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 output cost is fuel's cost to manufacture electrical energy in thermal turbines. The use of electrical energy is currently rising increasingly following the increasing population. The research aims to optimize hydro generation to minimize thermal generation expense and address economic problems and pollution from shipping. With 2016b using Matlab applications and the lambda iteration process, the analysis method uses the Dragonfly Algorithm method. The analysis 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 simulation results the Dragonfly Algorithm in testing by considering the emission of 5 practical steps. Meanwhile, with the emission of 918,044 tonnes per day, the average cost of fuel consumption produced by the Lambda Iteration method is IDR 151,202,209 per day. Test results can enhance the fuel consumption cost of IDR 37,791 and emissions of 0.641 tons with the Dragonfly Algorithm process.

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

I. INTRODUCTION

Greenhouse emissions boost the demand for more oil, resulting in global climate change. The sustain economic development, energy is one of the fundamental elements. Electrical energy is one of the most vital for economic growth [1]. Due to the rising population and economy, Indonesia's need for electricity increases in one region, South Kalimantan.

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 electrical power delivery to the electrical grid and optimize the necessary load. Fuel costs are presently the primary portion of manufacturing costs, and electrical energy use is currently undergoing fast growth. PLN also aims to replace, by scheduling, 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 generation system's capability is expected to be greater than the system's total load requirements and power losses during standard service. A sustainable energy system needs to pay attention to the economic sector and the reliability, but it also requires 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 baseload. The thermal generation units are also run with higher running costs to satisfy the remaining load specifications[3].

Thermal power stations are a significant cause of polluting atmospheric sulfur 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 significantly accelerate, thus reducing the resultant pollution emissions.

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

Economic and Emissions Dispatch (EED), 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]. 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

DOI : 10.25139/inform.v6i1.3320

using the Modulated Particle Swarm Optimization (MPSO) approach to solve the EED machine's thermal problem and evaluated the comparison for optimum optimization of many artificial intelligence methods[6]. To solve sending economic emissions consisting of Combined Heat and Power Economic 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), deals with optimization power flow problems in the study guide. The algorithm stated is applied to obtain the optimum value variable power system control and address OPF issues. It will minimize power loss, voltage profile variations and monitor fuel costs, which are the critical 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 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. Jie Li et al. To optimize the Wind-Solar-Hydro power scheduling model [11].

As a guide, numerous experiments have attempted to maximize hydrothermal plants' economy and pollution using artificial intelligence techniques, 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 economically, and emission optimization for hydro and thermal power plants using the Dragonfly Algorithm method hydro generation the cost of thermal generation and solve economic problems and shipping pollution.

II. Research Methodology

The Dragonfly algorithm flowchart that the author did can be seen in Figure 1. The generating Flowchart from the Dragonfly algorithm, the system recognition process is a step taken to get the system's model outcomes. 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 thermal generator load (PLTU).
- In thermal generators, iterations are obtained using lambda (PLTU).
- Calculate 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 Dragonfly algorithm equation's value can be seen in equations (3) - (7).
- Dragonfly Algorithm calculates process and solution selection for economic optimization and emissions from thermal generation.

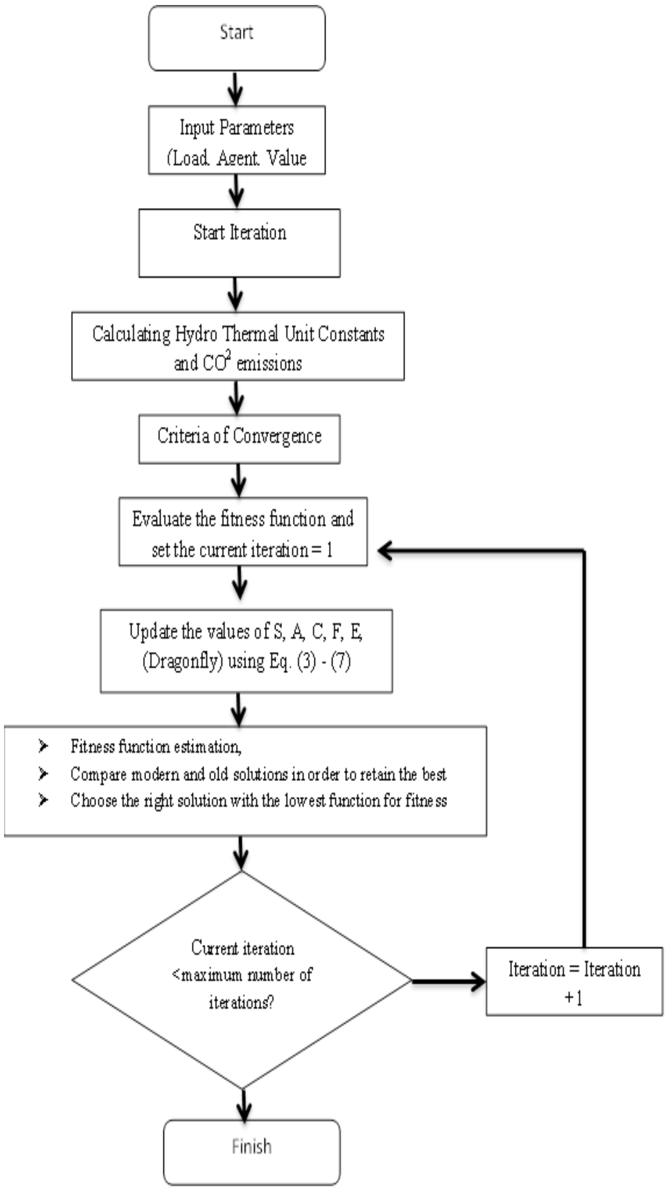

Figure 1. The Dragonfly algorithm

DOI : 10.25139/inform.v6i1.3320

A. Data Collection

Data sources were collected from the 150 kilovolts South Kalimantan power plant with 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 *PLTU Pulang Pisau* Unit design 1 with a capacity of 60 MW, *PLTU Pulang Pisau* Unit 2 with a capacity of 60 MW.

B. Power Plants Optimization

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

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

C. 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 considered in emission delivery issues based on Equation (1) [13].

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

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

D. Characteristics of Power Units

There are three types of generator types in the device: generation of simple load, generation of medium load, and peak load generation [3].

In this analysis, thermal generators' input-output characteristics are steam power plants per hour input to the generator unit in Btu. The generation expense is the multiplication of the cost (*IDR*) of the gasoline's calories, 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 with Equation (2). 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]:

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

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

E. Dragonfly Algorithm

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 optimization stages via the heuristic meta-algorithm, namely inquiry and consumption, the two swarming activities tend to be identical[9]. The following mathematical model using Equation (3)-(7).

- The Conduct of Separation:

$$S_i = \sum_{j=1}^{N} X - X_j \quad (3)$$

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 individual dragonfly's current location is indicated by X, Xj by the particular group's j-th position.

- Sustaining synchronized flight activity with groups of dragonflies:

$$A_i = \frac{\sum_{j=1}^{N} V_j}{N} \quad (4)$$

Where Vj reflects the velocity of the individual dragonfly group jth

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

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

- Conduct in foraging:

$$F_i = X^+ - X \quad (6)$$

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

- Conduct of enemy avoidance:

$$E_i = X + X^- \quad (7)$$

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

F. Economical Operation Lambda Iteration Method

The value of λ is derived from the estimation results in an iterative solution methodology with an initial approximate price that has been calculated in advance and before the value of ΔPi is accurate using Equation (8)-(11)[16].

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

$$\sum_{t=1}^{n} P_i = P_R \quad (8)$$

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

$$\frac{\partial Fi}{\partial Pi} = \lambda \quad (9)$$

Where λ is a multiplier of the Lagrange or

$$2a_i + b_i P = \lambda \quad (10)$$

Determining the value of Pi from the equation above is:

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

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:

or

$$\sum_i^n \frac{\lambda - b_i}{2a_i} = P_R \quad (12)$$

$$\lambda = \frac{PR + \sum_i^n = i\,\frac{bi}{2ai}}{\sum_i^n = i\,\frac{bi}{2ai}} \quad (13)$$

where:

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

N = number of generators within the system

PR = Complete load on the system (MW)

Fi = Function of Expense

A, b = Constancy

III. Result and Discussion

The testing process of the proposed method will be performed in this study. Compared with the economical lambda iteration scheduling method, the Dragonfly Algorithm method used will be used in Figure 2.

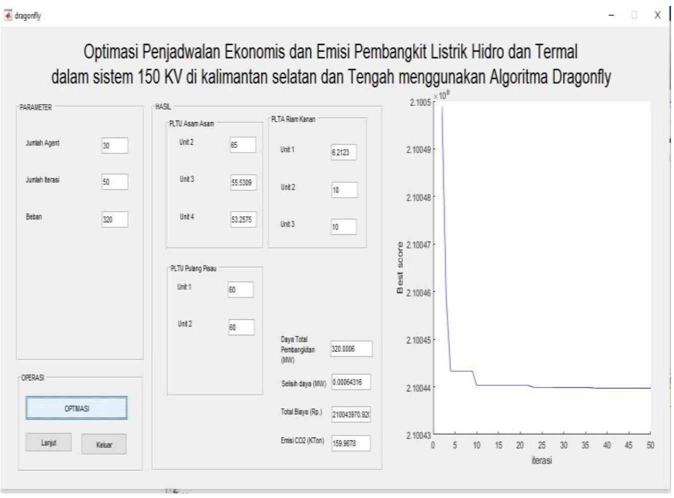

Figure 2. *Display Dragonfly Algorithm GUI in Matlab Software*

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 Algorithm, 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 Lambda Iteration

Each generator unit's characteristic function is determined in the initial stage based on the average energy output to the power generated by the second-order polynomial regression. 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)
- The formula for Fuel Cost Search = CT Fuel Consumption x Coal Price per Ton (Coal Price per Ton is derived from ESDM Data)

B. Testing Dragonfly Algorithm Method

The research consists of 3 *Asam-Asam* generator units and 2 *Pulang Pisau* generator units, checked without considering emissions and taking emissions into account. The experiment was performed in 5 phases using 320 MW of power from the generator load inputted into the Matlab program.

TABLE I
COST RESULTS COMPARISON OF THE 2 METHODS WITHOUT CONSIDERING EMISSIONS

NO	Dragonfly Algorithm	Iteration Lambda 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

DOI : 10.25139/inform.v6i1.3320

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 I. The average cost of fuel consumption is in the Dragonfly Algorithm process. After 5 measures, IDR 168,624,835, the cumulative cost of fuel consumption in the Lambda Iteration Process is From IDR 168,666,911. It can be shown that the Dragonfly Algorithm process carries out optimization. The total cost of producing consumption is IDR 41,856.

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 II
COST RESULTS COMPARISON OF THE 2 METHODS BY CONSIDERING EMISSIONS

Dragonfly Algorithm		**Iteration Lambda Method**	
Fuel Consumption Costs with Emissions	**Emissions per ton**	**Fuel Consumption Costs with Emissions**	**Emissions per ton**
IDR 151.398.354	915,22	IDR 151.436.204	917,51
IDR 154.247.570	936,28	IDR 154.286.132	936,51
IDR 148.129.253	909,95	IDR 148.166.286	910,18
IDR 153.527.768	927,34	IDR 153.566.150	927,57
IDR 148.519.146	898,22	IDR 148.556.276	898,45
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 II. Next, a 5-step experiment was performed, it was known that IDR151,164,418 per day with the emission of 917.40 tons per day was the average cost of fuel consumption produced by the Dragonfly Algorithm process. Meanwhile, with emission of 918,044 tonnes per day, the average cost produced by the Lambda Iteration method is IDR 151,202,209 per day. The findings show that the Dragonfly Algorithm approach will optimize the fuel consumption cost of IDR 37,791 and emission of 0.641 tons from the 2 forms of tests. The research's job restrictions are:

- To minimize the facility's running costs. The study uses heat rate equation data in thermal generators optimized for 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.

IV. CONCLUSION

The following findings are derived based on 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 Dragonfly Algorithm process's pollution is IDR 168.624.835. In contrast, the cumulative cost of fuel consumption in the Lambda Iteration Process is IDR 168.666.911. It can be shown that with an average of IDR 41.856, the Dragonfly Algorithm approach optimizes the cost of consumption generation. The average cost of fuel consumption provided by the Dragonfly Algorithm method is IDR 151,164,418 per day with an emission of 917.40 tonnes per day while measuring by considering the Dragonfly emission Algorithm 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 Lambda Iteration system is IDR 151,202,209 per day. The findings show that the Dragonfly Algorithm approach will optimize the fuel consumption cost of IDR 37,791 and emission of 0.641 tons from the 2 forms of tests. The further research development, emission gases such as sulfur dioxide (SO2), nitrogen oxides (NOx) can be added to apply economic optimization and emissions in thermal power plants. You can combine or compare the dragonfly algorithm method with other artificial intelligence optimization methods to use economic and emission optimization in thermal power plants for research development.

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DOI : 10.25139/inform.v6i1.3320

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