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Measures average sentence length

9.6

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ATM_BATCH_MINI_PROJECT_REPORT (final_draft)word

CHAPTER 1

INTRODUCTION

The increasing global demand for electricity, driven by population growth and industrial development, combined with concerns over climate change and energy security, has prompted a significant shift towards more sustainable energy solutions. Renewable Energy Sources (RES), particularly wind and solar energy, have become crucial in transitioning from fossil fuel-based power generation to cleaner, more sustainable alternatives. However, the intermittent nature of RES, such as fluctuations in solar irradiance and wind speed, poses challenges for ensuring a reliable and stable electricity supply.

Battery Energy Storage Systems (BESS) have emerged as a key enabling technology to address these challenges. BESS helps to [1] store excess energy generated during periods of high RES availability and dispatch it during times of [1] low generation or peak demand. This capability not only improves grid resilience but also enhances the economic efficiency of RES by enabling better load matching and reducing the reliance on conventional, carbon-intensive energy sources. The integration of RES and BESS is, therefore, crucial for optimizing energy distribution systems and achieving sustainability goals. This work presents a comprehensive analysis of the cost efficiency of distribution systems integrated with both RES (wind and solar energy) and BESS. By developing an optimal load scheduling strategy, the study aims to minimize overall energy costs while ensuring grid reliability. Using the IEEE 33 and 69 bus systems as test cases, this research evaluates the performance of the proposed scheduling strategy under different operational scenarios, providing valuable insights into the economic and technical benefits of integrating RES and BESS into modern distribution systems. The findings of this research can inform the development of more sustainable, resilient, and cost-effective power distribution networks, contributing to the global transition towards clean energy.

CHAPTER 2

REVIEW OF LITERATURE

The analysis of the positions of Distributed Generator (DG) and the integration of transmission and distribution systems is done in [1]. [2] presents a new method to solve the network reconfiguration problem in the presence of DGs to minimize real power loss and improve the voltage profile in the distribution system. [3] explores the utilization of demand response and load shifting in hybrid microgrid systems. The load demand is predicted through Convolutional Neural Network (CNN) and the joint dispatch of energy and spinning reserve capacity performed with the integration of RES and BSS (Battery Storage System) to satisfy the expected load demand and penalize undesired outcomes in [4]. [5] explores the optimal arrangement of DG using Genetic Algorithm (GA) obtained based on fixed penetration level. The State of Charge (SoC) value for each hour before placing the battery based on the demand is estimated, and the battery is placed in the optimal location of the fixed capacity. When integrated with a RES, techniques of network optimization and network penetration of DGs are explored in [6] and [7]. These methods focus on optimizing the performance of the network. [8] explores using renewable energy to schedule residential loads considering the hour of the day and the price of power. Similar to this, the integration of renewable energy in a smart grid is explored in [9]. The work explained also emphasizes the importance of an algorithmic approach for the strategic scheduling of loads. The scheduling of micro-grid loads and the integration of RES is explored in [10]. [11] focuses on scheduling the loads such that maximum demand response is achieved. The integration of two different RES, microturbines, and EVs are explored in [12]. [13] explores the various sizes of BESS across various test cases, including the IEEE 33 and 69 Bus systems.

Furthermore, [14] focuses on scheduling algorithms for distribution systems incorporating Photo Voltaic (PV) and Battery Energy Systems (BES), aiming to minimize costs and manage renewable energy and storage systems. Joint load scheduling and voltage regulation integrating solar, wind, and hydropower are discussed in [15] and optimal scheduling incorporating Distributed Generators (DGs) with renewable energy and battery systems is explored in [16]. The integration of Renewable Energy Sources (RES), particularly solar energy, into smart grids poses significant challenges due to their inherent variability and intermittency, which is addressed in [17], by proposing an optimal scheduling mechanism aimed at enhancing the efficiency and reliability of smart grids. By advanced algorithms, the proposed method seeks to minimize operational costs and promote sustainable energy practices.

Integrating solar energy generation with load management strategies studied in [18], enhances their energy efficiency and reliability. It helps in reducing operational costs, minimizing [28,29] the [28] dependency on non-renewable energy sources, and contributing [28,29] more to sustainable energy. [19] proposes a residential energy scheduling for solar energy in smart grids, which involves managing household loads, storage batteries, utility grids, and renewable resources. It introduces an Action-Dependent Heuristic Dynamic Programming (ADHDP) method for enhancing microgrid's efficiency. It reduces electricity costs and improves load balancing, performing the PSO algorithm. [20] presents a method to minimize overall cost and maintain home comfort by optimizing Heat Ventilation and Air Conditions (HVAC), Electric Vehicle (EV), and Energy Storage System (ESS) with the help of the Lyapunov Optimization Technique (LOT). Integration of [30] RES and ESS is approached by using Demand Response (DR) [21] which gives a reduction in [30,31] operational cost [31] in microgrids. Mathematical methods like Mixed Integer Quadratically Constrained Programming (MIQCP) and CPLEX solver are used in General [32] Algebraic Modeling System (GAMS) to optimize the investment cost and to enhance the lifespan of ESS. With the above in consideration, the objectives of the work include strategizing the scheduling of loads over the hours of the day to achieve the lowest price possible.

3

CHAPTER 3

SCOPE OF THE PRESENT WORK

The objectives of this work are:

Minimization of energy costs through load scheduling.

Integration of solar and wind-generated energy to reduce consumer bills.

Optimal load scheduling for cost-effective energy utilization.

Integration of BESS for improved system resilience.

CHAPTER 4

EXPERIMENTAL PROCEDURES

This chapter discusses the various strategies employed to schedule loads and integrate both [33] solar and wind-generated energy as Renewable Energy Sources (RES). The integration of [34] solar and wind energy allows for a more comprehensive approach to optimizing energy utilization while considering economic constraints. Initially, each RES is [35] integrated separately to analyze their individual [35] impacts on load scheduling and system efficiency. Subsequently, both [36] solar and wind energy are combined to further [36] enhance system performance and cost-effectiveness. Finally, the system is integrated with a Battery Energy Storage System (BESS), which enables better energy management by storing excess energy during periods of low demand and releasing it when needed. This combined approach ensures optimal load scheduling, improved energy utilization, and reduced overall [37] operational costs.

4.1 Test Cases

Two different loading cases have been considered for the work done. In each of these, different time frames and system conditions have been taken into consideration [38] [39] , for more precise results. The positions of DGs [40] are assumed to be the same as shown in the topology diagrams, [41] for both the IEEE 33 and 69 buses. Two different scenarios are considered, along with two [42] topologies of both bus systems.

4.1.1 Test Case 1

For this case, the IEEE 33 bus as [43] shown in Fig 4.1 [43] is considered. [44] Here, two scenarios are considered and [45] the [46] peak load limit per hour is 3715 kW. The data for loads per hour is taken from [1] and [47] the data for solar and wind energy generated per hour is taken from [2]. The load variations for the scenarios considered are [48] as shown in Fig 4.2 and Fig 4.3.

6

6

6

Figure 4.1: Single Line Diagram with Tie Lines of 33 bus system

Figure 4.2: Load curve of IEEE 33 bus system Scenario-1

Figure 4.3: Load curve of IEEE 33 bus system Scenario-2

4.1.2 Test case 2

For this case, [50] the IEEE 69 bus shown in Fig 4.4 with two different scenarios is considered. Here the [51] peak load limit per hour is 3849.89 kW. The data for loads per hour is taken from [1] and [52] the data for wind energy generated per hour are taken from [2]. The load variation for the scenarios considered is as follows in Fig [53] 4.5 and 4.6 respectively. [54]

Figure 4.4: Single Line Diagram with Tie Lines of 69 bus system

Figure 4.5: Load curve of IEEE 69 bus system Scenario-1

Figure 4.6: Load curve of IEEE 69 bus system Scenario-2

4.2 Time Tagged Pricing

According to the Time Tagged Pricing (TTP), the cost per kWh varies with respect to [55] each hour. The main aim is to reduce total [56] cost of operation. It is scheduled with a strategy where more loads are to be [57] scheduled during hours with lower TTP. TTP data for an 24-hour [58] period [59] is provided in

Table 3.1. This data sourced [60] from [2], is used to schedule the loads [61] in [61] this work.

Table 4.1: TTP Data

Hour

Price($kWh)

Hour

Price($kWh)

1

0.033

13

0.215

2

0.027

14

0.572

3

0.02

15

0.286

4

0.017

16

0.279

5

0.017

17

0.086

6

0.029

18

0.059

7

0.033

19

0.05

8

0.054

20

0.061

9

0.215

21

0.181

10

0.572

22

0.077

11

0.572

23

0.043

12

0.572

24

0.037

4.3 Principle

When the cost of energy (TTP) is low, more load is scheduled, and when the cost of energy is high, less load is scheduled.[62] This focuses mainly on minimizing the cost of a distribution system. The values of costs are taken from Table 4.1. The process of scheduling[63] is shown as a flowchart in Fig 4.7 for multiple cases.

Figure 4.7: Flowchart for Proposed Algorithm

4.3.1 Case-1: Scheduling of Controllable loads

Step-1:[65] The loads for three different utilities are collected for 24 hours, which include:[65] Fixed[65] loads –[65] loads that cannot be altered throughout the day. These include small industries, agricultural utilities, etc. Controllable loads – loads that can be shifted over the hours of the day,[66] but not cut down. These loads must be fulfilled but can be shifted through the hours of the day. These include commercial loads, such as businesses, storage units, etc. Curtailable loads – loads that can be shifted[67] or reduced based on the demand of the hour. These include the residential loads of the day, which cover apartments and housing units. Based on this classification, the strategy to arrive at an economic[68] solution for the scheduling has been devised as[68] explained in further steps.

Step-2:[69] This step deals with the organization of controllable loads. Here, the following strategy is utilized:

The hours are compared with each other throughout the day. Hours that have the highest load

are separated first.

These loads are organized based on their respective Time Tagged Price (TTP), giving the hourwith[70] the highest price the most priority.

After this, hours with the least TTPs are organized, with the hour having the least TTP whencompared [71] to giving the most priority.

With this classification, the hours with the highest and lowest TTPs are zeroed in and comparedwith [72] each other in terms of their loads.

If the load of the hour with a higher TTP is larger than the hour [73] with a lower TTP, the load valuesare [74] subtracted to find the difference.

This difference is taken and added to the hour with the lower TTP, hence [75] reducing the load onthe [76] hour with high TTP.

This method of organization is followed until the loads are scheduled at the lowest possible price.

Step-3: This step focuses on keeping the total loads within the limit per hour, with a strategy as follows:

Once the curtailable loads are shifted, the total load per hour is evaluated.

At this step, the new total load for the entire day will be equal to [77] the initial total load calculated.• When comparing the per-hour total load, which is the sum of the three different loads considered, the newly obtained value of the load must not exceed the peak limit per hour.

In a situation where it does exceed [78] the peak load limit, the new value of the total load is subtracted from the set peak load and the difference is shifted to a different hour that [79] fulfills the set constraints.

Step-4: This step focuses on the scheduling of curtailable loads. The following strategy is utilized to schedule the loads:

Once step 3 organization is completed, the total load per hour is calculated [80] and [8] the cost for thefollowing [81] is also calculated. The load prices are compared hour to hour with [82] the initial price corresponding to the unhampered values of the data.

Since the method focuses on obtaining a solution with the least price, the residential loads arecurtailed[83] when a particular case arises as follows:

When the newly computed load exceeds the peak load limit at[84] an hour, the new load is subtractedfrom[84] the peak limit to find the difference.

This difference is then curtailed from the residential load value at an hour where the price ishigher[85] than the other hours comparatively.

This method is not actively utilized in the work done,[86] since curtailing the loads would lead to the grid. Though the method[88] would yield a solution that has[89] a considerably low price for the given period of[89] 24 hours, it may not be the best method when real-life situations are considered. Within the four steps of the organization explained above, the total price is expected to reduce, making a feasible method of organization that can be used in real-life situations.

4.3.2 Case-2: Integrating PV Energy

In this, two different methods have been analyzed, wherein[91] [91], [91] [91] in the first method, PV is integrated into the system and loads are scheduled. In the second method, the controllable loads are shifted first for lower prices and[92] PV is integrated.

Method I: Integration of PV with base controllable loads: PV energy is integrated into base commercial loads to achieve price reduction, resulting change[93] in total load and price.

PVCommercial(h) = LCommercial(h) – PV(h) (4.1)

where,

PVCommercial(h) is the commercial load obtained after integration[94] solar[95] energy,

LCommercial[96](h) is the initial commercial load considered before scheduling.

PV(h) is the solar energy produced.

After the integration, the total load is calculated as follows:

$$\text{LTotal}(h) = \text{PVCommercial}(h)+\text{LResidential}(h)+\text{LIndustrial}(h) \quad (4.2)$$

where,

LTotal(h) is the total load obtained after integration [97] of PV,

LResidential(h) is the residential load present in h hour before scheduling,

LIndustrial [98] (h) is the industrial load present [99] in h hour before scheduling.

$$\text{Lprice}(h) = \text{LTotal}(h) \ast \text{Price} \quad (4.3)$$

LPrice(h) is the total price calculated after integration [100] of solar energy,

Price is the cost of energy at 'h' hour.

Method II: Integration of PV with Scheduled Controllable Loads: In this method, the controllable loads are scheduled as per equations 4.1 to 4.3. However, the PV is integrated after the loads are scheduled [101] considering [102] the TTP. [103]

4.3.3 Case-3: Integration of wind energy

in this, two different methods have been analyzed, wherein, in the first method, wind energy is integrated into the system and [104] loads are scheduled. In the second method, the controllable loads are shifted first for lower prices and [105] wind energy is integrated.

Method I: Integration of Wind energy [106] with base [106] Commercial loads: [106] Wind energy is integrated into base commercial loads to achieve price reduction, resulting in a change in total load and price.

$$\text{WindCommercial}(h) = \text{LCommercial}(h) - \text{Wind}(h) \quad (4.4)$$

where,

WindCommercial(h) is the commercial load after the integration of wind energy,

LCommercial [107] (h) is the initial commercial load considered before scheduling,

Wind(h) is the wind energy produced during hour h.

After the integration, the total load is calculated as follows:

$$\text{LTotal}(h) = \text{WindCommercial}(h)+\text{LResidential}(h)+\text{LIndustrial}(h) \quad (4.5)$$

where,

LTotal(h) is the total load after wind energy integration,

WindCommercial(h) is the result obtained from equation 4.1,

LResidential(h) is the residential load present in hour h before scheduling,

LIndustrial(h) is the industrial load present [108] in hour h before scheduling.

The price of energy consumption at hour h is calculated using the following equation 4.3.[109]

Lprice(h) = LTotal(h) ∗ Price (4.6)

where,

LPrice(h) is the total price calculated after the integration of wind energy,

LTotal(h) is obtained from equation 4.2,

Price is the cost of energy at 'h' hour.

Method II: Integration of Wind Energy with Scheduled Commercial Loads: In this method, the controllable loads are scheduled as per equations 4.4 to 4.6. However, the wind energy is integrated after the loads are scheduled[110] considering[111] the TTP.

4.3.4 Case-4: Combining PV and Wind energy

To optimize cost reduction and efficient renewable energy utilization[113] [114], this case proposes a hybrid approach combining Case-2 and Case-3. Specifically, wind energy is integrated with controllable loads, while PV energy is paired with curtailable loads. This integrated methodology leverages the strengths of both renewable energy sources and load types. Wind energy, with its variable output, is matched with controllable loads that can [115] adjust to changing energy availability. Meanwhile, PV energy, with its predictable peak output, is aligned with curtailable loads that can be temporarily reduced or shifted during periods of high energy demand. By effectively combining these two approaches, the proposed methodology aims to minimize costs, maximize renewable energy utilization, and promote a more efficient and sustainable energy management system. In [116,117] buses 6 and 31 of the IEEE 33 Bus System, Wind-based DG has been used [116,117]. For [118,119] bus 13 of the same bus system, PV-based DG has been used. [118,119] For the IEEE 69 bus system, the Wind-based DG has been placed in positions 12 and 59. For [120] bus 29 of the same system, PV-based DG has been used. [120]

4.3.5 Case-5: Integrating Battery Energy Storage System (BESS)

In Case-5, a Battery Energy Storage System (BESS) is integrated with the Renewable Energy Source (RES) infrastructure to optimize energy utilization, mitigate intermittency, and reduce costs. The BESS stores excess energy generated by RES during off-peak hours, allowing for its subsequent utilization during peak hours or periods of reduced RES output due to climatic fluctuations or other disruptions. This integrated approach enables a more efficient, resilient, and [121] cost-effective energy management system.

The incorporation of BESS yields significant benefits, including:

Cost reduction by minimizing dependence on the grid during peak hours

Enhanced RES utilization efficiency

Reduced energy waste during off-peak periods

Improved overall system reliability and stability

The position of BESS in IEEE [122] 33 Bus System is at bus 28 [13] and [122] for the IEEE 69 Bus System is at bus 61 [13]. Considering the intermittency of RES, the BESS system stores energy when demand is low, maintaining a stable total cost per day. Although the integration of [123] BESS increases the initial capital cost, this investment can be recovered over the system's operational lifetime, ultimately reducing the overall cost. This integrated BESS-RES configuration forms a critical component of the proposed methodology, facilitating a more sustainable, efficient, and economically viable energy management framework.

4.3.6 Load Flow Analysis

As scheduling of [124] the load starts, it has to be considered that the voltages between the bus nodes may change, as well as the losses in the buses. To calculate the value of loss, a technique called Backward - Forward Sweep Analysis (BFSA) is used. It is mandatory to estimate the losses found in the system for the new demand curve and compare it with the old demand curve and [126] this aids to evaluate [126] the efficacy of the proposed scheduling process. The process mainly has two parts namely forward sweep [127] and backward sweep.

4.3.6.1 Backward Sweep Algorithm

It is used to find the current in each bus from the supply side to the demand side and add the values in such a way using Kirchoff's Current Law (KCL) that can determine the current supplied by the provider. This is used in the forthcoming steps.

(4.7)

4.3.6.2 Forward Sweep Algorithm

It is used to calculate [128] the voltages in every bus and store it [128] in the respective node from the first bus on the supply side using the current found in the previous step. Now this [129] gives us the bus voltage of each buses [129] in the IEEE 33 bus Radial system.

√

Vcurr = Vprev – 3 · Iprev branch · Z (4.8)

Vcurr is the voltage in the current bus and [130] Vprev is the voltage at the previous bus of the same

iteration.

4.3.6.3 Power Loss Calculation

Figure. 4.8 represents a simple radial network as an example [131] to show the power loss calculation between tth and t+1th bus. Here the [132] term 't' represents the bus number.

Figure 4.8: Single line [133] diagram of a simple radial network

Qt+1 = Qt − QLoss,t − QLt+1 (4.9)

Q

− Yt2|Vt+1|2 − QLt+1

(4.10)

|V

(4.11)

The power loss between tth [134] and t+1th bus is given by,

(4.12)

The sum of all these line losses gives the total power loss in ith hour. [135]

n

PLoss(i) = XPLoss(t,t+1)

(4.13)

t=1

6

6

CHAPTER 5

RESULTS AND DISCUSSION

In this chapter, the results of various cases, under different loading scenarios for IEEE 33 and 69 Bus systems are analyzed.

5.1 IEEE 33 BUS SYSTEM

The system has a peak load limit of 3715 kW per hour and a peak limit for wind and PV energy of 1046.2 kW.

5.1.1 Scenario-1

The PV and wind energy variation for scenario 1 is shown in Fig 5.1.

Figure 5.1: Energy variation observed in PV and Wind energy over 24 hours

Case-1: The base case scenario represents the initial condition without load scheduling or RES integration. Scheduling controllable loads alone yields a considerable 11.31% price reduction relative to the base case. Table 5.1 shows the cost reduction of the system.

Case-2: The base case is characterized by higher demand values and cost prices. Due to this, Table 5.1: Cost comparison of 33 bus system after scheduling

Condition

Total Load (kW)

Price($)

Base case

50104.41

9528.14727

Scheduling Controllable loads

50104.41

8450.13

the grid may tend to lose its reliability and fluctuations may occur. The integration of PV energy gives a cost difference of 13.08%. PV energy helps mitigate the strain on the grid and promotes cost-effectiveness. Scheduled controllable load values are taken from case-1 [143] and integrated with PV energy, with a reduction of [144] 24.98%. This results in a higher percentage of cost reduction. Here, a maximum amount of PV energy can be utilized to supply loads. Table 5.2 shows the cost reduction after the integration of PV energy as a [145] RES and Fig 5.2 shows the hourly power loss of the system [145] after the integration of PV energy.

Table 5.2: Cost comparison of 33 bus system [146] after integration of PV energy

Parameters	Total Load (kW)	Total Price ($)
Base	50104.41	9528.147
Base with PV	47148.85	8281.68
Sch. loads with PV	44847.415	7147.64

Figure 5.2: IEEE 33 bus system - Scenario-1 Hourly power loss after integration of PV energy.

Case-3: This case deals with the integration of [147] wind energy with controllable loads for scenario -1. In this case, when wind energy is integrated into controllable or curtailable loads after shifting, the total reduction in price is 60.42 %. Here, the integration of wind energy in controllable and curtailable loads yields the same result. Compared to other cases, this case yields the most reduction in total cost due to the integration of RES after scheduling. In the very [148] same case, when wind energy is integrated before the scheduling of controllable loads, a reduction of 49.11 % in price is observed as [149] shown. Table 5.3 shows the reduction of cost [151] and [150] Fig 5.3 shows the hourly power loss after the integration of [151] wind energy.

Table 5.3: Cost comparison of 33 bus system after integration of wind energy

Parameters

Total Load (kW)

Total Price ($)

Base

50104.41

9528.147

Base with wind

21001.916

4848.509

Sch. loads with wind

21001.916

3770.483

Figure 5.3: IEEE 33 bus system - Hourly power loss after integration of wind energy

Case-4: The integration of RES with controllable and curtailable loads yielded significant reductions in total price. Notably, combining wind and PV as an RES, [1] and scheduling loads based on availability and demand, [152] resulted in substantial cost savings. A comparative analysis of the results [153] revealed that integrating RES after load scheduling produced the most optimal outcomes. Table 5.4

[154] shows the cost reduction and Figure 5.4 shows the hourly power loss of the system. Specifically, this integrated approach yielded the highest total price reduction and promoted efficient energy utilization.

Table 5.4: Cost comparison of 33 bus system scenario 1 after integration of PV wind and scheduling

Parameters

Cost reduction (%)

Total load (kW)

Case-1

11.31

50104.41

Case-4

61.64

28208.86967

Figure 5.4: Power loss after combining PV and wind

Case-5: Here, [155] a BESS is integrated along [155] with the two RES to support their intermittent nature. By [156] utilizing the same to store excess energy generated during low-demand hours, the intermittency of the RES integrated here can be managed, [156] yielding higher reductions in price and energy loss as in Figure5.5 [157] and Table5.5. [157]

Table 5.5: Cost reduction after integration of BESS.

Total Loss (kW)

Total Loads (kW)

Price ($)

Price reduction (%)

827.35

21518.63

2575.44

72.97%

Figure 5.5: IEEE 33 bus system-Scenario-1 hourly power loss and price after integration of BESS

5.1.2 Scenario-2

The PV and wind energy variation for scenario 2 is shown in Fig 5.6.

Figure 5.6: Energy variation observed in PV and Wind energy over 24 hours

Case-1: The base case scenario represents the initial condition without load scheduling or RES integration. Scheduling controllable loads alone yields a considerable price reduction of 2.25% compared to the base case. Table 5.6 shows the cost reduction of the system.[158]

Table 5.6: Cost comparison of 33 bus system after scheduling

Condition

Total Load(kW)

Price($)

Base case

81796.87

14495.85942

Scheduling Controllable loads

81796.87

14169.19272

Case-2: The base case is considered, wherein unscheduled loads are integrated with PV energy, yielding a cost reduction of 22.06%. Whereas, when RES is integrated into scheduled loads difference [159] concerning the case is 24.31%. The above case is re-scheduled for a reduction of cost,[160] yielding 24.35%. Table 5.7 shows the cost reduction and[161] Figure 5.7 shows the hourly power loss of the system.

Table 5.7: Cost comparison of 33 bus system[162] after integration of PV energy

Parameters

Total Load (kW)

Total Price ($)

Base

81796.87

14495.85

Base with PV

72614.26

11297.6

Sch. loads with PV

72614.26

10970.94

Figure 5.7: IEEE 33 bus system - Scenario-2 hourly power loss for PV energy.

Here, a slight variation in cost is observed compared to the previous condition. Maximum solar energy is consumed during this period, which gives a lower operational price.

Case-3: This case analyzes the integration of wind energy as a RES with controllable loads. The integration of wind energy produces much higher reductions in price as compared to[163,164] the integration of PV energy,[163] due to its availability across 24 hours of the day. Table 5.8 shows the cost reduction and[165] Figure 5.8 shows the hourly power loss of the system after the integration of wind energy.

Table 5.8: Cost comparison of 33 bus system after integration of wind energy

Parameters

Total load (kW)

Total Price ($)

Base

81,796.87

14,495.85

Base with wind

66738.62

10717.54507

Base with wind sch.

66738.62

10717.54507

Figure 5.8: IEEE 33 bus system - Hourly power loss after integration of wind energy

Case-4: The integration of RES with controllable and curtailable loads yielded significant reductions in total price. Notably, combining wind and PV as an RES,[1] and scheduling loads based on availability and demand,[166] resulted in substantial cost savings. A comparative analysis of the results[167] revealed that integrating RES after load scheduling produced the most optimal outcomes. Table 5.8 shows the cost reduction and[168] Figure 5.9 shows the hourly power loss of the system after the integration of PV and wind energy.

Table 5.9: Comparison after integration of wind, PV and[169] scheduling

Parameters

Cost reduction (%)

Total load (kW)

Case-1

2.25

81796.87

Case-4

45.95

7833.740977

Figure 5.9: Power loss after combining PV and wind

Specifically, this integrated approach yielded the highest total price reduction and promoted efficient energy utilization.

Case-5: Here, a BESS is integrated along with the two RES to support their intermittent nature. By utilizing the same to store excess energy generated during low-demand hours, the intermittency of the RES can be managed, yielding higher reductions in price and energy loss. Table 5.10 shows the cost reduction and Figure 5.10 shows the hourly power loss of the system after integration of

BESS with case-4.

Table 5.10: Cost reduction after integration of BESS.

Total Loss (kWh)

Total Loads (kW)

Price ($)

Price reduction (%)

1806.75

52231.88

7096.38

51.04%

Figure 5.10: IEEE 33 bus system-Scenario-2 hourly power loss and price after integration of BESS

Comparing the two scenarios analyzed here, Scenario 2 yields better results for all the 5 cases used for analysis. Scenario 2 has a much better production profile with regards to Wind energy. Due to its consistency, the system has reduced dependency on the grid. Scenario 1 of the same system has loads that are [173] concentrated on some hours of the day. This is due to scheduling [174] of the loads considering the load demand and price across the day. This reduces the effectiveness of the RES integrated into the system.

5.2 IEEE 69 BUS SYSTEM

The IEEE 69 bus is considered, with a peak load limit of 3849.89 kW per hour and a peak limit of 1046.2 kW for wind energy. The data for loads per hour is taken from [1] and [175] the data for wind energy generated per hour are taken from [3]. The figure below displays the loss recorded for controllable and curtailable loads for the 69 bus system for 24 hours. It is observed that losses occurring in controllable loads are much more unpredictable, [176] as compared to [176] the [176] other loads. The single-line diagram with tie lines of the 69 bus system is shown in Figure 4.4.

5.2.1 Scenario-1

Case-1: The difference in price in controllable scheduling concerning the base case is 8.73%. The price variation is low because curtailable loads are not curtailed since it [177] [177] is not required. Also, the load value remains constant due to this cause. The below [178] Table 5.11 shows a brief explanation.

Table 5.11: Cost comparison of 69 bus system after scheduling

Condition

Total Load(kW)

Price($kWh)

Base case

51923.02469

9873.952021

Scheduling Controllable loads

51923.02469

9011.045634

Case-2: Without load scheduling, the initial data shows high energy demand and costs, straining the grid. However, after the integration of [179] RES and adjustments made in controllable loads, costs dropped by 8.73%. Load scheduling is key [180] here because it helps reduce grid strain and lower overall costs. Table 5.12 shows the cost reduction and [181] Figure 5.11 shows the hourly power loss of the system after the integration of PV energy. [182]

Table 5.12: Cost comparison of 69 bus system after integration of PV energy

Parameters

Total Load (kW)

Total Price ($kWh)

Base

51923.02

9873.95

Base with PV

48967.5

8627.48

Sch. loads with PV

48967.5

7764.57

Case-3: The same [183] method for integrating wind energy as an RES as utilized [184] for the IEEE 33 bus system is followed here. The cost reduction is much higher here due to the availability of wind energy throughout the day. Table 5.13 shows the cost reduction and [185] Figure 5.11 shows the hourly power loss after integrating wind energy into the system.

Case-4: The integration of [186] RES with controllable and curtailable loads yields significant reductions in total price. Notably, combining wind and PV as an RES, [1] and scheduling loads based on

Figure 5.11: IEEE 69 bus system - Hourly power loss for PV energy. Table 5.13: Cost comparison of 69 bus system scenario 1 after integration of wind energy

Parameters

Total load (kW)

Total Price ($)

Base

51,923.02

9,873.95

Base with wind

36,864.76

6,727.29

Base with wind sch.

36,864.76

5,864.39

Figure 5.12: IEEE 69 bus system - Hourly power loss after integration of wind energy.

availability [188] and demand, resulted [189] in substantial cost savings. A comparative analysis of the results [190] revealed that integrating RES after load scheduling produced the most optimal outcomes. Specifically, this integrated approach yielded the highest total price reduction and promoted efficient energy utilization. Table 5.12 shows the cost reduction and [191] Figure 5.13 shows the hourly power loss after integrating solar and wind energy.

Table 5.14: Comparison after integration of wind, PV and [192] scheduling

Parameters

Cost reduction (%)

Total load (kW)

Case-1

8.73

51923.02469

Case-4

24.17

38308.19728

Figure 5.13: Power loss after combining PV and wind

Case-5: Here, BESS is integrated along with RES to support their intermittent nature. By utilizing the same to store excess energy generated during low-demand hours, the intermittency of RES can be managed, yielding higher reductions in price and energy loss and improving the overall reliability of the approach. Table 5.15 shows the cost reduction and Figure 5.14 shows the hourly power loss after integration of BESS in case-4.

Table 5.15: Cost reduction after the integration of BESS.

Total Loss (kWh)

Total Loads (kW)

Price ($)

Price reduction (%)

380.02

23784.59

4568.99

53.72%

5.2.2 Scenario-2

Case-1: The difference in price obtained after the scheduling of controllable loads in the base case is 2.05%. The price variation is low because curtailable loads are preserved to maintain grid stability. Due to this, the load value remains constant. Table 5.16 shows the cost reduction of the system after scheduling.

Figure 5.14: IEEE 69 bus system-Scenario-1 hourly power loss and price after integration of BESS Table 5.16: Cost comparison of 69 bus system after scheduling

Conditions

Total Load (kW)

Price ($)

Base case

84766.87812

15022.19763

Scheduling Controllable loads

84766.87812

14714.16513

Case-2: The base case is integrated with PV energy, yielding a difference of 21.30% before scheduling. Scheduled loads are considered and integrated with PV, yielding a difference of 23.34%. Table 5.17 shows the cost reduction and Figure 5.15 shows the hourly power loss of the system after integrating PV energy.

Table 5.17: Cost comparison of 69 bus system after integration of PV energy

Parameters

Total Load (kW)

Total Price ($)

Base

84766.87

15022.1

Base with PV

75584.27

11823.9

Sch. loads with PV

75584.27

11515.9

Case-3: The same [198] method for integrating wind energy as RES as utilized for the IEEE 33 bus system is followed here. Evidently, the integration of wind energy yields better price reduction, due to its availability across the day. Table 5.18 shows the cost reduction and Figure 5.15 shows the hourly power loss of the system after integrating wind energy.

Figure 5.15: IEEE 69 bus system - Hourly power loss for PV energy.

Table 5.18: Cost comparison of 69 bus system scenario 2 after integration of wind energy

Parameters

Total load (kW)

Total Price ($)

Base

84,766.88

15,022.20

Base with wind

69,708.62

11,875.54

Base with wind sch.

69,708.62

11,875.54

Figure 5.16: IEEE 69 bus system Hourly power loss after integration of wind energy

Case-4: The integration of RES with controllable and curtailable loads yielded significant reductions in total price. Notably, combining wind and solar RES, and scheduling loads based on availability and demand, resulting in substantial cost savings. A comparative analysis of the results revealed that integrating RES after load scheduling produced the most optimal outcomes. Specifically, this integrated approach yielded the highest total price reduction and promoted efficient energy utilization. Table 5.19 shows the cost reduction and Figure 5.17 shows the hourly power loss of the system after integrating PV and wind energy.

Case-5: Here, a BESS is integrated along with the two RES to support their intermittent nature Table 5.19: Comparison after integration of wind, PV and scheduling

Parameters

Cost reduction (%)

Total load (kW)

Case-1

2.05

84766.87812

Case-4

30.64

64401.69908

Figure 5.17: Power loss after combining PV and wind

as done in scenario 1. By utilizing the same to store excess energy generated during low-demand hours, the intermittency of the RES integrated here can be managed, yielding higher reductions in price and energy loss as follows. Table 5.20 shows the cost reduction and Figure 5.18 shows the hourly power loss of the system after integrating solar energy.

Table 5.20: Cost reduction after integration of BESS.

Total Loss (kWh)

Total Loads (kW)

Price ($)

Price reduction (%)

343.79

21774.42

3150.37

79.02%

Comparing the two scenarios analyzed here, Scenario 2 yields better results for all the 5 cases used for analysis. Scenario 2 has a much better production profile with regards to Wind energy. Due to its consistency, the system has reduced dependency on the grid. The loads across 24 hours are dispersed consistently, providing better cost and loss reductions. The load demand across the day is spread out, and combining this with the proposed technique makes the reduction across the scenario better.

Figure 5.18: IEEE 69 bus system-Scenario-2 hourly power loss and price after integration of BESS

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CHAPTER 6

CONCLUSIONS

The work done above has made it clear that with organized scheduling, the overall costs concerning different loads throughout the day can be well maintained under control. Here, two scenarios in terms of system conditions are considered. The work done above utilizes an approach that prioritizes the consumers when the loads are scheduled, such that the final result is practically feasible. The DG and BESS positions for both the test systems are fixed. Following an attempt to vary the position of DGs, the prices and loads concerning the hour may differ, leading to a change in the expected price. Along with this, the renewable energy generated per day may also vary, causing changes to the final prices.

The presented work makes it clear that the integration of two RES along with the strategic scheduling of loads, comparing the peak prices and demand over 24 hours of the day creates a considerable reduction in the cost in both the scenarios of the systems taken into consideration.This [214] has made the method highly cost-effective and energy-efficient. The integration of storage systems

215 has proved useful in managing the intermittency of the RES and storing surplus energy generated during hours with lower power requirements, which can be utilized to fulfill a larger 216 set of loads during peak hours, ultimately reducing the overall cost and increasing the effectiveness of scheduling.

The integration of electric vehicles may also provide a different scene with respect to load utilization since they can act as both charging and discharging loads. The integration of this method to a transmission system would help reduce losses considerably, along with efficient utilization of generated energy.

Signature of the Guide

Name of the Guide: Dr. Narayanan K (SAP/EEE/SEEE) 219

1.	*BESS helps to store excess energy generated during periods of high RES availability and dispatch it during times of low generation or peak demand.*	Unclear sentences	Clarity
2.	*The integration of RES and BESS is, therefore, crucial for optimizing energy distribution systems and achieving sustainability goals.*	Unclear sentences	Clarity
3.	*This work presents a comprehensive analysis of the cost efficiency of distribution systems integrated with both RES (wind and solar energy) and BESS.*	Unclear sentences	Clarity
4.	*By developing an optimal load scheduling strategy, the study aims to minimize overall energy costs while ensuring grid reliability.*	Unclear sentences	Clarity
5.	*The analysis of the positions of Distributed Generator (DG) and the integration of transmission and distribution systems is done in [1].*	Unclear sentences	Clarity
6.	the Distributed	Determiner use (a/an/the/this, etc.)	Correctness
7.	~~real~~ → actual	Word choice	Engagement
8.	*load; Load*	Text inconsistencies	Correctness
9.	the Convolutional	Determiner use (a/an/the/this, etc.)	Correctness
10.	*explores the optimal arrangement of DG using Genetic Algorithm (GA) obtained based on fixed penetration level.*	Ungrammatical sentence	Correctness

11.	~~a~~ RES	Determiner use (a/an/the/this, etc.)	Correctness
12.	*When integrated with a RES, techniques of network optimization and network penetration of DGs are explored in [6] and [7].*	Unclear sentences	Clarity
13.	*price; Price*	Text inconsistencies	Correctness
14.	~~price of power~~ → power price	Wordy sentences	Clarity
15.	*explores using renewable energy to schedule residential loads considering the hour of the day and the price of power.*	Incorrect phrasing	Correctness
16.	~~Similar to this~~ → Similarly	Wordy sentences	Clarity
17.	~~a smart~~ → an intelligent	Word choice	Engagement
18.	~~is~~ → are	Faulty subject-verb agreement	Correctness
19.	~~such~~ → so	Incorrect phrasing	Correctness
20.	~~are~~ → is	Faulty subject-verb agreement	Correctness
21.	~~various~~	Wordy sentences	Clarity
22.	, and	Punctuation in compound/complex sentences	Correctness

23.	*The integration of Renewable Energy Sources (RES), particularly solar energy, into smart grids poses significant challenges due to their inherent variability and intermittency, which is addressed in [17], by proposing an optimal scheduling mechanism aimed at enhancing the efficiency and reliability...*	Unclear sentences	Clarity
24.	],	Punctuation in compound/complex sentences	Correctness
25.	~~smart~~ → intelligent	Word choice	Engagement
26.	*By advanced algorithms, the proposed method seeks to minimize operational costs and promote sustainable energy practices.*	Unclear sentences	Clarity
27.	],	Comma misuse within clauses	Correctness
28.	*It helps in reducing operational costs, minimizing the dependency on non-renewable energy sources, and contributing more to sustainable energy.*	Incorrect phrasing	Correctness
29.	*It helps in reducing operational costs, minimizing the dependency on non-renewable energy sources, and contributing more to sustainable energy.*	Unclear sentences	Clarity
30.	*Integration of RES and ESS is approached by using Demand Response (DR) [21] which gives a reduction in operational cost in microgrids.*	Unclear sentences	Clarity

31.	*Integration of RES and ESS is approached by using Demand Response (DR) [21] which gives a reduction in operational cost in microgrids.*	Incorrect phrasing	Correctness
32.	the General	Determiner use (a/an/the/this, etc.)	Correctness
33.	~~both~~	Wordy sentences	Clarity
34.	~~The integration of~~ → Integrating	Wordy sentences	Clarity
35.	*Initially, each RES is integrated separately to analyze their individual impacts on load scheduling and system efficiency.*	Unclear sentences	Clarity
36.	*Subsequently, both solar and wind energy are combined to further enhance system performance and cost-effectiveness.*	Unclear sentences	Clarity
37.	~~overall~~	Wordy sentences	Clarity
38.	considered	Wordy sentences	Clarity
39.	consideration,	Punctuation in compound/complex sentences	Correctness
40.	DG positions	Wordy sentences	Clarity
41.	diagrams,	Punctuation in compound/complex sentences	Correctness
42.	*Two different scenarios are considered, along with two topologies of both bus systems.*	Unclear sentences	Clarity

43.	*For this case, the IEEE 33 bus as shown in Fig 4.1 is considered.*	Ungrammatical sentence	Correctness
44.	*For this case, the IEEE 33 bus as shown in Fig 4.1 is considered.*	Unclear sentences	Clarity
45.	, and	Punctuation in compound/complex sentences	Correctness
46.	*Here, two scenarios are considered and the peak load limit per hour is 3715 kW.*	Unclear sentences	Clarity
47.	, and	Punctuation in compound/complex sentences	Correctness
48.	~~as~~	Conjunction use	Correctness
49.	~~case~~ → Case	Confused words	Correctness
50.	*For this case, the IEEE 69 bus shown in Fig 4.4 with two different scenarios is considered.*	Unclear sentences	Clarity
51.	, the	Punctuation in compound/complex sentences	Correctness
52.	, and	Punctuation in compound/complex sentences	Correctness
53.	~~as follows in Fig~~ → in Figures	Wordy sentences	Clarity
54.	, respectively	Punctuation in compound/complex sentences	Correctness
55.	~~with respect to~~ → concerning, for, to	Wordy sentences	Clarity
56.	the total	Determiner use (a/an/the/this, etc.)	Correctness

57.	~~to be~~	Wordy sentences	Clarity
58.	~~an 24-hour~~ → a 24-hour	Determiner use (a/an/the/this, etc.)	Correctness
59. -	~~an 24-hour period~~ → 24 hours	Wordy sentences	Clarity
60.	~~sourced~~	Wordy sentences	Clarity
61.	*This data sourced from [2], is used to schedule the loads in this work.*	Incorrect phrasing	Correctness
62.	*When the cost of energy (TTP) is low, more load is scheduled, and when the cost of energy is high, less load is scheduled.*	Unclear sentences	Clarity
63.	scheduling process	Wordy sentences	Clarity
64.	~~loads~~ → Loads	Confused words	Correctness
65.	*Step-1: The loads for three different utilities are collected for 24 hours, which include: Fixed loads – loads that cannot be altered throughout the day.*	Incorrect phrasing	Correctness
66.	day,	Punctuation in compound/complex sentences	Correctness
67.	~~shifted~~ → moved, turned	Word choice	Engagement
68.	*Based on this classification, the strategy to arrive at an economic solution for the scheduling has been devised as explained in further steps.*	Ungrammatical sentence	Correctness
69.	~~Step-2~~ → Step 2	Misspelled words	Correctness
70.	~~hourwith~~ → hour with	Misspelled words	Correctness

71.	~~whencompared~~ → when compared	Misspelled words	Correctness
72.	~~comparedwith~~ → compared with	Misspelled words	Correctness
73.	~~the hour~~ → that	Wordy sentences	Clarity
74.	~~valuesare~~ → values are	Misspelled words	Correctness
75.	~~hence~~	Wordy sentences	Clarity
76.	~~onthe~~ → on the	Misspelled words	Correctness
77.	~~be equal to~~ → equal	Wordy sentences	Clarity
78.	*In a situation where it does exceed the peak load limit, the new value of the total load is subtracted from the set peak load and the difference is shifted to a different hour that fulfills the set constraints.*	Unclear sentences	Clarity
79.	*In a situation where it does exceed the peak load limit, the new value of the total load is subtracted from the set peak load and the difference is shifted to a different hour that fulfills the set constraints.*	Incorrect phrasing	Correctness
80.	~~is calculated~~	Wordy sentences	Clarity
81.	*Once step 3 organization is completed, the total load per hour is calculated and the cost for thefollowing is also calculated.*	Ungrammatical sentence	Correctness
82.	, with	Punctuation in compound/complex sentences	Correctness

83.	~~arecurtailed~~ → are curtailed	Misspelled words	Correctness
84.	*When the newly computed load exceeds the peak load limit at an hour, the new load is subtractedfrom the peak limit to find the difference.*	Incorrect phrasing	Correctness
85.	~~ishigher~~ → is higher	Misspelled words	Correctness
86.	~~done~~	Wordy sentences	Clarity
87.	~~done,~~	Incorrect phrasing	Correctness
88.	~~method~~ → technique	Word choice	Engagement
89.	*Though the method would yield a solution that has a considerably low price for the given period of 24 hours, it may not be the best method when real-life situations are considered.*	Unclear sentences	Clarity
90.		Tone suggestions	Delivery
91.	*In this, two different methods have been analyzed, wherein, in the first method, PV is integrated into the system and loads are scheduled.*	Incorrect phrasing	Correctness
92.	, and	Punctuation in compound/complex sentences	Correctness
93.	in a change	Incorrect phrasing	Correctness
94.	the integration	Determiner use (a/an/the/this, etc.)	Correctness
95.	of solar	Wrong or missing prepositions	Correctness
96.	~~LCommercial~~ → Commercial	Misspelled words	Correctness

97.	the integration	Determiner use (a/an/the/this, etc.)	Correctness
98.	and LIndustrial	Conjunction use	Correctness
99.	~~present~~	Wordy sentences	Clarity
100.	the integration	Determiner use (a/an/the/this, etc.)	Correctness
101.	~~scheduled~~ → planned	Word choice	Engagement
102.	, considering	Punctuation in compound/complex sentences	Correctness
103.	*However, the PV is integrated after the loads are scheduled considering the TTP.*	Unclear sentences	Clarity
104.	, and	Punctuation in compound/complex sentences	Correctness
105.	, and	Comma misuse within clauses	Correctness
106.	*Method I: Integration of Wind energy with base Commercial loads: Wind energy is integrated into base commercial loads to achieve price reduction, resulting in a change in total load and price.*	Ungrammatical sentence	Correctness
107.	~~LCommercial~~ → commercial	Misspelled words	Correctness
108.	~~present~~	Wordy sentences	Clarity
109.	: 4.3	Incorrect punctuation	Correctness
110.	~~scheduled~~ → planned	Word choice	Engagement
111.	, considering	Punctuation in compound/complex sentences	Correctness

112.	~~energy~~ → Energy	Confused words	Correctness
113.	*To optimize cost reduction and efficient renewable energy utilization*	Misplaced words or phrases	Correctness
114.	*To optimize cost reduction and efficient renewable energy utilization, this case proposes a hybrid approach combining Case-2 and Case-3.*	Unclear sentences	Clarity
115.	~~can~~	Wordy sentences	Clarity
116.	*In buses 6 and 31 of the IEEE 33 Bus System, Wind-based DG has been used.*	Incorrect phrasing	Correctness
117.	*In buses 6 and 31 of the IEEE 33 Bus System, Wind-based DG has been used.*	Unclear sentences	Clarity
118.	*For bus 13 of the same bus system, PV-based DG has been used.*	Incorrect phrasing	Correctness
119.	*For bus 13 of the same bus system, PV-based DG has been used.*	Unclear sentences	Clarity
120.	*For bus 29 of the same system, PV-based DG has been used.*	Incorrect phrasing	Correctness
121.	~~and~~	Wordy sentences	Clarity
122.	*The position of BESS in IEEE 33 Bus System is at bus 28 [13] and for the IEEE 69 Bus System is at bus 61 [13].*	Ungrammatical sentence	Correctness
123.	~~the integration of~~ → integrating	Wordy sentences	Clarity

124.	*As scheduling of the load starts, it has to be considered that the voltages between the bus nodes may change, as well as the losses in the buses.*	Incorrect phrasing	Correctness
125.	*loss; Loss*	Text inconsistencies	Correctness
126.	*It is mandatory to estimate the losses found in the system for the new demand curve and compare it with the old demand curve and this aids to evaluate the efficacy of the proposed scheduling process.*	Ungrammatical sentence	Correctness
127.	*The process mainly has two parts namely forward sweep and backward sweep.*	Incorrect phrasing	Correctness
128.	*It is used to calculate the voltages in every bus and store it in the respective node from the first bus on the supply side using the current found in the previous step.*	Unclear sentences	Clarity
129.	*Now this gives us the bus voltage of each buses in the IEEE 33 bus Radial system.*	Ungrammatical sentence	Correctness
130.	, and	Punctuation in compound/complex sentences	Correctness
131.	~~as an example~~	Wordy sentences	Clarity
132.	, the	Punctuation in compound/complex sentences	Correctness
133.	~~Single line~~ → Single-line	Misspelled words	Correctness
134.	~~tth~~ → the	Misspelled words	Correctness

135.	~~ith hour~~ → an hour	Incorrect phrasing	Correctness
136.	*In this chapter, the results of various cases, under different loading scenarios for IEEE 33 and 69 Bus systems are analyzed.*	Unclear sentences	Clarity
137.	cases,	Punctuation in compound/complex sentences	Correctness
138.	*Table 5.1 shows the cost reduction of the system.*	Incorrect phrasing	Correctness
139.	~~Case-2~~ → Case 2	Misspelled words	Correctness
140.	~~system~~ → systems	Incorrect noun number	Correctness
141.	, and	Punctuation in compound/complex sentences	Correctness
142.		Tone suggestions	Delivery
143.	~~case-1~~ → case 1	Misspelled words	Correctness
144.	~~with a reduction of~~ → reducing	Wordy sentences	Clarity
145.	*Table 5.2 shows the cost reduction after the integration of PV energy as a RES and Fig 5.2 shows the hourly power loss of the system after the integration of PV energy.*	Incorrect phrasing	Correctness
146.	~~system~~ → systems	Incorrect noun number	Correctness
147.	~~the integration of~~ → integrating	Wordy sentences	Clarity
148.	~~very~~	Wordy sentences	Clarity

149.	, as	Punctuation in compound/complex sentences	Correctness
150.	, and	Punctuation in compound/complex sentences	Correctness
151.	*Table 5.3 shows the reduction of cost and Fig 5.3 shows the hourly power loss after the integration of wind energy.*	Unclear sentences	Clarity
152.	*Notably, combining wind and PV as an RES, and scheduling loads based on availability and demand, resulted in substantial cost savings.*	Ungrammatical sentence	Correctness
153.	~~of the results~~	Wordy sentences	Clarity
154.	, and	Punctuation in compound/complex sentences	Correctness
155.	*Case-5: Here, a BESS is integrated along with the two RES to support their intermittent nature.*	Unclear sentences	Clarity
156.	*By utilizing the same to store excess energy generated during low-demand hours, the intermittency of the RES integrated here can be managed, yielding higher reductions in price and energy loss as in Figure5.5 and Table5.5.*	Unclear sentences	Clarity
157.	*By utilizing the same to store excess energy generated during low-demand hours, the intermittency of the RES integrated here can be managed, yielding higher reductions in price and energy loss as in Figure5.5 and Table5.5.*	Ungrammatical sentence	Correctness

158.	*Table 5.6 shows the cost reduction of the system.*	Incorrect phrasing	Correctness
159.	, the difference	Incorrect phrasing	Correctness
160.	cost reduction	Wordy sentences	Clarity
161.	, and	Punctuation in compound/complex sentences	Correctness
162.	~~system~~ → systems	Incorrect noun number	Correctness
163.	*The integration of wind energy produces much higher reductions in price as compared to the integration of PV energy, due to its availability across 24 hours of the day.*	Incorrect phrasing	Correctness
164.	*The integration of wind energy produces much higher reductions in price as compared to the integration of PV energy, due to its availability across 24 hours of the day.*	Unclear sentences	Clarity
165.	, and	Punctuation in compound/complex sentences	Correctness
166.	*Notably, combining wind and PV as an RES, and scheduling loads based on availability and demand, resulted in substantial cost savings.*	Ungrammatical sentence	Correctness
167.	~~of the results~~	Wordy sentences	Clarity
168.	, and	Punctuation in compound/complex sentences	Correctness
169.	, and	Comma misuse within clauses	Correctness

170.	*Case-5: Here, a BESS is integrated along with the two RES to support their intermittent nature.*	Unclear sentences	Clarity
171.	, and	Punctuation in compound/complex sentences	Correctness
172.	the integration	Determiner use (a/an/the/this, etc.)	Correctness
173.	~~that are~~	Wordy sentences	Clarity
174.	the scheduling	Determiner use (a/an/the/this, etc.)	Correctness
175.	, and	Punctuation in compound/complex sentences	Correctness
176.	*It is observed that losses occurring in controllable loads are much more unpredictable, as compared to the other loads.*	Incorrect phrasing	Correctness
177.	*The price variation is low because curtailable loads are not curtailed since it is not required.*	Incorrect phrasing	Correctness
178.	~~The~~ below	Determiner use (a/an/the/this, etc.)	Correctness
179.	~~the integration of~~ → integrating	Wordy sentences	Clarity
180.	~~key~~ → critical, vital	Word choice	Engagement
181.	, and	Punctuation in compound/complex sentences	Correctness
182.	*Table 5.12 shows the cost reduction and Figure 5.11 shows the hourly power loss of the system after the integration of PV energy.*	Unclear sentences	Clarity

183.	~~same~~ → exact	Word choice	Engagement
184.	~~as utilized~~	Wordy sentences	Clarity
185.	, and	Punctuation in compound/complex sentences	Correctness
186.	~~The integration of~~ → Integrating	Wordy sentences	Clarity
187.	RES,	Punctuation in compound/complex sentences	Correctness
188.	~~availability~~ → Availability	Improper formatting	Correctness
189.	~~resulted~~ → resulting	Incorrect verb forms	Correctness
190.	~~of the results~~	Wordy sentences	Clarity
191.	, and	Punctuation in compound/complex sentences	Correctness
192.	, and	Comma misuse within clauses	Correctness
193.	*Case-5: Here, BESS is integrated along with RES to support their intermittent nature.*	Unclear sentences	Clarity
194.	, and	Punctuation in compound/complex sentences	Correctness
195.	price difference	Wordy sentences	Clarity
196.	*Table 5.16 shows the cost reduction of the system after scheduling.*	Incorrect phrasing	Correctness
197.	*Table 5.17 shows the cost reduction and Figure 5.15 shows the hourly power loss of the system after integrating PV energy.*	Incorrect phrasing	Correctness

198.	~~same~~ → exact	Word choice	Engagement
199.	~~as utilized~~	Wordy sentences	Clarity
200.	reduction,	Punctuation in compound/complex sentences	Correctness
201.	*Table 5.18 shows the cost reduction and Figure 5.15 shows the hourly power loss of the system after integrating wind energy.*	Incorrect phrasing	Correctness
202.	*Notably, combining wind and solar RES, and scheduling loads based on availability and demand, resulting in substantial cost savings.*	Incorrect phrasing	Correctness
203.	~~of the results~~	Wordy sentences	Clarity
204.	, and	Punctuation in compound/complex sentences	Correctness
205.	. Table	Punctuation in compound/complex sentences	Correctness
206.	, and	Comma misuse within clauses	Correctness
207.	, and	Punctuation in compound/complex sentences	Correctness
208.	*The load demand across the day is spread out, and combining this with the proposed technique makes the reduction across the scenario better.*	Unclear sentences	Clarity
209.	controlled	Wordy sentences	Clarity

210.	*The work done above utilizes an approach that prioritizes the consumers when the loads are scheduled, such that the final result is practically feasible.*	Unclear sentences	Clarity
211.	*Along with this, the renewable energy generated per day may also vary, causing changes to the final prices.*	Unclear sentences	Clarity
212.	day,	Punctuation in compound/complex sentences	Correctness
213.	considered	Wordy sentences	Clarity
214.	. This	Improper formatting	Correctness
215.	~~useful~~ → helpful	Word choice	Engagement
216.	~~larger~~ → more extensive	Word choice	Engagement
217.	~~with respect to~~ → concerning, for, to	Wordy sentences	Clarity
218.	~~to~~ → into	Wrong or missing prepositions	Correctness
219.	~~SEEE~~ → SE	Misspelled words	Correctness
220.	*concerns over climate change and energy security, has prompted a*	Cumulative energy, emissions, and water consumption for geothermal electric power production	Originality
221.	*oals. This work presents a comprehensive analysis of the cost efficiency of distribution systems integrated with both RES (wind and solar energy) and BESS. By developing an optimal load scheduling strategy, the study aims to minimize overall energy costs while ensuring grid reliabi*		Originality

222.	*lity. Using the IEEE 33 and 69 bus systems as test cases, this research evaluates the performance of the proposed scheduling strategy under different operational scenarios, providing valuable insights into the economic and technical benefits of integrating RES and BESS into modern distribution sys*		Originality
223.	*tems. The findings of this research can inform the development of more sustainable, resilient, and cost-effective power distribution networks, contributing to the global transition towards clean energy. CHAPTER 2 REVIEW OF LITERATURE The analysis of the positions of Distributed Generator (DG) and t...*		Originality
224.	*presents a new method to solve the network reconfiguration problem in the presence of*	دانلود ترجمه مقاله کمینه سازی اتلاف توان در سیستم توزیع توسط پیکربندی مجدد شبکه در مجاورت تولید پراکنده (DG) - مقاله جو https://maghalejoo.com/doc/4683/%D9%85%DB%8C%D9%86%DB%8C%D9%85%D9%85-%DA%A9%D8%B1%D8%AF%D9%86-%D8%A7%D8%AA%D9%84%D8%A7%D9%81-%D8%AA%D9%88%D8%A7%D9%86-%D8%AF%D8%B1-%D8%B3%DB%8C%D8%B3%D8%AA%D9%85-%D8%AA%D9%88%D8%B2%DB%8C%D8%B9/	Originality
225.	*to minimize real power loss and improve the voltage profile*	A fuzzy-based optimal reactive power control	Originality

226.	*The State of Charge (SoC) value for each hour before placing the battery based on the demand*	Loss Minimization of Distribution Systems by Coordinated Operation of Battery and EVs in the Presence of DGs	Originality
227.	*placed in the optimal location of the fixed capacity.*	Loss Minimization of Distribution Systems by Coordinated Operation of Battery and EVs in the Presence of DGs	Originality
228.	*[16]. The integration of Renewable Energy Sources (RES), particularly solar energy, into smart grids poses significant challenges due to their inherent variability and intermittency, which is addressed in [17], by proposing an optimal scheduling mechanism aimed at enhancing the efficiency and relia...*		Originality
229.	*rids. By advanced algorithms, the proposed method seeks to minimize operational costs and promote sustainable energy practices. Integrating solar energy generation with load management strategies studied in [18], enhances their energy efficiency and reliability. It helps in reducing operational cos...*		Originality
230.	*DURES This chapter discusses the various strategies employed to schedule loads and integrate both solar and wind-generated energy as Renewable Energy Sources (RES). The integration of solar and wind energy allows for a more comprehensive approach to optimizing energy utilization while considering e...*		Originality

231.	*ints. Initially, each RES is integrated separately to analyze their individual impacts on load scheduling and system efficiency. Subsequently, both solar and wind energy are combined to further enhance system performance and cost-effective*		Originality
232.	*management by storing excess energy during periods of low demand and releasing it*	The Role of AI and Machine Learning in Renewable Energy Management - https://www.firewinder.com/the-role-of-ai-and-machine-learning-in-renewable-energy-management/	Originality
233.	*as shown in Fig 4.2 and Fig 4.3.*	Experimental Investigations on Powder Mixed Electric Discharge Machining – IJERT https://www.ijert.org/experimental-investigations-on-powder-mixed-electric-discharge-machining	Originality
234.	*ing PV and Wind energy To optimize cost reduction and efficient renewable energy utilization, this case proposes a hybrid approach combining Case-2 and Case-3. Specifically, wind energy is integrated with controllable loads, while PV energy is paired with curtailable loads. This integrated methodol...*		Originality
235.	*ources and load types. Wind energy, with its variable output, is matched with controllable loads that can adjust to changing energy availability. Meanwhile, PV energy, with its predictable peak output, is aligned with curtailable loads that can be temporarily reduced or shifted during periods*		Originality

236.	*of high energy demand. By effectively combining these two approaches, the proposed methodology aims to minimize costs, maximize renewable energy utilization, and promote a more efficient and sustainable energy management system. In buses 6 and 31 of the IEEE 33 Bus System, Wind-based DG has been us...*	Originality
237.	*ased DG has been used. For the IEEE 69 bus system, the Wind-based DG has been placed in positions 12 and 59. For bus 29 of the same system, PV-based DG has been used. 4.3.5 Case-5: Integrating Battery Energy Storage System (BESS) In Case-5, a Battery Energy Storage System (BESS) is integrated with ...*	Originality
238.	*ncy, and reduce costs. The BESS stores excess energy generated by RES during off-peak hours, allowing for its subsequent utilization during peak hours or periods of reduced RES output due to climatic fluctuations or other disruptions. This integrated approach enables a more efficient, resilient, an...*	Originality
239.	*tem is at bus 61 [13]. Considering the intermittency of RES, the BESS system stores energy when demand is low, maintaining a stable total cost per day. Although the integration of BESS increases the initial capital cost, this investment can be recovered over the system's operational lifetime, ultim...*	Originality

240.	*cing the overall cost. This integrated BESS-RES configuration forms a critical component of the proposed methodology, facilitating a more sustainable, efficient, and economically viable energy management framework. 4.3.6 Load Flow Analysis As scheduling of the load starts, it has to be considered t...*		Originality
241.	*A comparative analysis of the results revealed that*	New imaging technique measures elasticity of multiple eye components https://bioengineer.org/new-imaging-technique-measures-elasticity-of-multiple-eye-components-simultaneously/	Originality
242.	*A comparative analysis of the results revealed that*	New imaging technique measures elasticity of multiple eye components https://bioengineer.org/new-imaging-technique-measures-elasticity-of-multiple-eye-components-simultaneously/	Originality
243.	*due to the availability of wind energy throughout the*	Electricity from Wind for Off-Grid Applications in Bangladesh: A Techno-Economic Assessment	Originality
244.	*A comparative analysis of the results revealed that*	New imaging technique measures elasticity of multiple eye components https://bioengineer.org/new-imaging-technique-measures-elasticity-of-multiple-eye-components-simultaneously/	Originality

245.	*al load (kW) Case-1 8.73 51923.02469 Case-4 24.17 38308.19728 Figure 5.13: Power loss after combining PV and wind Case-5: Here, BESS is integrated along with RES to support their intermittent nature. By utilizing the same to store excess energy generated during low-demand hours, the intermittency ...*		Originality
246.	*em Hourly power loss after integration of wind energy Case-4: The integration of RES with controllable and curtailable loads yielded significant reductions in total price. Notably, combining wind and solar RES, and scheduling loads based on availability and demand, resulting in substantial cost sav...*		Originality
247.	*A comparative analysis of the results revealed that*	New imaging technique measures elasticity of multiple eye components https://bioengineer.org/new-imaging-technique-measures-elasticity-of-multiple-eye-components-simultaneously/	Originality
248.	*made the method highly cost-effective and energy-efficient. The integration of storage systems has proved useful in managing the intermittency of the RES and storing surplus energy generated during hours with lower power requirements, which can be utilized to fulfill a larger set of loads during pe...*		Originality