind[41]. These sources are connected near to the load-points for fulfilling the load demands. In recent days, power systems are considered as distributed energy systems with various RES along the automatic control as well as the communication[42]. Several countries started to implement the renewable energy sources in power systems in an integrated environment[43].

Countries like Germany, Ireland and Denmark aggressively implemented the (VRE) variable renewable energy systems as well as operating with the annual variable renewable energy penetration of above 20% at national level[44]. Furthermore, currently Ireland limits the instantaneous penetration (55%). And the variable renewable energy provides annual energy of 5% and 13% in United States and Europe[45].

The solar energy and wind-power are different from the thermal generators, since they possess uncertain as well as variable power results that are established by the local weather conditions[46]. The conventional generators like gas plants and coal are dispatchable as they change their power for meeting the variations in load.

As more variable renewable energies are implemented into the power systems, the future grid would have several inverter based generators as well as more distributed than existing power system that is dominated by the synchronous generators. Generally, the VRE (variable renewable energy) resources utilize inverters for connecting grids than the synchronous generators.

Implementation of renewable energy sources in power system has massive amount of inverter

generators and also it fluctuates between the inverter dominated as well as generator dominated on daily basis.

Impacts of renewable energy sources in power systems

The study [47] highlighted the future generation of the energy, contributed by the RES (renewable energy sources). Further, the conservative power-plants discharges the GHG (greenhouse gas) as well as energy crisis that was diminished by the RES (renewable energy sources) of PV (photovoltaic) and wind energies. Moreover, the impact of renewable distributed generation as well as cost of outage power, calculated by the evaluation of reliability. The requirement of the consumer load with the PV, wind turbines and the electric storage satisfied by the assessment of the distribution system. Further, the study analysed the reliability influence by the suggested method. From the experimental analysis, the results depicted improvised performance.

Similarly, in this study [48] the RES (renewable energy sources) of the mathematical model rely on the meteorological data processing was suggested. Further, the study made a system of photovoltaic wind-energy assessment combined with the pump storage hydro plant. Finally, the study stated that the suggested method had better efficiency than the battery storage systems.

In this article, [13], the reliability of the power systems was increased as well as the dependency was diminished by the RES measures. Further, the conventional micro grid power-systems were improvised as well as the cost of energy was decreased by the photovoltaic, wind turbines and battery storage. The RES based technology has achieved overall better performance.

4. VARIOUS ALGORITHMS USED FOR OPTIMIZING POWER CONTROL PARAMETERS

The uncertainties of RES would bring several impacts to the reliability and stability of power-systems. So various studies have implemented different algorithms for improving the overall system stability and performance. In such way, this study [49] suggested a new generation-rescheduling algorithm that modifies the generation output for mitigating the changes in power flows as well as relieves the probability of overload. The suggested algorithm prevents

the power congestion as well as balances the load and renewable generations in the power systems. Moreover, this study also suggested a probabilistic technique to evaluate system uncertainty problems in power-systems by the generation rescheduling algorithm. From the analysis, the study stated that the suggested technique enhances the reliability of the power systems with higher penetration levels of RES (renewable energy sources)[50].

ASO algorithm

This study [51] constructed a RPO (reactive power optimization) technique of the power grid with higher penetration of solar as well as wind energy and provides new FASO (fast atom search optimization) algorithm for reaching set of solution to reactive power optimization problems. Further, this algorithm preserves prominent merits of avoiding premature convergence as well as higher searching efficacy when compared to original ASO algorithm that was employed for determining the generator's voltage, transformer's tap ratio, reactive output power of solar and wind energies as well as SVC (static VAR compensator). Moreover, the objective functions must be reduced to maintain the reliable and safe operations of power grid. The regulation capacities of PV (photovoltaic) stations and wind farms were evaluated on the basis of various weather conditions like solar irradiation and wind speed. Finally, the study verified that the suggested algorithm can meet requirements of optimal regulation and also can obtain the regulation schemes with more convergence speed as well as the convergence stability, when compare to prevailing methods.

PSO-SSA Algorithm

Several studies employed particle swarm optimization and salp swarm algorithm for obtaining high efficiency. In such way, in this study [52], PSO method was involved, in which the suggested system efficiently tracked MPP in the crucial environmental conditions such as partial shading of irradiance and temperature as well as larger fluctuations. The searching agents must be initialized on the basis of PSC variations. And this study [53] stated that GWO technique depicted improvised performance, as well as the output power oscillations are minimized by the integration[54, 55].

The photovoltaic (PV) system possibility was depicted after the evaluations. Additionally, the sliding mode was designed in the study [56] for

the photovoltaic system due to the rapid change of the atmospheric conditions. Moreover, the gains of optimal SMC is identified by the particle swarm optimization algorithm[57].

The output voltage, which was introduced by the buck boost converter as well as it assures about better energy transfer. Further, the disadvantages such as partial shading was not allowed for generating maximum power. This algorithm with particle swarm optimization was utilized for overcoming these limitations as well as irradiances found in the study [58]. By the zeta converter, the solar photovoltaic output power was optimized, and with the step down device, some voltage would be regulated. Moreover, based on MRAC (model reference adaptive control), the design is similar to the conventional structure of PID. In order to reach the maximum power, the particle swarm optimization with more tracking speed as well as more tracking accuracy will be helpful with respect to the study. Finally, the simulation outcomes depicted that, higher efficacy was obtained via hybrid algorithms in every stages. In order to enhance the simulation process, the study utilized 3 phase linear transformer. Additionally, the batteries are charged without losing efficacy from the hybrid algorithm.

5. RESEARCH GAP, CHALLENGES AND FUTURE DIRECTIONS

It is with a significant importance to provide the more practical, critical and research gaps regarding the RES in power system control and operations[59]. The major issue with RES based power generation is the deviation in the production capacity at various time intervals, flexibility in the selection of location and operation control and the size of individual units. This section identifies the research gap from the existing literatures that enable to prepare various incentive mechanism to overcome the following problems. Some of the constrains in the implementation of solutions to these problems are the requirement of sophisticated information for controlling the load and the source, thermal loading limit and physical circuit constrains and requirement of thermal management for allowing the uninterrupted power flow. The disadvantages of solar PV are the huge installation and high commission cost and a storage process such as batteries. Further the solar PV comprise charge controller, inverter, battery storage and

controllable loads. The main disadvantage of wind energy is that it is affected from huge intermittent nature and hence a proper storage mechanism based on artificial intelligence has to be adopted to reduce the overall cost.

In general, distributed generation comprise power converts to be utilized as an interface in between the connecting grid and the energy source. These power converters controls the machines present in these generators. Some of the main challenges in implementing the various solutions are discussed below.

During the change of voltage range in between the secondary and primary side to maintain the grid voltage within the desired range, the major drawback is the rise of higher cost and operation. Because of the intermittent nature of the solar energy, voltage could be increased or decreased rapidly. So the system needs to rise its operating time in order to keep the voltage within the range required. This in turn affect the system lifetime. In case of controlling grid voltage, one of the major limitation is the huge reaction time when compared with the vital power generation modification from PV systems. This reaction is an important aspect in the control design that considers the switching operations. Furthermore even for the short reaction handling case, the system would be translated to switching process of the devices thereby decreasing the lifetime. Apart from this the paper[34] found few unresolved topic and unexplored points which enhance the research regarding the solar and wind complementarity are incorporation of quality assured technique to prevent measurement error that interfere in the complementarity analysis, proper definition of reference metrics for allowing the comparison of various outputs from complementarity analysis. Further the climatic change impacts could directly affect the source complementarity.

Power generation, transmission followed by distribution operations of the conventional power systems over a wide geographical area were performed under an individual operator with few technical complexities. Due to huge increasing energy demand, the modern power systems are generally operating around the stability margins. If a major imbalance occurs the system do not possess adequate time for

closing the deficit causing the cascading failures. Few important research gaps are mentioned below

Consideration of deviations of few significant parameters in the modern systems like frequency response, stability, inertia indices for the assessment of reliability. Hence the existing papers should investigate the capability of extensive parameters in enhancing the security and reliability of the modern power systems. Online coordination of various control methods in the power systems could enable the decrease of power outages. The existing papers must consider a smart grid features for adopting a protective function design which is free from cyber-attacks.

6. RESEARCH GAP

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Table 1: Survey on significant outcomes of existing studies

S.No	Author	Renewable Energy Sources	Area of the study	Metric used	Significant outcomes
1	[69]	Solar and Wind	European countries	Linear least square regression for optimization	The study observed an optimum scenario of 82% of penetration rate (26% of solar and 74% of wind) of the renewable sources.
2	[70]	Solar and Wind	China	Profit coefficient, synergy rate and coefficient of variation	The paper observed that the integration of sub regions might be selected as alternatives for making full utilization of these energies.

3	[71]	Solar and Wind	America	Pearson correlation coefficient and coefficient of variance	The paper found that complementary peaks of wind and solar production appear on daily and annual level
4	[72]	Hydropower and solar	Poland	Ramp rate	The results of the paper depicted the possibility of smoothing the generation of solar power by the integrated usage with hydropower
5	[73]	Hydropower and solar	China	Annual solar curtailment and net revenue rates	The integrated usage of hydropower and solar can resolve the issues of solar variability.
6	[74]	Hydropower and solar	Poland	coefficient of variance and S.D	The outcome represented that minimum hydropower could compensate for solar PV variability
7	[75]	Solar and Wind	Europe	Correlation coefficient	The paper observed a degree of local complementarity in between solar and wind sources in various regions with the hour-time scale
8	[76]	Hydropower and Wind	Brazil	Correlation coefficient	A huge level of complementarity in between the solar and wind sources in the region investigated
9	[77]	Solar and Wind	Brazil	Amplitude related index and time related index	The paper found that the usage of hybridized wind solar power systems might be highly efficient than individual wind and solar system
10	[78]	Solar and Wind	Australia	Interquartile range and relative coefficient of variation	The intermittency and variability occurred by the individual source generation might be strongly mitigated by the integrated usage with other sources.

11	[79]	Solar and Wind	China	Kendall correlation coefficient	The paper observed that northern and northwestern regions presented significant solar and wind complementarity
12	[80]	Solar and Wind	Britian	S.D and Pearson correlation coefficient	The study determined that the regular variability in the total power is always decreased by solar incorporation. This situation with minimum seasonal variability is 30% of wind and 70% of solar
13	[81]	Hydropower and wind and hydro	brazil	Cluster analysis and Pearson coefficient	This study observed that Brazillian wind resource is highly significant and presented huge complementarity with hydropower resources
14	[82]	Solar and hydropower	Italy	S.D	This paper state that at hourly scale, a high share of hydropower permits the reducing of energy balance variability. At daily and monthly temporal scale, opposite reaction occurs due to low variability of the solar power
15	[83]	Concentrated solar and wind power	The southern part of the Iberian Peninsula	S.D	The study observed that more benefits are obtained in accordance to power mix when compared to single site installation

7. CONCLUSION

Now a days power systems faces various ground breaking challenges to meet the growing demands of industries. Hence recent research focus on the renewable energy source to overcome the research gaps. This study emphasizes the barriers in installing wind and solar power systems with adoptable solutions. Further, the challenges of power system with respect to the non-linearized function is

rectified by the artificial intelligence. This study also elaborated about the significance of AI algorithms in optimization of power system like forecasting, scheduling as well as control, etc. Moreover, certain articles like salp swarm optimization, Atom search optimization and Particle swarm optimization were examined in this article for enhancing the overall performance of power system. This study only examined the optimization analysis, but it also

investigated several types of storage system for the improvisation of power system with respect to operation characteristics, application as well as cost. The future analysis deals with in-depth revision of the existing of the existing characteristics for further improvements of the performance.

Declaration of Interest

I Am Vinay Kumar Tatikayala Hereby State That The Manuscript Title Entitled “A Comprehensive Survey On The Impact Of Renewable Energy Sources In Power System Operation And Control” Submitted To Soft Computing, I Confirm That This Work Is Original And Has Not Been Published Elsewhere, Nor Is It Currently Under Consideration For Publication Elsewhere. And I Am Research Scholar in Department of Electrical Engineering, Madhav Institute of Technology and Science, Madhya Pradesh, India.

I’m the corresponding author of our paper, my contribution work on this paper is to Writing, developing, and reviewing the content of the manuscript. And my co-author Shishir Dixit work is to cite the figure, table and references. Equally I have done 50% and my second author has done 50% of the work .We are the entire contributors of our paper. Any other third party people are not involved in this paper.

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Figures

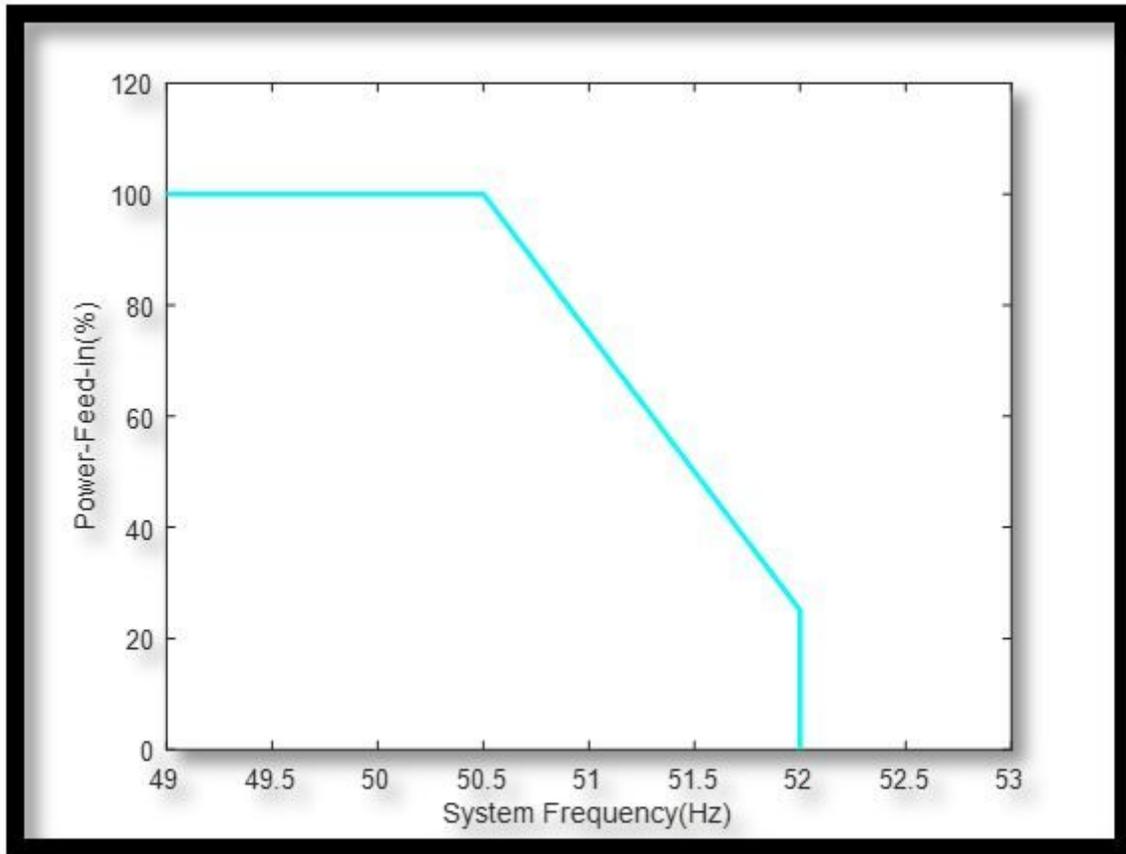


Figure 1

Power curtailment during the over-frequency for renewable power plants