Demand Side Energy Management in Deregulated Environment: A Review

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Abstract.

Demand for Electric Power is elevating because of increasing consumers in the market. With the rise of Smart Grids, customers can also actively get participated in Energy Management Schemes. These schemes are called Demand Response Programs which can reduce the electricity bills and can also give them incentives or perks. The primary intention of DRPs is to diminish energy utilization in course of peak hours and improve the load factor. Also, Renewable Energy Sources do act as an adjunct source besides the grid but it further complicates the system. Certain challenges are there in implementation of DRPs which make Demand Side Management still a faraway dream. The paper presents a review of that and the challenges associated with it.

Keywords. Demand Response, Demand Response Program, Demand Side Management, Smart Grid

1. INTRODUCTION

Low carbon methods along with the energy efficiency have gained the attention of the world for a better world. Researchers all over the world have proved that demand response programs are efficient in decreasing the content of carbon dioxide as it is directly dealing with lesser use of Thermal Power Plants. Factors like unpredictable weather; integration of RES with the Grid among other complicates the DRP. The argument continues to the fact that this complication is not at site level but at organizational level. Commercial huge firms, public sector units, lot of smaller level stand alone electricity loads , complicated decision-making, etc. can halter the uptake of DSR. Participation prices which are hidden, issues of bounded rationality and energy application type for different organisations limit the organization ability to participate in DSR also.

2. COMMON ENERGY MANAGEMENT STRATEGIES

Program in [1] provides a captivating incentive for industrial consumers by managing smartly during energy crisis duration. A system with an energy storage unit connected behind-the-meter with a big-scale wind power generator is mentioned in [2]. Analysis of BTM benefits along with resiliency capability of the energy storage units is discussed in

[3]. [4] Shows how exciting opportunities are possible with digitization of BTM assets and optimization can be completed using AI and ML. Bi-level optimization exploiting genetic algorithm and linear programming is discussed in [5]. In paper [6], hydrogen energy storage is used for attenuating the irregularities of renewable .Study in [7] examines the bio mimetic energy management along with scope for construction industry reinvention. [8] Highlights the economic approaches in regulations and policies which support sustainability in energy and building.

3. DEMAND SIDE ENERGY MANAGEMENT

[9] Presents two simulation concepts to combine DR strategies into EMS. In [10] quality and quantity of DR were governed by customer experiences affected directly by connectivity, control and care. Findings of literature in [11] has deeply targeted on DR potential along with economic, theoretical and achievable potentials. [12] aims to study market of DR - risk nexus. Design along with operation optimization is addressed in [13] to gain the complementary benefits of sub-systems while advancing individual systems. [14] Effectively handles interoperability along with integration in various heterogeneous devices at consumer end which comes along with plug-play feature, zero configuration coherent networking. In [15] integrated demand response (IDR) is discussed where all types of energy customers (electricity, heat, natural gas, etc.) partake in DR. [16] formulates conflicting yet co-operative liaison between the utilities and end-users as a Stackelberg game where equilibrium points are attained by backward induction method. At the equilibrium, the utility company adopts real-time pricing scheme. [17] Scrutinizes history of DRPs and the practices of DR in the US, other nations in Asia and Europe which proves that DRPs is a hit in lot of nations for decrement of outage. However equipment price and standardization lacking still causes setback.

4. DEMAND SIDE ENERGY MANAGEMENT OF POWER SYSTEM

The model in [18] expresses that genetic-based heuristic updates accuracy of energy demand prediction whereas intra-day prediction refinements further decreases day-ahead prediction error. An online droop-based DR, generalized is popularized for application in islanded MGs frequency control in [19]. [20] Addresses issues which are related to bumpiness of supply, PV penetration, back-feeding, etc. In [21] recent use of deregulation in Indian Power Sector has been described [22] Proposes a simple solution by reducing proper management of Electricity distribution .Use of convoluted PV Model, Wind Turbine and home needs, developed in Simulink in [23] by Load Shifting method for HEMS controller. An energy detection algorithm depending on generalized stochastic resonance is adopted in [24] to improve the spectrum sensing accuracy with the conditions of low signal-to-noise ratio without alleviating the system overhead. In the proposed method of [25], loads which are in controlling nature are relocated to time when the difference between load and RE generated power is maximum which is in consideration to the consumers' welfare. In [26] by application of probability theory uncertain optimization model is transformed into a complicated optimization problem. EMS framework which is of three stage is proposed in [27]. Detailed reviewing of 34 power-to-heat demand response projects of large scale of is done in [28]. The literature review suggests that period of energy sector restructuring popularized uncertainty to energy companies regarding P2H DR. In [29] to resolve the issues of setting UFLS parameters stochastically, a MILP formulation is used for optimization framework. In [30], a distributed optimization method which is based on alternating direction method of multipliers algorithm with Gaussian back substitution is proposed. In [31] The electrode boiler is steered based on the predicted imbalance price, making use of the price volatility and single imbalance pricing mechanism as used in Belgium. In [32] novel online generalized droop control is introduced to apply in islanded MGs frequency control. [33] Propose an energy prediction model using genetic heuristic. The article [34] aims of optimizing the energy costs that will be transferred to users depending on its stratum. Implementation of an efficient hybrid energy trading market along with reduced price and peak to average ratio of electricity is done in [35]. Optimization problem with lot of constraints is solved using heuristic algorithms in [36]

5. OPTIMIZATION TECHNIQUES OF POWER SYSTEM

Power systems are very large and complex so its optimization problems are difficult to solve. [37] Proposes a system with multi energy inputs and outputs, 2m + 1 point estimation probabilistic scheduling scheme [38] overviews mathematical optimization methods.[39] has work on Optimization of Reactive Power Dispatch[40] Explores potential of metaheuristic methods and an improved salp swarm algorithm is proposed .In [41] Information gap decision theory technique is proposed. A microgram reactive power management approach in iterative nature and power-electronic converter depending renewable technologies is proposed in [42].

[43] Shows how Electricity prices on market are becoming volatile. There is a chapter which describes various algorithms used in optimization methods in [44]. In [45] Researchers have proposed novel bi layer Volt-Var based control strategy. In [46] an index of loss of power supply probability and of heat supply probability is formulated. Some authors have worked on Hybrid approach [47] which is based on marriage of firefly algorithm and adaptive fuzzy PSO. There is a work which reports a Volt/Var algorithm in [48].Parameters like frequency or voltage can be used as a factor for design of advanced metering infrastructure in SGs as in [49] like under-frequency load shedding. In [50] ORPD issues are solved by formulating smart controller with effective monitoring the real power loss of SGN. Elephant herd optimization which is a firefly evolutionary algorithm is used and power flow is limited in transmission network and summation with DGs. Various combinations of multi objective PSO and fuzzy decision making methodology is utilized in [51].

Steady state voltage stability index called by load margin, can be selected as network performance indicators as done in [52] with a PSO used to modify DSM program in the time steps of planning horizon and load margin is reduced. In [53] a decoupling optimization framework is devised which solely treat problems sequentially from the demand to generation can side with benefit caused by DR is allocated between users using cooperative game theory. Classic DSM technique implemented in [54] for IEEE 33 bus system .An exclusive literature review on impacts of DSM on trustworthiness of power systems discussed in[55]. Linear model for resource scheduling of Micro Grids and algorithms attached to it are attracting focus currently due to simplicity and fast computation as discussed in [56].

6. CONCLUSION

There is a need of development for a fair, centralised and 24-hour analysis control based system using local measurements for consumer and utility with a secure, and organized bidirectional communication which involves the consumer engagements and perks, without increasing the complexity of the system and lasting equity between supply and demand is needed.

Objective functions for research work should consider following parameters:

1) Minimization of Uncertainties (Load, Price, Voltage Deviations, Forecasting), Active Power losses, Violation limits
2) Maximization of exceptional amalgamation of distinct variables in optimization problem, Input Output control, Self Maintenance, Reactive Power dispatch
3) Scheduling of Battery storage, type of market, interoperability, integration and penetration of RES, data acquisition, storage and processing.
4) Maintain balance of actual time and its control effects and results os optimization, system flexibility with increase in the degrfes of freedom, standardization

7. REFERENCES

[1] Amam Hossain Bagdadee,Muhammad Aurangzeb·,Sajid Ali, Li Zhang , Energy management for the industrial sector in smart grid system, 2020 7th International Conference on Power and Energy Systems Engineering (CPESE 2020), 26–29 September 2020, Fukuoka, Japan, Energy Reports, Volume 6, Supplement 9, December 2020, Pages 1432-1442

[2] Vincenzo Trovatoa, Bharath Kantharaj, Energy storage behind-the-meter with renewable generators: Technoeconomic value of optimal imbalance management, Electrical Power and Energy Systems, 2020

[3] Khashayar Mahani·, Seyyed Danial Nazemi·, Maryam Arabzadeh Jamali·, Mohsen A.Jafari, Evaluation of the behind-the-meter benefits of energy storage systems with consideration of ancillary market opportunities, The Electricity Journal, Volume 33, Issue 2, 106707, March 2020

[4] Fereidon Sioshansi , Chapter 3,Creating value behind-the-meter: Digitalization, aggregation and optimization of behind-the-meter assets, Behind and Beyond the Meter , Digitalization, Aggregation, Optimization, Monetization, Pages 47-82, 2020

[5] Martina Capone, Elisa Guelpa,Vittorio Verda, Multi-objective optimization of district energy systems with demand response, Energy, 2021

[6] Mohammadreza Daneshvar , Behnam Mohammadi-Ivatloo Kazem Zare , Somayeh Asadi, Transactive energy management for optimal scheduling of interconnected microgrids with hydrogen energy storage, i n t e r n a t i o n a l journal o f hydrogen energy, 2020

[7] E.Fregonara, Methodologies for Supporting Sustainability in Energy and Buildings. The Contribution of Project Economic Evaluation, Energy Procedia, Volume 111, March 2017, Pages 2-11

[8] Olusegun Aanuoluwapo, Oguntona Clinton Ohis Aigbavboa , Biomimetic reinvention of the construction industry: energy management and sustainability, Energy Procedia Volume 142, December 2017, Pages 2721-2727

[9] Ines Leobner, Peter Smolek, Bernhard Heinz, Philipp Raich, Alexander Schirrer, Martin Kozek, Matthias Rössler, Benjamin Mörzinger, Simulation-based Strategies for Smart Demand Response, Journal of Sustainable Development of Energy, Water and Environment Systems , 2017

[10] Sarah J. Darby, Demand response and smart technology in theory and practice: Customer experiences and system actors, Energy Policy,2020

[11] Géremi Gilson Drankaa,b, Paula Ferreirac, Review and assessment of the different categories of demand response potentials, Energy, 2019

[12] Joana Sousa , Isabel Soares, Demand response, market design and risk: A literature review, Utilities Policy , 2020

[13] YizheXu , ChengchuYan, HuifangLiu, JinWang , ZhangYang ,Yanlong Jiang, Smart energy systems: A critical review on design and operation optimization, Sustainable Cities and Society, Volume 62, November 2020, 102369

[14] Rafiullah Khan a , Sarmad Ullah Khan , Design and implementation of UPnP-based energy gateway for demand side management in smart grid, Journal of Industrial Information Integration , 2017

[15] Wujing Huang, Ning Zhang , Chongqing Kang, Mingxuan Liand Molin Huo, From demand response to integrated demand response: review and prospect of research and application, Protection and Control of Modern Power Systems , 2019

[16] Mohammad Shakeri , Md. Rokonuzzaman , Demand Response Programs in Conventional and Smart Grid Electricity Networks: Chronological Development in Different Regions, Test Engineering and Management ·, April 2020

[17] Andreea Valeria Vesa , Tudor Cioara , Ionut Anghel, Marcel Antal, Claudia Pop , Bogdan Iancu, Ioan Salomie and Vasile Teodor Dadarlat , Energy Flexibility Prediction for Data Center Engagement in Demand Response Programs, Sustainability , 2020

[18] Farshid Habibi,Qobad Shafiee, Hassan Bevrani, Online generalized droop-based demand response for frequency control in islanded microgrids, Springer-Verlag GmbH Germany, part of Springer Nature , 2019

[19] Imane Worighi, AbdelilahMaach, Abdelhakim Hafid[d] Omar Hegazy[ab] Joeri Van Mierlo, Integrating Renewable Energy in Smart Grid System: Architecture, Virtualization and Analysis, Sustainable Energy, Grids and Networks, 2019

[20] M. B. Zala, A basic overview and study about deregulation & restructuring concept for indian power sector, International Journal For Technological Research In Engineering, 2017

[21] S. G. SaiP. SuryaK. GunalanSmart Institutions Using Energy Management System, 4th International Conference on Electrical Energy Systems (ICEES), 2018

[22] Izaz Zunnurain, Md. Nasimul Islam Maruf , Automated Demand Response Strategies using Home Energy Management System in a RES-based Smart Grid, 4th International Conference on Advances in Electrical Engineering, Dhaka, Bangladesh, 2017

[23] Tingting Yang, Tiancong Huang, Haifeng Zhang, Peiyi Li,Canyun Xiong,and Yucheng WuDemand Response Management Research Based on Cognitive Radio for Smart Grid, Hindawi Wireless Communications and Mobile Computing, Wiley, 2020

[24] Seyed Mehdi Hakimia,b, Arezoo Hasankhanic, Miadreza Shafie-khahd, João P. S. Catalão, Demand Response Method for Smart Microgrids Considering High Renewable Energies Penetration, Sustainable Energy Grids and Networks, 2 March 2020

[25] Zhihong Xu, Yan Gao, Muhammad Hussain, Panhong Cheng, Demand Side Management for Smart Grid Based on Smart Home Appliances with Renewable Energy Sources and an Energy Storage System ,Mathematical Problems in Engineering, Hindawi, Article ID 9545439, Volume 2020

[26] R.Seshu Kumar, L. Phani Raghav, D. Koteshwara Raja, Arvind R. Singh, Impact of multiple demand side management programs on the optimal operation of grid-connected microgrids, Applied Energy, 2021

[27] Vladimir Z. Gjorgievski , Natasa Markovska , Alajdin Abazi , Neven Dui, The potential of power-to-heat demand response to improve the flexibility of the energy system: An empirical review, Renewable and Sustainable Energy Reviews, 17 October 2020

[28] Ali Rafinia, Jamal Moshtagh, Navid Rezaei,Towards an enhanced power system sustainability: An MILP underfrequency load shedding scheme considering demand response resources, Sustainable Cities and Society 59 (2020) 102168

[29] Zhu, Hongbo, Gao, Yan, Hou, Yong, Real-Time Pricing for Demand Response in Smart Grid Based on Alternating Direction Method of Multipliers, Mathematical Problems in Engineering, 2018

[30] Jens Baetens , Jeroen De Kooning , Greet Van Eetvelde and Lieven Vandevelde **,**Imbalance price prediction for the implicit demand response potential evaluation of an electrode boiler, 4th Annual APEEN Conference Energy Demand-Side Management and Electricity Markets, Covilhã, Portugal, 2019

[31] Farshid Habibi , Qobad Shafee, Hassan Bevrani, Online generalized droop-based demand response for frequency control in islanded microgrids, The Smart/Micro Grids Research Center (SMGRC), University of Kurdistan - Iran, Electrical Engineering, Research Team, 2020

[32] Andreea Valeria Vesa, Tudor Cioara, Ionut Anghel, Marcel Antal, Claudia Pop, Bogdan Iansu, Ioan Salomie, Vasile Teodor Dadarlat, Energy Flexibility Prediction for Data Center Engagement in Demand Response Programs, Sustainability, 2020

[33] Edwin Marcelo , García Torres, Estimated cost of electricity with time horizon for micro grids based on the policy response of demand for real price of energy, 2020

[34] Rabiya Khalid, Nadeem Javaid, A.s. Al-Mogren, Muhammad Umar Javed, Load balancing in decentralized smart grid trade system using blockchain, Journal of Intelligent & Fuzzy Systems, 2019

[35] Hafiz Majid Hussain, Nadeem Javaid, Sohail Iqbal, Qadeer Ul Hasan, Khursheed Aurangzeb, Musaed Alhussein, An Efficient Demand Side Management System with a New Optimized Home Energy Management Controller in Smart Grid, Energies, MDPI, 2018

[36] Jaser A. Sa'ed, Zakariya Wari, Fadi Abughazaleh, Jafar Dawud, Salvatore Favuzza, Gaetano Zizzo, Effect of Demand Side Management on the Operation of PV-Integrated Distribution Systems, Applied Sciences, 2020

[37] Manijeh Alipour, Kazem Zare and Mehdi Abapour, MINLP Probabilistic Scheduling Model for Demand Response Programs Integrated Energy Hubs, IEEE Transactions on Industrial Informatics, 2017

[38] Frie Ayalew , Seada Hussen , Dr. Gopi Krishna Pasam, Optimization techniques in power system: review,International Journal of Engineering Applied Sciences and Technology, 2019 Vol. 3, Issue 10, ISSN No. 2455-2143, Pages 8-16

[39] Souhil Mouassa, Francisco Jurado,Tarek Bouktir, Muhammad Asif Zahoor Raja, Novel design of artificial ecosystem optimizer for large-scale optimal reactive power dispatch problem with application to Algerian electricity grid, Neural Computing and Applications, 2020

[40] Andrei M. Tudose , Irina I. Picioroaga, Dorian O. Sidea and Constantin Bulac , Solving Single- and Multi-Objective Optimal Reactive Power Dispatch Problems Using an Improved Salp Swarm Algorithm, Energies, 2021

[41] Abouzar Samimi, Navid Rezaei, Robust optimal energy and reactive power management in smart distribution networks: An info-gap multi-objective approach, Int Trans Electr Energ Syst. 2019

[42] Akshita Gupta, Arun Kumar, Dheeraj Kumar Khatod, Optimized scheduling of Hydropower with increase in solar and wind installations, Energy , 2019

[43] Stefan Roth, Lukas Stumpe, Benedikct Scmiegel, Johannes Schilp, An optimization-based approach for the planning of energy flexible production processes with integrated energy storage scheduling , 13th CIRP Conference on Intelligent Communication in Manufacturing Engineering, 2020

[44] Jeremy Lin, Fernando Magnago and Juan Manuel Alemany, Optimization Methods Applied to Power Systems: Current Practices and Challenges, Classical and Recent Aspects of Power System Optimization, 2018

[45] Haixiao Li, Mingxuan Mao, Kuo Guo, Gaofeng Hao, Lin Zhou, A decentralized optimization method based two-layer Volt-Var control strategy for the integrated system of centralized PV plant and external power grid, Journal of Cleaner Production, 2021

[46] Chen Lingmin ,Wu Jiekang a, Wu Fan , Tang Huiling, Li Changjie, Xiong Yan Energy flow optimization method for multi-energy system oriented to combined cooling, heating and power, Energy, 2020

[47] Mostafa Nasouri Gilvaei , Hossein Jafari , Mojtaba Jabbari Ghadi ,Li Li , A novel hybrid optimization approach for reactive power dispatch problem considering voltage stability index, Engineering Applications of Artificial Intelligence , 2020

[48] M. Crosa, F. D'Agostino, S. Massucco, P. Pongiglione, M. Saviozzi, F. Silvestro The Podcast Project: an Application of Volt/Var Optimization to the Electric Distribution Network of Sanremo (Italy), IEEE, 2019

[49] Smgrc Uok, Optimal design of an adaptive under-frequency load shedding scheme in smart grids considering operational uncertainties, The Smart/Micro Grids Research Center (SMGRC), University of Kurdistan - Iran, Electrical Engineering, Research Team, 2020

[50] Eity Sarker, Pobitra Halder, Mehdi Seyedmahmoudian, Elmira Jamei, Ben Horan, Saad Mekhilef, Alex Stojcevski, Progress on the demand side management in smart grid and optimisation approaches, International Journal of Energy Research, Wiley, 2020

[51] E. Muthukumaran, S. Kalyani, Development of smart controller for demand side management in smart grid using reactive power optimization, Soft Computing, Methodologies and Application | Issue 2/2021

[52] H. Shayeghi, m. Alilou, b. Tousi, r. Dadkhah doltabad, multi-objective optimization of demand side management in the presence of dg and demand response, international Journal of Industrial Electronics and Electrical Engineering, ISSN(p): 2347-6982, ISSN(e): 2349-204X Volume-6, Issue-3, Mar.-2018

[53] Jelena Poncko, Multi Objective Demand Side Management at Distribution Network Level in Support of Transmission Network Operation, IEEE Transactions on Power Systems ,Volume: 35, Issue: 3, May 2020

[54] Xi Luo, Yanfeng Liu, Pinga Feng, Yuan Gao, Zhenxiang Guo, Optimization of a solar-based integrated energy system considering interaction between generation, network, and demand side, Applied Energy, 2021

[55] Dr. K. Balamurugan, V. Deva dharshini, Ajith Bhaskar, P. Pukazhvanan, Analysis of Demand Side Management of Distribution Systems, International Research Journal of Engineering and Technology (IRJET), Volume: 06 Issue: 03 | Mar 2019

[56] Hussein Jumma Jabir, Jiashen, Dahaman Ishak, Hamza Abunima, The Impacts of Demand-Side Management on Electrical Power Systems: A Review, Energies, 2018

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