Optimization Economic and Emissions of Hydro and Thermal Power Plants in 150 KV Systems using the Dragonfly Algorithm

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Optimization Economic and Emissions of Hydro and Thermal Power Plants in 150 KV Systems using the Dragonfly Algorithm

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Abstract — Electricity is one of the energies required by daily living, since the greater demand for electricity increases greenhouse emissions that create emission gases resulting in global climate change. The main portion of the cost of output is the cost of fuel to manufacture electrical energy in thermal turbines, and the use of electrical energy is currently rising increasingly in accordance with the increasing population. The research aims to optimize hydro generation in order to minimize the expense of thermal generation and address economic problems and pollution from shipping. With 2016b matlab applications and the lamda iteration process, the analysis method uses the Dragonfly Algorithm method. In the analysis, it was found that the average cost of fuel consumption provided by the Dragonfly Algorithm method was IDR 151,164,418 per day with an emission of 917.40 tons per day, based on the results of the simulation of the Dragonfly Algorithm in testing by considering the emission of 5 experimental steps. Meanwhile, with an emission of 918,044 tonnes per day, the average cost of fuel consumption produced by the Lamda Iteration method is IDR 151,202,209 per day. An enhancement of the fuel consumption cost of IDR 37,791 and emissions of 0.641 tons can be obtained by test results with the Dragonfly Algorithm process.

Keywords — Electricity, Economic and Emssions dispatch, Dragonfly Algorithm.

I. INTRODUCTION

Greenhouse emissions boost the demand for more oil, resulting in global climate change. In order to sustain economic development, energy is one of the fundamental elements. Electrical energyis one of the most vital energies for economic development[1]. Due to the rising population and economy, the need for electricity in Indonesia is increasing in one region, South Kalimantan, as well.

In 2018, the Province of South Kalimantan consumed 4,058 GWh of electricity with a household sector dominated by demand per consumer sector of approximately 2,046 GWh (50 %), a sector of approximately 1,172 GWh (29 %), an industry sector of approximately 564 GWh (14 %) and a public sector of approximately 275 GWh (7 %)[2]. This allows the PLN (State Electricity Company) to safely and efficiently preserve the reliability of the delivery of electrical power to the electrical grid and to optimize the basic load. Fuel costs are presently the primary portion of manufacturing costs, and electrical energy use is currently undergoing fast growth. PLN also continues to aim to replace, by scheduling, the use of costly fuels for economically viable fuels[3].

The generation units are not in the same setting as the load in an electrical power grid linked to the interconnection network. Furthermore, the cost of manufacturing these units is different. The capability of the generation system is expected to be greater than the total load requirements and power losses in the system during normal service. A sustainable energy system needs to pay attention to the economic sector and to reliability, but it also needs a system that recognizes environmental damage[1].

Optimizing the timing of hydrothermal generation in the electric power grid is a reasonably inexpensive way to satisfy consumer requirements. During the optimization time, the overall running cost is higher than the cost of thermal generation. Due to efficient running costs, hydro generation units are used to bear the base load. In addition, the thermal generation units are run with higher running costs to satisfy the remaining load specifications[3] .

Thermal power stations are a significant cause of polluting atmospheric sulphur dioxide (SO2), nitrogen oxides (NOx) and carbon dioxide (CO2)[4]. In comparison, if production is improved, the energy efficiency and the volume of carbon emitted into the air from thermal power plants would greatly accelerate, thus reducing the resultant pollution emissions.

Thus, the optimization of short-term hydrothermal scheduling can be applied to reduce gas emissions resulting in recent environmental disruption, with the prerequisite that a hybrid economic short-term hydrothermal emission scheduling is also created in addition to minimizing the fuel cost of thermal power generation[5]. To find solutions to the optimization problems of thermal hydro power plants, there are many approaches used. These techniques of optimization are divided into two, namely the deterministic technique and the technique of artificial intelligence.

Economy and Emissions Dispatch (EED), in order to fix economic and social aspects, has been the most important optimization in the operation of the power plant and control problems. Guanghui Yuan, et al, respectively. Using the PSO and AFSA Algorithm Hybrid process, they have the objective of minimizing coal use, pollution emissions and buying costs[4]. In order to minimize coal consumption and CO2 gas leakage emissions in thermal power plants, Ehab E. Elattar analyzed the optimization theme, namely economic dispatch and emissions, using the modified shuffle frog leaping (MSFLA) algorithm system [5]. Vinay Kumar Jadoun, et al. Investigated using the Modulated Particle Swarm Optimization (MPSO) approach to solve the thermal problem of the EED machine and evaluated the comparison for optimum optimization of many artificial intelligence methods[6]. To solve the issue of sending economic emissions consisting of Combined Heat and Power Economy Emission Dispatch (CHPEED) and Dynamic Economic Emission Dispatch (DEED), Hossein Nourianfar, et al investigated using Time-Varying Acceleration Coefficient-Particle Swarm Optimization combined (TVAC-PSO) with Exchange Market Algorithm (EMA)[7]. From M. Amiri, et al. Examined using the floating search space swarm-based optimization approach, the proposed method will offer competitive solutions to problems in the distribution of economic pollution by increasing precision, reducing computational budgets and achieving better performance[8].

The authors would apply the Dragonfly Algorithm in this analysis, based on the Dragonfly algorithm principle that begins statically as a starting point and energetic behavior of the dragonfly herd. At the two main stages of optimization via the heuristic meta algorithm, this clustered action is used as a parable, namely inquiry and use[9]. The optimization strategy in meta-heuristic hybrids, DA (Dragonfly Algorithm) to deal with problems with optimization power flow in the study guide. To obtain the optimum value variable power system control and to address OPF issues, the algorithm stated is applied. It will minimize power loss, voltage profile variations and monitor fuel costs, which are the key goals of the OPF problem[9]. There is, however, no study using the Dragonfly algorithm on economic optimization and pollution.

A comparatively recent algorithm is the Dragonfly algorithm. There have been some previous reports. To deal with the OPF (optimal power flow) problem, Shilaja C, et al used the Dragonfly algorithm and analyzed the comparison with the IEEE 30 bus system [9]. The Dragonfly algorithm was used by Sureshkumar, et al, to mitigate device errors based on objective power flow control functions such as actual power and reactive power[6]. Ling-Ling Li and others, et al. To refine short-term projections for the wind power model [10], the Dragonfly algorithm was used. From Jie Li, et al. To optimize the Wind-Solar-Hydro power scheduling model [11], the Dragonfly algorithm was used.

As a guide, numerous experiments have attempted to maximize the economy and pollution of hydrothermal plants using techniques of artificial intelligence, claiming that thermal generation costs can be reduced. Based on this data, in the 150 kilovolt system in South and Central Kalimantan, the researchers conducted economic and emission optimization for hydro and thermal power plants using the Dragonfly Algortihm method with the goal of optimizing hydro generation so as to minimize the cost of thermal generation and solve economic problems and shipping pollution.

III. RESEARCH METHODOLOGY

A. *Power Plants Optimization*

For the delivery of generator loads, the operation of the electric power grid is necessary in order to achieve optimum operation. Coordination of the loading of massive electric power produced by the central power plant units needs to be aligned in order to obtain cheap fuel consumption costs[11]:

1) *Economic Dispatch*

Economic distribution is one means of calculating the quantity of power to be generated by each generator unit in order to fulfill a given load by optimally separating the load on the generating units in the system in order to rationalize the cost of generating fuel consumption[12].

B. *Combined Economic and Emission Dispatch*

Economic and Emission Dispatch are optimized to fix ignored emission challenges in economic delivery and fuel cost goals are not taken into account in emission delivery issues[13].

$$\text{Min}\ Objective = w1 \times F1(P_{si,m}) + w2 \times \text{PRm} \times F1(P_{si,m}) \qquad (1)$$

w1: Factor of weight for the purpose of fuel cost
w2: Factor weighting for the purpose of emissions costs
F1: Fuel cost objectives
F2: Emission Objectives
Psi, m: Thermal unit power output
PRm: Price penalty factor

C. *Characteristics of Power Units*

In the device, there are three types of generator types, namely generation of simple load, generation of medium load and generation of peak load[3].

1) Thermal Generators' Input-Output Characteristics

In this analysis, the input-output characteristics of thermal generators are steam power plants per hour input to the generator unit in the form of Btu. The generation expense is the multiplication of the cost (IDR) of the calories in the gasoline, in this case gas, with the generator's hourly calorie requirements (Btu / h). The power generated as a result is written as PG[14].

The characteristics create a correlation as a function of the generator output between the generator inputs. The input-output characteristic equation of the power plant defines the relationship between the amount of fuel (coal) needed in the binomial function method to generate a certain power in a power plant, namely[15]:

$$(F) = xP2 + yP + z \qquad (2)$$

Keterangan :
F = Fuel cost (Coal)
P = Generating power yield (MW)
x, y, z = Constant

D. DRAGONFLY ALGORITMH

The Dragonfly Algorithm is an algorithm for artificial intelligence that serves as an optimization for decision-making.

The dragonfly algorithm began with static dragonfly actions as the starting point and enthusiastic crowds. In the two main stages of optimization via the heuristic meta algorithm, namely inquiry and consumption, the two swarming activities tend to be identical[9]

The following mathematical model, using Eq, describes this action. (3) - (7).

1) The Conduct of Separation::

$$S_i = \sum_{j=1}^{N} X - X_j \tag{3}$$

Where j = 1; 2;...; N, I = 1; 2;...; Np, N is the number of distinct classes of dragonflies and Np is the number of populations of dragonflies. The current location of the individual dragonfly is indicated by X, Xj by the j-th position of the individual group.

2) Sustaining synchronized flight activity with groups of dragonflies::

$$A_i = \frac{\sum_{j=1}^{N} V_j}{N} \tag{4}$$

Where Vj reflects the velocity of the individual dragonfly group jth

3) Conduct for each person to enter each other (Cohesion):

$$C_i = \frac{\sum_{j=1}^{N} X_j}{N} - X \tag{5}$$

4) Conduct in foraging::

$$F_i = X^{+} - X \tag{6}$$

Where X + represents the current position of the human dragonfly with the optimum fitness score.

5) Conduct of enemy avoidance::

$$E_i = X + X^{-} \tag{7}$$

Where X- represents, with the worst health score, the present location of the actual dragonfly.

E. Economical Operation Lambda Iteration Method

The value of λ is derived from the results of the estimation in an iterative solution methodology with an initial approximate price that has been calculated in advance and before the value of ΔPi is accurate[16].

The number of load requests PR is proportional to the combined capacity of all generators while the power losses on the transmission line are ignored[16].

$$\sum_{t=1}^{n} P_i = P_R \tag{8}$$

A requirement for the optimum distribution from the ith generator of production costs is

$$\frac{\partial Fi}{\partial Pi} = \lambda \tag{9}$$

Where λ is a multiplier of the lagrange or

$$2a_i + b_i P = \lambda \tag{10}$$

Determining the value of Pi from the equation above is:

$$Pi(k) = \frac{\lambda(k) - bi}{2ai} \tag{11}$$

The equation above can be iteratively solved.

The value of λ is obtained by replacing the value of Pi in equation 7 with equation 8, resulting in the following results:

$$\sum_{i}^{n} \frac{\lambda - b_i}{2a_i} = P_R \tag{12}$$

or

$$\lambda = \frac{PR + \sum_{i}^{n} = i\frac{bi}{2ai}}{\sum_{i}^{n} = i\frac{bi}{2ai}} \tag{13}$$

Where:

Pi = The power produced by the ITH generator (MW)

N = Number of generators within the system

PR = Complete load on system (MW)

Fi = Function of Expense

A, b = Constancie

F. DATA COOLLECTION

Data sources were collected from the 150 kilovolt South Kalimantan power plant with the requirements of the 50 MW Asam Asam Steam Power Plant (PLTU) unit 2, the 60 MW PLTU Asam Asam unit 3 and the 60 MW PLTU Asam Asam unit 4. Hydroelectric Power Plant Riam Kanan (PLTA) with a capacity of 30 MW, and a 150 kilovolt Central Kalimantan Power Plant with a design of PLTU Pulang Pisau Unit 1 with a capacity of 60 MW, PLTU Pulang Pisau Unit 2 with a capacity of 60 MW.

G. METHOD OF RECOGNITION

By generating a Flowchart from the Dragonfly algorithm, the system recognition process is a step taken to get the model outcomes from the system. In this method of recognition, the steps include:

- Starting is a system-starting process.
- Input parameters are a data input method in the form of iteration values, the load from the thermal generator (PLTU).
- In thermal generators, iterations are obtained using lambda (PLTU).
- Calculating constants using polynomial regression of the second order.
- The Convergence Criterion is a criterion for estimation or software verification.
- Fitness feature evaluation is a function of the algorithm of the dragonfly.
- Updating the value of the Dragonfly algorithm equation can be seen in equations (3) - (7).
- Dragonfly Algorithm calculation process and solution selection for economic optimization and emissions from thermal generation.

The Dragonfly algorithm flowchart that the author did can be seen in Figure 1.

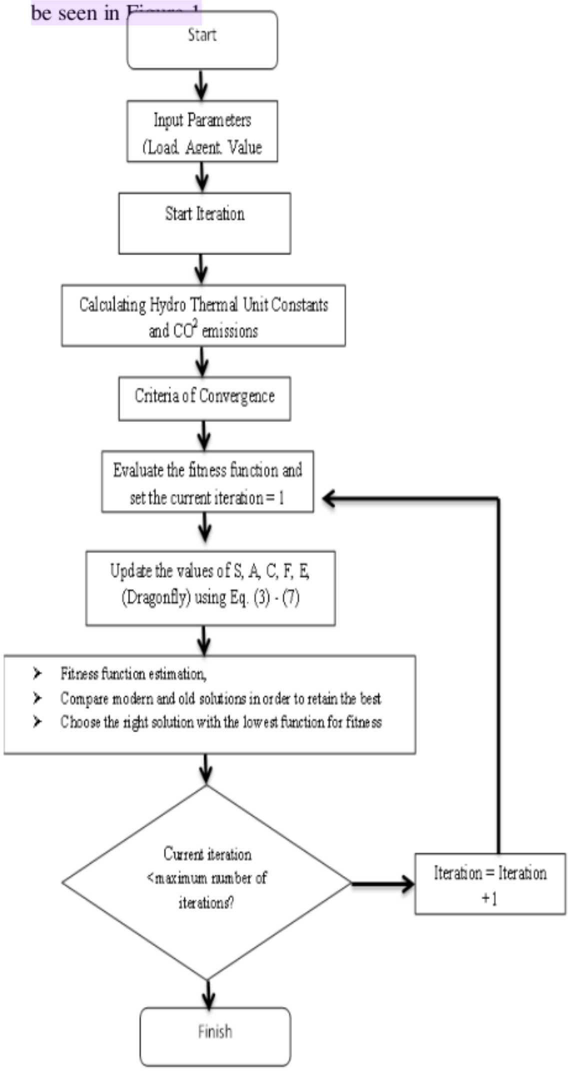

Figure 1. *Flowchart Dragonfly Algorithm*

IV. Result And Discussion

The testing process of the proposed method will be performed in this study. Compared with the economical lamda iteration scheduling method, the Dragonfly Algorithm method used will be used. In Figure 2, the display on the GIU can be seen.

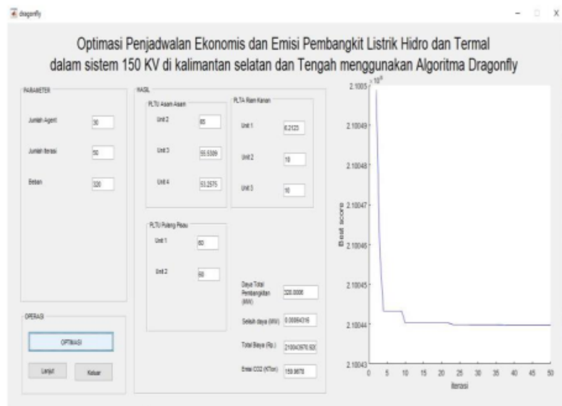

Figure 2. *Display Dragonfly Algorithm GUI in Matlab Software*

In the GIU Display, there is an Icon Parameter Number of Agents, Number of Iterations and Loads which will be used as input for optimization, the Result Icon in the Giu is the power optimization value of each of the Asam-Asam PLTU, Pulang Pisau PLTU and Riam Kanan PLTA using Dragonfly Algortihm, The Total Power Plant Icon (MW) is the Optimization Value of the power determined by the Load on Parameters and the total of the power optimization value of each of the Asam-Asam PLTU, Pulang Pisau PLTU and Riam Kanan PLTA, Icon Total Cost (IDR) and Emissions CO2 is the result of the Dragonfly Algorithm, while the graph on Giu shows the iteration value of the total cost (IDR)

A. Testing with Lamda Iteration

The characteristic function of each generator unit is determined in the initial stage on the basis of the average energy output to the power generated by polynomial regression of the second order, and then the function of each generator is obtained using equations 2 and 8:

PLTU Asam Unit 3, $C1=1{,}3846+2{,}55000(50)+0{,}0128(50)^2$
PLTU Asam Unit 4, $C1=0{,}6895+3{,}1445(61)-0{,}0034(61)^2$
PLTU Asam Unit 2, $C1=0{,}6155+0{,}4583(61)+0{,}0023(61)^2$
PLTU Pulpis Unit 1, $C1=4{,}8669+0{,}2975(59)+0{,}0056(60)^2$
PLTU Pulpis Unit 2, $C1=0{,}3330+0{,}9909(59)-0{,}0031(59)^2$

In the following research, the calculation method for economic planning with and without emissions is as follows:

- Enter the value of Power Demand.
- Determine the minimum and maximum requirements for generation limits
- Alpha, Beta and Gamma are order 2 polynomial regressions obtained from a matrix using matlab software.
- The CT consumption formula = Alpha + (Beta x Power P1) + (Gamma * Power PI^2)
- Formula for Fuel Cost Search = CT Fuel Consumption x Coal Price per Ton (Coal Price per Ton is derived from ESDM Data)

B. Testing Metode Dragonfly Algorithm

The research consists of 3 Asam-Asam generator units and 2 pulang pisau generator units, which are checked without considering emissions and taking emissions into account.

1) Testing should not take pollution into account.

The experiment was performed in 5 phases using 320 MW of power from the generator load inputted into the Matlab program.

Table 1 Cost Results Comparison of the 2 methods without considering emissions

NO	Dragonfly Algoritmh	Iteration Lamda Method
1	IDR167.927.206	IDR167.969.188
2	IDR174.470.095	IDR174.513.713
3	IDR165.756.426	IDR165.797.865
4	IDR170.819.341	IDR170.862.046
5	IDR164.151.106	IDR164.192.144
Average	IDR168.624.835	IDR168.666.991

The findings show that the total value of the cost of fuel consumption from the two strategies is not the same, based on the data in table 1. The average cost of fuel consumption is in the Dragonfly Algortihm process, after 5 measures of experimentation IDR 168,624,835, while the cumulative cost of fuel consumption in the Lamda Iteration Process is From IDR 168,666,911. It can be shown that optimization is carried out by the Dragonfly Algortihm process. The total cost of producing consumption is IDR 41,856 6

2) Testing With Consider Emissions

The experiment was carried out in 5 steps and used a load of 320 MW. Determined the weighting factor W1 = 1/2 and W2 = 1/2 for the test

Table 2 Cost Results Comparison of the 2 methods by considering emissions

	Dragonfly Algorirhm		Iteration Lamda Method	
No	Fuel Consumption Costs With Emissions	Emissions per ton	Fuel Consumption Costs With Emissions	Emissions per ton
1	IDR 151.398.354	915,22	IDR 151.436.204	917,51
2	IDR 154.247.570	936,28	IDR 154.286.132	936,51
3	IDR 148.129.253	909,95	IDR 148.166.286	910,18
4	IDR 153.527.768	927,34	IDR 153.566.150	927,57
5	IDR 148.519.146	898,22	IDR 148.556.276	898,45
Ave	IDR 151.164.418	917,402	IDR 151.202.210	918,044

It is understood that the cost of fuel consumption from the two strategies is not the same, based on the data in table 2. Next, a 5-step experiment was performed, it was known that IDR151,164,418 per day with an emission of 917.40 tons per day was the average cost of fuel consumption produced by the Dragonfly Algorthm process. Meanwhile, with an emission of 918,044 tonnes per day, the average cost produced by the Lamda Iteration method is IDR 151,202,209 per day. The findings show that the Dragonfly Algorthm approach will achieve an optimization of the fuel consumption cost of IDR 37,791 and an emission of 0.641 tons from the 2 forms of tests carried out.

The research's job restrictions are:

- In order to minimize the running costs of the facility, the study uses heat rate equation data in thermal generators optimized to the performance of the plant.
- Emissions take only CO2 gas into account,
- Generating conditions are called natural conditions and are not taken into consideration when there is a system malfunction.

V. CONCLUTION

The following findings are derived on the basis of the outcomes of simulation and research in the study:

For a 5-step trial, the average cost of fuel consumption in research without considering the pollution of the Dragonfly Algortihm process is IDR 168.624.835, while the cumulative cost of fuel consumption in the Lamda Iteration Process is IDR 168.666.911. It can be shown that with an average of IDR 41.856, the Dragonfly Algortihm approach optimizes the cost of consumption generation

The average cost of fuel consumption provided by the Dragonfly Algorthm method is IDR 151,164,418 per day with an emission of 917.40 tonnes per day while measuring by considering the emission of the Dragonfly Algortihm method with a 5-step experiment. Meanwhile, with an emission of 918,044 tonnes per day, the average cost of fuel consumption produced by the Lamda Iteration system is IDR 151,202,209 per day. The findings show that the Dragonfly Algorthm approach will achieve an optimization of the fuel consumption cost of IDR 37,791 and an emission of 0.641 tons from the 2 forms of tests carried out.

For further research development, emission gases such as sulfur dioxide (SO2), nitrogen oxides (NOx) can be added for the application of economic optimization and emissions in thermal power plants.

For research development, you can combine or compare the dragonfly algorithm method with other artificial intelligence optimization methods for the application of economic and emission optimization in thermal power plants.

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