Economic Load Dispatch Problem for BESS Based Ancillary Services considering Electric Vehicles (PEVs/BEVs) and Renewable Energy Sources

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Abstract: Economic Load dispatch problem is one of the most challenging problems in power system planning, operation and control. The main objective in the operation and planning of electric power generation is to meet the power load demand at the minimum possible cost while satisfying all the constraints. In the proposed research, the authors has presented the mathematical formulation of economic load dispatch problem incorporating renewable energy sources, plug-in electric vehicles (PEVs) and battery electric vehicles (BEVs). Further, the surplus power from the standby electric vehicles can be used for ancillary services. This mathematical formulation of economic load dispatch problem will be helpful to the researchers, who are working in the field of economic load dispatch problems with due consideration to electric vehicles (EVs) and Renewable energy sources (RES).

Keywords: BEVs, Economic Load Dispatch, PEVs, Renewable Energy Sources.

1. INTRODUCTION

Electrification of the transport system is also a key measure to eliminate the greenhouse gas emissions and air pollutants with the reduced dependency on fossil fuels. The use of electric vehicles is an effective way to reduce carbon emissions and noise pollution. Electric vehicles are becoming more popular in motor vehicle market universally and will prove to be a promising solution to reduce the pollution in a short time. But the electric vehicles are causing another new challenge to power system operation and control. To increase the access of EVs, large scale electricity charging facilities are being provided to allow the vehicles to plugged into the power system and charge their batteries directly. An increased number of these vehicles will cause significant uncertainties in the power system operation due to the random nature of their charging behaviors and hence increasing the power demand. So the continuously growing demand for energy has encouraged the researchers to consider the renewable sources of energy. Moreover more research is required to be done to reduce global warming and degradation of the ecosystem.

2. ECONOMIC LOAD DISPATCH

The Economic Load Dispatch (ELD) problem may be stated very concisely as determining the loadings of the various thermal generators available in the power system for which the total cost of generation is minimized, maintaining the power balance equality constraint and the generation capacity inequality constraints.

Earlier the ELD problem was dealing only with the conventional thermal power generators, which use non-renewable resources of energy. Nowadays, due to limited fuel resources and environmental concerns alternate methods of energy generation like solar and wind have gained popularity other than conventional thermal power generation. These sources have gained a remarkable importance in the current scenario of research and development. The emissions from thermal power plants will be reduced along with the operational cost of power generated using renewable energy sources. The unlikely combination of coal and solar under suitable circumstances provides an elegant solution for large scale power generation with reduced emissions and pollutants. The capital investment on renewable sources like solar and wind are more but the operational cost is less. Moreover these sources are weather dependent and the out is intermittent and vary widely in a short span of time. So these sources always require some backup when supply is less or unavailable. The complete mathematical formulation of Economic load dispatch problem has been divided into the sub-sections: (i) Classical Economic Load Dispatch (ii) Economic Load Dispatch with Renewable Energy Sources (iii) Economic Load Dispatch with BEVs/PEVs/BESS (iv) Economic Load dispatch with BEVs/PEVs/BESS and Renewable Energy Sources.

ABBREVIATIONS

P_n^G =Power of n-th generating unit

$P_{n(\min)}^G$ =Minimum power of n-th generating units

$P_{n(\max)}^G$ = Maximum power of n-th generating units

NG=Total number of generating units

n=index for power generating units

P^{Loss} =Coefficient of power loss

$F(P^G)$ =Total Fuel cost of power generating units

a_n = Fuel Cost Coefficient of power generating units

b_n = Fuel Cost Coefficient of power generating units

c_n = Fuel Cost Coefficient of power generating units

3. MATHEMATICAL FORMULATION

The foremost objective of the economic load dispatch is to minimize the total fuel cost of the power generating units subject to the fulfillments of different constraints. The overall objective function of the single area dynamic dispatch problem can be categorized to the following sub-sections [1-6]:

3.1 Classical Approach for Economic Load Dispatch Problem

The mathematical formulation of conventional economic load dispatch problem for one hour can be represented as:

$$F(P^G) = \sum_{n=1}^{NG} [a_n (P_n^G)^2 + b_n P_n^G + c_n)] \tag{1}$$

The economic load dispatch of power generating units for 'H' Hours may be represented as:

$$F(P^G) = \sum_{h=1}^{H} \left(\sum_{n=1}^{NG} [a_n (P_n^G)^2 + b_n P_n^G + c_n)] \right) \tag{2}$$

3.1.1 Classical Approach for Cubical ELD

To establish the output of the power of an online generating units the economic load dispatch problem aims to congregate the system load at least price whilst fulfilling the system constraints. So as to attain correct dispatch outcomes, a cubical function is used for modeling the unit cost.

$$F(P^G) = \sum_{n=1}^{NG} [a_n (P_n^G)^3 + b_n (P_n^G)^2 + c_n P_n^G + d_n)] \tag{3a}$$

The Cubical ELD with Valve Point effect can be represented as:

$$F(P^G) = \sum_{n=1}^{NG} [a_n (P_n^G)^3 + b_n (P_n^G)^2 + c_n P_n^G + d_n)] + \left| \varphi_n \sin(\gamma_n (P_{n(\min)}^G - P_n^G)) \right| \tag{3b}$$

3.1.2 Classical Approach for Heat and Power Economic Load Dispatch

The heat and power economic load dispatch problem of a system is to resolve the unit heat and power production. The mathematical formulation for heat and power ELD may be described as:

$$F_{Power}(P_n^G) = \sum_{n=1}^{NG} \left(c_n + b_n \times P_n^G + a_n \times (P_n^G)^2 \right) \tag{4a}$$

$$F_{Heat}(P_n^G) = \sum_{n=1}^{NG} \left(g_n + h_n \times P_n^G + q_n \times (P_n^G)^2 \right) \tag{4b}$$

$$F_{Overall}(P_n^G) = \sum_{n=1}^{NG} \left(c_n + b_n \times P_n^G + a_n \times (P_n^G)^2 + g_n \times P_n^G + h_n \times (P_n^G)^2 + q_n \times (P_n^G)^2 \right) \tag{4c}$$

The objective function for heat and power ELD considering valve point loading effects can be reframed as:

$$F_{Power}(P_n^G) = \sum_{n=1}^{NG} \left(c_n + b_n \times P_n^G + a_n \times (P_n^G)^2 + \left| \varphi_n \sin(\gamma_n (P_{n(\min)}^G - P_n^G)) \right| \right) \tag{5a}$$

$$F_{Heat}(P_n^G)=\sum_{n=1}^{NG}\left(g_n+h_n\times P_n^G+q_n\times(P_n^G)^2+\left|\varphi_n\sin(\gamma_n(P_{n(\min)}^G-P_n^G))\right|\right) \tag{5b}$$

$$F_{Overall}(P_n^G)=\sum_{n=1}^{NG}\left(c_n+b_n\times P_n^G+a_n\times(P_n^G)^2+g_n\times P_n^G+h_n\times(P_n^G)^2+q_n\times(P_n^G)^2+\left|\varphi_n\sin(\gamma_n(P_{n(\min)}^G-P_n^G))\right|\right) \tag{6}$$

All the above mentioned objective functions are subjected to the following equality and inequality constraints:

1) Power balance constraint

$$\sum_{n=1}^{NG}P_n^G=P^{Demand}+P^{Loss} \tag{7}$$

Where, the Power Loss, P^{Loss} may be represented as:

$$P^{Loss}=\sum_{n=1}^{NG}\sum_{m=1}^{NG}P_n^G B_{nm}P_m^G \tag{8}$$

if B_{i0} and B_{00} matrices for loss coefficients are given, then the above equation can be modified as:

$$P^{Loss}=P_n^G B_{nm}P_m^G+\sum_{n=1}^{NG}P_n^G\times B_{i0}+B_{00} \tag{9}$$

The expanded version of the above equation may be represented as:

$$P^{Loss}=[P_1 \quad P_2 \quad \cdots \quad P_{NG}]\begin{bmatrix}B_{11} & B_{12} & \dots & B_{1n}\\ B_{21} & B_{22} & \dots & B_{2n}\\ \vdots & \vdots & \ddots & \vdots\\ B_{n1} & B_{n2} & \dots & B_{nn}\end{bmatrix}\begin{bmatrix}P_1\\ P_2\\ \vdots\\ P_{NG}\end{bmatrix}+[P_1 \quad P_2 \quad \cdots \quad P_{NG}]\begin{bmatrix}B_{01}\\ B_{02}\\ \vdots\\ B_{0NG}\end{bmatrix}+B_{00} \tag{10}$$

2) Generator limit constraint

$$P_{n(\min)}^G\le P_n^G\le P_{n(\max)}^G \qquad n=1,2,3,\dots,NG \tag{11}$$

3) Ramp rate limits

$$P_n^G-P_0^{G_o}\le UR_n \qquad n=1,2,3,\dots,NG \tag{12}$$

$$P_n^{G_o}-P_n^G\le DR_n \qquad n=1,2,3,\dots,NG \tag{13}$$

$$\max[P_{n(\max)}^G,(UR_n-P_n^G)]\le P_n^G\le\min[P_{n(\max)}^G,(P_n^{G_o}-DR_n)] \qquad n=1,2,3,\dots,NG \tag{14}$$

4) Prohibited Operating Zones

$$\begin{cases}P_{n(\min)}\le P_n\le P_{n(\min),1}^{POZ}\\ P_{n(max),m-1}^{POZ}\le P_n\le P_{min,m}^{POZ}; \quad m=2,3,\dots.N_{POZ}\\ P_{n(\max),m}^{POZ}\le n_i\le P_{n(\max)} \quad ;m=N_{POZ}\end{cases} \tag{15}$$

3.2 Economic Load Dispatch Problem with Renewable Energy Sources

The overall objective function for the Economic load dispatch problem considering renewable energy sources may be described as:

$$F(P^G)=\sum_{n=1}^{NG}[a_n(P_n^G)^2+b_nP_n^G+c_n)] \quad (16a)$$

The dispatch of power generating units for 'H' Hours may be represented as:

$$F(P^G)=\sum_{h=1}^{H}\left(\sum_{n=1}^{NG}[a_n(P_n^G)^2+b_nP_n^G+c_n)]\right) \quad (16b)$$

This eqn.(16b) represented the mathematical formulation for economic load dispatch problem for Dispatch. The hour 'h' may be varied for 1 to H-th Hour for time varying load demand.

3.2.1 Cubical Economic Load Dispatch with Renewable Energy Sources

To establish the output of the power of an online generating units the economic load dispatch problem aims to congregate the system load at least price whilst fulfilling the system constraints. So as to attain correct dispatch outcomes, a cubical function is used for modeling the unit cost [2-4].

$$F(P^G)=\sum_{n=1}^{NG}[a_n(P_n^G)^3+b_n(P_n^G)^2+c_nP_n^G+d_n)] \quad (17a)$$

The Cubical ELD with Valve Point effect can be represented as:

$$F(P^G)=\sum_{n=1}^{NG}[a_n(P_n^G)^3+b_n(P_n^G)^2+c_nP_n^G+d_n)]+\left|\varphi_n\sin(\gamma_n(P_{n(\min)}^G-P_n^G))\right| \quad (17b)$$

3.2.2 Heat and Power Economic Load Dispatch with Renewable Energy Sources

$$F_{Power}(P_n^G)=\sum_{n=1}^{NG}\left(c_n+b_n\times P_n^G+a_n\times(P_n^G)^2\right) \quad (18a)$$

$$F_{Heat}(P_n^G)=\sum_{n=1}^{NG}\left(g_n+h_n\times P_n^G+q_n\times(P_n^G)^2\right) \quad (18b)$$

$$F_{Overall}(P_n^G)=\sum_{n=1}^{NG}\left(c_n+b_n\times P_n^G+a_n\times(P_n^G)^2+g_n\times P_n^G+h_n\times(P_n^G)^2+q_n\times(P_n^G)^2\right) \quad (18c)$$

and the objective function for heat and power ELD considering valve point loading effects can be reframed as:

$$F_{Power}(P_n^G)=\sum_{n=1}^{NG}\left(c_n+b_n\times P_n^G+a_n\times(P_n^G)^2+\left|\varphi_n\sin(\gamma_n(P_{n(\min)}^G-P_n^G))\right|\right) \quad (19a)$$

$$F_{Heat}(P_n^G)=\sum_{n=1}^{NG}\left(g_n+h_n\times P_n^G+q_n\times(P_n^G)^2+\left|\varphi_n\sin(\gamma_n(P_{n(\min)}^G-P_n^G))\right|\right) \quad (19b)$$

$$F_{Overall}(P_n^G) = \sum_{n=1}^{NG}\left(c_n + b_n \times P_n^G + a_n \times (P_n^G)^2 + g_n \times P_n^G + h_n \times (P_n^G)^2 + q_n \times (P_n^G)^2 + \left|\varphi_n \sin(\gamma_n (P_{n(\min)}^G - P_n^G))\right|\right) \quad (20)$$

All the above mentioned objective functions are subjected to the following equality and inequality constraints:

1) Power balance constraint

$$\sum_{n=1}^{NG} P_n^G = P^{Demand} + P^{Loss} \quad (21)$$

$$\sum_{n=1}^{NG} P_n^G + P^{\mathrm{Re}newable} = P^{Demand} + P^{Loss} \quad (22)$$

Where,

$$P^{Loss} = \sum_{n=1}^{NG}\sum_{m=1}^{NG} P_n^G B_{nm} P_m^G \quad (23)$$

if B_{i0} and B_{00} matrices for loss coefficients are given, then the above equation can be modified as:

$$P^{Loss} = P_n^G B_{nm} P_m^G + \sum_{n=1}^{NG} P_n^G \times B_{i0} + B_{00} \quad (24)$$

The expanded version of the above equation may be represented as:

$$\mathrm{P}^{\mathrm{Loss}} = [P_1 \quad P_2 \quad \cdots \quad P_{NG}] \begin{bmatrix} B_{11} & B_{12} & \cdots & B_{1n} \\ B_{21} & B_{22} & \cdots & B_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ B_{n1} & B_{n2} & \cdots & B_{nn} \end{bmatrix} \begin{bmatrix} P_1 \\ P_2 \\ \vdots \\ P_{NG} \end{bmatrix} + [P_1 \quad P_2 \quad \cdots \quad P_{NG}] \begin{bmatrix} B_{01} \\ B_{02} \\ \vdots \\ B_{0NG} \end{bmatrix} + \mathrm{B}_{00} \quad (25)$$

2) Generator limit constraint

$$P_{n(\min)}^G \le P_n^G \le P_{n(\max)}^G \qquad n = 1, 2, 3, \ldots, NG \quad (26)$$

3) Ramp rate limits

$$P_n^G - P_0^{G_o} \le UR_n \qquad n = 1, 2, 3, \ldots, NG \quad (27)$$

$$P_n^{G_o} - P_n^G \le DR_n \qquad n = 1, 2, 3, \ldots, NG \quad (28)$$

$$\max[P_{n(\max)}^G, (UR_n - P_n^G)] \le P_n^G \le \min[P_{n(\max)}^G, (P_n^{G_o} - DR_n)] \qquad n = 1, 2, 3, \ldots, NG \quad (29)$$

4) Prohibited Operating Zones

$$\begin{cases} P_{n(\min)} \le P_n \le P^{POZ}_{n(\min),1} \\ P^{POZ}_{n(max),m-1} \le P_n \le P^{POZ}_{min,m}\,; \quad m = 2,3,\ldots.N_{POZ} \\ P^{POZ}_{n(\max),m} \le n_i \le P_{n(\max)} \quad ; m = N_{POZ} \end{cases} \tag{30}$$

3.3 Economic Load Dispatch with Plug-in electric vehicles and Battery electric vehicles

The overall objective function for the Dynamic dispatch considering PEVs and BEVs may be represented as:

$$F(P^G) = \sum_{n=1}^{NG} [a_n (P_n^G)^2 + b_n P_n^G + c_n)] \tag{31a}$$

The dispatch of power generating units for 'H' Hours may be represented as:

$$F(P^G) = \sum_{h=1}^{H} \left(\sum_{n=1}^{NG} [a_n (P_n^G)^2 + b_n P_n^G + c_n)] \right) \tag{31b}$$

This eqn.(31b) represented the exact mathematical formulation for Dynamic Dispatch. The hour 'h' may be varied for 1 to H-th Hour for time varying load demand.

3.3.1 Cubical ELD with Plug-in electric vehicles and Battery electric vehicles

To establish the output of the power of an online generating units the economic load dispatch problem aims to congregate the system load at least price whilst fulfilling the system constraints. So as to attain correct dispatch outcomes, a cubical function is used for modeling the unit cost.

$$F(P^G) = \sum_{n=1}^{NG} [a_n (P_n^G)^3 + b_n (P_n^G)^2 + c_n P_n^G + d_n)] \tag{32a}$$

The Cubical ELD with Valve Point effect can be represented as:

$$F(P^G) = \sum_{n=1}^{NG} [a_n (P_n^G)^3 + b_n (P_n^G)^2 + c_n P_n^G + d_n)] + \left| \varphi_n \sin(\gamma_n (P^G_{n(\min)} - P_n^G)) \right| \tag{32b}$$

3.3.2 Heat and Power ELD with Plug-in electric vehicles and Battery electric vehicles

$$F_{Power}(P_n^G) = \sum_{n=1}^{NG} \left(c_n + b_n \times P_n^G + a_n \times (P_n^G)^2 \right) \tag{33a}$$

$$F_{Heat}(P_n^G) = \sum_{n=1}^{NG} \left(g_n + h_n \times P_n^G + q_n \times (P_n^G)^2 \right) \tag{33b}$$

$$F_{Overall}(P_n^G) = \sum_{n=1}^{NG} \left(c_n + b_n \times P_n^G + a_n \times (P_n^G)^2 + g_n \times P_n^G + h_n \times (P_n^G)^2 + q_n \times (P_n^G)^2 \right) \tag{33c}$$

and the objective function for heat and power ELD considering valve point loading effects can be reframed as:

$$F_{Power}(P_n^G) = \sum_{n=1}^{NG} \left(c_n + b_n \times P_n^G + a_n \times (P_n^G)^2 + \left| \varphi_n \sin(\gamma_n (P^G_{n(\min)} - P_n^G)) \right| \right) \tag{34a}$$

$$F_{Heat}(P_n^G)=\sum_{n=1}^{NG}\left(g_n+h_n\times P_n^G+q_n\times(P_n^G)^2+\left|\varphi_n\sin(\gamma_n(P_{n(\min)}^G-P_n^G))\right|\right) \tag{34b}$$

$$F_{Overall}(P_n^G)=\sum_{n=1}^{NG}\left(c_n+b_n\times P_n^G+a_n\times(P_n^G)^2+g_n\times P_n^G+h_n\times(P_n^G)^2+q_n\times(P_n^G)^2+\left|\varphi_n\sin(\gamma_n(P_{n(\min)}^G-P_n^G))\right|\right) \tag{35}$$

The overall fuel cost function considering BEVs and PEVs has to be reduced within the following constraints:

1) Power balance constraint

$$\sum_{n=1}^{NG}P_n^G=P^{Demand}+P^{Loss} \tag{36}$$

Case-1: During Charging

$$\sum_{n=1}^{NG}P_n^G=P^{Demand}+P^{Loss}+\sum_{n=1}^{NPEVs}P^{PEVs}+\sum_{n=1}^{NBEVs}P^{BEVs} \tag{37}$$

Case-2: During Discharging

$$\sum_{n=1}^{NG}P_n^G=P^{Demand}+P^{Loss}-\sum_{n=1}^{NPEVs}P^{PEVs}-\sum_{n=1}^{NBEVs}P^{BEVs} \tag{38}$$

Where,

$$P^{Loss}=\sum_{n=1}^{NG}\sum_{m=1}^{NG}P_n^G B_{nm}P_m^G \tag{39}$$

if B_{i0} and B_{00} matrices for loss coefficients are given, then the above equation can be modified as:

$$P^{Loss}=P_n^G B_{nm}P_m^G+\sum_{n=1}^{NG}P_n^G\times B_{i0}+B_{00} \tag{40}$$

The expanded version of the above equation may be represented as:

$$P^{Loss}=[P_1\quad P_2\quad\cdots\quad P_{NG}]\begin{bmatrix}B_{11}&B_{12}&\dots&B_{1n}\\B_{21}&B_{22}&\dots&B_{2n}\\\vdots&\vdots&\ddots&\vdots\\B_{n1}&B_{n2}&\dots&B_{nn}\end{bmatrix}\begin{bmatrix}P_1\\P_2\\\vdots\\P_{NG}\end{bmatrix}+[P_1\quad P_2\quad\cdots\quad P_{NG}]\begin{bmatrix}B_{01}\\B_{02}\\\vdots\\B_{0NG}\end{bmatrix}+B_{00} \tag{41}$$

2) Generator limit constraint

$$P_{n(\min)}^G\le P_n^G\le P_{n(\max)}^G \qquad n=1,2,3,\dots,NG \tag{42}$$

3) Ramp rate limits

$$P_n^G-P_0^{G_o}\le UR_n \qquad n=1,2,3,\dots,NG \tag{43}$$

$$P_n^{G_o} - P_n^G \le DR_n \qquad n = 1,2,3,...,NG \tag{44}$$

$$\max[P_{n(\max)}^G, (UR_n - P_n^G)] \le P_n^G \le \min[P_{n(\max)}^G, (P_n^{G_o} - DR_n)] \qquad n = 1,2,3,...,NG \tag{45}$$

4) Prohibited Operating Zones

$$\begin{cases} P_{n(\min)} \le P_n \le P_{n(\min),1}^{POZ} \\ P_{n(max),m-1}^{POZ} \le P_n \le P_{min,m}^{POZ}\ ; \quad m = 2,3,\ldots N_{POZ} \\ P_{n(\max),m}^{POZ} \le n_i \le P_{n(\max)} \quad ; m = N_{POZ} \end{cases} \tag{46}$$

4. CONCLUSION

In the proposed research, the authors has successfully presented the mathematical formulation of economic load dispatch problem with due consideration to plug-in electric vehicles, battery electric vehicles and renewable energy sources (solar and wind power), which is one of the challenging problems in power system operation control and planning. The mathematical modeling is formulated to effectively use the renewable energy sources in electrified transport system and to use the power from the standby units of EVs as BESS in ancillary services. The proposed mathematical formulation will be helpful to the researchers, who are working in the area of economic load dispatch problems by considering the impact of Renewable energy sources (RES), electric vehicles (EVs) i.e. battery electric vehicles, plug-in electric vehicles with BESS based ancillary services.

REFERENCES

[1] J. S. KOTHARI, D. P., DHILLON, *power system optimization*, Second. PHI Learning, 2014.

[2] K. W. Cheung, S. Member, P. Shamsollahi, D. Sun, J. Milligan, and M. Potishnak, “Energy and Ancillary Service Dispatch for the Interim ISO New England Electricity Market,” vol. 15, no. 3, pp. 968–974, 2000.

[3] Y. Lin, P. Barooah, and J. L. Mathieu, “Ancillary services through demand scheduling and control of commercial buildings,” vol. 8950, no. c, pp. 1–12, 2016.

[4] G. Singh, K. Dey, K. V. N. P. Kumar, A. Kumar, S. Rehman, and K. Gaur, “Ancillary Services in India-Evolution , Implementation and Benefits,” 2016.

[6] M. Singh and J. S. Dhillon, “Electrical Power and Energy Systems Multiobjective thermal power dispatch using opposition-based greedy heuristic search,” vol. 82, pp. 339–353, 2016.

[7] N. Jap, J. S. Dhillon, and D. P. Kothari, “Synergic predator-prey optimization for economic thermal power dispatch problem,” vol. 43, pp. 298–311, 2016.

[8] V. K. Kamboj, S. K. Bath, and J. S. Dhillon, “Solution of non-convex economic load dispatch problem using Grey Wolf Optimizer,” *Neural Comput. Appl.*, 1934.

[9] D. Singh and J. S. Dhillon, “Ameliorated Grey Wolf Optimization for Economic Load Dispatch,” *Energy*, 2018.

[10] B. Qu, B. Qiao, Y. Zhu, J. Liang, and L. Wang, “Dynamic power dispatch considering electric vehicles and wind power using decomposition based multi-objective evolutionary algorithm,” *Energies*, vol. 10, no. 12, 2017.

[11] P. You, S. Member, Z. Yang, and M. Chow, “Optimal Cooperative Charging Strategy for a Smart Charging Station of Electric Vehicles,” pp. 1–11, 2015.

[12] S. Pal, S. Member, R. Kumar, and S. Member, “Electric Vehicle Scheduling Strategy in Residential Demand Response Programs with Neighbor,” vol. 3203, no. c, 2017.

[13] W. Gu, H. Yu, W. Liu, J. Zhu, and X. Xu, “Demand response and economic dispatch of power systems

considering large-scale plug-in hybrid electric vehicles/electric vehicles (phevs/evs): A review," *Energies*, vol. 6, no. 9, pp. 4394–4417, 2013.

[14] P. Goyal, A. Sharma, S. Vyas, and R. Kumar, "Customer and Aggregator Balanced Dynamic Electric Vehicle Charge Scheduling in a Smart Grid Framework," pp. 276–283, 2016.

[15] M. R. Andervazh and S. Javadi, "Emission-economic dispatch of thermal power generation units in the presence of hybrid electric vehicles and correlated wind power plants," *IET Gener. Transm. Distrib.*, vol. 11, no. 9, pp. 2232–2243, 2017.