Modernized energy management system: A review

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Abstract. The usage of renewable energy system (RES) and its management is vital for reliable electrical energy delivery without pollution. In the scenario of increase in distributed generations (DGs), to utilize the generated electricity from RES without any wastage, to avoid the consumption of electricity during peak hours, to store and retrieve energy in an efficient way from the battery, there is a need for overall energy management system (EMS). As the prices for electricity and pollution are reduced, the review of available methodologies is discussed in this paper. The EMS takes decision based on the predicted load demand. So, the different prediction methodologies and their benefits are also discussed here. Though the electric vehicles (EVs) are considered as load in power system, the storage facility of the EVs are also used as power backup facilities through vehicle to grid (V2G) technology. This paper provides a review on the complete management of RES, EVs, batteries and load.

Key words: Energy Management System (EMS), Electrical Vehicles (EVs), Battery Management System (BMS), Load forecasting, Renewable Energy Sources (RES), Grid

1. INTRODUCTION

One of the important factors for the growth of a country is electrical energy. But in the current situation, the cost per unit is increasing and energy availability is insufficient [1]. To encounter the rapid growth of load, there is a need to increase the generation of power. Based on the requirement, many resources like, renewable or non-renewable energy sources can be used for generating power. The power generation from renewable source is clean and eco-friendly. But its indeterminate nature leads to the poor reliability of the system and wastage of renewable energy. In an electricity market, the load forecasting [2]-[8] is essential one for power generation, transmission and distribution. The information provided by load forecasting may lead a proper planning and operating of the system components. It helps to take important decisions on electricity market. These decisions includes generating electric power, purchasing of electric power from grid or from RES, load switching operations, development or extension or modification of infrastructure for proper planning, voltage control etc., Prediction of load and prediction of distributed generation (DG) plays a major role in meeting the load demand. After prediction of load, the generation for the respective demand through various algorithms or techniques is easy in terms of balancing. Microgrids (MGs) featured by storage or battery source, distributed energy resources like solar, wind, EVs and loads are planned significantly in order to improve the self- sustainability of further distribution systems [9]-[20]. Based on the present scenario, the MGs have to be controlled and coordinated in smart means [16]-[27], like
Microgrid Supervisory Controllers (MGSC) and Energy Management Systems (EMS).

By integrating the DGs with grid through Energy Management System (EMS), the consumer can achieve reliable, low cost electricity with reduced CO2 gas emission. Renewable Energy (RE) sources in MG will become a solution for fixed power generation, depletion of fuels, unmet demand and pollution [21], [25]-[30]. In order to achieve reliability and reduce wastage, it is necessary to develop a hybrid system combining different renewable sources with energy storage facility. The optimal utilization of this hybrid system depends on the energy management of various components involved. Renewable energy resources are currently being used on a large scale mainly to reduce the environmental pollutants, to achieve social and economic benefits, hence meeting the increased load demand. The available RE sources are Solar[25]-[30], Wind[12] &[15], Biofuel, Biomass, Geothermal, Tidal, Wave power etc., Among these solar and wind plays main role in meeting demand. Although these sources suffer from high capital cost & intermittent in nature, yet they are useful in supplying power to various levels. Other sources may include battery source [9]-[11], [13], [14], and EV’s [18], [20], for reducing the cost at peak load time. In future, Electrical Vehicles (EVs) [22]-[24] also plays a major role during peak power demand. The Plug in Electric Vehicle (PEV) has bidirectional transfer capability such as providing Vehicle to grid (V2G) technology and consuming power from grid as Grid to Vehicle (G2V) technology. The proper choice of battery [21]-[26] should be made for longer life. The EMS should combine all the sources and calculate the power availability to take decision on storing or discharging to get the maximum benefit. The remaining sections deals with the exhaustive review of existing EMS, their advantages and limitations.

2. ENERGY MANAGEMENT SYSTEM

Energy management system will perform the tasks like monitoring, measuring, controlling, instructing and implementing the management algorithms in order to use the renewable power effectively and economically to meet the demand. The proposed EMS architecture and its functionality are discussed below.

2.1. EMS architecture:

The architecture of proposed EMS is given in figure 1. It collects the data from grid, Battery Management System (BMS), EVs, DG (Solar, Wind) and Load demand prediction. Based on the instantaneous values, the EMS controls the various sources and storage.

The characteristics of the proposed EMS is

- It modifies the power flow among the network, estimates the available power and provides an option to store the energy, protect and maintain the energy backup.
- With the coordination of all the resources like solar, wind, battery and EVs, it will help the reduction of peak demand on grid, reduction of cost per unit and provides a way to gain through reduction of monthly current bill.

In the proposed EMS, EVs can be treated as load at charging mode and as a source in discharging mode. Discharging mode includes self-discharge, EV usage and grid interface. Figure 2 gives the functionality of the proposed EMS. When the required load demand is lesser towards the installed distributed generation, remaining generated power is used at BMS for batteries to be charged. Otherwise, if DG is lesser than the demand, the BMS will also supply along with DG to meet the demand.

If DG, in addition to BMS provides power which is lesser than the demand, then there is a possibility to take supply from EV (V2G technology). If DG, EV (V2G technology) and BMS are unable to meet the demand, then the supply will be taken from grid.
The real time performance of EMS is analyzed for a smart building in coordination with solar and wind generation to meet the uncertainty demand [15], [31]. The author compares the results with various algorithms and found that the modified fuzzy prediction interval model shows an accurate result for energy management. The framework is done by considering the 780 homes at demand side management [17, 26]. The author uses fuzzy logic controller for EMS considering residential loads which has DG- solar and wind setup and battery as backup [21]. The battery charging management system is proposed for EVs using V2G technology [22]. A hardware model is developed with the integration of renewable sources and grid [27]-[30]. Though the grid integration aid the reliability and provides various opportunities, there are few challenges in grid integration [32].
3. DISTRIBUTION GENERATION WITH RENEWABLE ENERGY SOURCES

The author discusses about the understanding of EMS for a microgrid which are having solar panels, wind energy, a diesel generator, a battery bank, and a water supply system and also the demand side management which reduces the cost of the energy [26]. The real time data of a specific location in Chile is used. This uses all the renewable sources, diesel generator and is used to fill the water tank. Here EMS will manage to reduce the diesel cost. The authors provide various technological requirements for the enhancements of SCADA, EMS systems for effective management in terms of price increments in Renewable Energy Resources [33]-[42].

Figure 3. Configuration of PV, wind & battery sources with grid

Figure 3 shows the interconnection of solar, wind and battery system through DC/AC system to load through switch2 and to grid through switch1. If demand is met, the additional power from RES is given to grid through switch1. If demand is not met then load will be supplied from both RES and grid.

4. GRID SYSTEM

Interconnected network which can able deliver a reliable electrical supply to consumers is called as grid system. It can be classified as micro grid, macro grid & smart grid.

- Micro Grid: A small scale generation plants, can be at demand side itself.
- Macro Grid: These are large scale generation plants.
- Smart Grid: These are controlled by advanced technology based equipments which can able to take decision to manage the demand.

5. BATTERY MANAGEMENT SYSTEM (BMS)

The optimal sizing and optimal allocation of the Distributed Energy Resources are the key factors for cost reduction of the power system. The management schemes for optimal size of batteries used in households applications at demand side are proposed in [43]. The temporal patterns of generation and consumption have a great impact on battery sizing and cost. The comparison of two different Demand side management schemes are discussed [43]. First approach is the Game-theoretic scheduling (GTS) and the second approach is additional constraint to GTS approach where the self-consumption of PV cell is considered before the minimization of cost. The optimum size and location of battery energy storage system (BESS) including wind and solar energy for voltage regulation considering life span of battery is proposed in [44]. The major factors for life span of battery are operating temperature, depth of discharge and level of the charging currents supplied and discharging currents drawn from the battery are given in [45]. The data on speed of the wind and the solar irradiance was modeled to get the accurate size. The extension of life span of BESS leads to improvement of voltage regulation profile, minimization of costs and losses. Convex optimization problem was used to obtain the optimum size
of BESS in off-grid micro grids [46]. Two-step cost based method was proposed to obtain optimum value of BESS in microgrid. A unit commitment problem is solved for optimization operation of microgrid at first and convex optimization is used to determine the optimum value of BESS which results in non-convex non-linear problem and is transformed to convex problem in the next step[47]. Using Firefly Algorithm (FA), the battery sizing is enhanced through optimal scheduling. This technique reduces the supply cost and power loss probability. The problem of economic scheduling between diesel generator and BESS [48] was solved. Optimum value of Grid-Connected Solar Battery Systems for household applications in Australia was presented in [49]. To reduce the annual cost of energy consumed, Genetic algorithm based time series simulation is proposed. Based on tuning the charge and discharge cycles of battery, solar resource and under time of use (TOU) tariff, size of PV and battery systems is optimized. As TOU tariff varies optimization structure varies accordingly. The PV-Battery Systems sizing has been computed through Techno-Economical Model (TEM) for Microgrids was proposed in [50]. The main objectives in this paper are energy and power autonomy, capital costs and payback period. A general TEM with solar power, azimuth angle, size of battery, ratings of converter, capital investment and electricity tariffs was developed. The procedure for hybrid trolley-bus to reduce the size of the batteries through the real case study is presented in [51]. For hybrid trolley bus, a novel two step optimization procedures based on recursive algorithm is presented for optimal size of battery. The simulation on real time measurements of three lithium high specific energy and power batteries are examined and analyzed and the best solution among three are determined. The Optimum value of Solar, Diesel and Battery systems in Hybrid Electric Ship System (HESS) was developed by Two-Stage Stochastic Programming Model (TSOPM) [52]. To model the problem of Hybrid power system with ESS, PV power and diesel generator, a two-stage stochastic mixed-integer non-linear programming is used. For generation of scenarios with a specified probability Monte Carlo sampling approach is used and to decrease the computational burden, reduction method is used. To minimize the yearly gross price to be paid for the usage of net zero energy home (NZEH) a method is proposed [53]. On minimizing the objective function, size of the battery is determined representing the yearly gross price to be paid. This proposed method is applied to South Australian NZEH including roof top solar PV system. Keeping wind generator as main source and remaining as reserve sources, configuration of system is determined in regard to total annual cost and its energy reliability. To obtain the required configuration of the overall system, the Non-dominated Sorted Genetic Algorithm (NSGAII) is used. The desired reliability TAC and LPSP minimization based optimization methods are available for regulating the effective price. To analyze the robustness, the cost sensitive analysis is available. Under high speed potential the cost effectiveness will be low and under low speed potential the integration of solar PV system is required [54].

6. ELECTRICAL VEHICLES (EVS)

The demand in electric supply will be increased drastically due to replacement of conventional vehicle by Electrical Vehicles (EV’s). In that situation Electrical Vehicles play a major role in doing V2G and G2V technology. A report [55] says by 2030 India will be using EV’s as follows.

|                | %Total sales 2030 UB | 2030 LB | Million Numbers 2030 UB | 2030 LB |
|----------------|----------------------|---------|--------------------------|---------|
| Private Cars   | 20                   | 60      | 14.1                     | 42.2    |
| Taxis          | 25                   | 65      | 2.6                      | 6.8     |
| Buses          | 25                   | 65      | 0.9                      | 2.3     |
| 2 wheelers     | 20                   | 60      | 65.9                     | 197.8   |
| 3 wheelers     | 33                   | 65      | 12.6                     | 24.7    |
| Total/ wtd.avg | 21                   | 61      | 96                       | 274     |

Table 1. Future sales of EVs (Cumulative 2017-30)
From the Table 1, it may be seen that there will be more usage of EV which increases the additional load demand. These EV’s will not only act as loads but also as energy sources in peak times i.e., V2G technology. In [1] the EMS in distribution system including V2G integrated microgrid was done. This V2G integration strategy is implemented using a multi-agent system and applied to a microgrid.

In [9] battery SOC is estimated using unscented Kalman-filter method comparing Kalman filter method. It reduces error to 1.5% and cost component is not considered. A prediction method for load during peak prices (<100kW) the charges [10] is proposed. It uses the existing data sources and adds to GPS tracker. There are some specified assumptions to be made for modeling of a system. Initially, the utilization of EVs is similar to the conventional vehicles today. Based on this, the ratio of EVs in individual places is same similar to regularly used vehicles and the travel done by EVs will be the similar to regularly used vehicles. ECMS-type [11] is offered for parallel hybrid electric vehicles based on energy prediction and limitations requires vehicle configuration and vehicle modeling, engine fuel rate map, battery model, motor model, vehicle longitudinal dynamic model, transmission model, driver model etc. A case study of 780[17] homes are considered who are participating in demand response management and limitation is if any new equipment is installed or added at the load side, those data should also should be provided by the consumer. In[18] the data of 2000 non-residential EV Supply equipments (EVSEs) near Northern California of 2013 is used to estimate the possible benefits of SEV charging to reduce the electricity bill used by EV’s. It requires lot of attention towards the driving patterns and charging-discharging profiles. In [20] consumers of 1000 no. are considered and their demand patterns are noted, through that the demand management is set. It requires data, such as vehicle departure time, arrival time, charging time, discharging time etc. and is provided to an aggregator. Capacity fade and power fade factors, SOC, DOD are estimated [23] with an intelligent charge algorithm. Here a particular type of battery, Li-ion is considered. A renewable source connected Plug-in Electric Vehicle (PEV) is considered for EM for a smart home in [56] which charges the battery of PEV to reduce the consumer's consumed prices at the time-of-use tariff, during the required load demand and PEV.

7. FUTURE LOAD DEMAND:

A report [57] says that by 2030 there may be end of fossil fuels. In [33], author says that the overall demand would raise 2.2 times more than current scenario. Here are some feasible solutions for meting load demand

7.1. Demand meeting solutions:
- Energy efficiency (EE).
- Demand-side management (DSM) and distributed generation (DG).
- Full consumption of the available generating and transmissible capacities.
- Novel additional plants.
- Expanding existing plants.
- Encouraging usage of Renewable Sources.

8. LOAD FORECASTING

Load forecasting refers to accurate prediction of load demand from the past historical data. There are several factors [58] to be considered while predicting load demand. Some of them are

i) Atmospheric conditions: The atmospheric conditions include temperature, wind speed, solar radiation, rain fall, humidity, mass of cloud covering etc., will show major effect on prediction of load.
ii) Calendar days: It includes working days, holidays, weekends, festivals etc.
iii) Different types of consumer loads: The loads such as domestic, commercial, industrial etc. will have different load patterns.
iv) Aerial factor: The areas such as rural, urban areas will have different pattern users existing. Some occasions like wedding occasions, Events planning etc. will also have an effect on prediction.

v) Economic factors: It included GDP (Gross Domestic Price), which show the economic growth of that particular area.

8.1 Load forecasting classification:
The load forecasting is broadly categorized as:

- Long-term forecasting: Forecasting for more than a year comes under this type and is mainly for estimating future expansion, purchasing of new equipments, hiring of staff etc.
- Medium-term forecasting: Forecasting from a week to year comes under this type and is done mainly for estimating fuel supply schedule, unit maintenance etc.
- Short-term forecasting: Forecasting from day to day comes under this type.

8.2. Load prediction methods:
Based upon the load types the techniques may be classified as Traditional Forecasting technique, Modified Traditional Technique and Soft Computing Technique [2], [32], [38][39]. The list of forecasting methods is given below [58]-[59].

a) Regression: In this, the dependent variable examines to specified independent variable.
b) Multiple Linear Regressions: This is used to obtain the relationship between load and the parameters like temperature, humidity, wind speed and type of the day.
c) Time Series Analysis: This is carried by modelling patterns in a time series plot for reliable predictions and are used for future.
d) Artificial Neural Networks: This is a soft computing method which performs the non-linear modelling.
e) Expert Systems: In this system, a computer program can understand, clarify, and gives the acquired information whenever needed.
f) Fuzzy Logic: The required information is given based on the comparison of qualities.

Figure 4. Load forecasting techniques Categories

The load forecasting techniques categorization is shown in figure 4. In load forecasting past historical data is taken as input and the network is trained, after that, a comparative analysis is done to evaluate Mean Absolute Percent Error (MAPE).
9. CONCLUSION

An exhaustive literature review of the technologies strategies applied in proposed EMS is presented in this paper. The selection and understanding of individual task are given briefly. The proposed EMS handles electrical, economic and environmental issues. Keeping in view of future load demand, an EMS has to be designed properly. Through load forecasting techniques, the available power and power to be generated can be easily predicted. Proper scheduling of EVs i.e charging and discharging time can be made by different techniques available. Proper selection of battery in terms of State of Charge and the Health can help the EMS in meeting the demand. Hence the proposed EMS perform the tasks like monitoring, measuring, controlling, instructing and implementing the algorithms in order to use the renewable power effectively and economically to meet the demand.

REFERENCES

[1] H. S. V. S. Kumar Nunna, SwathiBattula, SuryanarayanaDoulla and Dipti Srinivasan, “Energy Management in Smart Distribution Systems with Vehicle-to-Grid Integrated Microgrids”, ISSN 1949-3053, IEEE transactions on smart grid, 2016
[2] Arunesh Kumar Singh, Ibraheem, S. Khatoon, Md. Muazzam,” An Overview of Electricity Demand Forecasting Techniques” National Conference on Emerging Trends in Electrical, Instrumentation & Communication Engineering, Vol.3, No.3, 2013
[3] Kominiagbe, JairoCugliari, ID and Julien Jacques, “Short-Term Electricity Demand Forecasting Using a Functional State Space Model”, MPDI, Energies, Article, 2 May 2018.
[4] Wenjie Zhang, HaoQuan, and Dipti Srinivasan, ” An Improved Quantile Regression Neural Network for Probabilistic Load Forecasting”, IEEE Transactions On Smart Grid, Issn:1949-3053, 2018
[5] Fang Yuan Xu, XinCun, Mengxuan Yan, Haoliang Yuan, Member, Yifei Wang, Member, Loi Lei Lai, “Power Market Load Forecasting on Neural Network with Beneficial Correlated Regularization”, IEEE Transactions On Industrial Informatics, Vol. 14, No. 11, November 2018
[6] Dunnan Liu, Long Zeng, Canbing Li, Kunlong Ma, Yujiao Chen, and Yijia Cao, “A Distributed Short-Term Load Forecasting Method Based on Local Weather Information”, IEEE Systems Journal, 2016
[7] Xishun Wang, Minjie Zhang, Senior member, IEEE, and FenghuiRen, “Learning Customer Behaviors for Effective Load Forecasting”, Ieee Transactions On Knowledge And Data Engineering,.2018
[8] Kanggu Park, Seungwook Yoon, And Euisok Hwang,” Hybrid Load Forecasting for Mixed-Use Complex Based on the Characteristic Load Decomposition by Pilot Signals”, IEEE, VOLUME 7, 2019
[9] Weida WANG, Xiantao WANG, Changle XIANG, Chao WEI1, Yulong ZHAO,” Unscented Kalman Filter-based Battery SOC Estimation and Peak Power Prediction Method for Power Distribution of Hybrid Electric Vehicles”, IEEE,2018
[10] George Hilton, Mahdi Kiaee, Thomas Bryden, Borislav Dimitrov, Andrew Cruden, and Alan Mortimer, “A Stochastic Method for Prediction of the Power Demand at High Rate EV Chargers”, IEEE Transactions On Transportation Electrification, Vol. 4, No. 3, September 2018
[11] Shaojian Han, Fengqi Zhang, and Junqiang Xi,” A Real-Time Energy Management Strategy Based on Energy Prediction for Parallel Hybrid Electric Vehicles”, IEEE,2018
[12] Yuan-Kang Wu, Po-En Su, Ting-Yi Wu, Jing-Shan Hong, and Mohammad Yusri Hassan,” Probabilistic Wind Power Forecasting Using eather Ensemble Models”, IEEE Transactions on Industry Applications,2018
[13] Mao Yang, Xinxin Chen, Jian Du, And Yang Cui,"Ultra-Short-Term Multistep Wind Power
Prediction Based on Improved EMD and Reconstruction Method Using Run-Length Analysis”, *IEEE, 2018*

[14] Yi Wu , Wei Li , Youren Wang, And Kai Zhang,” Remaining Useful Life Prediction of Lithium-Ion Batteries Using Neural Network and Bat-Based Particle Filter”,*IEEE, 2019*

[15] Syed Furqan Rafique, Jianhua Zhang, Muhammad Hanan, Waseem Aslam, Atiq Ur Rehman, and Zmarrak Wali Khan ,”Energy Management System Design and Testing for Smart Buildings Under Uncertain Generation (Wind/Photovoltaic) and Demand”, *Tsinghua Science and Technology*, ISSN 1007-0214 04/13 pp 254–265, Volume 23, Number 3, June 2018

[16] H. Roh and J. Lee, “Residential demand response scheduling with multiclass appliances in the smart grid,” *IEEE Trans. Smart Grid*, Jul 2015

[17] N. Hassan, Y. Khalid, C. Yuen, S. Huang, M. Pasha, K. Wood, and S. Kerk, “Framework for minimum user participation rate determination to achieve specific demand response management objectives in residential smart grids,” *International Journal of Electrical Power and Energy Systems*, vol. 74, pp. 91–103, Jan. 2016

[18] E. C. Kara, J. S. Macdonald, D. Black, M. Brges, G. Hug, and S. Kiliccote, “Estimating The Benefits Of Electric Vehicle Smart Charging At Non-Residential Locations: A Data-Driven Approach,” *Applied Energy*, vol. 155, pp. 515 – 525, Mar. 2015

[19] H. Nunna and S. Doolla, “Demand response in smart distribution system with multiple microgrids,” *IEEE Trans. Smart Grid*, vol. 3, no. 4, pp. 1641–1649, Dec. 2012

[20] F. Rassaei, W. Soh, and K. Chua, “Demand response for residential electric vehicles with random usage patterns in smart grids,” *IEEE Transactions on Sustainable Energy*, Jun. 2015

[21] P. Sushma Devi and M. Venu Gopala Rao, “Design of Energy Management System for Residential Grid-Connected Microgrid with HRES”, *IJCTA*, 9(29), pp. 131-139, 2016

[22] M. Musio, M. Porru, A. Serpi, I. Marongiu, and A. Damiano, “Optimal electric vehicle charging strategy for energy management in microgrids,” in *IEEE International Electric Vehicle Conference (IEVC)*. pp. 1–8, 2014

[23] A. Hoke, A. Brissette, D. Maksimovíc, A. Pratt, and K. Smith, “Electric vehicle charge optimization including effects of lithium-ion battery degradation,” in *IEEE Vehicle Power and Propulsion Conference (VPPC)*, pp. 1–8, Sep. 2011

[24] A. Hoke, A. Brissette, K. Smith, A. Pratt, and D. Maksimovic, “Accounting for lithium-ion battery degradation in electric vehicle charging optimization,” in *IEEE Journal of Emerging and Selected Topics in Power Electronics*, vol. 2, no.3, pp 691-700, Jul 2014

[25] M. Ortega-Vazquez “Optimal scheduling of electric vehicle charging and vehicle-to-grid services at household level including battery degradation and price uncertainty,” in *IET Generation, Transmission & Distribution*, vol. 8, no. 6, pp. 1007–1016, Jun. 2014

[26] Rodrigo Palma-Behnke, Carlos Benavides, Jacqueline Llanos, Doris Saez, “Energy management system for a renewable based microgrid with a demand side management mechanism”, *IEEE, 2011*

[27] Rekha S, Roopa N, Swathi M, Shalini B N, Vani S Badiger,” Smart Home Energy Management System Including Renewable Energy Based On Zigbee”, *IJARIIE-ISSN (O)-2395-4396, Vol-2 Issue-5 2017*

[28] Sompol Kohsri and Boonyang Plangklang,” Energy Management and Control System for Smart Renewable Energy Remote Power Generation”, *9th Eco-Energy and Materials*
[31] Mahammad A. Hannan, Mohammad Faisal, Pin Jern Ker, Looe Hui Mun, Khadija Parvin, Teuku Meurah Indra Mahlia, And Frede Blaabjerg, “A Review of Internet of Energy Based Building Energy Management Systems: Issues and Recommendations”
10.1109/ACCESS. 2018

[32] Hussain Shareef, Maytham S. Ahmed, Azah Mohamed, Eslam Al Hassan, “Review on Home Energy Management System Considering Demand Responses”, Smart Technologies, and Intelligent Controllers”, 2169-3536 (c) IEEE, 2018

[33] Arunesh Kumar Singh, Ibraheem, S. Khatoon, Md. Muazzam, D. K. Chaturvedi, “Load Forecasting Techniques and Methodologies: A Review”, 2nd International Conference on Power, Control and Embedded Systems, 978-1-4673-1049-9/12 IEEE 2012

[34] Corentin Kuster, Yacine Rezgui, Monjur Mourshed, “Electrical load forecasting models: a critical systematic review”, http://dx.doi.org/doi:10.1016/j.scs.2017

[35] Henrik Steinherz Hippert, Carlos Eduardo Pedreira, and Reinaldo Castro Souza, “Neural Networks for Short-Term Load Forecasting: A Review and Evaluation”, 0885–8950/01$10.00 © IEEE, 2001

[36] E. Goutard, “Renewable Energy Resources in Energy Management Systems”, IEEE PES Innovative Smart Grid Technologies Conference Europe, 2010

[37] K Sekar, V Duraisamy, “Efficient Energy Management System For Integrated Renewable Power Generation Systems”, Journal Of Scientific & Industrial Research, vol 74, pp 325-329, 2015

[38] Mohamed S. Taha, Student Member, IEEE, Hussein Hassan Abdeltawab, and Yasser Abdel-Rady I. Mohamed, “An Online Energy Management System for a Grid-Connected Hybrid Energy Source”, 2168-6777 (c)IEEE, 2018

[39] Mabrook Al-Rakhami, Abdu Gumaei, Ahmad Alsanad, AtifAlamri and Mohammad Mehedi Hassan, “An ensemble learning approach for accurate energy load prediction in residential buildings”, 2169-3536 (c)IEEE 2018

[40] P. D. Matthewman,”Techniques for load prediction in the electricity-supply Industry” PROC. ZEE, Vol. 115, No. 10, OCTOBER 1968

[41] Sahil Ali, “The future of Indian electricity demand”, BROOKINGS INDIA, OCTOBER 2018.

[42] Alireza Askarzadeh, “A discrete chaotic harmony search-based simulated annealing algorithm for optimum design of PV/wind hybrid system”, SCIENCE DIRECT, ELSEVIER, SOLAR ENERGY, 7 September 2013

[43] Matthias Pilz, Omar Ellabban, and Luluwah Al-Fagih, “On Optimal Battery Sizing for Households Participating in Demand-Side Management Schemes”, [physics.soc-ph], 24 Apr 2019

[44] Khawaja Khalid Mehmood, SaadUllah Khan, Soon-Jeong Lee, ZunaibMaqsoodHaider, Muhammad Kashif Rafique, Chul-Hwan Kim,” Optimal sizing and allocation of battery energy storage systems with wind and solar power DGs in a distribution network for voltage regulation considering the lifespan of batteries”, ISSN 1752-1416, IET Renewable Power Generation doi:10.1049/iet-rpg.2016.0938, May 2017

[45] Mingfei BAN, Jilai YU, Mohammad SHAHIDEHPOUR, Danyang GUO,”Optimal sizing of PV and battery-based energy storage in an offgridnanogrid supplying batteries to a battery swapping station”, MPCE, CROSSMARK, Springer, May 2018

[46] Morteza Zolfagharia, Navid Ghaffarzadeh, Ali Jahanbani Ardakanib,”Optimal sizing of battery energy storage systems in off-grid micro grids using convex optimization”, Journal of Energy Storage ELSEVIER,2019

[47] Muhammad SufyanID, Nasrudin Abd Rahim, Chia Kwang Tan, Munir Azam Mohammad, Siti Rohani Sheikh Raihan,” Optimal sizing and energy scheduling of isolated microgrid considering the battery lifetime degradation”, RESEARCH ARTICLE, PLOS ONE, 2019

[48] Thair Mahmoud,”Optimal sizing of Battery Energy Storage Systems (BESS) in microgrids”, RESEARCH GATE, 2016
[49] Jiaming Li, “Optimal Sizing of Grid-Connected Photovoltaic Battery Systems for Residential Houses in Australia”, *Renewable Energy*, September 2018

[50] S. Bandyopadhyay, G. R. Chandra Mouli, Zian Qin, L. RamirezElizondo, and Pavol Bauer, ”Techno-economical Model based Optimal Sizing of PV-Battery Systems for Microgrids”, *Transactions on Sustainable Energy, IEEE*, 2019

[51] Luisa Alferia, Antonio Bracaleb, Pierluigi Caramia, Diego Iannuzzi, Mario Pagano, “Optimal battery sizing procedure for hybrid trolley-bus: A real case study”, *Electric Power Systems Research*, ELSEVIER, 2019

[52] A. Dolatabadi, R. Ebadi, B. Mohammadi-ivatloo, “A Two-Stage Stochastic Programming Model for the Optimal Sizing of PV/Diesel/Battery in Hybrid Electric Ship System “*Journal of Operation and Automation in Power Engineering Vol. 7, No. 1, May 2019*

[53] Vanika Sharma, Mohammed H. Haque, Syed Mahfuzul Aziz, “Energy cost minimization for net zero energy homes through optimal sizing of battery storage system”, *Renewable Energy, ELSEVIER*, 2019

[54] Nguessan S. Attemene, Krehi S. Agbli, Siaka Fofana, Daniel Hissel, “Optimal sizing of a wind, fuel cell, electrolyzer, battery and supercapacitor system for off-grid applications”, *ScienceDirect*, 2019

[55] https://www.brookings.edu/wp-content/uploads/2018/10/The-future-of-Indian-electricity-demand.pdf.

[56] Xiaohua Wu, Xiaosong Hu, Scott Moura, Xiaofeng Yin, Volker Pickert, ”Stochastic control of smart home energy management with plug-in electric vehicle battery energy storage and photovoltaic array” *Journal of Power Sources, Elsevier*, 2016

[57] https://www.business-standard.com/article/economy-policy/india-s-coal-reserves-may-exhaust-by-2040-108090801025_1.html.

[58] Shahida Khatoon, Ibraheem, Arunesh Kr. Singh, Priti, ”Effects of Various Factors on Electric Load Forecasting: An Overview”, *IEEE*, 2014

[59] Vikas Gupta, Seema Pal, ”An Overview of Different Types of Load Forecasting Methods and the Factors Affecting the Load Forecasting”, *IJRASET Volume 5 Issue IV*, April 2017