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Survey on Power Transmission Behaviour of Microgrid

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Abstract— The power transmission network, as a standard between utilization centers and power generation, includes a limited capability in addition to its own security concerns. Deregulation in electricity markets took place when the transmission network was not capable to hold the entire desired transactions are owing to certain contraventions in its functioning limits. Deregulations in electricity markets, if not controlled, can pave the way to oligopoly and market power. Hence, this survey intends to review various topics related to grid power transmission in power systems. Accordingly, the algorithmic classification for the surveyed papers was analyzed and portrayed. In addition, the performance measures and the maximum performance achievements are also analyzed and demonstrated in this survey along with the research gaps and challenges.

Keywords— *Power transmission; MG; Performance measures; Research gaps; Maximum achievements.*

Nomenclature

Acronyms	Description
MG	MicroGrid
TEP	Transmission Expansion Planning
IDM	Inner Dependency Model
DMM	decision-making model
MIP	Mixed Integer programming
BD	Benders Decomposition
MSMC	Monte Carlo
PG	power grid
LM	Laplacian matrix
TUC	thermal unit commitment
FWPTPQI	fuzzy-wavelet packet transform-based power quality Index
ACE	Area Control Error
DC	direct current
MP	mathematical programming
EM	electromagnetic
HV	High Voltage
PSO	Particle Swarm Optimization
RESs	Renewable Energy Sources
SC	scenario creation
SoC	State of Charge

I. INTRODUCTION

Transmission in power system exists as one of the leading element of the electric power production [1] [2]. It not only offers an association among distribution and generation, but it also offers consistent surroundings to demanders and suppliers. The intention of a power transmission network is to convey power from production plants to load centres efficiently, economically, reliably and securely [3] [4] [5]. As many realistic transmission systems are increasingly expanding, TEP entails recognizing of where to include new circuits to congregate the enlarged requirement by transferring the power to new network from old one. In the preceding few years, investigations in the area of grid power transmission have practiced an expansion [6] [7]. Several reports and papers regarding novel designs have been available in the technical literature owing to the development of the novel optimization algorithms, computer power accessibility, and the larger uncertainty level established by the power sector deregulation. MG, a newly rising power technology is expected to acquire an increasing part in upcoming power systems owing to its vast advantages [8] [9] [10]. The requirement for more flexible electricity systems, environmental impact, and energy savings, are motivating the improvement of grid in power systems [11] [12]. The MG concept has been implemented as a solution to the challenge of integrating numerous power generations without disturbing the deployment, particularly when RES are exploited [13] [14] [15]. RES entail numerous aspects: reliability, efficiency, cost, safe correlation to the electric grid, ability to deal with MG's, reduced environmental impact, energy storage, and improvement of enhanced control and monitoring approaches. The most widespread RES is, wind PV, and hydroelectric powers [16] [17] [18].

A number of publications portray the wide-ranging planning crisis skilfully; Transmission system planners have a tendency to utilize numerous techniques to deal with the expansion dilemma [19] [20] [21]. Planners exploit various expansion designs to find out a most favorable TEP by reducing the numerical objective function with respect to the number of constraints [22]. At present, provided the speedy improvement of technologies that depend on electricity, the distribution of electricity in the worldwide energy mix is rising quicker than the entire primary supply of energy [23]. As a result, power enhancement during transmission is turning out to be a progressively more significant problem so as to offer reliable, sustainable and affordable energy in appropriate fashion, not only in grown-up countries but specifically in developing financial systems. As a result, particularly transmission in power system [23] and energy inconveniences has captured the concentration of the research society [24].

This survey has reviewed various works related to the grid power transmission in power systems. Here, various algorithmic classifications, which are adopted in the surveyed papers, are demonstrated along with their maximum performances. Along with it, the performance measures examined by the reviewed works are also portrayed in this survey. The paper is organized as follows. Section II analyzes the various related works and reviews done under this topic. In addition, section III describes the various analyses on the grid power transmission in power systems and section IV presents the research gaps and challenges. Finally, section V concludes the paper.

II. LITERATURE REVIEW

A. Related works

In 2018, He *et al.* [1] has established a technique based on the impact of the power system on the cash movement of the PG and introduces an investment scheme for DMM by means of system dynamics scheme. In addition, considering a city, as an illustration, to carry out an experimental analysis, the adopted method puts forward recommendations and strategy effects for the investment after the improvement of the electricity market.

In 2017, Turaj *et al.* [2] have adopted MIP design, where every set of generators was positioned in a specific island. These combination parameters may guarantee the generator synchronism next to islanding. In addition, two DC load flow approaches were implemented to design connectivity and grouping parameters. The implemented mixed integer design was resolved by means of BD method. On deploying BD method, the CPU calculation time was minimized considerably. Finally, transient stability simulations were made to authenticate the accurateness of the implemented technique.

In 2017, Cadini *et al.* [3] have established a technique, where the explanation of the network dynamics was completed by the establishment of a new restoration design that is responsible for the functioning conditions during a dangerous weather incident. The consequential design was further resolved by a modified sequential MSMC technique so as to enumerate the influence of dangerous weather occasions on the consistency/availability concerts of the PG. Finally, the established technique was confirmed with regard to the simulation outcomes.

In 2013, Rodrigo *et al.* [4] have suggested that if a PG was wide-ranging and nodes were very much linked, the coupling strength, which causes synchronization will be mostly based on the eigenvalues of the LM, as it occurs in homogeneous networks comprising of identical nodes. Alternatively, if a PG was lightly linked, the coupling strength which causes synchronization will be intensely connected to the network correlation coefficient, that implies that a several count of connections amongst which causes nodes do not favor the synchronizability of the PG. Finally, the adopted method was confirmed with regard to the simulation outcomes.

In 2012, Hugh *et al.* [5] have presented an analysis on PG, which exploits a MP design to examine the effect of raising the transmission link capability amongst the two disparate grids that were not performed earlier, and thus the problem of larger grid incorporation for determining alternative RERs. From the simulation, as wind capacity rises, costs of minimizing CO_2 emissions decrease with improved transmission capability among grids, even though this could not be brought out in all circumstances. Moreover, costs of minimizing CO_2 emissions were found to be poorer throughout the days of drought.

In 2013, Pahwa *et al.* [6] have introduced a scheme that concerns on operating the thermal units and battery controllable load in a synchronized manner. Moreover, introduced scheme contemplates the transmission restraints. The presented technique exploits a tabu search method for optimization, which was separated into two measures. Initially, actual load was governed by controllable battery and load. At last, the schedule of TUC issue was determined in the revised load. Finally, the simulation outcomes display the authentication of introduced technique and confirm the performance and efficiency of the process for controllable battery and load.

In 2011, Peter and Rolf [7] has defined two theories to rise voltage quality and power capability of the grid. In the suggested scheme, reactive power produced by solar inverters was exploited to cause an impact on the grid voltage locally. In addition, a controllable tap changer at low-voltage was capable to cause an impact on the voltage MG. Accordingly grid allowance can be evaded in numerous circumstances or nonetheless it could be postponed. Voltage variations owing to fluctuating power input can also be minimized using this scheme.

In 2011, Walid *et al.* [8] have proposed a novel FWPTPQI to combine prevailing power quality manifestations as the output depending on fuzzy inference systems. The fuzzy schemes permit in dealing with the uncertainties related with the electric power quality assessment. In addition, the introduced scheme was exploited in two cases. From the results, the outcome of the adopted scheme was found to be harmonious with prevailing circumstances. A relative analysis on deploying diverse wavelet basis operations was measured, and outcomes point out that PG indices with fewer amount wavelet coefficients assist in minimizing the size of data processed that was essential in smart grid presentations.

In 2018, Rafael *et al.* [9] have suggested the stages of both independent PG and a single combined grid. Characteristic path length, degree allocation between centrality, network diameter, and global clustering coefficient were investigated so as to recognize the network topology and to elucidate the noted differentiations between countries. Moreover, it was statistically analyzed if those measures extent or not with network size and classification of PG as small-world systems. Finally, the outcomes develop the current perceptive of power network topology that was necessary for producing synthetic PG's and in the evaluation of network robustness.

In 2011, Yannick *et al.* [10] have introduced three designs, that deals with the cases, in which cross-border transmission-capacity parameters were identical to zero, infinity and a specific limited rate, correspondingly. It was remarkably this latest design, which offers novel perceptions in the distribution of wind power, depending on portfolio model. In addition, cross-border transmission-capacity obtainable for wind-power flows was found to be an efficient measure to restrain hourly wind-power deviations.

In 2008, Petr *et al.* [11] have adopted two standards for assessment of power balance control of UCTE interconnection, namely, the average value of ACE and the standard variation of ACE. An approach for allocating reasonable values for the two principles was also determined. This practise guarantees that the UCTE grid was functioned in a secure mode and no region accomplishes control at the expenditure of further areas. As the reasonable values of the ACE standard variation were based on a selected design of ACEs, the adopted scheme was examined based on its coincidence.

In 2018, Alberto et al. [12] have suggested a synthetic PG generator with a DC failure simulator. Here, the influence of every parameter and their connections reveals the constructive insights for interferences that were intended at minimizing the probabilities of errors in conventional and upcoming power systems. Furthermore, conclusions obtained from a range of diverse PG topologies proffer more generalization than usually obtained when analyzing precise test cases. Finally, the outcomes offer the basis for upcoming models of developing power transmission systems beneath uncertainty.

In 2018, Hassan *et al.* [13] have established a novel technique that solves the issues in PG by offering a wide-ranging hypothetical examination and thereby offering appropriate experimental confirmations. The result of this experiment revealed that the EM wave generated by a HV power system does not have any impact on the power attained at the output of a PV module. In addition, this impact exaggerates if current of the power transmission turns higher to react to the load demand, and turns down by rising the distance among the conductors and PV module. At last, to define the utilization of PV systems, a least distance of 200 m among HV power and PV panels was suggested.

In 2015, Sreedharan *et al.* [14] have adopted a scheme based on the synchronized optimization of PG. Accordingly, PSO scheme regulates the settings of PG control in order to increase the renewable dissemination at the entire layers of grid. In addition, the outcomes reveal that synchronized reactive power management of electrical PG could increase the renewable penetration of the grid, anyhow, various case experiments with diverse renewable power profile at every layer of the grid were left over to get optimized. Hence, this analysis suggests that reactive power management at every layer of the PG could be a good aspirant to handle with intermittency of RESs.

In 2016, You *et al.* [15] has established a TEP co-optimization design as a MIP issue. A SC technique was also suggested to incarcerate the deviation and association of both wind and load power across the areas for large-scale PG's. The attained results symbolize that wind and load uncertainties could be established easily into the MIP issue and further resolved to attain the co-optimized TEP. Finally, the results demonstrate that the established TEP model and SC technique can develop the expansion effect considerably via designing more comprehensive information of load and wind deviations.

B. Algorithmic Classification

Various algorithms are adopted in the reviewed work, which comprises of techniques such as, tarrif policy, BD technique, MCS technique, LM, MP approach, Tabu search, Data acquisition, IDM model, RT-nested SW model, LP approach, PSO Scheme and MIP model. From the review, the tarrif policy approach was adopted in [1], and BD algorithm was implemented in [2]. Accordingly, MCS technique was implemented in [3], and LM was implemented in [4]. In addition, MP approach and Tabu search were suggested in [5] and [6] respectively. Also, data acquisition and IDM model was implemented in [7] and [11] correspondingly. RT-nested SW algorithm was adopted in [12], and LP approach was implemented in [13]. Likewise, PSO algorithm was implemented in [14], and MIP model was adopted in [15].

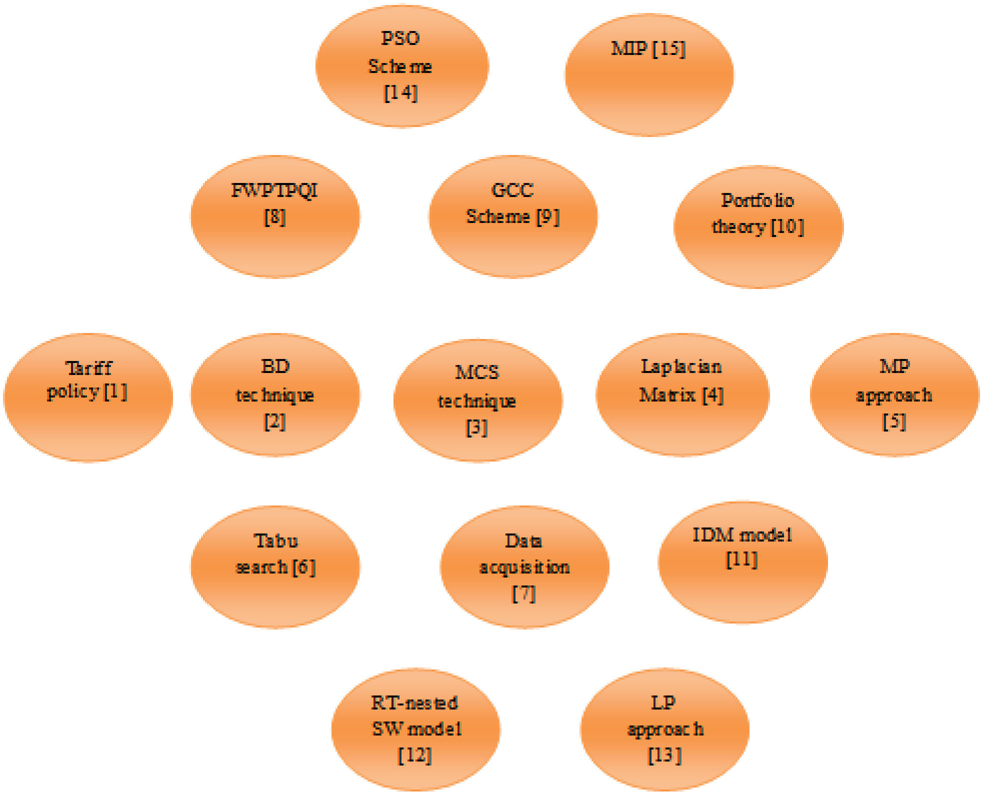

Fig. 1: Algorithmic classification of the reviewed works

C. Maximum Performance Achieved

The maximum performance achieved by various performance metrics is given by Table I. From the table, the resident load was adopted in [1] has attained a higher value of 2512.3MW. CPU time was implemented in [2] has attained a higher value of 0.343 sec and cost function implemented in [2] has attained a higher value of 156.8MW and power implemented in [12] has attained a higher value of 4,377 MW. Accordingly, average wind output and Confidence interval have attained a higher value of 175MW and 95% respectively. Also, voltage and current have presented increased values of 400KV and 496A, which were determined in [9] and [13]. Likewise, rotor angle was measured in [2], and it has adopted a value of 1500. Similarly, wind speed and length was deployed in [1], and they have attained optimal values of 9.42m/s and 15. Moreover, wind capacity has presented increased percentage of 30 and was determined in [5]. Also, SoC and spinning reverse was determined in [6], and they have attained better values of 75%, 5MW. network diameter and k factor have presented increased values of, 0.395 and 488MW/Hz which was determined in [10] and [11] respectively.

TABLE I. MAXIMUM PERFORMANCE ACHIEVED BY THE REVIEWED WORKS

Sl. No	Measures	Maximum value	Citation
1	Resident load	2512.3MW	[1]
2	CPU time	0.343 sec	[2]
3	Cost function	156.8MW	[2]
4	Power	4,377 MW	[12]

5	Average wind output	175MW	[5]
6	Confidence interval	95%	[12]
7	Voltage	400KV	[9]
8	Current	496 A	[13]
9	Rotor angle	150^0	[2]
10	Wind speed	9.42m/s	[3]
11	Length	15	[3]
12	Wind capacity	30%	[5]
13	SoC	75%	[6]
14	Spinning reverse	5MW	[6]
15	Network diameter	0.395	[10]
16	k factor	488MW/Hz	[11]

D. Performance Measures

The performance measures of the reviewed works are given by Fig.2. Various measures such as resident load, CPU time, cost, Power, average wind output, confidence interval, voltage, current, rotor angle, wind speed, length, capacity factor of wind, SoC, spinning reverse, network diameter and k factor were obtained from the reviewed works. Accordingly, resident load was determined in [1] and [3]. CPU time was adopted in [2] and [3], and cost was measured in [2] and [15]. In addition, power was determined in [4] [6] [7] [12] [13] and [15]. Average wind output was determined in [5] and [10], and confidence interval was adopted in [12]. Accordingly, voltage was measured in [7] [8] and [9], and current was determined in [8] and [13].

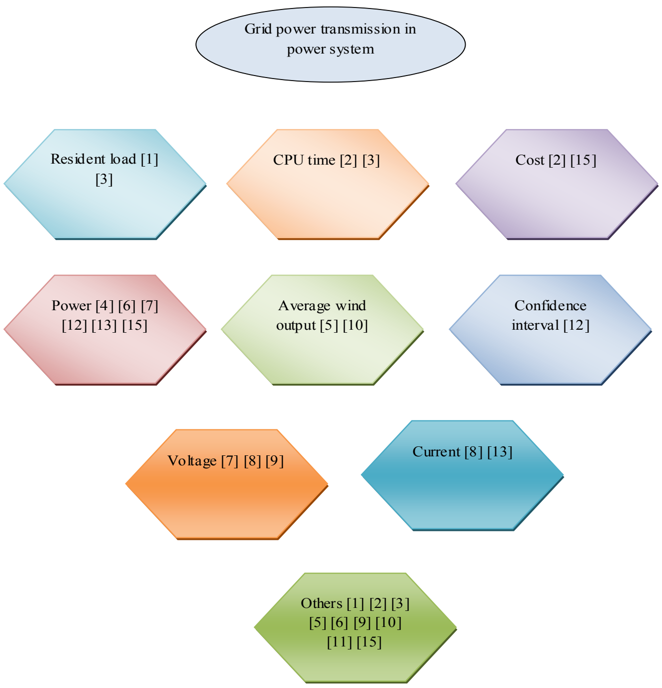

Fig. 2: Performance measures of the reviewed works

E. Load Categorization

The various loads adopted in each papers is described in this section. Forecast load was deployed in [1], and reactive load was adopted in [2]. In addition, electricity load was suggested in [3], and annual load was exploited in [5]. Forecast load and reactive load were deployed in [6] and [7] respectively. Also, electricity load, reactive load, and annual load were exploited in [11] [14] and [15 correspondingly. The classification of loads attained from the reviewed papers is given by Table II.

TABLE II. **LOAD CLASSIFICATIONS ACHIEVED BY THE REVIEWED WORKS**

Citation	Reactive load	Forecast load	Electricity load	Annual load
[1]		✓		
[2]	✓			
[3]			✓	
[5]				✓
[6]		✓		
[7]	✓			
[11]			✓	
[14]	✓			
[15]				✓

III. RESEARCH GAPS AND CHALLENGES

Modeling a grid with the correct infrastructure was a challenging issue, since, "investments in new generation or new transmission facilities can have long lives of 40 to 50 years or more." As a result, "the business decision to invest in such projects carries inherent risks that other technologies could prove to be more cost-effective over time or that the proposed investment could face premature obsolescence." The challenge was to plan for uncertainty, particularly concerning the rapidity of technological advancement and infrastructure for the future. Professionalists' assessing the electrical power grid exists as a multifaceted, interdependent system and they require the risk management investments in long-term.

Several schemes, which obtains appropriate solutions for the coordinated transmission grid problem minimizing the expansion costs and improving technical characteristics of power system was suggested, but there is no any consideration on more precise reliability aspects of the power system. Also, Stochastic approaches have been found to offer high renewable penetration and best possible expansion plan regarding operation, investment and reliability costs, anyhow, there exists certain requirement of certain supplementary enhancements for permitting a faster resolution. These above mentioned challenges are considered for motivating the enhancement of efficient transmission in power systems.

IV. CONCLUSION

The grid power transmission network as a standard between utilization centers and power generation has a limited capability in addition to its own security concerns. In addition, congestion in electricity markets takes place when the transmission network was not capable to hold the entire desired transactions owing to certain contraventions in its functioning limits. Accordingly, in this survey, various papers were analyzed, and the corresponding techniques adopted in each surveyed paper were described. In addition, the performance measures concerned in each paper were illustrated, and along with it, the maximum performance measures attained were also illustrated. In addition, the load parameters were also described. Thus the survey provides the detailed analysis of grid power transmission from the reviewed papers.

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