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SOLVING A DAY HEAD LOAD SCHEDULING ISSUES BY DI-OBJECTIVE POWER OPTIMIZATION FOR LOAD SIDE MANAGEMENT IN SMART GRID

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ABSTRACT:
The deployment of demand side management (DSM) strategies, which leverage distributed energy resources (DERs) to lower operating costs, emissions of pollutants, and different factors, is essential to the energy management of smart grids (SG). This study uses the DSM technique to address the day-ahead scheduling challenge in, while taking various customer types into account in order to lower operational costs and to reduce the pollution emission. Participants in the DSM strategy include non-responsive consumers who are unable to change or reduce loads, and responsive consumers who are able to do so. Energy storage systems (PSSs), diesel generators (DGs), and wind energy sources (WES) are the DERs utilized in the suggested day-ahead scheduling challenge. The multi-objective wind driven optimization (MOWDO) technique is used to solve the day-ahead scheduling problem with tri-objective function. The decision making mechanism (DMM) is used to determine the optimal solution in search space. The MOWDO algorithm is used to solve the day-ahead scheduling multi-objective issue, according to simulation results. The suggested model is used in SG while taking into account the operational cost and reduction of pollution emission as constraints here in order to obtain balanced power at the user's end in order to evaluate its efficacy.
Keywords—Smart Grid (SG), Multi objective wind driven optimization (MOWDO), Diesel Generators (DG), Decision Making Mechanism (DMM), Wind energy sources (WES), Power Storage System (PSS), Demand side management (DMS).

INTRODUCTION :

Global energy consumption rises as a result of population growth. Utilizing fossil fuels is not a wise decision because it pollutes the environment, which has an adverse effect on it [1]. To prevent climate change, emissions must be reduced globally. Therefore, for effective energy management that lowers financial costs can be taken into consideration. Because an electrical network's functionality depends on the utility and consumer power balance, it is crucial. The grid will operate in a hazardous and unreliable manner if the power balance between consumers and utilities is not maintained. As a result, in SG, proper DSM strategy implementation is crucial. Customers can take part in load shifting and curtailment as well as SG through the DSM strategy, which aims to achieve balancing power and user happiness. Additionally, SG combines non-renewable and renewable energy sources to meet demand under ideal circumstances. In order to reduce the output power forecast errors of renewable energy sources, the SG operator can be taken into consideration for DSM techniques in the day-ahead problem scheduling. It can also assist in load shifting and load curtailing [2].

The goal of the DSM plan is to maximize both the economic cost and environmental emission of various activities carried out in India. With DSM, various loads can be managed, including planning, monitoring, and execution that directly impacts the way in which consumers use electricity, resulting in a reduction of costs [3]. DSM uses DERs, such as solar and wind energy sources, DGs, and PSSs in SG to provide minimal emissions and optimal electricity at an affordable cost. Numerous studies on the DSM strategy have already been implemented, taking into account DERs in SG and utilizing various optimization strategies to solve multi-objective functions - maximization or minimization problems. Additionally, [4] studies load curtailment for operating cost and environmental emission in SG. Various DSM strategies are examined in [5,6] depending on the decision-making mechanism. Because scheduling is based on size and seating, operational costs are decreased and power distribution is reliable. By coordinating between the market price and loads at the user end, the operational cost and pollution are taken into account as the multi-objective function [7]. In order to reduce operational costs and pollution emissions, the day-ahead scheduling problem in SG is therefore adopted in this study. The DSM strategy in SG is used in conjunction with the tri objective function of load diminution cost, which takes curtailable loads (CLs) into consideration, and coordination between SLs and wind WT output power. The MOWDO technique is utilized to solve the tri objective function in SG, and DMM is employed to achieve the optimal solution in the search space.

The structure of the following sections of the suggested day-ahead scheduling model: In Section 2, the suggested system model for the day-ahead scheduling problem is shown. Section 3 highlights the numerical and simulation methodology. Results are reviewed in brief in Section 4, and the conclusion stated in Section 5.

SYSTEM MODEL:

1. *Cost of Operation and optimization of emission of Pollution:*

Using the DSM approach and DERs, the day-ahead scheduling problem in SG is regarded as a multi-objective function. The reduction of operational costs and pollution emissions, the reduction of Cls costs, and the coordination of SLs and WTs output power are among the aim functions. The suggested objective functions should be accurately modelled mathematically as follows:

$$\sum_{n=1}^{N}[\sum_{k=1}^{K}\{\delta E_{DG}^{2}(t,k)+\omega\delta E_{DG}(t,K)+\sigma\}+\{C_{su}\times\gamma^{on}(t,k)\}+\{C_{sd}\times\gamma^{off}(t,k)\}]$$

$$\sum_{n=1}^{N}\ [\sum_{k=1}^{K}\{\beta E_{DG}^{2}(t,k)+y\delta E_{DG}(t,K)+\phi\}]+$$

$$\sum_{n=1}^{N}\ [\{\lambda_{Grid}^{E}\times E_{Grid}(t)\}+\{\varphi_{Grid}\times E_{Grid}(t)\}]$$

$$+\sum_{n=1}^{N}[\sum_{x=1}^{X}\{C_{op}^{k}\times E_{PSSs}^{Discharge}(t,x)\}+\sum_{x=1}^{K}C_{op}^{k}\times E_{PSSs}^{Charge}(t,x)] \quad (1)$$

The DGs on and off state are represented by the terms γ^{on} and γ^{off} & DGs cost factor is denoted by δ and σ in Eq. 1. Although λ_{Grid}^{W} represents the energy market price , PSSs power of charging and discharging in time duration t and is represented by $E_{PSSs}^{Charge}(t,x)$ & $E_{PSSs}^{Discharge}(t,x)$, where C_{op}^{k} is the operational cost of PSSs , E_{DG} and E_{Grid} depicts the grid and DGs powers.

2. *Total Cost of the system:*

When assessing the system's cost, this part takes into account constraints such as expected energy not served (EENS) and value of loss load limits. The overall cost of the system in which certain external influences occur is shown by Equation 2.

$$C_{T}=\sum_{n=1}^{N}C^{DG}(t)+\sum_{j=1}^{J}C^{PSSs}(t)+EENS(t)\times VOLL(t) \quad (2)$$

$C^{DG}(t)\rightarrow$

$C^{PSSs}(t)\rightarrow$ PSSs during the time slot t sec

$VOLL(t)\rightarrow$

$EENS(t)\rightarrow$ Value of Loss Load

Expected Energy not served during the time slot t sec

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SYSTEM METHODOLOGYUTILIZING THE MOWDO TECHNIQUE, THE SIMULTANEOUS OPTIMIZATION OF THE TRI OBJECTIVE FUNCTION IN SG CONSISTS OF OPERATIONAL COST BY TAKING CURTAILABLE LOADS (CLS) INTO ACCOUNT AND OUTPUT POWER COORDINATION BETWEEN SHIFT ABLE LOADS (SLS) AND WTS [8]. FURTHERMORE, THE OPTIMIZATION PROBLEM OF OPERATIONAL COST IS NON-CONVEX AND NON-LINEAR. TO AVOID LOCAL MINIMA, THE LIKELIHOOD OF EXPLORATION (GLOBAL MINIMIZING) IN THE SEARCH SPACE INCREASES GREATER THAN THE PROBABILITY OF EXPLOITATION (LOCAL MINIMIZATION). IN THIS MANNER, PARTICLES AVOIDED LOCAL MINIMA AND CONVERGED TO THE GLOBAL OPTIMUM SOLUTION WHILE OPTIMIZING OPERATIONAL COSTS. THE FOLLOWING IS HOW THIS METHOD IS USED IN THE SUGGESTED DAY-AHEAD SCHEDULING PROBLEM:

3. *Data diversion from the system model:*

Grid structure, technical and functional grid parameters, wind speed forecasting for the day-ahead scheduling challenge, market energy prices, and DGs units are among the input data.

4. *Setting up:*

The MOWDO approach imports technical and functional data in terms of electrical units for DERs, including DGs, ESSs, and wind energy.

5. *Implementation:*

The following steps demonstrate how to use MOWDO to implement the suggested day-ahead scheduling problem:

a. The objective functions are computed using Equations (1).
b. Look for non-dominated answers by doing a random search across the search space.
c. To identify the optimal solution, the non-dominated solutions are stored in the archive.
d. Ascertain each particle's location and speed.
e. Check the number of iterations and update each particle's position and velocity.

6. *Convergence:*

Use DMM and Equation 10 to identify the best non-dominated solution in the archive.

7. *Termination:*

If the optimal solution has already been identified, the procedure is over; if not, proceed to step a. Fig. 2 displays the MOWDO flow chart for the day-ahead scheduling issue in SG. The MOWDO technique's functionalities for the day-ahead scheduling problem in SG are as follows.

a. Schaffer function:

The defined variable limits are [10^{-3}; 10^{3}], and optimized solution ranges between [0,1]. The Schaffer function is given as stated below:

$$f_1(k) = k^2, f_2(k) = (k-2)^2 \qquad (3)$$

b. Kita Function:

The defined variable limits for Kita function ranges between [0,7]. Kita multi-objective function is given as follows:

$$f_1(k_1, k_2) = -k_1{}^2 + k2 \qquad (3)$$

and

$$f_1(k_1, k_2) = \frac{k_1}{2} + k2 + 1 \qquad (4)$$

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$$\frac{k_1}{6}+k_2 \leq \frac{13}{2}, \frac{k_1}{2}+\frac{15}{2}, 5k_1+k_2 \leq 30 \quad (5)$$

The Kita function is utilized to use the pressure effect in the MOWDO technique, which is based on the pressure function. Additionally, two functions—the ZDT1 and ZDT4 functions, respectively are employed to evaluate system model data, which illustrates the MOWDO technique's speed in the suggested condition 1, reveals that the suggested technique's computational time is 40 s with 100 iterations to converge to the optimal answer in the search space.

RESULTS ANALYSIS:

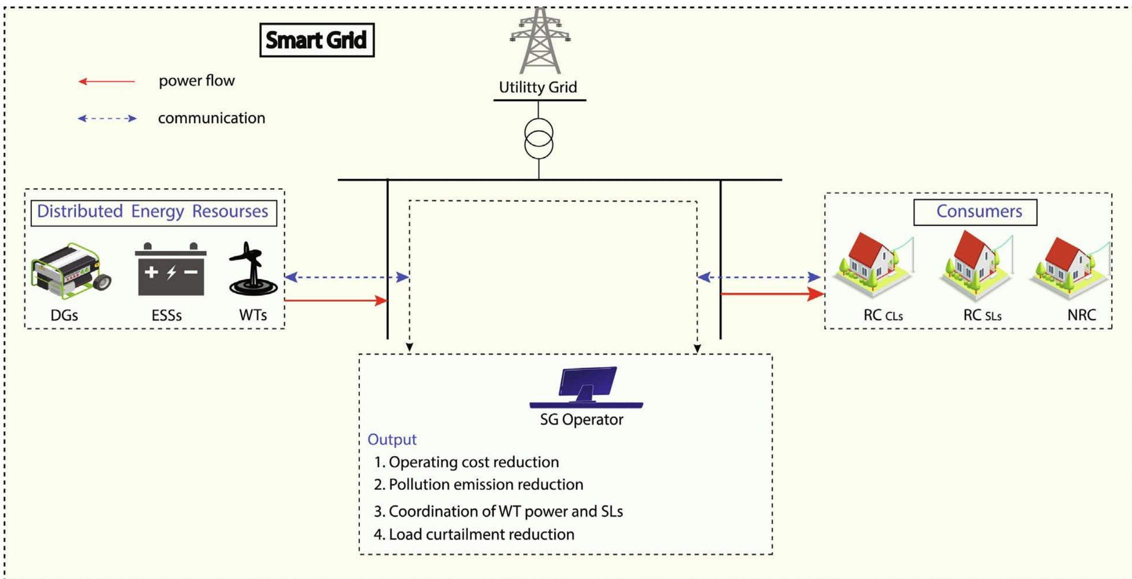

Fig. 1.Structural smart grid diagram

Condition -1 :

In this instance, SG optimizes the first objective function, which is the reduction of pollutants and operating costs. According to simulation results, utility grid operational costs and pollution emissions are 60% and 87%, respectively. As a result, utility grid operational costs and pollution emissions are higher than those of DERs. In order to reduce operational costs and pollution emissions in SG, DERs are involved in the suggested scenario.

Condition -2 :

In this instance, the optimization of the first and second objective functions in SG is regarded as a multi-objective function. In SG, operational expenses and the decrease of pollutant emissions are taken into account while making bids. The cost of RCCLs. The suggested objective function is decreased by taking into consideration the CLs' ideal scheduling. Figure 4 illustrates the MOWDO technique, which is used to find non-dominated solutions in the search space. Figure 2 illustrates the decision-making mechanism that yields the eighth solution, which is regarded as the best answer. According to simulation results, the utility grid, DG expenses, and ESS charging and discharging are all optimized simultaneously for the first and second objective functions. Decreased by 15%, 3%, 0.79%, and 0.03% in comparison to condition 1, while utility grid and DG pollution emissions are decreased by 14% and 2% in comparison to condition 1. As a result, it is being studied that the best Cls scheduling contributes significantly to SG's operational cost and pollutant emission optimization.

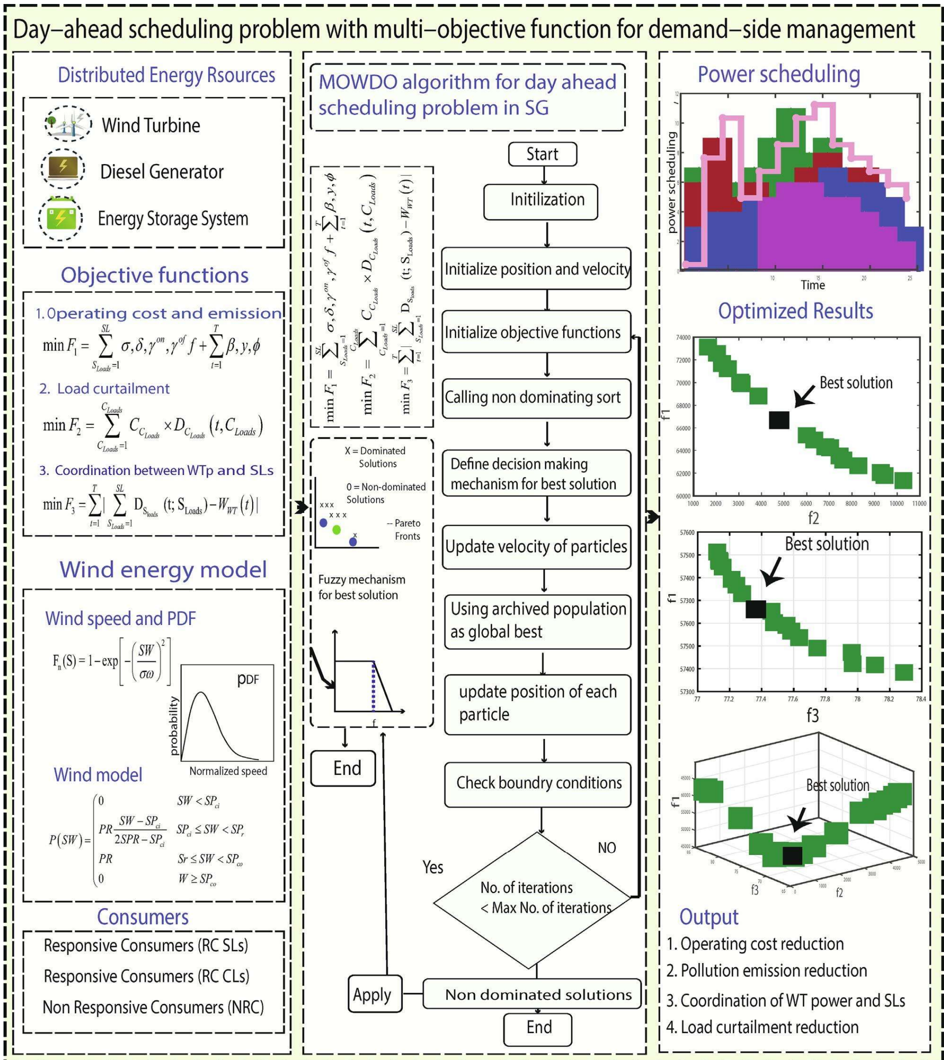

Fig. 2. Diagrammatic representation of the demand-side management day-ahead scheduling problem using a multi-objective function.

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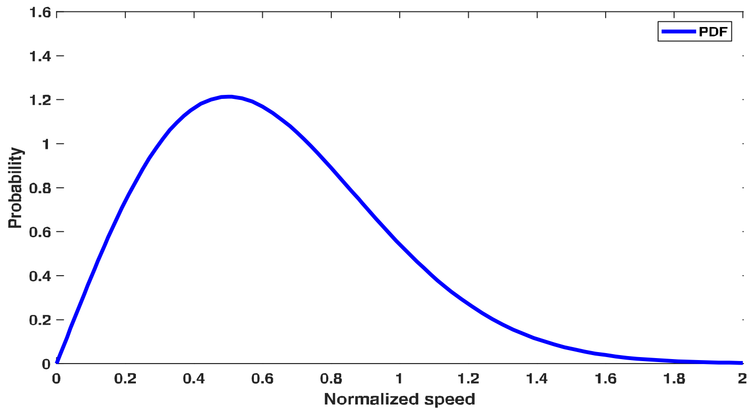

Fig. 3. PDF:Wind speed distribution model.

CONCLUSION:

It is insufficient for DSM to take into account several objectives such as : operational cost or load curtailment cost and pollution emission. However, because of dependency and trade-offs, it is difficult to accommodate several competing goals in DSM. Therefore, a model that addresses the aforementioned difficulties is required. In light of this, this study uses a di-objective function to address the day-ahead scheduling problem while concurrently optimizing di-objectives such as pollution emission, and operating cost. DERs such as wind turbines and two categories of consumers responsive and non-responsive for the benefit of utilities and end users, multi-objective day-ahead scheduling problem modelling takes energy storage systems and diesel generators into account. A fuzzy mechanism with Pareto fronts is used to optimize di-objectives in the developed day-ahead scheduling model with multi-objective optimization based on MOWDO. The outcomes of the four specified examples are used to examine the usefulness and applicability of the generated model. Without the use of DERs, Case 1 is examined, and it was observed that the utility grid's pollutant emissions and operating costs were high. In comparison to case 1, DGs and utility grid costs are lowered by 15% and 3%, respectively, while pollutant emissions are decreased by 2% and 14% in instance 2, which include DERs in the day-ahead scheduling problem.

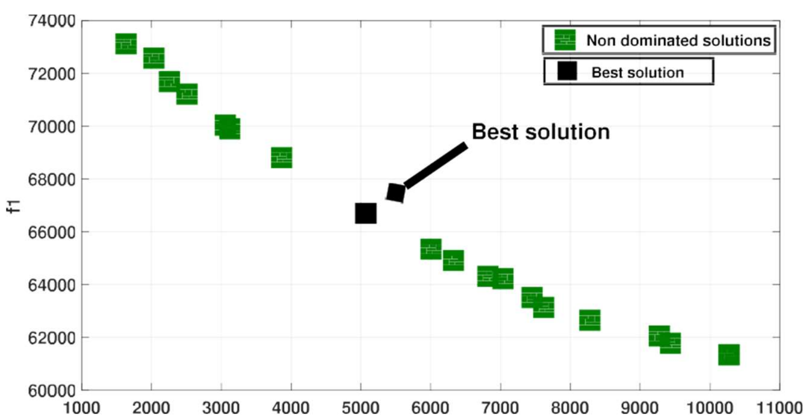

Fig4: Pareto Front solution using MWODO(condition 1 & 2)

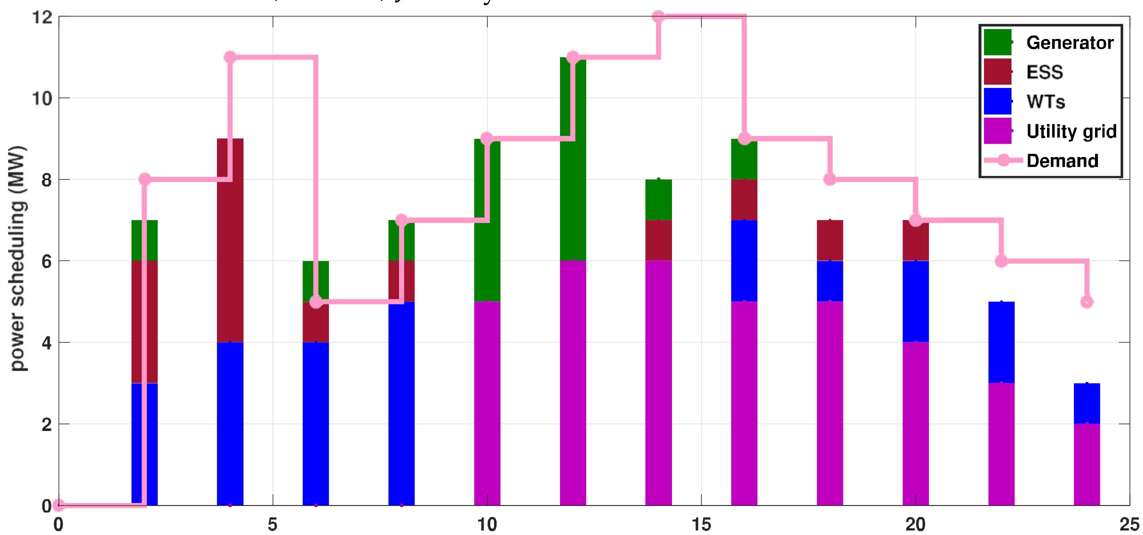

Fig 5 : Power scheduling of DERs.

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