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OPTIMIZATION OF ENERGY MANAGEMENT IN SOLAR/ WIND POWER STATIONS USING DEVELOPED ARTIFICIAL BEE/ANT HYBRID HEURISTIC ALGORITHM

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Abstract- Energy producers in solar/wind hybrid power plants sell electricity to an Eligible Consumer. That consumption facility must estimate on an hourly basis what it will consume the next day. Consumers only make their consumption estimates and commit how much they will consume at what time the next day. The aim is to minimize the total cost that will occur. The cost of responding to instant requests is high. An Artificial Bee/Ant Heuristic Algorithm has been developed to reduce energy costs. Using the developed Bee/Ant Hybrid Optimization, a computer program was created that allows for weather forecasts, load predictions, and production estimation. By using this computer program, unit assignment, production management, and load management have been done effectively. Thus, changes in solar/wind hybrid power plants and energy consumers were better monitored. Online optimization and coordination has become possible in power plants and energy consumers.

Keywords: Hybrid Optimization, Bee/Ant Algorithms, Energy Management, Solar/Wind Power Stations.

1. INTRODUCTION

Energy producers in solar-wind hybrid power plants submit their planned production and consumption estimates for the next day to the Market Management System via the internet every day. Consumption estimates are their consumption and the consumption of the facilities they sell if any. If energy producers in solar-wind hybrid power plants sell electricity to an Eligible Consumer, that consumption facility must estimate on an hourly basis what it will consume next day. Eligible consumers have the right to choose their suppliers, that is, they can get their electricity from the private sector as well as from the Electricity Distribution Companies. The consumer can obtain electricity at a more affordable price. Energy producers in solar-wind hybrid power plants also offer sales in addition to their daily production schedules. Consumers only make consumption estimates and commit how much they will consume at what time the next day. After the participants complete their data entries, the system is closed to data entry by the Market Manager. System day ahead price, and orders are created. The total cost that will occur during that day is brought to a minimum. The system makes a combination calculation that includes all hours of the day and instructs the company that reduces the total cost. Although the offers of other companies are lower, they are not accepted. With the publication of the instructions, the day ahead planning is completed. Although the production and consumption amount of the day ahead are balanced, there are deviations in real-time.

If one of the solar-wind hybrid power plants is disabled due to a malfunction or a large consumption facility starts to operate suddenly, it disrupts the balance. In order to achieve this balance, the system balance is tried to be achieved by using the offers presented in the power market. Production is easy to plan, but consumption is almost impossible to predict. The cost of responding to instant requests is high. The Artificial Bee/Ant Heuristic Algorithm has been developed to reduce energy costs. This hybrid optimization made it possible to make weather forecasts, load predictions, and production estimation. Unit assignment, production management, and load management were done effectively. Thus, changes in Solar/Wind Hybrid Power Plants and Energy Consumers were better monitored. Online optimization and coordination has become possible in power plants and energy consumers.

2. ENERGY MANAGEMENT IN SOLAR/WIND HYBRID POWER STATIONS

Load estimation calculation in Solar/Wind Hybrid Power Plants is necessary for the planning of electrical services. This calculation should be consistently estimated in terms of both magnitude and geographic location of the electrical charge for different processes of the planning range. The main purpose of the load estimation calculation is to determine the hourly total load value of the system [1]. In load estimation calculations, system load, system peak load value is determined. Hourly, daily, weekly, and monthly values of production energy in Solar/Wind Hybrid Power Plants are estimated. Due to the load estimation calculation, it provides extremely high savings for the institutions providing electricity service. Load calculations are used to control processes and decisions such as unit determination, fuel allocation and offline network analysis in Solar/Wind Hybrid Power Plants. System load is a dynamic and randomly moving process made up of thousands of separate components.

Load behavior in Solar/Wind Hybrid Power Plants is affected by factors such as economic factors, time, day, season, and weather. Unit Determination, hourly plans for the operation of units in Solar/Wind Hybrid Power Plants are optimized in order to minimize system operating costs. The decisions taken should be compatible with load balance, sloping reserve, production, ramp speed limits [2]. In Solar/Wind Hybrid Power Plants, upper and lower limitations of wind speed should be calculated. It is difficult to consistently estimate the output due to the uncertainty of wind speed. Power generation output is greatly affected by wind power. Wind speed estimation; It is much more difficult when considered as a predictions problem in a time series.

In Solar/Wind Hybrid Power Plants, weather forecasting constitutes an important place in time-dependent forecasting problems. Consistent calculations of the temperature and the amount of rainfall are required in different geographic areas. It includes items such as weather forecasts, numerical weather values, climate monitoring, drought detection, severe weather activities, sudden flood warnings, stream monitoring, and control [3]. There is a strong relationship between outdoor temperature and electrical power demand. In load forecasts calculations, hourly weather values should be known. The performance of short-term load predictions calculations is evaluated with actual temperatures [4].

3. OPTIMIZATION OF ENERGY MANAGEMENT USING DEVELOPED BEE/ANT HYBRID HEURISTIC ALGORITHM

The Artificial Bee Colony algorithm is inspired by the intelligent foraging behavior of honey bees. It offers a solution based on herd intelligence in numerical optimization problems. The natural behavior of bees is given in Figure 1.

Figure 1. The Natural behavior of bees

The collective intelligence of honey bee colonies in foraging has three basic components. These are nectar sources, worker bees, and scout bees. The quality of a nectar source depends on parameters such as proximity to the hive, richness or density of its content. Worker bees are those who search for nectar sources and carry information about the nectar source. Scout bees are groups of bees that watch the dance of the worker bees to decide which resource to search for. The amount of nectar is the objective function value that represents the quality of that solution.

The number of solutions is equal to the number of workers. In the beginning, a random starting position is created. In the next step, worker, scout, and scout bees evaluate and update the population. Resources express problem solutions. If bees find a better source than their current source during their research, they will memorize the new source. After all worker bees have finished the search, position information is shared with the scout bees. Scout bees evaluate the information obtained from the worker bees and select sources depending on the amount of nectar. The best source chosen represents the best problem solution [5]. The ant colony is in the class of herd-based algorithms. Ants live in colonies. It is an algorithm derived from ants that solve their problems by sharing work and helping each other. The natural behavior of ants is given in Figure 2.

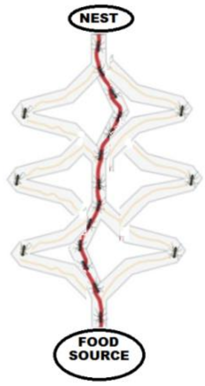

Figure 2. The natural behavior of ants

Ants are not capable of full vision. However, it leaves a chemical pheromone substance in finding the shortest path between the food and its home. A shorter path is chosen by directing the ants to the area where the odor is intense. The number of ants must be determined for the problem to be solved. The higher the number of ants, the better the solution, but the more time it takes. The more parameter that specifies how many times to search for solutions, the better the solution, but the more time it takes. The parameter determines that the algorithm will reset the pheromone traces if it cannot find a better solution during the iteration. It can take integer values between 1 and 50. If it is minimized, the local best value compression time will be shortened. At the end of each iteration, pheromone amounts are evaporated at a rate according to this parameter. This value takes a value between 0 and 1. If it is raised, the probability of jamming at the local best value is reduced. The significance ratio of the pheromone takes an integer value between 1 and 10 in the ant's decision to take a new direction in the route. The effect of the operation time of that node on the ant's decision to add a new process takes an integer value between 1 and 10. Each pheromone is reset. Then, the pheromone coefficient takes an integer value between 1 and 10, depending on the amount of pheromone to be found in the pathways. If it is increased, it decreases the relative importance of subsequent pheromone changes [6].

4. OPTIMIZATION OF ENERGY MANAGEMENT USING DEVELOPED HYBRID HEURISTIC ALGORITHM

Artificial Bee/Ant Hybrid Heuristic Algorithm developed for optimization of energy management is shown in Figure 3.

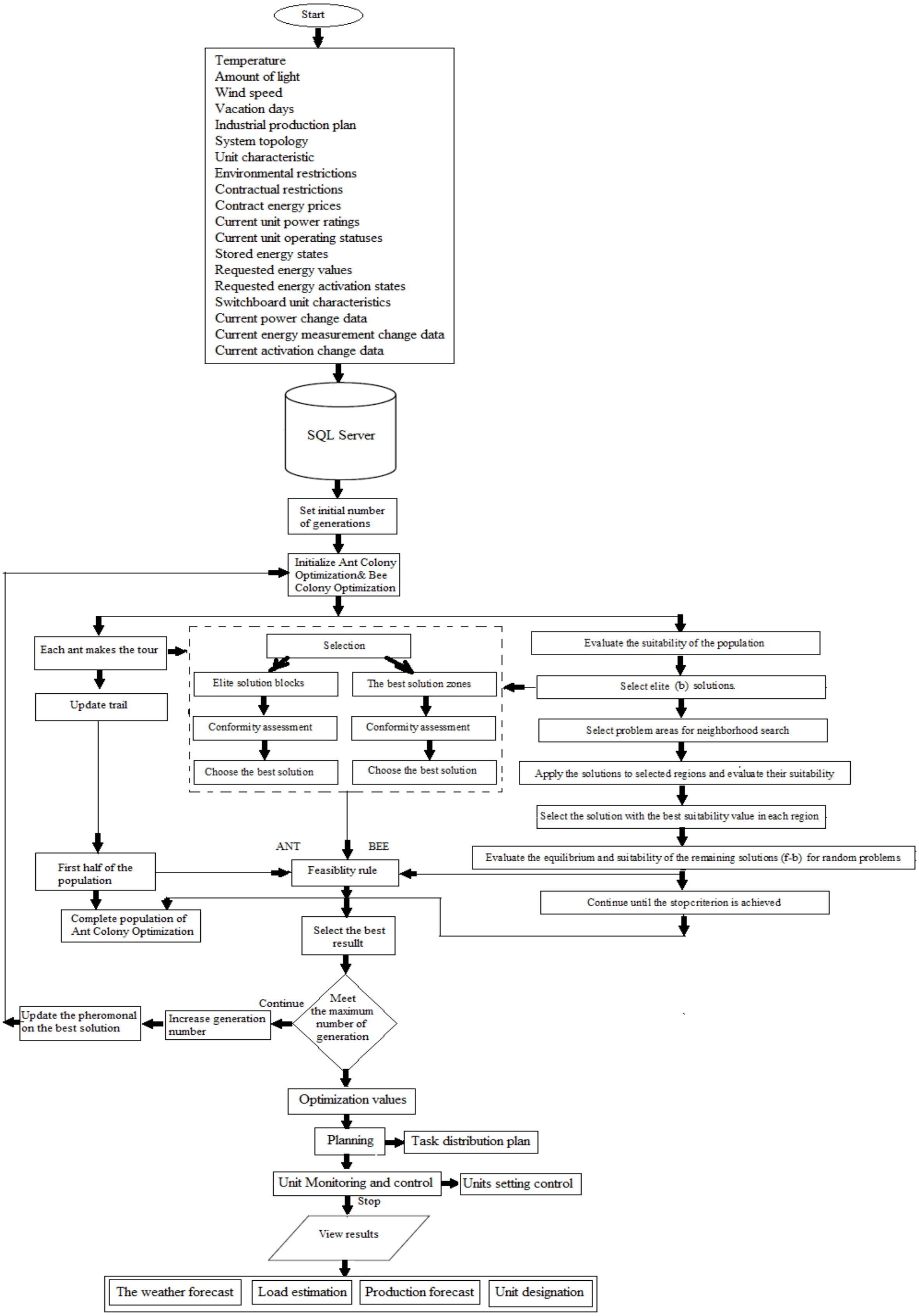

Figure 3. Artificial bee/ant hybrid heuristic algorithm created for optimization of energy management

Measured, predicted and previous year's air temperature, amount of light falling on the ground, wind speed data are entered. The determined public holidays and industrial production plans of this year are entered. System topology and unit characteristics are entered. Environmental and contractual restrictions, contract energy price data are entered. Current unit power values and operating states are entered. The current stored energy content, current energy values of the requests and activation states are entered. Power station characteristics, Current power change data, current energy measurement change data, current activation change data are entered as data. Optimization solutions are obtained by using the created Artificial Bee/Ant Hybrid Algorithm. Using these data, high-level work planning is made for all flexible components. Units are controlled by creating task distribution plans. Setpoints are determined using data obtained from planning. Control and inspection of components are made at minute intervals. Thus, units can be monitored and controlled using setpoints and start/stop commands. By using the data obtained here, audits and controls are carried out to change the planned values and contractual values [7]. The basic steps of the algorithm are as follows:

Step 1. Enter the number of experiments, the maximum number of generations and the number of the population (N).

Step 2. Enter the substation information.

Step 3. Enter; temperature, amount of light, wind speed, vacation days, industrial production plan, system topology, unit characteristic, environmental restrictions, contractual restrictions, contract energy prices, current unit power ratings, current unit operating statuses, stored energy states, requested energy values, requested energy activation states, switchboard unit characteristics, current power change data, current energy measurement change data, current activation change data.

Step 4. Generate N chromosomes for the initial population.

Step 5. Set the total number of bars, number of rows, number of columns, depth of network embedding.

Step 6. Calculate suitability for each solution.

Step 7. If the maximum number of generations is reached, identify and store the chromosome that is the best fit in the experiment.

Step 8. Increase the number of experiments if maximum number of generations is reached, but the maximum number of experiments is not reached.

Step 9. Start the experiment again.

Step 10. If the maximum number of generations is not reached, go to step 5.

Step 11. Go to Step 18 if both the maximum generation number and the maximum number of experiments are reached.

Step 12. Divide the N number of chromosomes into binary groups and cross.

Step 13. Apply mutation to N chromosomes.

Step 14. Select the best N number of chromosomes for the next generation from the chromosomes obtained by N number of chromosomes, N number of chromosomes and N number of mutations.

Step 15. Increase the number of generations by 1 and go to Step 5.

Step 16. Calculate core parameters of the 3N number of chromosomes when the eddying condition is not met.

Step 17. Identify the best chromosome in all experiments

Step 18. Calculate the average of the best chromosome of each experiment.

Step 19. View results; the weather forecasts, load estimation, production forecasts, unit designation.

Optimization of energy management program interface created is shown in Figure 4.

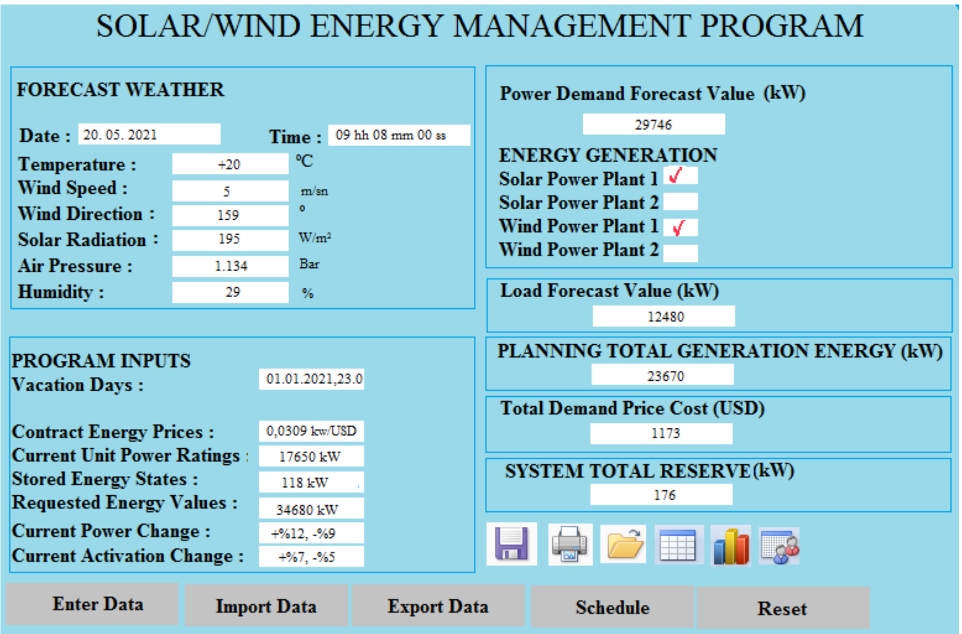

Figure 4. Optimization of energy management program interface created

The Forecasts interface allows the import of weather forecasts data and measurements from external sources such as weather forecasts services. Externally imported weather forecasts; The difference between external forecasts data and locally measured weather data should be minimized. This algorithm has been adapted to local field measurements using the developed algorithm. The obtained weather forecasts data is used as input to planning functions. Basic data for weather forecasts; taken as data from weather forecasting institutes. In Figure 5, the Created Weather Forecasts Main Screen is given.

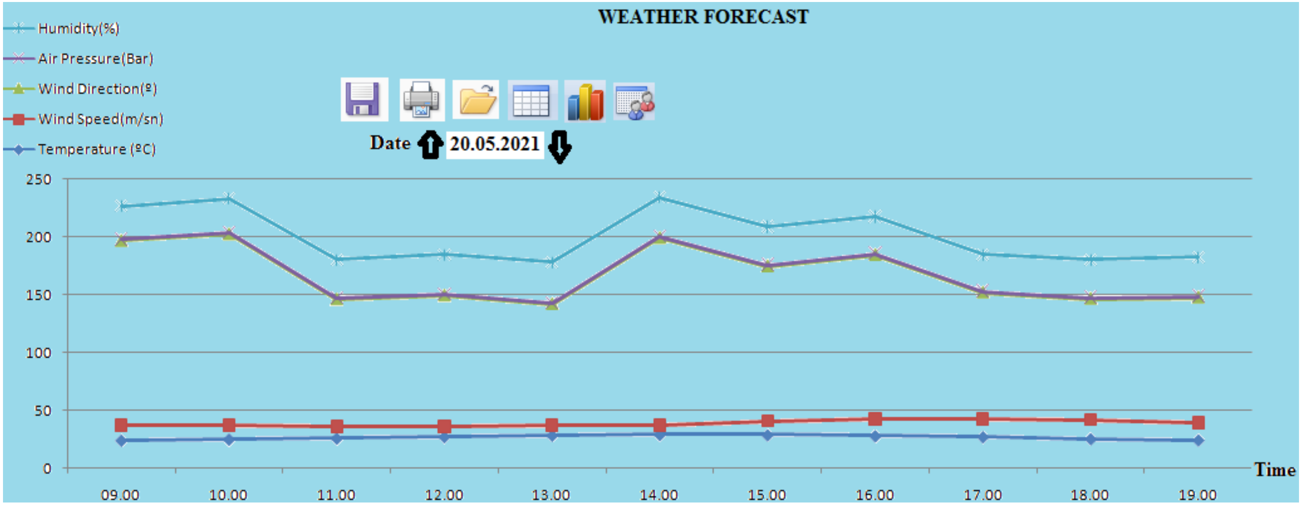

Figure 5. The weather forecasts main screen created

The Weather Forecasts Main Screen allows to set the starting time and the forecasts range. Thanks to this function, users can view different airspaces defined in the system. If air process measurements are available, the actual values of each air data measurement are displayed. External weather information is imported manually. The calculation function is started manually. Forecasted weather data plans are entered. This information and plans are imported from the relevant excel file. Weather forecasts calculation results are exported as an excel file. In Figure 6, the power demand estimation detail screen is given, obtained by using the developed algorithm.

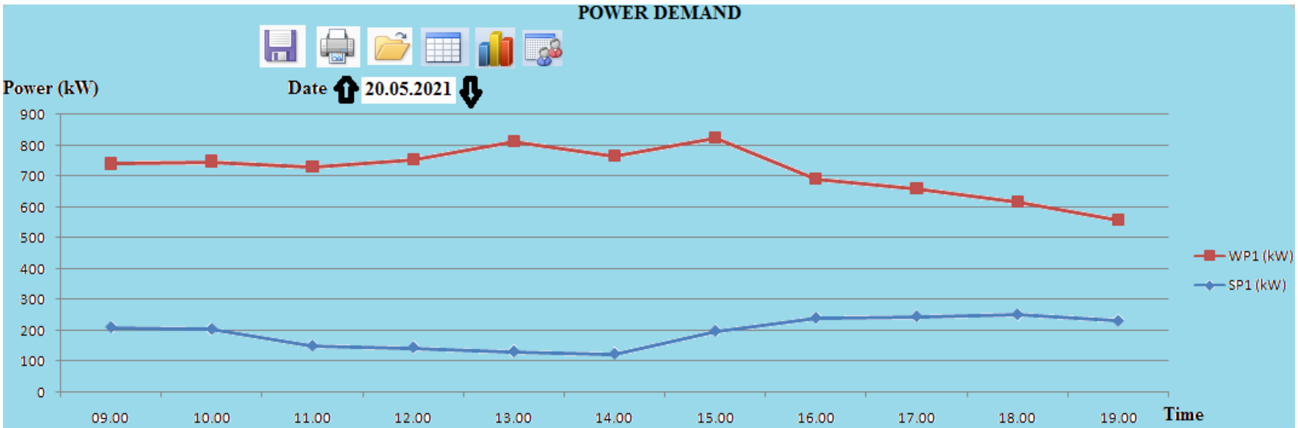

Figure 6. The power demand forecasts detail screen created

Allows the user to change the settings of their parameters using this screen. Here, External Variables and Calendar information are entered. The obtained data is imported from the excel file. Forecasts plans are entered manually. Information on these is imported from the excel file. It allows the calculated forecasts planning for demand to be displayed on a trend screen. In the production forecasts, the estimated production of renewable solar/wind energy sources is calculated depending on the predicted weather conditions. Using the developed algorithm, two weather variables are converted to the expected power generation, sectionally, and linearly. In Figure 7, The Generation Power Forecasts Main Screen Generation Forecasts Main Screen is given.

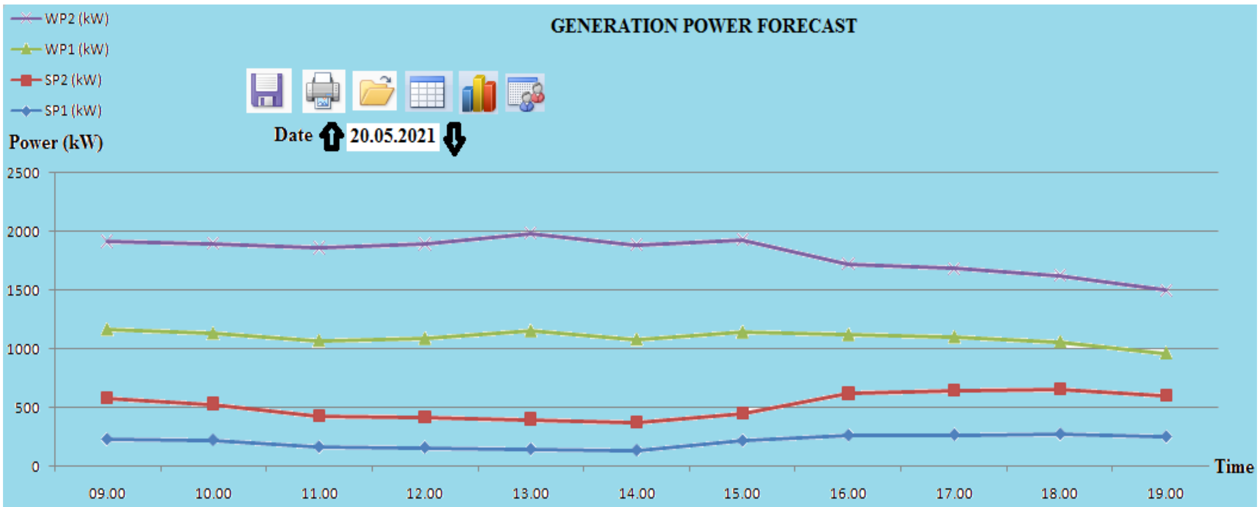

Figure 7. The generation power forecasts main screen created

The Generated Production Forecasts Main Screen allows start time and calculation range to be determined. The forecasts data is provided, allowing the weather-related forecasts settings to be changed for each unit. Predictions calculation is started manually. Predictions plans are entered. Data is imported from the excel file. Relevant results are output from excel file. In addition, for each edible production class, relevant renewable production states are selected. Details regarding respective renewable generation unit are displayed.

5. CONCLUSIONS

An artificial bee/ant heuristic algorithm has been developed to reduce energy costs. Using this hybrid optimization, a computer program was created that allows for weather forecasts, load predictions, and production estimation. By using this program, unit assignment, production management, and load management have been done effectively. The Weather Forecasts main screen allowed you to set the starting time and the forecasts range. Thanks to this function, users can view different airspaces defined in the system. Thus, changes in solar/wind hybrid power plants and energy consumers were better monitored. Online optimization and coordination has become possible in power plants and energy consumers. By using this computer program, better planning and more accurate estimation in energy production and management has become possible by energy generating companies. Thus, these companies will be able to make more profit by making energy management more effective. The gain to be obtained by using different energy sources at right time will increase.

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BIOGRAPHY

Mehmet Zile was born in Ankara, Turkey, 1970. He received the B.Sc. degree from Yildiz Technical University, Istanbul, Turkey, the M.Sc. degree from Gazi University, Ankara, Turkey and the Ph.D. degree from Yildiz Technical University, all in Electrical and Electronic Engineering, in 1992, 1999, and 2004, respectively. Currently, he is an Assistant Professor of UTIYO at University of Mersin, Mersin, Turkey. He is also an academic member of UTIYO Information Systems and Information Technology Department at University of Mersin and teaches information systems and control systems**.** His research interests are in the area of control systems and electrical machines. He is a member of IEEE.