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GRID OPTIMIZATION - A DETAILED SURVEY

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ABSTRACT

Almost engineers in the field of power system operation and control are essential to adopt recent methodologies in optimization techniques for effective grid maintenance. A smart grid is an arrangement of a habitual electrical power distribution system with two-way communication between suppliers and customers. This two-way bifacial power flow along with its information is expected to carry energy savings, cost reductions, and improved reliability and security. By integrating various renewable energy resources like wind, solar, Biomass, and Biofuel power generation and etc. are involved in a smart grid, which makes more complicated the system analysis. Based on the difficulties has been recorded and solved every day with aid of soft computing techniques concerning its real-time operation and control. In this regard, it acquaints with new challenges to smart grid that initiates and seeks effective research to multiple points in a grid. This survey has an intent on grid optimization through its components, power-sharing, power demand, factors affecting power demand, power losses of smart grids.

KEYWORDS— Grid Optimization, Smart grid,Deep Learning.

INTRODUCTION

The smart grid is the type of electrical grid with communications technology tools to collect information, such as in order regarding the behaviors of provider and customer, in an automatic manner to develop the effectiveness, reliability, financial side, and sustainability of the making and distribution of electricity [9-10].In any smart grid system, optimal energy management (OEM) is a crucial problem because it unswervingly affects both the technical (e.g., operation and control) and economic (i.e., profit) aspects of such an energy system. In present times, the smart grid has been proposed as a solution to improve greenhouse gas emission and the efficiency and energy management in electric power grids. Chief components in the smart grid are distributed energy resources and renewable energy sources, rooftop photovoltaic (PV), electric vehicles (EVs), distributed energy storage systems, etc. Those renewable energy sources and distributed energy resources are expected to replace the impure fossil-based energy sources to generate electric power and to increase the mobility and suppleness of power grids.

At present, Power quality has become a worry to every consumer; A weak power quality may give a disappointing response of the equipment and devices and obstruct the power system in many ways [1-2]. One of the chief causes of power quality worsening is the use of nonlinear loads such as drives, computers, converters, etc., which cause- voltage sag/swell, disturbance, spikes, harmonic distortion, noise, just to mention a few [3-4]. Moreover, the weakening of conventional energy sources has covered the way for renewable energy sources, but these sources are not companionable with the already existing grids and their integration again adds to power quality issues [5-7].

The key factors of grids that analogize with presented grids which is given in the table 1.1. Due to the troubles discussed above, on hand grids are under difficulty to distribute the increasing demand for power which has recommended the concept of distributed generation systems (DGs) using renewable energy sources increases generation, improves efficiency, improves power quality, cuts energy cost and expenditures, which can be attained using the structure of smart grids [8].

Existing Grid	Smart Grid
Single-way communication	Bidirectional communication
Electromechanical	Fully Digital
only some sensors	Fully Sensors
Centralized production	Distributed production
Manual Observing	Self-Observing
Breakdown and Collapse	Commutable and islanding
Only some consumer choices	lots of consumer choices
Physical restoration	Self-healing
Restricted control	Extensive control

Table 1.1 key factors of grids

Beyond that generation concerning in smart grids, A few factors are affecting the power demand in the smart grid due to time such as seasons, the day of the week, the hour of the day, and weather like temperature, humidity, wind, sky coverage, etc, And types of consumers on residential, commercial or industrial. At last, the communication networks act an important function in smart grid operation and control. By means of adopting current upgradation in network features makes smarter in grid operation. Continually, Smart meters are placed in this system to monitor power transactions in consumer end, which is possible to get hacked the measures. The main intent of this surveying is to find out the issues and its location on the entire grid system over this smart grid optimization such as generation Optimization, Transmission Optimization, Distribution Optimization and Demand Response which will be detailed in further sections.

Smart Grid Optimization

Smart Grid optimization is to build the normal grid "as fine as possible" [7]. It needs to get the perfect equilibrium among reliability, efficiency, availability, and price. The advantage of Grid Optimization is to a.) Develop the utilization of present infrastructure and defer funding in new power system operation and control methodologies. b.) Bring down the overall charge of delivering power to end users. c.) develop the reliability of power grid. d.) decrease resource usage and emissions of contaminant and other pollutants [8].

Generation Optimization

Generation optimization with the existence of distributed generations (DG) One aspect of Smart Grid is to contain distributed generations (DG) including fuel cells, renewable, micro turbines etc. DGs are more uncertain, which makes dispatching decisions even more challenging. E.g., it is hard to predict near-term wind availability and velocity[].

Smart grids are collected of a massive number of devices of different types, from solar inverters and smart meters to electrical substation tools and sensors on power lines. Electricity can be formed by various processes from the steady production of a nuclear plant, to the storage via electric vehicles, and integration of renewable energy which production may depend on ecological factors. A vast distribution and energy transport network formed over the years but it is neither mastered nor optimized. Optimal placement of DG effectively provides reduce of active power losses, Maximizing DG capacity, Minimization of loading in preferred lines with Constraints include voltage, thermal, short circuit, and generator active power and reactive power abilities[9].

Transmission optimization

Transmission networks are usually enormous in size, running throughout several states or even across the international limits. They are interconnected, which means that the breakdown of one region may cause the collapse of the entire network. Minimization of operating boundaries or maximum use of presented transmission assets with improved system security and reliability requires new control tools to perform power flow computing on the categorize of milliseconds. Quick fix of large-scale algebraic equations is critically essential for timely power control computation. Scale of transmission network: 10,000 or more buses, or 20,000 by 20,000 Jacobian matrix. Desirable computing time: milliseconds. Jacobian-free Newton–Krylov (JFNK) technique to explain nonlinear arithmetical systems of equations. Parallel computing scheme on modern architecture supercomputers using multilevel parallelization techniques. Faster power flow solver in a Smart Grid, Smart Grid creates quick power flow solver still more critical. Installations of novel generation of sensors, like Phase Measurement Units (PMUs), and integrated telecommunication networks supply faster updates of information on network components. Coupled with quicker power flow resolve, all of this allows faster computation and faster decision-making including state estimation, fault detection & location, and quick restoration.

Distribution optimization

Voltage control

The intention of voltage control in distribution networks is to adjust the tap position of transformer regulators in order to attain the target of reducing power losses while maintaining satisfactory voltage profiles. The change of voltage is along a number of onload tap changers (OLTCs), every competent of regulating the voltage of the output of a transformer at one point in the network. Reduce power losses and switching (tap change) costs Subject to power flow equations, voltage limitations, both phase to neutral and phase to phase current constraints, including cables, overhead lines, transformers, neutral and grounding resistance; tap change constraints shunt capacitor change constraints. Conservative Voltage Reduction (CVR) is the thought of lessen the use of voltage to end-use consumers such that their demands, and energy consumption, reduced. The most prominent benefit of CVR is the peak load reduction, which hence reduces the price of power delivery because it expenses more to run peaking generation units. CVR has an additional benefit of reducing power loss. CVR usually makes use of both capacitors and voltage regulators [10].

Feeder configuration

Feeder configuration is to modify the corresponding constructions of allocation feeders by shifting the open/closed conditions of the partial or tie switches. The intention is to decrease the total system power loss although keeping the generation cost of distributed generators at minimum [10].

Benefits of feeder configuration, develop network load balancing, cut power losses, and avoid service disruption in casing of power outage. Most of the existing feeder reconfiguration approaches have primarily centered around the issue of how to efficiently solve the underlying discrete optimization problem. These approaches include genetic algorithms, Tabu search, heuristic methods, and dynamic programming. Genetic algorithms (Sivanagaraju et al. 2006; Koichi et al. 1992) , Tabu search (Rugthaicharoencheep and Sirisumrannukul 2009) Heuristic methods (Milani et al. 2008; Zhou et al. 1997)

Phase balancing

The goal of phase balancing is to maximize the feeder capacity utilization, to improve power quality, and to reduce energy losses. It is a “combinatorial optimization” problem. It is a “combinatorial optimization” problem. The solution is the assignment of customer load to which of the three phases. Normal algorithms for such troubles are tabu search, simulated annealing, genetic algorithms and thorough search [16].

Demand management

Demand management works to lessen electricity utilization in residences, workplaces, and industrials unit by frequently observing electricity consumption and actively supervision how appliances consume energy. It involve of demand-response programs, smart meters and variable electricity charge, smart buildings with smart appliances, and energy dashboards. United these modernizations let utility companies and customers to handle and respond to the deviations in electricity demand further effectively [18].

OPTIMIZATION TECHNIQUES APPLIED TO SMART GRID

Some optimization techniques have been implemented to various types of smart grid problems. These techniques consist of a spacious collection of mathematical modeling, as well as apply the mathematical programming algorithms like linear and nonlinear programming, dynamic programming, and interior-point methods. Other techniques include artificial intelligence (AI) methods, such as neural networks and fuzzy systems, and evolutionary methods, such as genetic algorithms and the simulated annealing [10]. connection between the main decision-making tools in power system and the classical optimization problems shows in Fig 2.0.

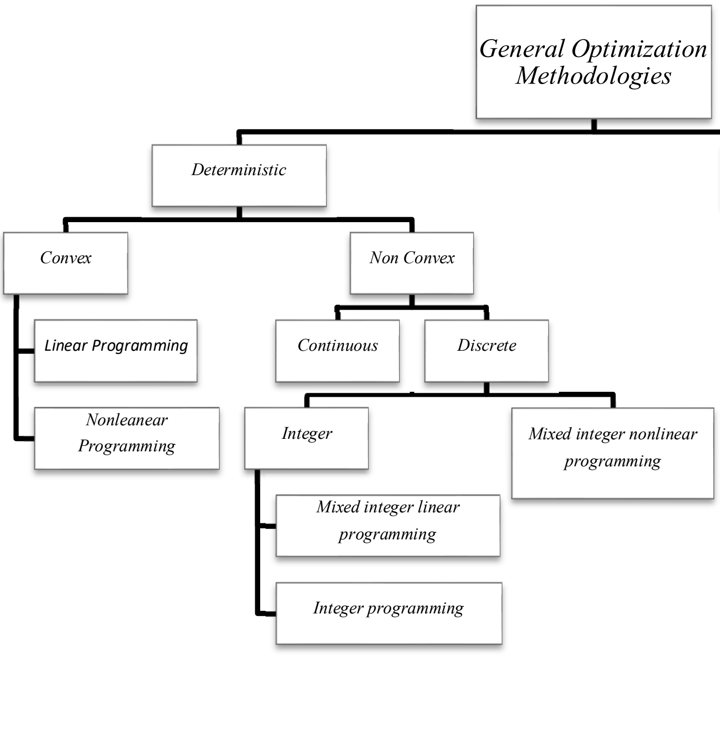

Fig 2.0 Optimization Techniques

The techniques observed in this chapter can be distributed as follows:

- Linear programming (LP)
- Mixed-integer programming (MIP)
- Decomposition methods
- Stochastic programming (SLP)
- Artificial intelligence methods (AI)

These optimization methods can be distributed into three major groups: (1) Deterministic methods, (2) stochastic methods, and (3) heuristic and artificial intelligence methods.

Deterministic methods consist of linear programming, mixed-integer programming, decomposition methods, and Lagrange relaxation techniques. Stochastic methods consist of Monte Carlo simulation, chance-constrained programming, Pareto curves, and risk management approaches. Finally, the genetic algorithm, particle swarm optimization method, and evolutionary methods are part of the artificial intelligence methods. While there are further methods, the most familiar ones are presented as models to show up the difficulty of the problems.

Optimization of grid can be attained by screening the load performance [11], changing the peak hours electricity demand into off-peak and quick healing of some power failure [12]. It as well aids in constructing energy reservoirs to meet the additional demand, addition of plug-in electrical vehicles [13], gathering real time user data and share with the utility companies [14].

From the literature, few cases were highlighted which was successfully applied to smart grid for optimization such as

- PSO based Optimized charging station for PHEVs, Matlab simulations were performed on five electric vehicles. Then after applying PSO algorithm on they were compared with gravitational-search optimization algorithm (GSA) [13].

- PSO based Phaser measurements in power grid, A PSO based model is proposed according to IEEE bus bar system to optimize substations with the help of PMUs.
- PSO Demand Management a system consisting on demand response management and distributed generation in combined. To work out the non-linear manners of demand response PSO is used since its rapid searching speed [18].
- ANNs load forecasting two models are designed for prediction of loads from ANNs and then used them for peak-load-prediction. [19].
- ANNs Short term load forecasting on the root of days four models for load forecasting are planned and evaluated by ANN. Then finest model is selected for Forecasting.
- ANNs cost forecasting a model ANN is proposed from historical pricing data. Then skilled by the assist of Matlab toolbox a neural network. [20].
- ANNs finding of cyber attacks in smart grid a model skilled by ANNs proposed for variance detection of cyber attacks.
- ANNs Load profiling of PHEVs a model of 12 PEVs is proposed and trained by ANN. It forecast the load profiles of these PEVs with high accuracy than previous techniques. [21].
- GA Fault detection a technique followed by GA is introduced for fault detection in smart grid transmission and distribution line. [12].
- GA Cost reduction and energy management Different types of loads are modelled according to previous data. Then these models are trained and developed by GA. [14].
- GA price drop a model containing of batteries, controller and DC-AC inverter is intended and then GA is applied for 24 hours to stable loads. Finally optimised price is observed through different cases of loads. Authors choose GA as a better candidate for price reduction [22].
- GA Energy theft detection a framework based on GA, on load profile, is presented to detect frauds in consumer domain [23].
- GA Voltage control and protection GA is initialized to control three applications i.e., minimize the voltage difference, power loss and relays disturbance in a smart grid environment [20].
- ACO Voltage control over feeders a methodology based on cost consumption voltage control is introduced. This algorithm is used to solve problems related to optimized power control [11].
- ACO Load balancing Different algorithms are compared and evaluated. Finally, choose ACO algorithm for load balancing purpose [26].
- ACO Power distribution a model based on two power stations are proposed, analysed and evaluated with ACO algorithm. Authors discover ACO algorithm an efficient approach for power distribution. [25] For better communication within power plants, different techniques are proposed with the help of ACO.
- MA To share renewable energy with grid a model of energy sources is formulated and then it is proceeded through MA for sharing energy to rural areas.

The major disadvantages of the above applied methods are that the training period is too long and there are problems with being able to stick to a single solution during training [27]. In this connection, Machine learning algorithms are widely considered for classification as well as optimization associated with existing GA, PSO, etc. That has been proposed to overcome some of the disadvantages of the neural networks [28] with various power system problems.

Optimization Based on Deep Learning

Deep learning is a learning method that can extract big level abstractions from input data through a deep formation consisting of several processing layers. One of the typical deep learning structures is deep belief net (DBN), which is proposed by G. Hinton in [29]. In general DBN is constructed by multiple hidden layer (stochastic hidden cause)and one visible layer (input data), where different layers are linked by correspondence weights and the state or value of each unit is determined as a function of the values of connected units and the corresponding weights. The training of DBN is to conclude the states of all the unobserved variables in hidden layers and adjust the interacting weights between units such that the network is other possible to generate the experimental data in visible layer. After training, the top layer can be observational as the abstracted information (features) from the input data.DBN itself is an unsupervised learning model, which means it does not rely on labels of training samples and can learn based supervised learning algorithm can be summarized as follows. Based on training samples, DBN and BP improvement process learn the values of units in hidden layers and the interacting weights. Then replacing the visible layer by a new input sample (test sample), the network can generate an output as the classification result of the input. From the literature, a deep learning-based method in dropping problem scale for wireless network optimizations, [28].Here the test flow vectors has assigned as a learning structure to get the learning results, which are the link value vectors estimated by the learning algorithm. The learning result is then compared with the true result obtained from solving the optimization problem. Solving each problem will provide one pair of input (flow vector) and output (link values), and the data pairs are used as training samples for the learning algorithm. Thus, the deep learning-based algorithm is promising in improving the efficiency of solving large scale optimization problems. [28].In near future, studies on energy optimization in smart grid will progressively shifted to agent-based machine learning method signified by state of art deep learning and deep reinforcement learning, Especially deep neural network-based reinforcement learning methods are emerging and gain recognition to for smart grid application [28]

CONCLUSION

These surveys have intended on finding an AI based optimization technique which adopt for analysis of big power networks with smart grid. Across the literatures there are numerous troubles have to be accounted during the analysis and control of smart grid .There are definite benefits that are accomplished by optimizing the grid i.e., power transmission, distribution and utilization losses can be shrink, reliability of grid is attained and emission of hazardous and pollutant gases are abridged. Furthermore, it also aids in reducing the energy cost Moreover, the voltage fluctuation and uncertainty of power can be narrowed and protection failure of procedures can be foreshortened. Thus, the deep learning-based algorithm is promising in civilizing the efficiency of work out large scale optimization problems.

REFERENCES

[1] C. Smallwood, "Power quality issues relating to power line carrierautomated meter reading technology", IEEE rural Electric PowerConference, pp. BlII-B1I8, Apr. 2001, Little Rock, Arkansas, USA
[2] A Singh and B. Singh, "Power quality issues related to distributedenergy source integration to utility grids", IEEE India Conference(INDICON), pp. 1 - 5, Dec. 2010, Kolkata, India.
[3] D. Nair, A Nambiar, M. Raveendran, N.P. Mohan and S. Sampath "Mitigation of power quality issues using DSTATCOM", IEEE Emerging Trends in Electrical Engineering and Energy Management (ICETEEEM), pp. 65 - 69, Dec. 2012, Chennai, India.
[4] I. Hunter, "Power quality issues-a distribution company perspective" IEEE Power Engineering Journal, Vol. 15, pp. 75-80, Apr. 2001.
[5] F.R. Yu, Z. Peng, X. Weidong and P. Choudhury, "Communication systems for grid integration of renewable energy resources", IEEE Network, Vol. 25, pp. 22-29, Sept.-Oct.2011.
[6] A. Keyhani, "Chpater 1: Smart Power Grids, Smart Pow- er Grids," Springer, Berlin, Heidelberg, 2011, pp. 1-25.
[7] "A Vision for the Modern Grid," Technical Report, Na- tional Energy Technology Laboratory, Morgantown, 2008.
[8] A Sinha, S. Neogi, R.N. Lahiri, S. Chowdhury, S.P. Chowdhury and N. Chakraborty, "Smart grid initiative for power distribution utility in India", IEEE Power and Energy Society General Meeting, pp. 1-8, Jul. 2011, Sandiego, CA, USA
[9] M.R. R. Bhuyian, R. Mostafa, M.F. Khan, U. Zobayer, "Application of smart grid techniques for effective control in a mini-grid system", IEEE Developments in Renewable Energy Technology (ICDRET-2012), pp. 1-4, Jan. 2012, Dhaka, Bangladesh.
[10] X. Fan, S. Misra, G. Xue, D. Yang,"Smart Grid - The New and Improved Power Grid: A Survey", IEEE Communications Surveys & Tutorials, Vol. 14, pp. 944-980, 2012.
[11] T. Niknam, A. Ranjbar, A. Shirani, and A. Ostadi, "A new approach based on ant algorithm for volt/var control in distribution network considering distributed generation," Iranian Journal of Science & Technology, Transaction B, vol. 29, no. B4, pp. 1–15, 2005.
[12] M. Kezunovic, "Smart fault location for smart grids," IEEE Transactions On Smart Grid, vol. 2, no. 1, pp. 11–22, 2011.
[13] I. Rahman, P. M. Vasant, B. S. Mahinder Singh, and M. Abdullah- Al-Wadud, "Swarm intelligence-based smart energy allocation strategy for charging stations of plug-in hybrid electric vehicles," Mathematical Problems in Engineering, vol. 2015, 2015.
[14] A. Arabali, M. Ghofrani, M. Etezadi-Amoli, M. S. Fadali, and Y. Baghzouz, "Genetic-algorithm-based optimization approach for energy management," IEEE Transactions on Power Delivery, vol. 28, no. 1,

pp.162–170, 2013.
[15] M. Ahat, S. B. Amor, M. Bui, A. Bui, G. Guerard, and C. Petermann, "Smart grid and optimization," Amj Oper Res, vol. 3, pp. 196–206, 2013.
[16] C. Joe-Wong, S. Sen, S. Ha, and M. Chiang, "Optimized day-ahead pricing for smart grids with device-specific scheduling flexibility," IEEE Journal on Selected Areas in Communications, vol. 30, no. 6, pp. 1075–1085, 2012
[17] A. U. Haque, P. Mandal, J. Meng, and R. L. Pineda, "Performance evaluation of different optimization algorithms for power demand forecasting applications in a smart grid environment," Procedia Computer Science, vol. 12, pp. 320–325, 2012.
[18] B. Jiang and Y. Fei, "Dynamic residential demand response and distributed generation management in smart microgrid with hierarchical agents," Energy Procedia, vol. 12, pp. 76–90, 2011.
[19] M. A. Dimitrijevic, M. Andrejevic-Stovscovic, J. Milojkovi, and V. Litovski, "Implementation of artificial neural networks based ai concepts to the smart grid," Facta Universitatis, Series: Electronics and Energetics, vol. 27, no. 3, pp. 411–424, 2014.
[20] B. Neupane, K. S. Perera, Z. Aung, and W. L. Woon, "Artificial neural network-based electricity price forecasting for smart grid deployment," in Computer Systems and Industrial Informatics (ICCSII), 2012 International Conference on. IEEE, 2012, pp. 1–6.
[21] D. Panahi, S. Deilami, M. A. Masoum, and S. M. Islam, "Forecasting plug-in electric vehicles load profile using artificial neural networks," in Power Engineering Conference (AUPEC), 2015 Australasian Universities. IEEE, 2015, pp. 1–6.
[22] G. A. Mary and R. Rajarajeswari, "Smart grid cost optimization usingbgenetic algorithm," International Journal of Research in Engineeringband Technology, vol. 3, no. 7, pp. 282–287, May-2014.
[23] J. Nagi, K. Yap, S. Tiong, S. Ahmed, and A. Mohammad, "Detection of abnormalities and electricity theft using genetic support vector machines," in TENCON 2008-2008 IEEE Region 10 Conference. IEEE, 2008, pp. 1–6.
[24] P. C. Ramaswamy and G. Deconinck, "Relevance of voltage control, grid reconfiguration and adaptive protection in smart grids and genetic algorithm as an optimization tool in achieving their control objectives," in Networking, Sensing and Control (ICNSC), 2011 IEEE International Conference on. IEEE, 2011, pp. 26–31.
[25] K. M. Sim and W. H. Sun, "Ant colony optimization for routing and load-balancing: survey and new directions," IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans, vol. 33, no. 5, pp. 560–572, 2003.
[26] B. Hu, J. Gu, and Y.-D. Wang, "An ant colony optimization based method for power distribution network planning." Relay, vol. 33, no. 21, pp. 54–57, 2005
[27] L. Liu, X. Cao, Y. Cheng, L. Du, W. Song, and Y. Wang, "Energy efficient capacity optimization in wireless networks," in Proc. IEEEINFOCOM, 2014, pp. 1384–1392.
[28] W. Zhang, K. Liu, W. Zhang, Y. Zhang, and J. Gu, "Wi-fi positioning based on deep learning," in Proc. IEEE ICIA, 2014, pp. 1176–1179.
[29] Y. LeCun, Y. Bengio, and G. Hinton, "Deep learning," Nature, vol. 521,no. 7553, pp. 436–444, 201