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Energy network dispatch optimization under emergency of local energy shortage with web tool for automatic large group decision-making

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ABSTRACT

By large group decision-making, obtaining large group response plans within a limited amount of time plays a crucial role under emergency of local energy shortage. An energy network dispatch optimization under emergency of local energy shortage has been found to possess broad applications in energy system; however, the existing mechanism did not consider and failed to provide an approach to deal with the large group decision makers taking part in the energy network dispatch optimization. In this paper, the main contribution is that an energy network dispatch optimization under emergency of local energy shortage with web tool for automatic large group decision-making is proposed, in which anytime and anywhere, each expert can login in the system and provide his/her personal preference to the emergency of local energy shortage alternatives, and then the large group response plans to emergency of local energy shortage will be obtained within a limited amount of time. A case study and simulation results are presented that prove that the proposed model is feasible, and achieves better performance of energy network dispatch optimization under emergency of local energy shortage than the method proposed in the literature.

1. Introduction

In recent years, emergency events have occurred frequently around the world, natural events such as earthquake, tsunami, and hurricane, can cause severe environmental damage, e.g. loss of the energy and the living infrastructures [1]. The recovery of energy system is one of the most important because the other recovery operations are supported by enough available energy [2]. In general, emergency of local energy shortage decision making is characterized by time limitations, in which the multi-criteria large group decision-making problem is involved [3]. The use of multi-criteria group decision-making techniques has a long history in energy projects [4]. Energy network dispatch optimization under emergency of local energy shortage is complex and managing an appropriate type of the recovery of energy system change to satisfy stakeholders with various interests is challenging [5,6]. The total range of choices and variables in energy network dispatch optimization under emergency of local energy shortage is so vast that it is unlikely that one single model could integrate them all at once [7,8], in which often requires the involvement of developing a framework incorporate several models for multi-objective optimization problem under emergency of local energy shortage [9,10]. Andrianov et al. [11] proposed additional computational modules developed for the IAEA energy planning software MESSAGE; in their studies these modules are intended for multi-objective and robust optimization of deployment scenarios for nuclear energy systems with account for the uncertainty in technical and economical parameters. Somma et al. [12] presented a multi-objective optimization problem which was formulated to obtain the optimized operation strategies of a distributed energy systems, to reduce both energy costs and environmental impacts. Purwanto et al. [13] developed a multi-objective optimization model for a long-term generation mix in Indonesia, including two competing objective functions to seek the lowest cost of generation and the lowest CO_2 emissions while considering technology diffusion; in this work, the economic, environment, and adequacy of local energy sources is assessed. Zheng et al. [14] presented the study of a large-scale integrated energy system consisting of distributed district heating and cooling units and wind power generation interconnected via a power grid; in their study, a multi-objective group search optimizer with adaptive covariance is developed to optimize the power dispatch of the large-scale integrated energy system with the selected objectives compromising the competing benefits of both the power grid and the DHCs.

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However, the above mechanism did not consider and failed to provide an approach to deal with the large group decision makers taking part in the energy network dispatch optimization [15]. By large group decision-making, obtaining large group response plans within a limited amount of time plays a crucial role under emergency of local energy shortage [16,17].

In large group decision-making situations to energy network dispatch optimization under emergency of local energy shortage, it is very time consuming, expensive and impracticable using the existing group decision-making method [18,19]. In this extension of energy network dispatch optimization under emergency of local energy shortage, the problem concerned is (1) how to find a discrete finite set of alternatives A = {a_1,a_2, …,a_n} ($n \geq 2$) to the emergency of local energy shortage problems under uncertainty; (2)how to facilitate the large group elicitation of preferences and the overall consensus reaching process anytime and anywhere under emergency of local energy shortage [20,21]; and (3)how to effectively and automatically manage large group consensus and select the most desirable alternative(s) in the set A with reaching rational consensus within a limited amount of time [22,23].

In this paper, the main contribution is that an energy network dispatch optimization under emergency of local energy shortage with web tool for automatic large group decision-making (WTALGD) is proposed, in which anytime and anywhere, each expert can login in the system and provide his/her personal preference to the emergency of local energy shortage alternatives, and then the large group response plans to emergency of local energy shortage will be obtained within a limited amount of time. The energy network dispatch optimization under emergency of local energy shortage with web tool for automatic large group decision-making is not found into other similar works. In WTALGD, an automatic large group decision-making model is constructed to keep accuracy in the processes of energy network dispatch optimization computing with reaching rational consensus within a limited amount of time, i.e., at first, determining the emergency of local energy shortage alternatives set A by using the energy network dispatch optimization method proposed by Cai et al. [2]; second, automatic consensus modelling and optimizing with reaching rational consensus within a limited amount of time, and then selecting the most desirable emergency of local energy shortage alternative(s); finally, results indicate that the proposed model is feasible and effective, and achieves better performance of f large group response plans within a limited amount of time under emergency of local energy shortage than the non-WTALGD.

The remainder of the paper is organized as follows: Section 2 presents existing energy network dispatch optimization under emergency of local energy shortage. In Section 3, the proposed energy network dispatch optimization under emergency of local energy shortage with WTALGD is outlined. Then, in Section 4, a case study is presented along with a discussion of the results. Finally, in Section 5, concluding remarks are drawn.

2. Existing energy network dispatch optimization under emergency of local energy shortage

Based on the energy network dispatch optimization under emergency of local energy shortage proposed by Ref. [2], at first, determine the quantity, the capacity and availability of various energy sources in emergency-area-centered energy network; then, identify the initial energy situation under emergency conditions; and then, conduct the energy dispatch optimization by using a developed mixed-integer linear programming model; at the end, conduct sensitivity of the minimum dispatch time with respect to uncertainty parameters by partitioning the entire space of uncertainty parameters into multiple subspaces. The energy dispatch model is shown as follows:

$$\min J = T - \sum_{t \in ST} y_t \tag{1}$$

Subject to:

$$EV_{i,k,t} = EV_{i,k,t-1} + \sum_{j \in N\, j \neq i} \left(EI_{j,i,k,t} - EO_{i,j,k,t}\right) + \sum_{l \in M\, l \neq k} (EG_{i,l,k,t} - EC_{i,k,l,t}) + S_{i,k,t} - D_{i,k,t},\ \forall i,k,t \tag{2}$$

$$EG_{i,l,k,t} = XG_{i,l,k,t}\eta_{i,l,k},\ \forall i,l,k,t \tag{3}$$

$$XG_{i,j,k,t} \leq EV_{i,j,k,t-1},\ \forall i,j,k,t \tag{4}$$

$$EG_{i,j,k,t} \leq EG^u_{i,j,k},\ \forall i,j,k,t \tag{5}$$

$$EI_{i,j,k,t} \leq EO^u_{i,j,k,t-\tau_{i,j,k}},\ \forall i,j,k,t \tag{6}$$

$$EV_{i,k,t} \leq EV^u_{i,k},\ \forall i,k,t \tag{7}$$

$$D_{i,k,t} = \alpha^e EV_{i,k,t-1},\ \forall i,k,t \tag{8}$$

$$EI_{j,i,k,t} \leq EI^u_{j,i,k},\ \forall i,j,k,t \tag{9}$$

$$\sum_{j \in N, j \neq 1} EI_{j,i,k,t} \leq TEI^u_{i,k},\ \forall i,k,t \tag{10}$$

$$EO_{j,i,k,t} \leq EO^u_{i,j,k},\ \forall i,k,t \tag{11}$$

$$\sum_{j \in N, j \neq i} EO_{j,i,k,t} \leq TEO^u_{i,k},\ \forall i,k,t \tag{12}$$

$$-x_{i,k,t}U \leq RE_{i,k} - EV_{i,k,t} < (1 - x_{i,k,t})U,\ \forall i,k,t \tag{13}$$

$$y_t|N||M| \leq \sum_{i \in N} \sum_{k \in M} x_{i,k,t} < (y_t + 1)|N||M|,\ \forall t \tag{14}$$

$$y_t \geq y_{t-1},\ \forall t \geq 1 \tag{15}$$

Where J is the minimum recovery time of energy network; ST = {1,2, …, T} is time period set; y_t = {0,1}, if the energy requirement at each node in time period t has been satisfied, $y_t = 1$, otherwise, $y_t = 0$; $EV_{i,k,t}$ and $EV_{i,k,t-1}$ are the inventory quantity of type k energy at node i at time t and t−1; $EI_{j,i,k,t}$ is the input quantity of type k energy from node j to node i at time t; $EO_{i,j,k,t}$ is the output quantity of type k energy from node i to node j at time t; $EG_{i,l,k,t}$ is the generated amount of type k energy from the other energy types at node i at time t; $EC_{i,k,l,t}$ is the consumed amount of type k energy for converting to other energy types at node i at time t; $S_{i,k,t}$ is the energy supply of type k energy from outside of the studied energy network system to node i at time t; $D_{i,k,t}$ is the demand consumption of type k energy at node i at time t. $XG_{i,l,k,t}$ is available energy from $EV_{i,k,t-1}$ that can be converted to generate type k energy at node i at time t; $\eta_{i,l,k}$ is the associated energy conversion efficiency; $\tau_{i,j,k}$ is a time delay between the departure and the arrival of a transportation between nodes i to j. α^e is a given energy consumption factor; $x_{i,k,t}$ = {0,1} represents whether

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