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DEREGULATED POWER SYSTEM MANAGEMENT USING FACTS DEVICES: A REVIEW

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ABSTRACT—

A deregulated setting allows for the ideal placement and sizing of several FACTS devices. At each bus, customers must pay the service provider the Locational Marginal Price (LMP), which increases as the network becomes more congested. As a result, when there is congestion, the network's LMPs become uneven, which costs service providers a lot. This makes traffic management a challenging issue that needs to be resolved. While hybrid optimisation techniques based on flower pollination and particle swarm optimisation are used to determine the ideal size of these devices, Transmission Congestion Cost (TCC) is used to determine the best location for one or more FACTS devices. The results are compared with those of other developing approaches (FPA and PSO) after the proposed method is tested on an IEEE 30 bus system.

Keywords— Congestion Management, FACTS devices, Generation Reschedule, Demand Response, Distributed Generation, Electric Vehicles.

INTRODUCTION :

When power is being transferred from generating units to end users, transmission lines are crucial. Deregulation of a power system aims to reduce costs and increase energy efficiency, security, and reliability by encouraging competition in the electrical industry [1]. Electrical energy bidding strategy, transmission network congestion, preserving and enhancing the security and reliability of power system operation, and assessing the power market's solid financial status are some of the challenges facing the competitive power market. Power flows in transmission networks are regulated by a number of constraints.

If any of the constraints, such as the temperature, voltage, and stability limitations, are violated, the system is said to be "congested" [2]. Congestion has hindered transmission network power transactions and power market operations. Congestion in transmission networks can result in unstable power markets, cascading blackouts, increased energy costs in some places, and bad financial situations. ways to reduce the congestion and improve the transmission network's efficient use. The intended power transactions, which are carried out in compliance with market contracts or bids, cannot be dispatched by the crowded transmission network.

Many CM techniques are used globally in the restructured power market [4]. The structure and features of the electrical markets in different nations around the world determine these tactics. To lessen market congestion in the electrical sector, both market-based and non-market-based approaches are used. Examples of market-based CM strategies include the associated pricing strategies and congestion-reduction initiatives. These techniques provide system operators with transmission capacity signals and rely on the functioning and regulation of the power market. In non-market-based systems, transmission capacity is distributed among users without reference to market forces. These strategies include allocating network capacity to a certain transaction type depending on its priority, distributing transmission capacity among market participants based on their demands, and implementing a first-come, first-served policy. In recent years, a number of cutting-edge strategies have been proposed for the management of congestion in the deregulated power market, including demand response, generation rescheduling, electric vehicles, optimal distributed generation placement, and artificial intelligence-based strategies.

CONGESTION MANAGEMENT METHODS :

Several strategies are proposed for CM in the deregulated power market. Available transfer capability (ATC), load shedding, generation re-dispatch, network reconfiguration, and auction-based strategies are used to alleviate congestion in the early phases of the deregulated energy market. To alleviate congestion, the grid was segmented into zones based on the energy pricing at nodes and places. Artificial intelligence-based CM strategies, OPF, FACTS devices, nodal and zonal price-based processes, and generation rescheduling are frequently employed in competitive energy markets. Modern CM strategies are based on demand response, distributed generation, electric vehicles, and hybrid systems. In order to increase efficiency and lower electricity prices, deregulation is accomplished through the introduction of electrical markets. New organisational structures have emerged as a result of the electricity power market's unbundling. The goal of deregulation is to promote competition and remove monopoly power and market flaws that exist in vertically integrated systems.

The power system's structure both before and after deregulation is seen in Figure 1.1. Prior to deregulation, distribution and transmission were managed by a single entity, and following deregulation, the following unbundling of distribution, transmission, and generation occurred:

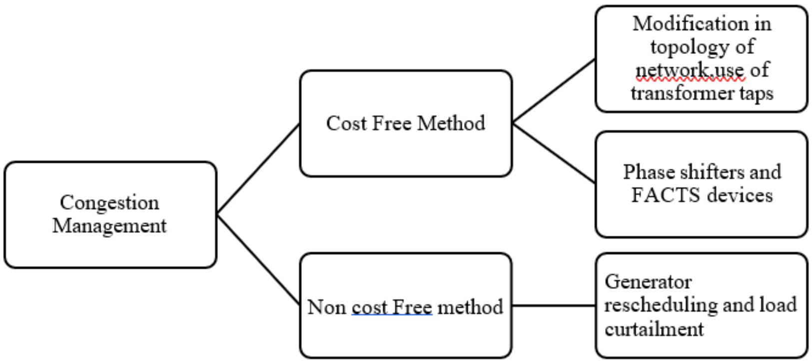


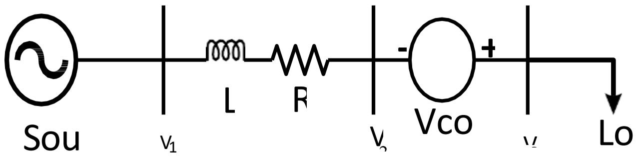
Figure 1: Congestion management methods

Congestion Management techniques

Galvanic isolation is the most important safety requirement for PV systems. In the absence of galvanic isolation, the capacitance between the PV cells and the ground metallic plate results in leakage ground current.

It reduces current leakage from photovoltaic sources to the grid. According to the National Electrical Code (NEC), galvanic separation is required for PV systems that are higher than 50V. Another advantage is that, should one side of the grid-connected PV system malfunction, it won't impact the other side. [4, 6] Congestion clusters and zones are identified in the power transmission network based on their impact on pertinent transmission constraints.

A zonal/cluster based paradigm is used to alleviate congestion in the competitive power markets by considering the real and reactive transmission congestion distribution characteristics [8]. The primary objective of OPF techniques is to provide optimal power transmission while complying with all gearbox and operating constraints. Transmission congestion can be easily managed by OPF techniques by fulfilling a set of constraints. For CM in a deregulated setting with operational, voltage, and thermal limitations, OPF-based approaches are frequently employed [9].
An OPF based model with minimization of curtailments in power transactions is proposed for CM in deregulated power market [10].



Flexible AC Transmission System (FACTS) Devices

Mainly two types of compensations are used

- **Series Compensation**

This kind uses a transmission line to connect FACTS devices in series. This kind of adjustment enhances the system's dynamic stability and provides greater control over power flow. By connecting multiple capacitor banks in series, the amount of compensation can be changed. Figure 1.6 shows a transmission line with series compensation. Thyristor Controlled Series Compensator (TCSC) and Fixed Series Compensation (FSC) are two types of series compensation.

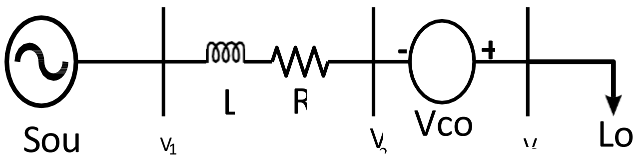


Figure 2: Series Compensation Diagram

- **Shunt Compensation**

Several FACTS devices are linked in parallel to the lines at specific nodes in this kind of compensation. In order to improve voltage regulation and losses, they inject current into lines to compensate for the load current. Figure 1.7 depicts a shunt adjusted gearbox line. Static Synchronous Compensator (STATCOM) and Static VAR Compensator (SVC) are examples of shunt compensation devices.

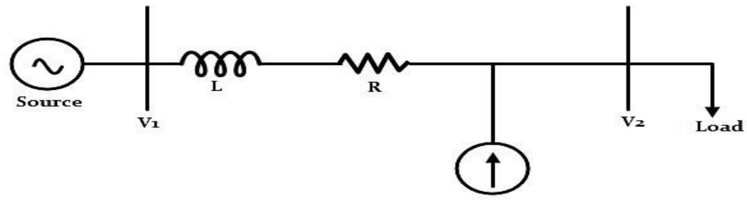


Figure 3: **Shunt Compensation Diagram**

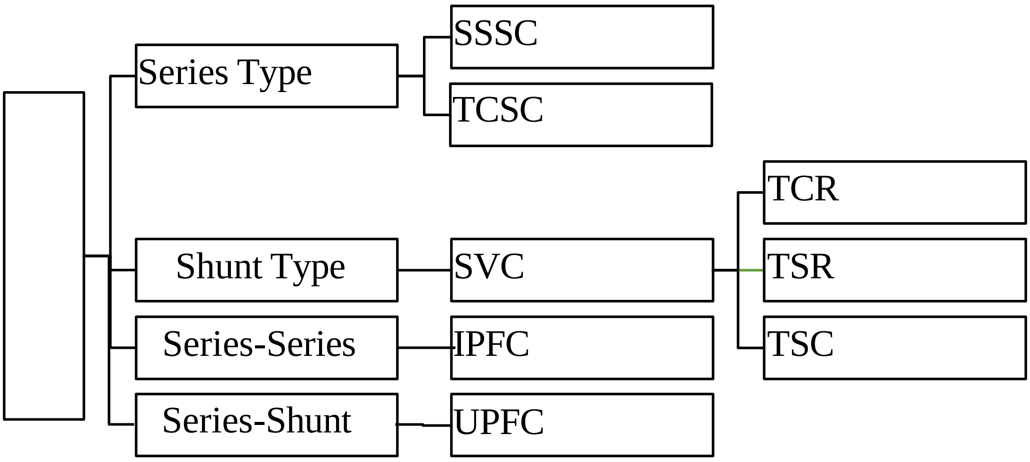


Figure 4**: Detailed View of FACT Devices Family**

Congestion Management by Generation Reschedule

In reorganised electricity markets, generation rescheduling (GR) is one of the most widely used CM methods. Congestion in the transmission network is minimised by rescheduling the generators' power outputs as it occurs. Based on real power generation rescheduling, the relative electrical distance idea reduces transmission congestion [25]. The truth For utilising quasi-dynamic thermal ratings of transmission lines to lower the cost of congestion during clearing time, a time market-based transmission CM algorithm is proposed, utilising load shedding and generator rescheduling [26]. The restru In uses short-, medium-, and long-term generator scheduling to reduce congestion.

Congestion Management by Electric Vehicles

Nowadays electric vehicles (EVs) are widely used in the restructured power system and especially in the distribution system. EVs are playing a major role in managing the congestion, stability, and reliability of the power market by balancing the load variations and changing the power flows in the network. By regulating EV charging using Lagrangian relaxation based on the partial decomposition method, an EV-based CM approach is suggested to alleviate power market congestion [42]. To control grid congestion, a two-level hierarchical control approach is suggested for EV integration [43]. Using EVs with intermittent RES, a probabilistic power flow-based approach is suggested to manage smart grid congestion [44]. With the integration of several EVs and heat pumps, a dynamic power tariff-based approach is suggested for congestion mitigation in distributed networks [45]. Congestion is reduced by using the vehicle to grid (V2G) concept.

Case Study :

On a modified IEEE 6 bus system, Power World Simulator has examined a number of popular CM approaches, such as distributed generation [37, 54], generation rescheduling [29], and FACTS [53]. The updated IEEE 6 bus system is shown in Figure 2. This system consists of three load buses and three generator buses. These CM techniques are fairly compared in order to alleviate the congestion problem. The CDF [55] values for each bus are listed in Table I, and two to six lines are considered congested lines for this system.

TABLE II. CDF VALUES WITH RESPECT CONGESTED LINE

Bus Number	*CDF*
1	0.0
2	0.1
3	-0.2
4	0.0
5	-0.2
6	-0.4

Bus 6 is the best location for DG deployment, according to CM, followed by buses 5 and 3. This is because, based on Table II, bus 6 has the lowest CDF value, which is -0.4. The optimum spot to put the FACTS device is on lines 2–6, as the CDF values are lowest at bus 6 and highest at bus 2. Table III lists the generation costs and losses associated with various approaches using a 10MW DG unit at bus 6 and a FACTS device on lines 2–6. Table III shows that these techniques lower the costs and losses associated with generating.

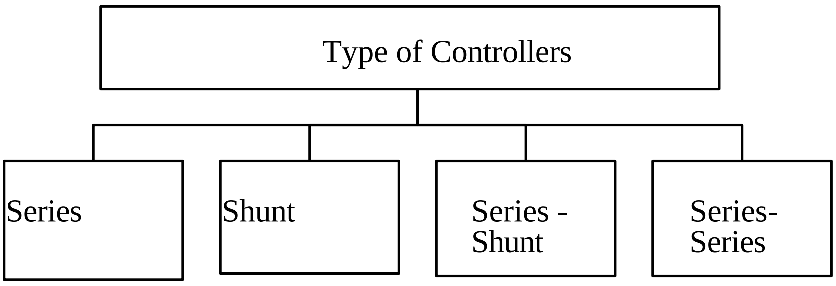


Figure 5: FACT controllers

of the power converter's step up/down feature, which also allows the inverter to step down the voltage in accordance with grid requirements. The three level boost converter has certain advantages in high voltage applications, including lowering the diode's reverse recovery losses, switching losses, and switch rating (IGBT), which is half that of a conventional boost converter and halved the diode rating. As a result, the cost is decreased and the operation is quicker than with a traditional boost converter. [9]

CONCLUSION :

This study presents a thorough examination of several CM strategies in competitive power markets. In the ever evolving restructured power market, CM has become a major issue. In this work, both conventional and contemporary CM techniques are applied. Historical information on the CM tactics and strategies employed in the various competitive power markets worldwide is included in the publications considered for this work.

REFERENCES :

[1] Y. R. Sood,N. P. Padhy, and H. O. Gupta, "Wheeling of power under deregulated environment of power system – a bibliographical survey," IEEETrans.Power Syst.,vol.17(3),pp.870-878,2002.

[2] M. I. Alomoush, and S. M. Shahidehpour, "Contingency-constrained congestion management with a minimum number of adjustments in preferred schedules," Int. Journal of Electrical Power and Energy Syst., vol.22(4), pp. 277–290, May 2000.

[3] R.D. Christie, B. F.Wollenberg, and I. Wangensteen, "Transmission management in the deregulated environment," Proc. IEEE, vol.88(2),pp.170–195, Feb. 2000.

[4] A. Pillay, S. P. Karthikeyan, and D. P. Kothari, "Congestion management in power systems-A review," Int. Journal of Electrical Power and EnergySyst., vol. 70, pp. 83-90, Sep. 2015.

[5] J. Aguado, V. Quintana, and M. Madrigal, "Optimization-based auction mechanism for inter-ISO congestion management," Proc. of IEEE PES, Summer Meeting, vol. 3, July 15-19, pp. 1647-1651, 2001.

[6] M. I. Alomoush, and S. M. Shahidehpour, "Generalized model for fixed transmission rights auction," Elect. Power Syst. Res., vol. 54(3), pp. 207-220, Jun. 2000. 245

[7] H. Glavitsch, and F. Alavardo, "Management of multiple congested conditions in unbundled operation of a power system," IEEE Trans. Power Syst., vol. 13(3), pp. 1013-1019, Aug. 1998.

[8] A. Kumar, S. C. Srivastava, and S. N. Singh, "A zonal congestion management approach using real and reactive power rescheduling," IEEE Trans. Power Syst., vol. 19(1), pp. 554-562, Feb. 2004.

[9] R. D. Christie, B. Wollenberg, and I. Wangensteen, "Transmission Management in the Deregulated environment," Proc. of IEEE, vol. 88(2), pp. 170-195, Feb. 2000.

[10] S. C. Srivastava, and P. Kumar, "Optimal power dispatch in deregulated market considering congestion management," Proc. of Int. Conf. on Elect. Utility Deregulation and Restructuring and Power Tech., DRPT, April 4-7, pp. 53-59, Apr. 2000.

[11] K. Vijayakumar, "Optimal location of FACTS devices for congestion management in deregulated power systems," Int. Journal of Computer Applications, vol. 16(6), pp. 29-37, 2011.

[12] X. Wang, Y. H. Song, Q. Lu, and Y. Z. Sun, "Series FACTS devices in financial transmission rights auction for congestion management," IEEE Power Eng. Rev., vol. 21(11), pp. 41-44, Nov. 2001.

[13] S. Phichaisawat, Y. H. Song, X. L. Wang, and X. F. Wang, "Combined active and reactive congestion management with FACTS devices," Electric Power Components and Syst., vol. 30(12), pp. 1195-1205, Dec. 2002.

[14] A. Naresh, and M. Nadarajah, "Influence of TCSC on congestion and spot prices in electricity market with bilateral contract," Electric Power Syst. Res., vol. 77(8), pp. 1010-1018, June 2007.

[15] H. Besharat, S. A. Taher, "Congestion management by determining optimal location of TCSC in deregulated power systems," Int. Journal of Electrical Power Energy Syst., vol. 30(10), pp. 563-568, Dec. 2008.

[16] S. P. Singh, and K. Arun Kumar Reddy, "Congestion mitigation using UPFC," IET Generation, Transmission & Distribution, vol. 10(10), pp. 2433-2442, July 2016.

[17] O. Ziaee, and F. F. Choobineh, "Optimal Location-Allocation of TCSC Devices on a Transmission Network," IEEETrans. Power Systems, vol. 32(1), pp. 94-102, Jan. 2017.

[18] E. Bompard, E. Carpenato, G. Chicco, and G. Gross, "The role of demand elasticity in congestion management and pricing," IEEE Proc., PES, Summer Meeting, vol. 4, pp. 2229-2234, 2000.

[19] P. Palensky, and D. Dietrich, "Demand side management: Demand response, intelligent energy systems, and smart loads," IEEE Trans. Industrial Informatics, vol. 7(3), pp. 381-388, Aug. 2011.

[20] H. Y. Yamin, S. M. Shahidehpour, "Transmission congestion and voltage profile management coordination in competitive electricity markets," Int. Journal of Electrical Power and Energy Syst., vol. 25(10), pp. 849-861, 2003.

[21] J. Wu, B. Zhang, and Y. Jiang, "Optimal day-ahead demand response contract for congestion management in the deregulated power market considering wind power," IET Generation, Transmission & Distribution, vol. 12(4), pp. 917-926, Feb. 2018.

[22] Z. Zhao, and L. Wu, "Impacts of High Penetration Wind Generation and Demand Response on LMPs in Day-Ahead Market," IEEE Trans. Smart Grid, vol. 5, no. 1, pp. 220-229, Jan. 2014.

[23] M. H. Moradi, A Reisi, and S. M. Hosseinian, "An optimal collaborative congestion management based on implementing DR," IEEE Trans. Smart Grid, Article in press, 2017.

[24] K. Singh, N. P. Padhy, and J. Sharma, "Influence of price responsive demand shifting bidding on congestion and LMP in pool based day ahead electricity markets," IEEE Trans. Power Syst., vol. 26(2), pp. 886-896, May 2011.

[25] G. Yesuratnam, and D. Thukaram, "Congestion management in open access based on relative electrical distances using voltage stability criteria," Elect. Power Syst. Res., vol. 77(12), pp. 1608-1618, Oct. 2007.

[26] M. M. Esfahani, and G. R. Yousefi, "Real Time Congestion Management in Power Systems Considering Quasi-Dynamic Thermal Rating and Congestion Clearing Time," IEEE Trans. on Industrial Informatics, vol. 12(2), pp. 745-754, Apr. 2016.

[27] O. B. Fosso, A. Gjejsvik, A. Haugstad, B. Mo, and I. Wangensteen, "Generation scheduling in a deregulated system: The Norwegian case," IEEE Trans. Power Syst., vol. 14(1), pp. 75-81, Feb. 1999.

[28] S. S. Reddy, "Multi-Objective Based Congestion Management Using Generation Rescheduling and Load Shedding," IEEE Trans. Power Syst., vol. 32(2), pp. 852-863, Mar. 2017.

[29] S. Dutta, S. P. Singh, "Optimal rescheduling of generators for congestion management based on particle swarm optimization," IEEE Trans. Power Syst., vol. 23(4), pp. 1560-1569, Nov. 2008.

[30] S. Balaraman, and N. Kamaraj, "Transmission congestion management using particle swarm optimization," Journal of Electrical Syst., vol. 7(1), pp. 54-70, 2011.

[31] A. K. Jain, S. C. Srivastava, and S. N. Singh, L. Srivastava, "Bacteria foraging optimization based bidding strategy under transmission congestion," IEEE Systems Journal, vol. 9(1), pp. 141-151, Mar. 2015.

[32] S. Verma, and V. Mukherjee, "Optimal real power rescheduling of generators for congestion management using a novel ant lion optimiser," IET Gener. Transm. Distrib., vol. 10(10), pp. 2548-2561, Jul. 2016.

[33] SumitVerma, and V. Mukherjee, "Firefly algorithm for congestion management in deregulated environment," Int. Journal of Eng. Science Tech., vol. 19(3), pp. 1254-1265, Sep. 2016.

[34] Barnali K. Sarkar, Abhijit Chakrabarti, and Abhinandan De, "Identification of preferable distributed generators locations for congestion relief in multi-bus power network," Energy and Power Eng., vol. 6(7), pp. 161-173, Jul. 2014. [35]S.Thangalakshmi,andP.Valsalal,"Congestion management using hybrid fish bee optimization," Journal of Theoretical andApplied Information Tech., vol. 58(2), pp. 405–412, Dec. 2013.

[36] M. A. Paqaleh, A. A. Tehrani Fard, and M. Rashidinejad, "Distributed generation placement for congestion management considering economic and financial issues," Electrical Eng., vol. 92(6), pp. 193-201, 2010.

[37] A. K. Singh, and S. K. Parida, "Congestion management with distributed generation and its impact on electricity market,"Int. Journal of Electrical Power and Energy Syst., vol.48, pp. 39-47, June 2013.

[38] B. K. Sarkar, A. Chakrabarti, and AbhinandanDe,ano, "Identification of preferable distributed generators locations for congestion relief in multi-bus power network ," Energy and Power Eng.,vol.6,pp.161 173,2014.

[39] Yog Raj Sood, and Randhir Singh, "Optimal model of congestion management in deregulated environment of power sector with promotion of renewable energy sources," Renewable Energy, vol. 35(8), pp. 1828-1836, Aug. 2010. [40] R. Hemmati, H. Saboori, and M. A. Jirdehi, "Stochastic planning and scheduling of energy storage systems for congestion management in electric power systems including renewable energy resources," Energy, vol. 133, pp. 380-387, Aus. 2017.

[41] T. M. Masaud, R. Deepak Mistry, and P. K. Sen, "Placement of large scale utility-owned wind distributed generation based on probabilistic forecasting of line congestion," IET Renewable Power Generation, vol. 11(7), pp. 979-986, June 2017.

[42] C. Shao, X. Wang, M. Shahidehpour, and B. Wang, "Partial decomposition for distributed electric vehicles charging control considering electric grid congestion," IEEE Trans. Smart Grid, vol. 8(1), pp.75-83, Jan. 2017.

[43] Junjie Hu, A. Saleem, Shi You, L. Nordstrom, M. Lind, and J. Qstergaard, "A multi-agent system for distribution grid congestion management with electric vehicles," Eng. Applications of Artificial Intelligence, vol. 38, pp. 45-58, Feb. 2015.

[44] R. Ruiz, P. Ruiz, S. Martin, and J. A. Aguado, "Probabilistic congestion management using EVs in a smart grid with intermittent renewable generation," Electric Power System Research, vol. 137, pp. 155-162, Aug. 2016.

[45] S. Huang, Q. Wu, M. Shahidehpour, and Z. Liu, "Dynamic Power Tariff for Congestion Management in Distribution Networks," IEEE Trans. Smart Grid, in press, 2018.

[46] M. A. Lpez, S. Martn, J. A. Aguado, and S. de la Torre, “V2G strategies for congestion management in microgrids with penetration of electric vehicles,” Electrical Power Syst. Res., vol. 104, pp. 28-34, Nov. 2013.

[47] C. Wang, X. Hong, Y. Li, and H. Wang, “A two layer model for electric vehicle charging optimization based on location marginal congestion price,” Power System Tech., vol. 40(12), pp. 3706-3714, Dec. 2016.

[48] A. Yousefi, T. T. Nguyen, H. Zareipour, and O. P. Malik, “Congestion management using demand response and facts devices,” Int. Journal of Electrical Power Energy Syst., vol. 37(1), pp. 78-85, 2012.

[49] R. S. Wibowo, N. Yorino, M. Eghbal, Y. Zoka, and Y. Sasaki, “FACTS devices allocation with control coordination considering congestion relief and voltage stability,” IEEE Trans. Power Syst., vol. 26(4), pp. 2302-2310, Nov. 2011. 246

[50] G. S. Jasmine, and P. Vijayakumar, “Congestion management in deregulated power system using heuristic search algorithms incorporating wireless technology,” Wireless Personal Communications,” vol. 94(4), pp. 2665-2680, June 2017.

[51] P. Rajagopal, V. Kumar Yadav, and Niranjan Kumar, “Flower pollination algorithm based multi-objective congestion management considering optimal capacities of distributed generations,” Energy, vol. 147, pp. 980-994, Mar. 2018.

[52] Yinliang Xu, Hongbin Sun, H. Liu, and Qing Fu, “Distributed solution to DC optimal power flow with congestion management,” Int. Journal of Electrical Power & Energy Syst., vol. 95, pp. 73-82, Feb. 2018.

[53] Chien-Ning Yu, and M. D. Ilic, “Congestion clusters-based markets for transmission management,” IEEE Power Eng. Society, Winter Meeting, vol. 2, pp. 821-832, 1999.

[54] A. Kumar, and C. Sekhar, “Congestion management with FACTS devices in deregulated electricity markets ensuring loadability limit,” Int. journal of Electrical Power and Energy Syst., vol. 46, pp. 258 273, 2013.

[55] Sudipta Ghosh, S. P. Ghoshal, and Saradindu Ghosh, “Optimal sizing and placement of distributed generation in a network system,” Int. Journal of Electrical Power Energy Syst., vol. 32(8), pp. 849-856, Oct. 2010.