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Original Research

Application of a genetic algorithm for planning loads of a power supply system with a network photo-power plant and a heat active consumer

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ABSTRACT

A novel approach is presented using a genetic algorithm to enhance the planning of household electrical loads in accordance with practical and user restrictions and homing signa, and sample results are shown. The goal is to minimize the end user's electricity bill in accordance with his / her preferences while taking into account the property of the energy services consumed. Circumscription are: the level of pledged power, end-user desire regarding the allowable and/or preferred times to operate each load, and the accessible power at each time period to account for fluctuations in the (unsteady) base load. The loading schedule is drawn up for one day. Internal load scheduling helps users to exploit of various energy service alternatives and reduce energy bills. Compared to the reference case in which there is no automatic scheduling. Thus, it is recognized that optimal adherence to thermal systems results in great savings for the utilities. Renewable liabilities are the problem of determining the generation schedule for units subject to design and operational constraints. The formulation of load planning was discussed, and the solution was obtained by the classical dynamic programming method. To tackle this issue, an algorithm was developed based on the swarm part optimization method, which is a population-based global search and optimization method. The performance of these algorithms has been tested on three-unit and four-unit systems and compared for total operating costs. In this article, a comparison of costs for different seasons was compared for normal heat load and the increase in heat load and power for normal heat load and the increase in heat load was a grid and solar power for a different season of simulations performed in MATLAB software.

Keywords: PV, Grid, Heat Load, Power, Battery, DG, Renewable Energy

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1. Introduction

Global energy demand, particularly for renewable energy, is rapidly rising. Environmental protection through pollution control, especially the release of greenhouse gas, has become a prime issue around the world. Although fossil fuel energy is still accessible in the near future, the era of plentiful cheap energy will come to an end. As a result, Albu et al. believe that researching alternate energy sources, notably renewable energy, as well as addressing the environmental challenges related to these sources, is now important [1] formal paraphrase Renewable energy generation is expected to account for 50% of electricity generation in the EU by 2040, around 30% in China and Japan, and over 25% in the USA and India; coal will account for less than 15% of electricity output outside Asia. Karimi and his colleagues [2] formalized paraphrase Coal or gas-fired power stations are used to generating electricity. Because of the increasing discrepancy in electrical loads between peak and off-peak hours, energy demand management is becoming increasingly difficult. The mismatch between peak demand and renewable energy output is becoming increasingly crucial as renewable energy's share to the overall power supply grows. The California Independent System Operator released a graph in 2012 that depicted power generation throughout of the day. Because of the tremendous rise of photovoltaics in California, the graph, denoted as the duck curve, depicts the widening disparity between hourly day energy demand relative to noon energy demand. F. and others [3]. After sunset, solar energy is no longer available, resulting in a sharp spike in energy demands from traditional energy sources in the mid-evening hours, as well as abnormally high peak demand. Similarly, the issue of energy disparity during peak and nonpeak hours has grown quite prominent in Hawaii as a result of the increasing adoption of solar production, leading to the known "Nessie curve." Peak demand can be regulated by storing surplus energy during off-peak time and using it when needed, according to studies. Viswanath, et al. [4] The storage of excess energy as thermal energy (TES) is likely to be very successful approach for inhouse energy management o benefits of improving energy efficiency and energy cost savings , as roughly half of the energy utilized in buildings is consumed for air conditioning. Heating, ventilation, and air-conditioning (HVAC) systems, in particular, account for 30–40% of building energy consumption; hence, controlling energy demand for temperature balancing is critical. Various building energy management (BEM) approaches have been presented in previous research to manage peak energy demand by adjusting the temperature set point and utilizing the structure's thermal mass. Several simulated and experimental studies conducted in the 1990s employed the mass of a building and regulated timely changes inhouse temperatures to lower building energy costs for space cooling. Braun [5] suggested a dynamic building control optimization technique to reduce total energy costs as well as peak electricity demand in buildings. Later tests contrasted the advantages of the dynamic building control method to those of the night setback control strategy. The best dynamic management might reduce peak cooling loads by up to 40% and transfer up to 51% of overall cooling loads to off-peak hours, according to the findings. In a separate study, Keeney and Braun [6] offered an optimum precooking technique based on cost minimization, which might save a 130,000-m2 office building up to $25,000 per month in energy costs during peak cooling season. Chen [7] developed an effective passive solar heating floor system inhouse to reduce energy consumption and running costs. According to the findings, predictive directorial operation of thermal mass passive solar floor heating systems could save between 10% and 27% in operating energy costs. Based on simplified model and simulation data from various group, Yang et al. [8] suggested a BEM technique that considers dynamic thermal properties. Yang et al. created a model based on a mixed-integer linear programming framework that includes dynamic thermal properties of buildings in the BEM strategy. Although the advantages of BEM are clear, lowering building energy costs without occupant comfort or breaking HVAC load limitations is difficult. To estimate system dynamics and to improve the temperature setpoints for thermal comfort as well as cost, Forouzan et al. [9], using stochastic dynamic programming combined with neural networks , have successfully designed and implemented a direct digital control system. In order to reduce the peak cooling demands, Braun [5] implemented novel methods for estimating trajectories of building zone temperature setpoint while maintaining a comfortable temperature level throughout crucial demand periods. Renewable energy, particularly solar energy, has the potential to be used in power supply systems, particularly in areas where centralized power systems are unavailable or when the electricity available is expensive. The expensive cost of photovoltaic power plant power equipment, on the other hand, remains a barrier to their widespread use. Optimizing non-stationary energy conversion processes in solar systems and, as a result, the features of their power equipment are primarily driven by cost reduction. The issue of a considerable disparity between insolation schedules and energy usage of various things is well known. Electrochemical batteries, which provide energy storage for reliable power delivery to users, are commonly employed to coordinate the energy balance of a solar system. Batteries, on the other hand, are sensitive to temperature, have a short lifespan, and are expensive. Electric energy from photovoltaic power plants can be stored not only in electrochemical batteries but also in less expensive water heating installations, which will lower the cost of a photovoltaic installation by reducing the capacity of the batteries while still providing hot water to the consumer[10]. Direct solar water heaters are widely available and are distinguished by their straightforward design and low cost. Depending on the design and technical qualities, the cost per unit area of the collector of different designs varies. Solar collectors with the simplest designs cost 2.3 thousand rubles per square meter. The effectiveness of these collectors is around 0.19 percent. More modern vacuum tube collectors cost more than 25 thousand rubles per m2, making them more expensive than solar panels on a per-unit basis. These complexes have a 0.51–0.57 efficiency [11]. Solar water heaters have the problem of being highly reliant on solar and weather conditions to function properly. The effectiveness of photoelectric conversion is largely unaffected by a wide range of changes in solar radiation energy, allowing photovoltaic power plants to increase their capabilities, including hot water supply using electric heating components. Residential, industrial, commercial, and government loads are among the several types of electrical loads. The electrical system's components vary depending on the country's economic, political, and social circumstances, among other factors. In Iraq's power distribution system, the variety factor of electrical loads has been investigated. According to the study [12], residential and industrial electricity loads increased at a faster-than-average rate. Residential loads are the most significant components of Iraqi electrical systems. Electrical receivers for inhouse appliances, lights, air conditioning and water heating, to name a few. The survey found that heating water uses the most electricity, accounting for 32.29 percent [13]. By avoiding higher tariffs during peak hours, thermal storage saves energy bills. Even at other times of the year, thermal energy can be captured and used as needed. For example, during hot months, heat can be gathered from solar collectors and used for space heating, if necessary, even in the winter. Users who can adapt to changing energy supply and demand benefit from energy storage [14]. A very urgent problem for Iraqi energy is reducing the load on the energy system, including through the commissioning of renewable energy generating capacities, primarily solar [15, 16]. Given the shortage of the Iraqi energy system, which is replenished by importing about 22% of electricity from Iran (against the backdrop of US sanctions on participants in cooperation with Iran), reducing the load on the energy system is a very urgent problem for Iraqi energy.

1.1. Objective

1- The objective of this paper is to implement the Demand side thermal load scheduling with renewable energy sources and an active heat consumer.
2- The algorithm is Genetic Algorithm will be used.

2.

3. Proposed model

The use of a genetic algorithm to enhance the management of household electric loads based on practical and pre-defined limits and incoming signals is explained. The goal is to keep the quality of energy services while lowering the end-bill. User ' One of the drawbacks is the contracted power level. Control actions over controllable thermal loads, such as shiftable loads, are used to attain this goal. end-user preferences for the permitted and/or desired seasons for each load's operation, as well as the accessible power in each season to account for changes in the (non-manageable) consumptions If a dynamic pricing structure is available ahead of time, load scheduling is done for a single day. As a result, it's common knowledge that committing to a good thermal system saves money for electric companies. Renewable commitment refers to the difficulty of defining a production schedule while keeping device and operating constraints conditions. To solve the problem, a population-based global search and optimization technique based on the genetic algorithm Optimization approach was developed. The efficiency of these algorithms was evaluated and the overall operating cost was compared. The studies were carried out on the example of the power supply of a house in Iraq with the characteristics: the power of thermal and electrical loads, etc [17].

3.1. Fitness function

The genetic algorithm is founded on Darwin's concept, which states that "the candidate who can survive will live, and the rest will perish." The appropriateness value of a procedure for solving the maximizing problem is determined using this idea. To convert a minimization problem to a maximizing problem, various appropriate transformations are usually applied. The objective function generates the fitness value f (x), which is employed in continuous genetic procedures. With this in mind, this work develops three basic metaphor-free and algorithm-specific parameter-free optimization algorithms. The proposed algorithms are detailed in the next section. Let f (x) be the minimization/ or maximization objective function. Suppose that there are ‘n' number of possible solutions for ‘m' number of design variables (i.e., population size, k=1, 2..., n). At any step of optimization, assume that the best candidate solution is getting the best value of f (x) (i.e., f (x) best) in all candidate solutions. Likewise, the unfavorable candidate gets the lowest value of f (x) (i.e., f (x) worst) in all possible solutions. If the value of j is Xj, k, i,

3.2. Problem formulation

When a power system's necessary load demand is supplied, the ELD problem's objective function is to minimize overall generating cost while satisfying various constraints. The following equation represents the goal function to be minimized:

$$F(P_{g} = \sum_{i=1}^{n} a_i P_{gi}^{2} + b_i P_{gi} + c_i$$

3.3. Power balance constraint

The sum of generated power from all available generators must be equal to total power consumption and loss of the system.

$$\sum_{i=1}^{n} P_{gi} - P_d - P_i$$

3.4. Generator limit constraint

The real power generation for each generator must be managed within its particular highest and lowest operating limits.

$$P_{gi}^{min} \leq P_{gi} \leq P_{gi}^{max} \; I = 1,2\ldots N$$

3.5. Implementation

When applying any optimization approach to the ELD issue, various constraints are taken into account. Two separate limitations are considered in this paper. The equality constraint states that the load demand must be fulfilled through the sum of all generated power, whereas the inequality constraint states that the generated powers must lay within the interval of minimum and maximum real power of each unit. The proposed method's flow chart for the ELD problem is presented in Fig. 1. The proposed Rao method's sequential steps are listed below.

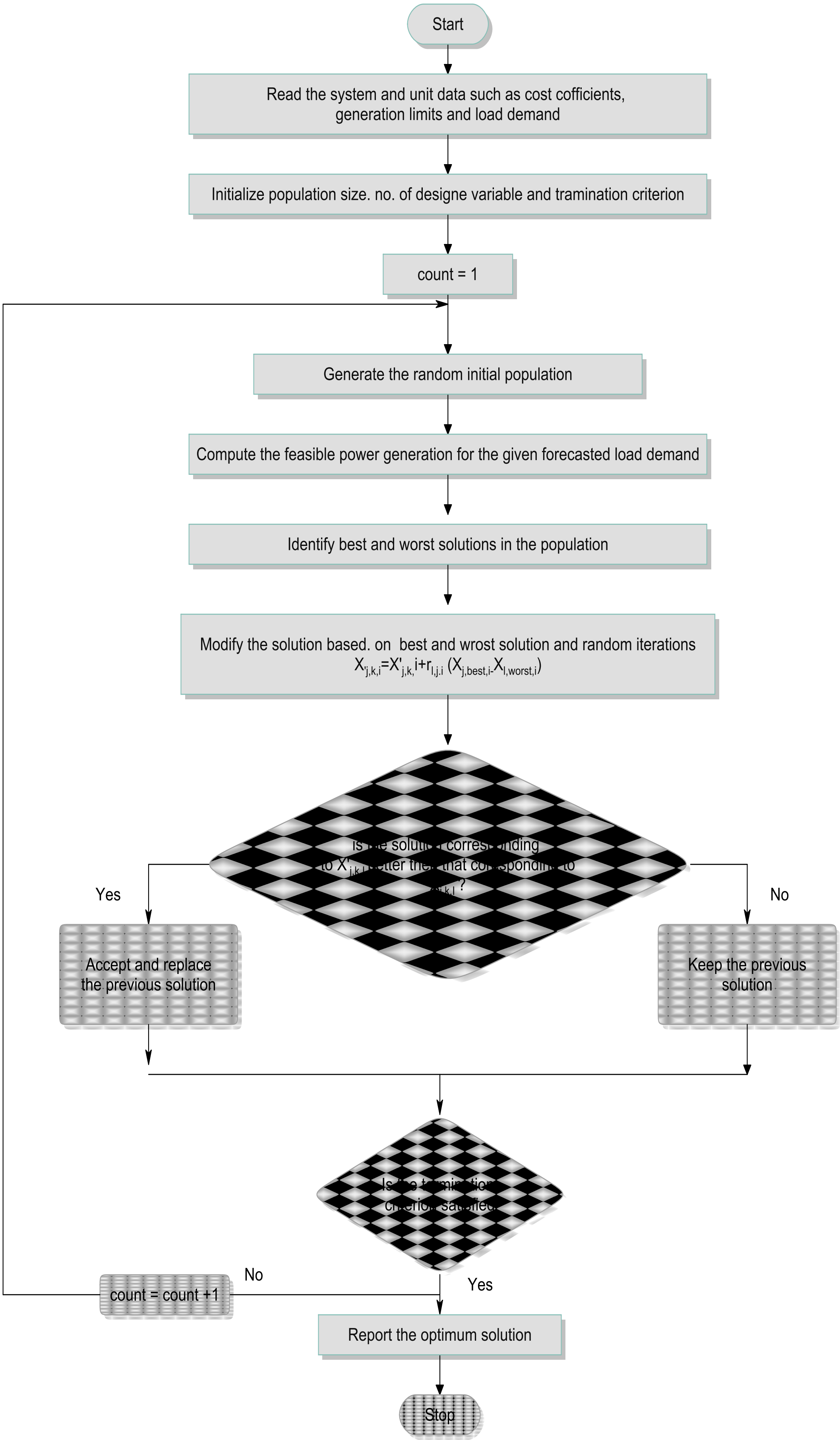


Figure 1. Flow chart for load scheduling

Step 1: Read the suggested test system's system and unit statistics, such as cost coefficients, generator limitations, and load demand.
Step 2: The population's individuals are randomly started based on the unit's limit, including individual dimensions. These first people must be viable candidate solutions that meet the practical operation constraint.
Step 3: The equality requirements must be satisfied by each set of solutions in the space. As a result, equality restrictions are verified. If any combination fails to fulfill the constraint, the power balance equation is used to set them.
Step 4: In the population, the evaluation (rating) function of each candidate Pgi is determined using the rating function F in equation (1). F is in this case.
$F= a\ X((P_{gi})^2\ + b\ X\ P_{gi} + C$
Where a, b, c are constants.
Step 5: Each value is compared to the rest of the population's values, and the best evaluation value is saved.
Step 6: Using the equation, update the best solution of the system variable (power generation) (3)
$X'_{j,k,I} = X_{j,k,i} + ga_{l,j,i}\ (X_{j,best,I} - |XX_{j,worst,i}|) + ga_{2l,j,i}\ |X_{j,l,i}\ \text{or}\ X_{j,k,i}|),-(X_{j,k,I}\ \text{or}\ X_{j,I,i}),(X_{j,l,i}\ \text{or}\ X_{j,k,i})),$ Eq.3
Step 7: Verify that all thermal unit limitations are met and that the system load demand is met. If they are, go to the next step; otherwise, proceed to step 9.
Step 8: Run the Genetic algorithm to find the best option for thermal power generation and total system running costs.
Step 9: Determine if the best solution has been found. If so, go to the next step; otherwise, proceed to step 3. And STOP after saving the best option and printing the results.

4. System description

The vast area and low population density of Iraq with the high potential of solar energy determine the prospects for the use of photovoltaic stations. The territory of Iraq is under the influence of solar energy, receiving about 2000 kW * h/m2/year, which determines the relevance of using solar energy technologies to support the country's economy by reducing electricity consumption on the Iraqi national electric grid [18].

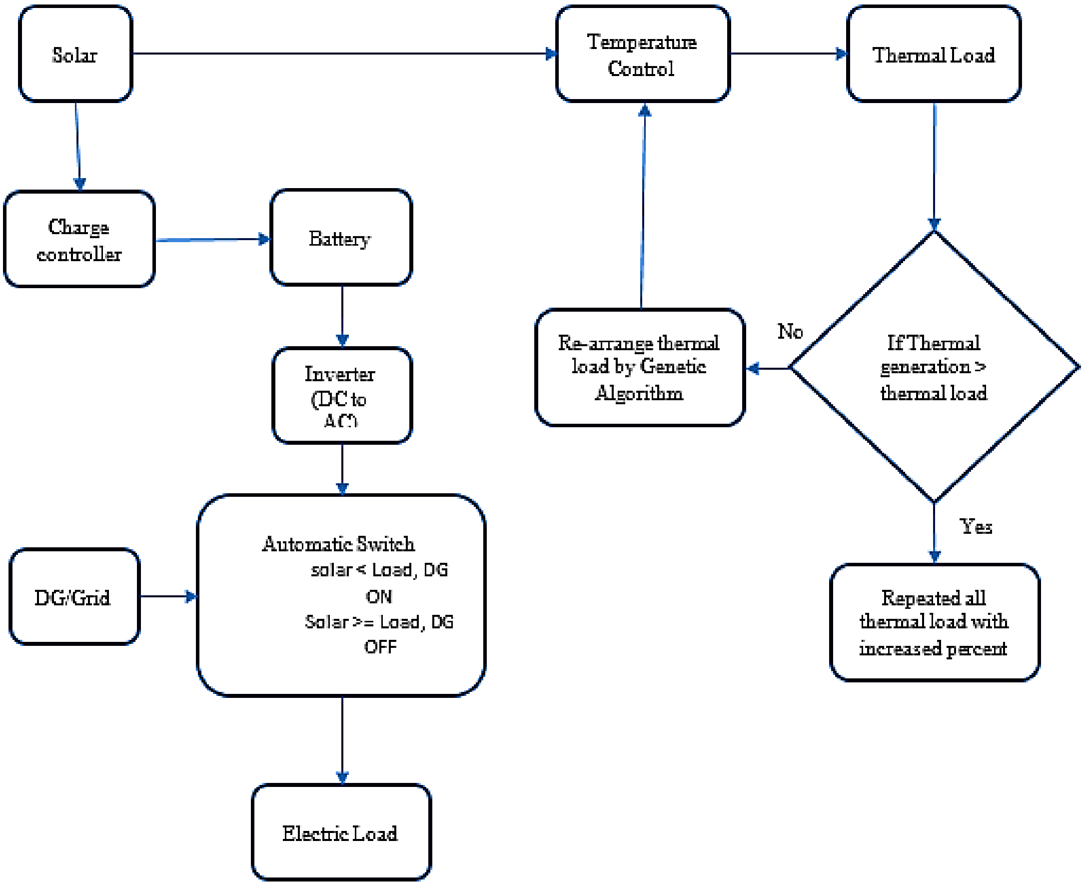
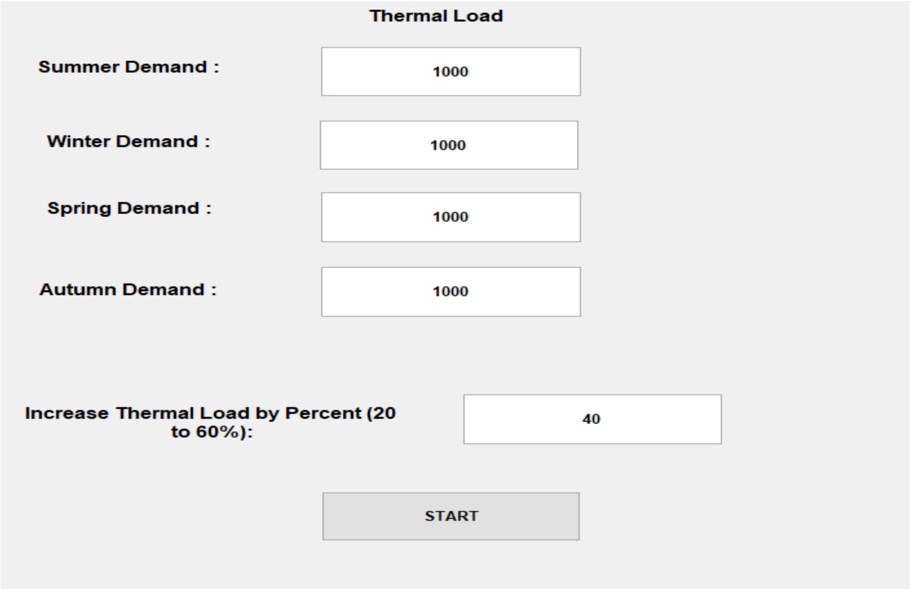


Figure 2. System model

Iraq is considered the second country in the world in terms of solar energy intensity. On the basis of the constructed map of the distribution of insolation over the territory of Iraq, potential areas for creating large large-scale solar power plants and show that Iraq is among the countries most suitable for the use of solar energy [19]. The choice of equipment for decentralized photovoltaic plants is determined by insolation and electricity consumption graphs. A diagram of the proposed independent hybrid photovoltaic installation with redundancy from an additional energy source-a diesel generator or a centralized network is shown in Fig. 2. The circuit differs from a conventional photovoltaic installation with electrochemical storage of electricity and a backup diesel generator in the presence of thermal loads, which are powered directly from the array of photovoltaic modules through a special thermal control.

The greater number of solutions for renewable grid are comprised through smart-grid control and energy storage. different studies show that diversed cases using heterogenous techniques for energy management, inclusive of energy storage, are required for long-term sustainability and reliability. They also provide a feasibility stud for integrating the produced solar energy within the grid, with fundamental reliability derived from different strategies for energy storage together with improved energy distribution algorithms.



Thermal Load

Summer Demand : 1000

Winter Demand : 1000

Spring Demand : 1000

Autumn Demand : 1000

Increase Thermal Load by Percent (20 to 60%): 40

Figure 3. Thermal load (Kwh)

Fig 3 showing the heat load of the GUI window, in this system we can enter the demand for heat load up to 20% to 60% in different seasons and enter the percentage increase in the heat load, the concept of the first load planning will be done by the normal load and by increasing the load on the introduced percentage and load schedule will be done.

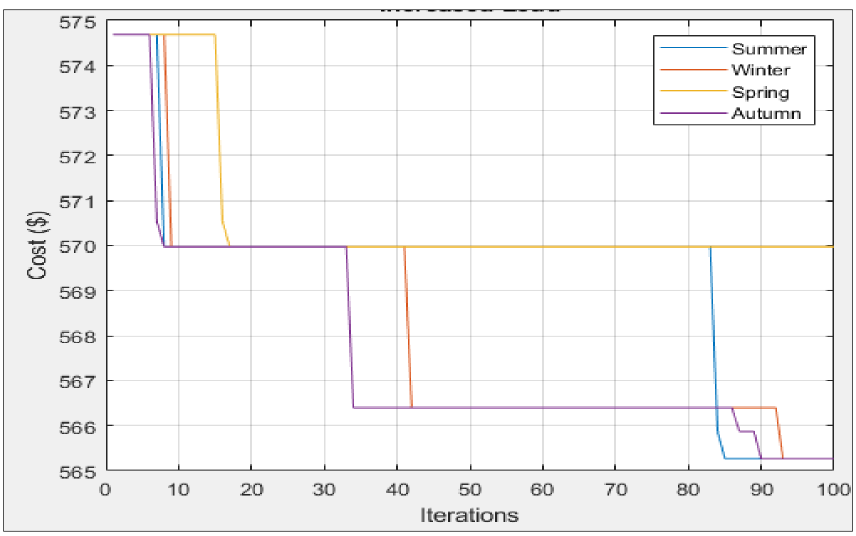


Figure 4. Cost for four different season when increase thermal load

Fig 4 shows the cost of the increased load for all seasons, the cost is reduced by consuming more power from the solar. The x-axis shows the number of iterations (generations). This evolution usually starts from a population of randomly generated population. After the iterative process is completed, it terminates for the next process and starts for the second population.

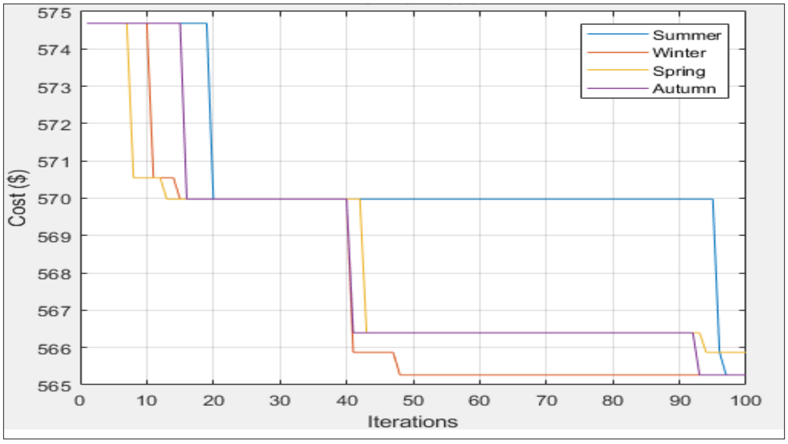


Figure 5. Cost for four different season when normal thermal load

Fig. 5 showing the cost ($) of normal Load for all seasons, the cost reducing (in percentage entered by the user), the normal load is scheduled as the same process in fig. 4.

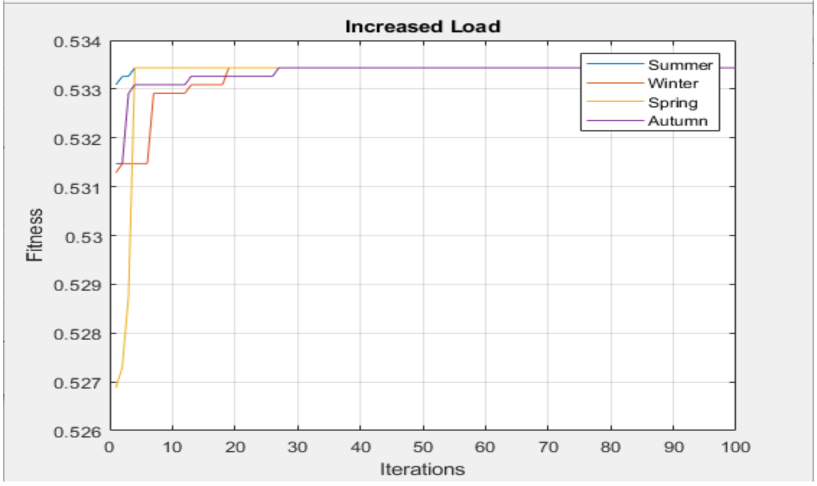


Figure 6. fitness for four different seasons when increase thermal load graph

Fig. 6 shows that in all seasons the load increases, the load increases (as a percentage entered by the user), the increase in load is planned as the same process before, the load is planned in iterations up to 100.

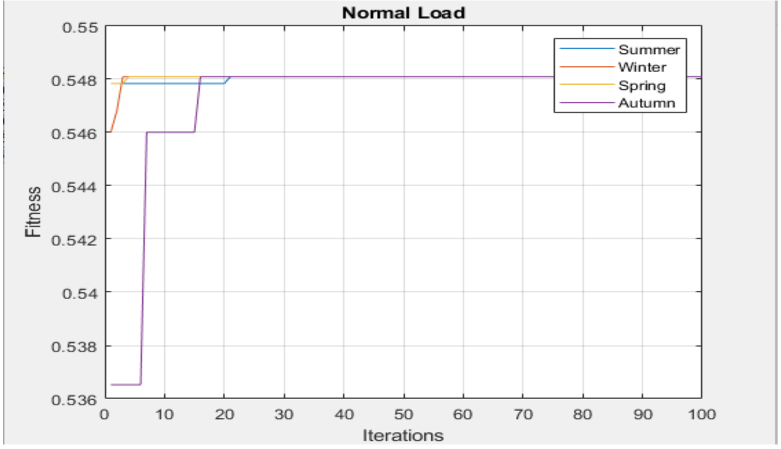


Figure 7. Fitness for four seasons with a normal heat load schedule

Fig 7 shows that the all-season load is normal (without an increase in percent). The load is scheduled by iterations up to 100. In the first iteration, the load is not scheduled, and after some iteration, the load is scheduled. And, while keeping constant.

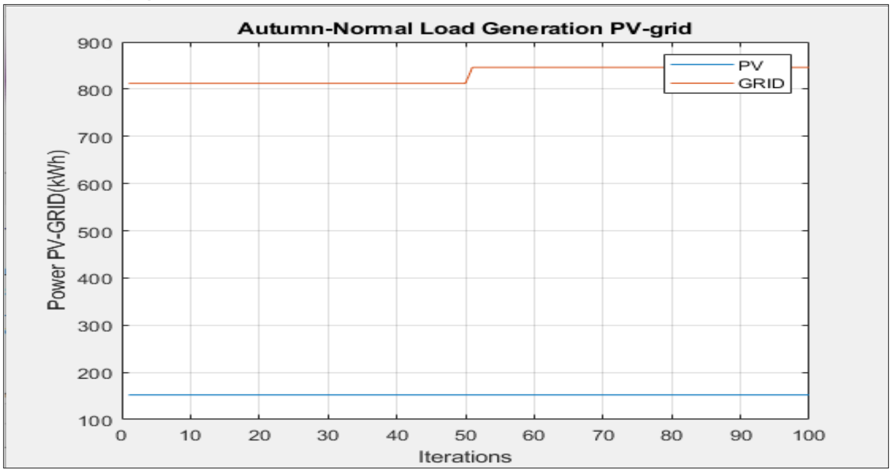


Figure 8. Autumn Normal Load Generation by PV and Grid

Fig. 8 shows the Autumn season Normal heat load state - in the autumn season, the consume power from the solar and grid is calculated, the consume power from the solar grid is 170.4 kWh and the consume power from the grid is 795.8 kWh in the autumn season.

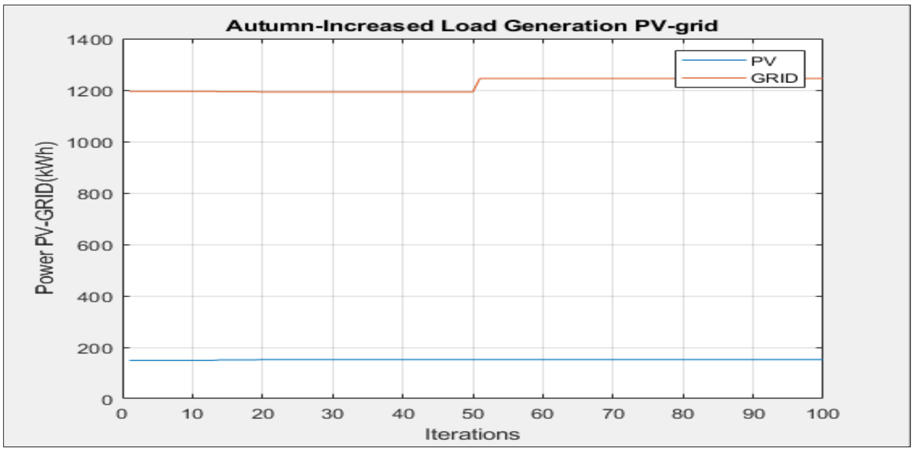


Figure 9. Autumn Increased Load Generation by PV and Grid

Figure 9 shows the autumn season increases the thermal state of the load - in the autumn season, the consumption power from solar energy and the grid is calculated, the consumption power from the solar energy is 154.8 kWh, and from the grid is 1380 kWh per day.

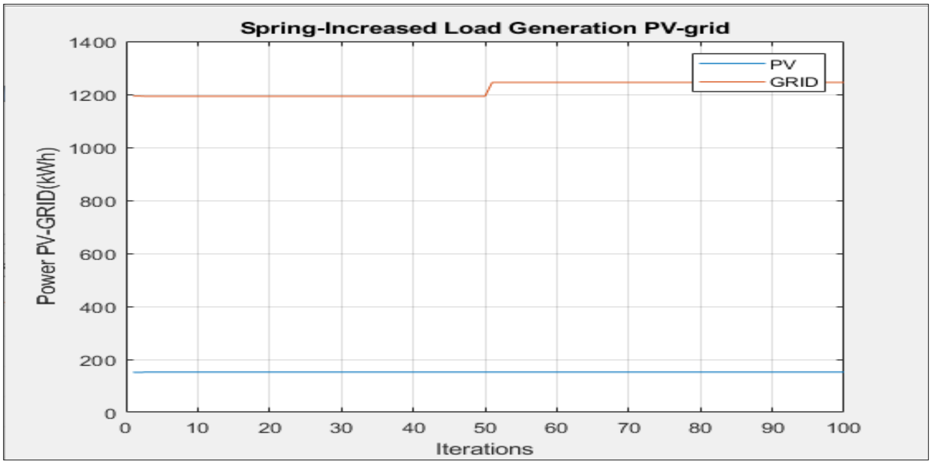


Figure 10. Spring Increased Load Generation by PV and Grid

Figure 10, showing the spring season, increases the thermal state of the load - in the spring season, the consume power from solar energy and the grid is calculated, the consume power from solar energy is 165.7 kWh, and the consume power from the grid is 1370 kWh per day .

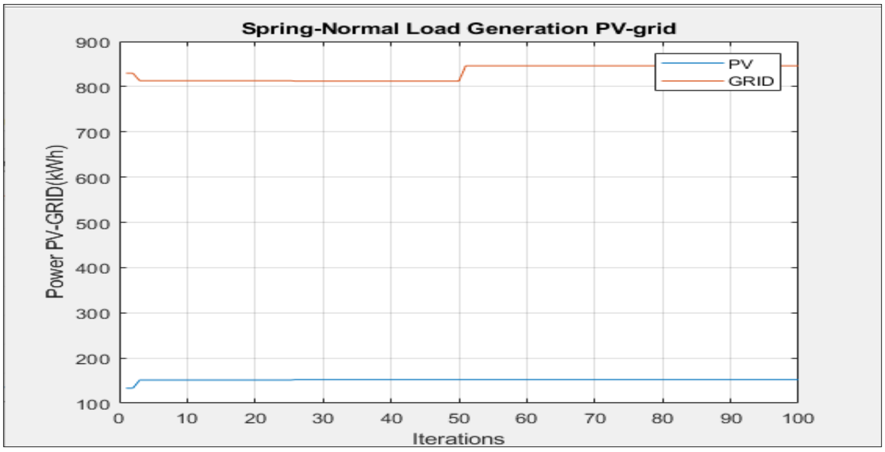


Figure 11. Spring normal Load Generation by PV and Grid

Figure 11, showing the spring season normal the thermal state of the load - in the spring season, the consume power from solar energy and the grid is calculated, the consume power from solar energy is 147.2 kWh, and the consume power from the grid is 821.8 kWh per day .

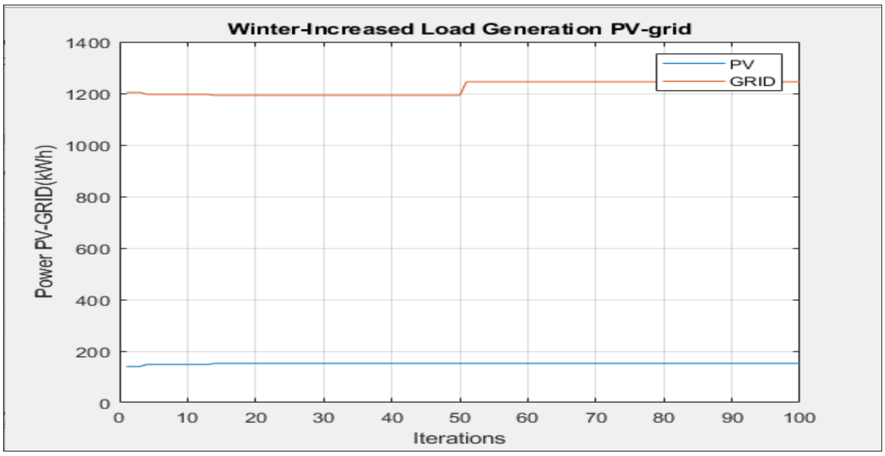


Figure 12. Winter Increased Load Generation by PV and Grid

Figure 12, showing the winter season, increases the thermal state of the load - in the winter season, the consume power from solar energy and the grid is calculated, the consume power from solar energy is 165.7 kWh, and the consume power from the grid is 1370 kWh per day .

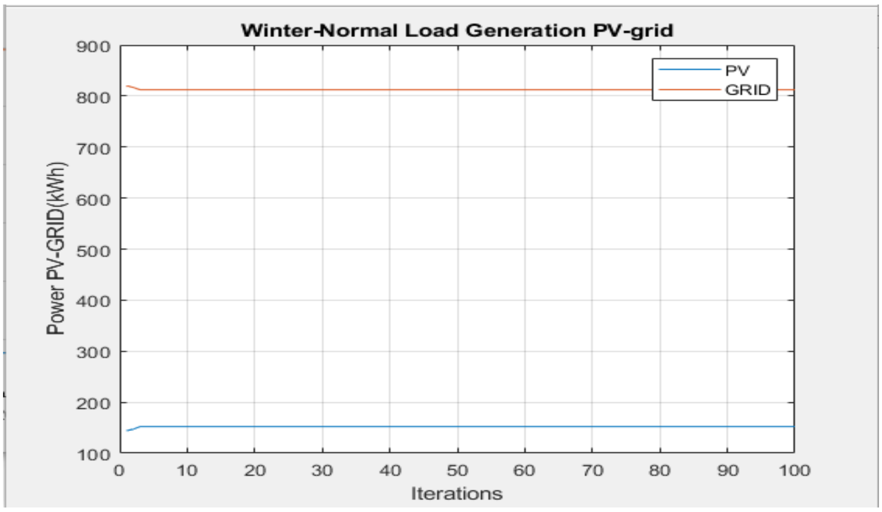


Figure 13. Winter Normal Load Generation by PV and Grid

Figure 13, showing the winter season normal the thermal state of the load - in the winter season, the consume power from solar energy and the grid is calculated, the consume power from solar energy is 169.3 kWh, and the consume power from the grid is 796.9 kWh per day .

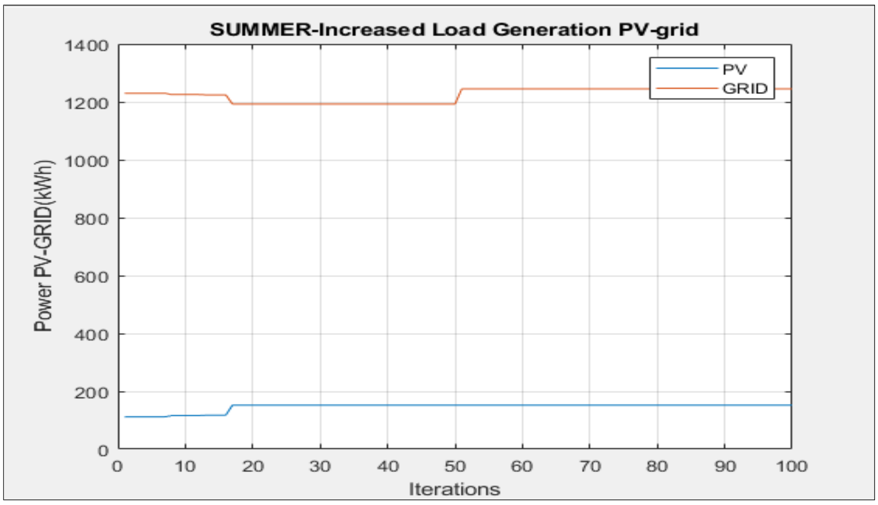


Figure 14. Summer increased load generation by PV and grid

Figure 14, showing the summer season, increases the thermal state of the load - in the summer season, the consume power from solar energy and the grid is calculated, the consume power from solar energy is 170.4 kWh, and the consume power from the grid is 1363 kWh per day .

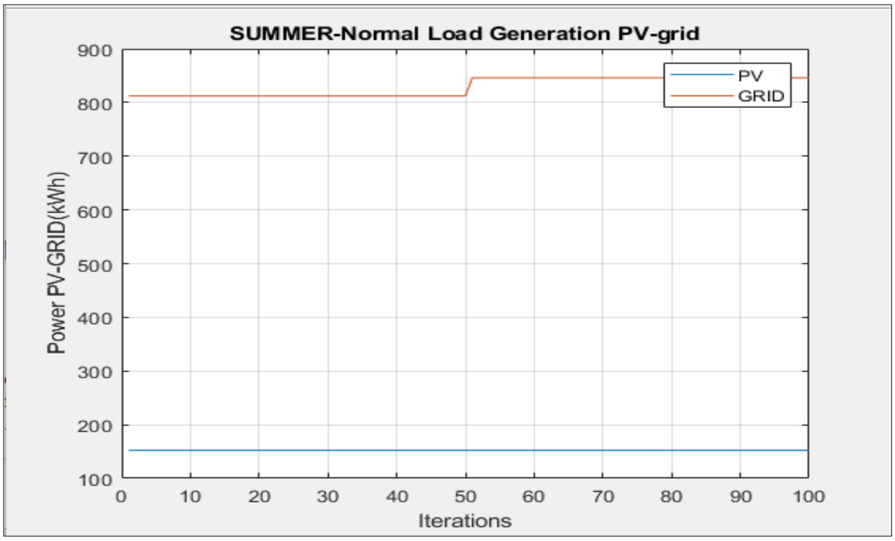


Figure 15. Summer normal load generation by PV and grid

Figure 15, showing the summer season normal thermal state of the load - in the summer season, the consume power from solar energy and the grid is calculated, the consume power from solar energy is 171.6 kWh, and the consume power from the grid is 794.7 kWh per day .

5. Result of the simulation

As a result of the simulation, it was found that for the complete power supply of the facility with electricity in the autumn season, the consumption of electricity from the solar and grid is calculated under normal heat load conditions, the power consumption from the solar is 170.4 kWh. power consumed from the network - 795.8 kWh. When the heat load conditions increase, the energy consumption from solar and grid energy is calculated, the energy consumption from solar energy is 154.8 kWh, and the power consumption from the grid is 1380 kWh per day. In the spring season, the energy consumption from the solar battery and the grid is calculated; under normal heat load conditions, the energy consumption from solar energy is 147.2 kWh, and the power consumed from the grid is 821.8 kWh. With an increase in the heat load, the energy consumption from solar and grid energy is calculated, the power consumption from the solar battery is 165.7 kWh, and the power consumed from the grid is 1370 kWh per day. In the winter season, the energy consumption from the solar panel and the grid is calculated under normal heat load conditions, the energy consumption from the solar battery is 169.3 kWh, and the power consumed from the grid is 796.9 kWh. With an increase in the heat load, the energy consumption from the solar and grid energy is calculated, the power consumption from the solar battery is 165.7 kWh, and the power consumed from the grid is 1370 kWh per day. In the summer season, the consumption of electricity from the solar panel and the grid is calculated under normal heat load conditions, the energy consumption from the solar battery is 171.6 kWh, and the power consumed from the grid is 794.7 kWh. With an increase in the heat load, the energy consumption from solar and grid energy is calculated, the power consumption from solar energy is 170.4 kWh, and the power consumption from the grid is 1363 kWh per day. Normal load up 20%, increased load power 20 to 60 (%), normal load 20% cost, increased load 20 to 60 (%) cost, and fitness function for the different seasons are shown in Tables 1 and 2.

Table 1. Normal load up 20% and increased load power 20 to 60 (%) for different season

		Autumn (kWh)	Spring(kWh)	Summer(kWh)	Winter(kWh)
Normal Load	PV	170.4	147.2	171.6	169.3
	Grid	795.8	821.8	794.7	796.9
Increased Load	PV	154.8	165.7	170.4	165.7
	Grid	1380	1370	1363	1370

Table 2. Normal load 20% and increased load 20 to 60 (%) cost and fitness function for different seasons.

		Autumn	Spring	Summer	Winter
Increase Load	Cost($)	570	570.8	570	570.5
	Fitness(S)	0.526	0.528	0.528	0.528
Normal Load	Cost($)	574.7	574	574.7	574
	Fitness(S)	0.5478	0.5409	0.5476	0.5471

Figure 16, showing that in all seasons the load is normal and increases the cost of the load (without an increase in percent), the load is planned in iterations up to 100. At the first iteration, the load is not planned, but after some iteration, the load is planned. And to maintain a constant cost for a normal load, costs are reduced (i.e., utility power consumption decreases and solar power consumption increases), load increases, load increases (as a percentage, as entered by the user), increased load is scheduled as the same process. The cost is to increase the load, the cost is reduced by consuming more energy from the solar.

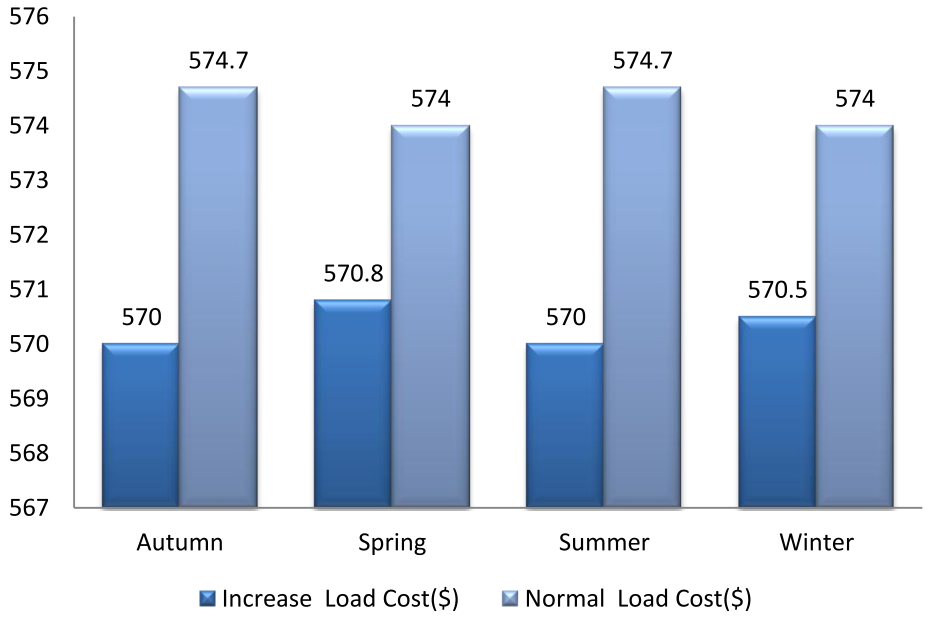


Figure 16. Normal load and increased load cost for different season

Figures 17, 18, and 19 show normal load and increased load fitness function for a different season, normal load and increased load pv power for different seasons, and normal load and increased load grid power for different seasons respectively.

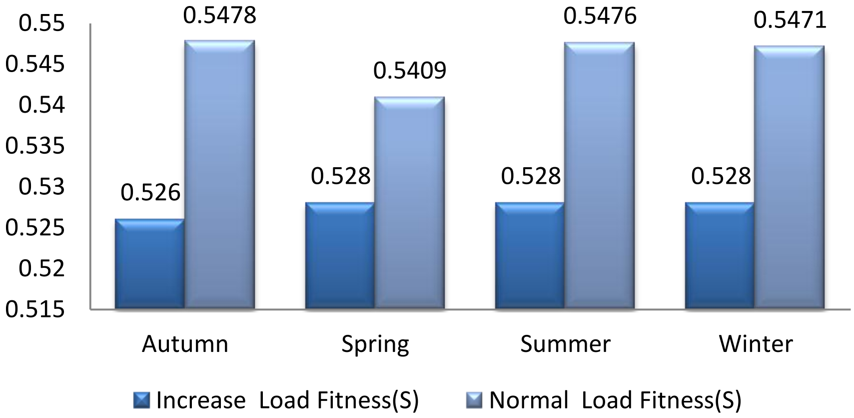


Figure 17. Normal load and increased load fitness function for different season

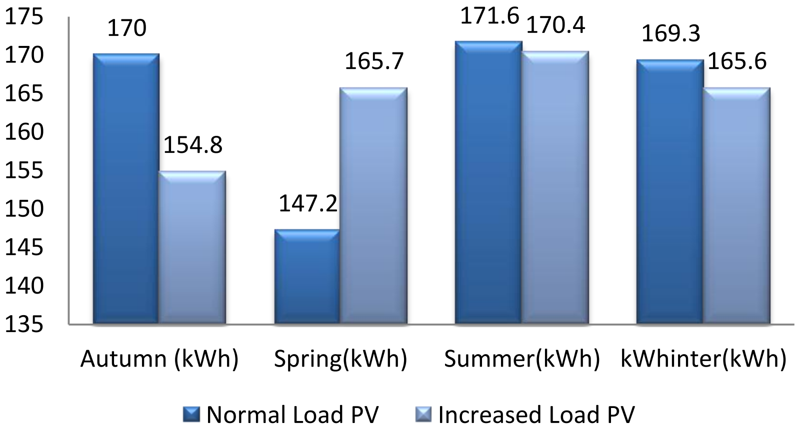


Figure 18. normal load and increased load PV power for different season

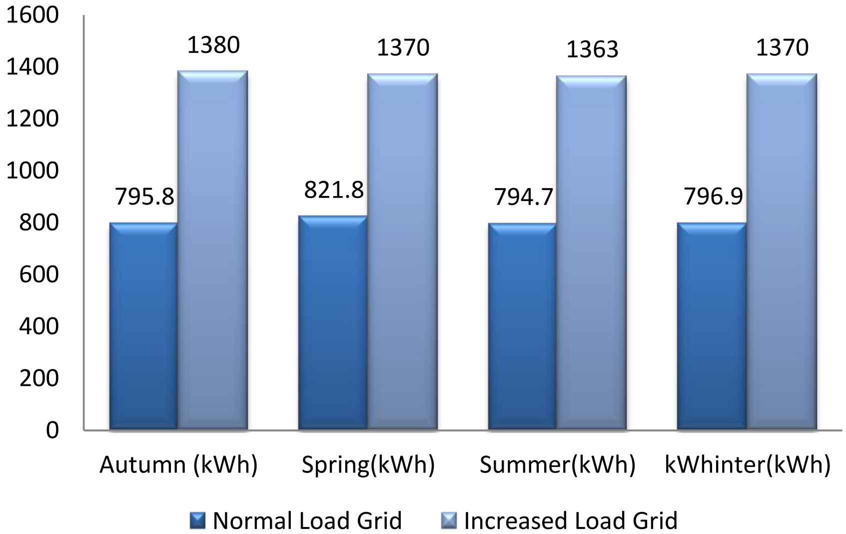


Figure 19. Normal load and increased load grid power for different season

6. Conclusions

This paper proposed an improved thermal load scheduling framework based on the genetic optimization algorithm, which takes into account shiftable loads with four distinct seasons. The genetic optimization algorithm is utilized to optimize the household load and deliver improved patterns using objective functions and without violating the domain constraint. The system is designed according to the customer's demand. In this system, we can enter the load as per the seasonal demand and enter the thermal load demand up to 20% to 60% for the different seasons. The load scheduling will be done by normal load, and then by increasing the load by the entered percent, the load schedule will be completed. The load scheduling is done by normal load and increased load. When applying any optimization approach to the ELD issue, various constraints are taken into the explanation. Two separate limitations are considered in this paper. The equality constraint expresses that the load demand must be fulfilled by the total sum of all generated, whereas the inequality constraint states that the generated power must lay within the interval of minimum and maximum real active power of each unit. To solve the load scheduling problem, population-based global search and optimization techniques based on genetic algorithms were developed. The efficiency of these algorithms was simulated in four different seasons, and cost comparisons for the different seasons were compared for normal thermal load and increased thermal load. As a result of the simulation, it was discovered that for the full power supply of the capability with electricity for various seasons power for normal thermal load and increased thermal load for the grid and solar system. The scheduling has been checked for the next 24 hours and the simulation was executed.

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