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Optimizing Economic Dispatch through Web-based Applications using Lambda Iteration Algorithm for Efficient Power System Operation

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Abstract – This research presents the development of an online economic dispatch web application using the lambda iteration method. The proposed method is implemented through a systematic process of problem formulation, optimization method selection, application design, and testing. The web application is created using MATLAB Web Apps and tested using generation data from the IEEE 30 bus system. The results demonstrate that the developed web application operates effectively and fulfills the desired specifications. Users can access the application via web browsers without the need for MATLAB installation on their devices. The study concludes that the developed economic dispatch web application can serve as a valuable tool for enhancing the efficiency and effectiveness of economic dispatch processes. The application can be further optimized by incorporating more comprehensive and user-friendly features.

Keywords: economic dispatch, lambda iteration, MATLAB, optimization, web applications

I. INTRODUCTION

In recent years, the use of web applications for power system analysis has become increasingly popular due to their convenience and accessibility. Economic dispatch is a fundamental problem in power systems that involves allocating generation among available power plants to meet the load demand at minimum cost [1], [2].

Various methods have been proposed to solve the economic dispatch problem, including lambda iteration, linear programming, quadratic programming, and artificial intelligence [3]–[5]. Among them, lambda iteration is a well-known optimization method for solving the economic dispatch problem. It is an iterative method that updates the generation of each power plant based on the lambda value, which represents the marginal cost of generation [2].

Previous studies [6], [7] have introduced software tools that address the economic load dispatch problem using the lambda iteration method. However, these tools are either standalone software or specialized software that requires installation and may not be accessible to users outside the organization.

In this paper, we propose a web application for economic dispatch using the lambda iteration method. The web application has been developed using MATLAB Web Apps and hosted on a server for easy access from any device with an intranet connection. This means that users within the organization can run the app in their web browsers without having MATLAB installed on their devices.

The proposed web application allows users to input load demand and generation cost data, then calculate the optimal generation for each power plant using the lambda iteration method. The results of the economic dispatch are displayed in the form of a graph and summary for easy visualization and analysis. We tested the proposed web application using generation data from the IEEE 30-bus system. The results showed that the web app was effective and accurate in solving the economic dispatch problem.

The proposed web application can be used as a tool for optimizing generation dispatch in power systems. We hope that this web application will contribute to the efficient and cost-effective operation of power systems.

II. METHODS

Economic Dispatch Formulation

Economic dispatch, also known as ED, is a method that aims to efficiently allocate power generation resources to meet electricity demand at the lowest possible cost. This involves considering the production costs of each generator as well as their operating limitations, such as minimum and maximum power output, start-up expenses, and ramping rates as demonstrated in Figure 1. The ED process strives to determine the most cost-effective approach to distribute available generation capacity while also fulfilling various operational and environmental requirements. Ultimately, the goal of economic dispatch is to minimize the total expenses of electricity production while ensuring the secure and dependable operation of the power system [1], [2], [8].

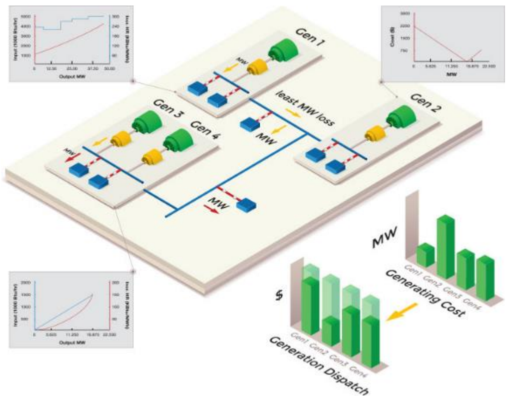

Figure 1. Economic dispatch [8]

One way to formulate economic dispatch is using an optimization algorithm that minimizes the cost of generating electricity subject to these constraints. The optimization problem can be written as follows:

1. Objective Function

The objective of economic dispatch is formulated as the minimization of F_T as presented in the equation (1) below,

$$F_T = \sum_{i=1}^{Ng} (a_i P_{gi}^2 + b_i P_{gi} + c_i)\ \$/h \qquad (1)$$

where,

F_T : generation cost function of the thermal units
P_{gi} : power generation of unit *i*
a_i, b_i, c_i : generation cost coefficient of unit *i*
Ng : number of the generation unit.

2. Equality Constraint

The equality constraint in economic dispatch is the sum of the output of all generators that must equal the electricity demand. This constraint can be represented mathematically in equation (2) as follows:

$$\sum_{i=1}^{Ng} P_{gi} = P_D \qquad (2)$$

where,

P_{gi} : power generation of unit *i*
P_D : total load demand
Ng : number of the generation unit.

3. Inequality Constraint

The inequality constraint in economic dispatch is the minimum and maximum generation levels for each generator. This constraint can be represented mathematically in equation (3) as follows:

$$P_{gi}^{min} \le P_{gi} \le P_{gi}^{max} \qquad (3)$$

where,

P_{gi} : power generation of unit *i*
P_{gi}^{min} : minimum power generation of unit *i*
P_{gi}^{max} : maximum power generation of unit *i*.

Lambda Iteration Method

Lambda iteration algorithm is a method for solving non-linear programming problems, such as the economic dispatch problem, by iteratively updating a set of values known as multipliers or lambdas [1]. These multipliers are used to adjust the objective function of the problem to better match the constraints of the problem. Figure 2 is a flowchart of the lambda iteration method of solution for the economic dispatch problem.

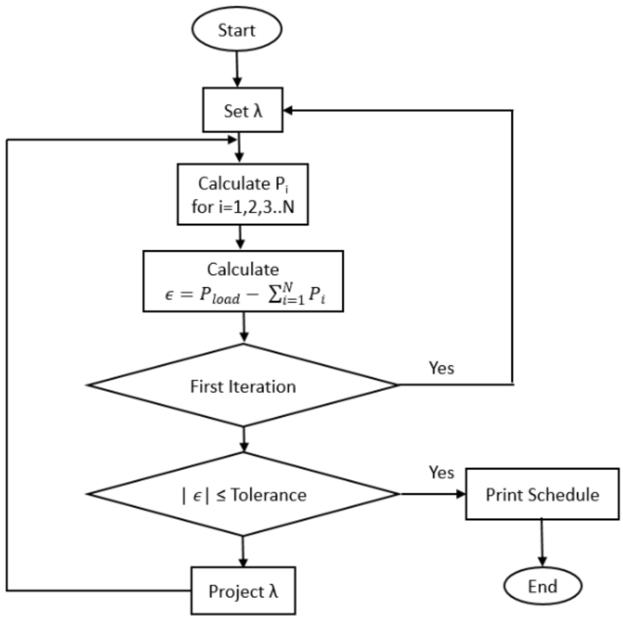

Figure 2. Lambda iteration method [1]

The algorithm begins by initializing the multipliers to some initial values, such as zero. Then, for each iteration, the algorithm performs the following steps:

1. The power generation at each generator is calculated based on the current values of the multipliers and the constraints of the problem.
2. The multipliers are updated based on the difference between the actual power generation and the target power generation for each generator.
3. The process is repeated until the difference between the actual and target power generation is below a certain tolerance level, indicating that the solution has converged.

MATLAB Web Apps

The MATLAB Web App Server enables the hosting of MATLAB applications and Simulink simulations as interactive web apps [9]. The server setup allows for the easy sharing of these apps through a three-step process, as illustrated in Figure 3.

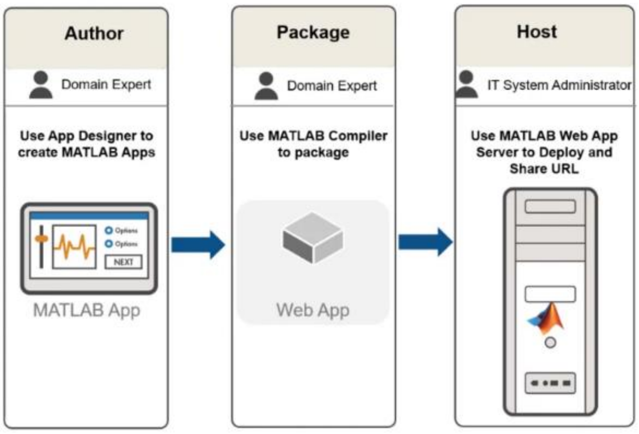

Figure 3. MATLAB Web Apps Workflow [9]

First, using App Designer, users can design professional applications within MATLAB by utilizing drag-and-drop visual components for user interface design and an integrated editor for programming component behavior. Next, the app is packaged as a web application using the MATLAB Compiler. Finally, the web app can be hosted and shared via the MATLAB Web App Server, making it accessible to anyone with the link. The MATLAB Web App Server simplifies the process of hosting and sharing MATLAB apps and Simulink simulations, eliminating the need for additional software.

Study Case

In this simulation, generation data obtained from the IEEE 30 bus system, as described in reference [10], is utilized. The system is comprised of six thermal generation units, and its generation cost function is presented in Table 1. Furthermore, the web-based application demo of the simulation is executed on a host server with MATLAB 2022a, which is equipped with an AMD Ryzen 7 Radeon RX Vega 10 Graphics, 2.3 GHz processor, and 8 GB of RAM.

Table 1. IEEE 30 bus system generation cost function

Unit	Generator Cost Function			P Min (MW)	P Max (MW)
	a	***b***	***c***		
Generator 1	0.00375	2.00	0	50	200
Generator 2	0.01750	1.75	0	20	80
Generator 3	0.06250	1.00	0	15	50
Generator 4	0.00834	3.25	0	10	35
Generator 5	0.02500	3.00	0	10	30
Generator 6	0.02500	3.00	0	12	40

III. RESULT AND DISCUSSION

Web Apps Interface

Figure 4 below shows the home page of the MATLAB web app accessed through the Chrome web browser. This page can be accessed through a configured link and can be accessed within the intranet network. Users can run the app in web browsers without having MATLAB installed on their devices.

Meanwhile, Figure 5 shows the display of the economic dispatch application using the lambda iteration method. In this application, the input data process includes data on the cost function of power generation, minimum and maximum power generation capacity, and load electricity data. Once the input data is complete, power generation optimization can be carried out by selecting the calculation button. The calculation results will then provide output data in the form of summary data and graphics, such as the optimal power generation cost, output power from each power generator, power generation cost of each power generator, and remaining power generation capacity.

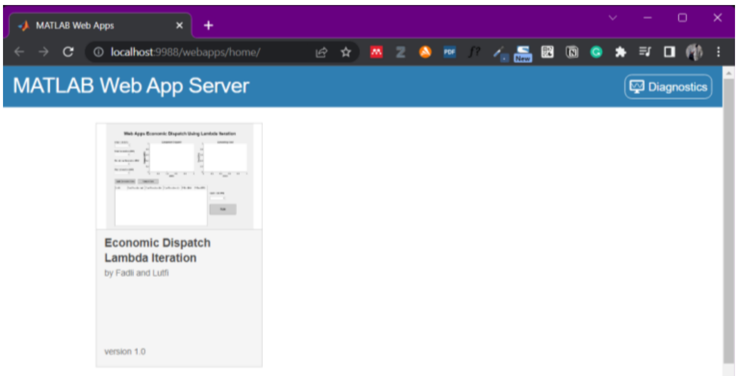

Figure 4. MATLAB web apps home screen

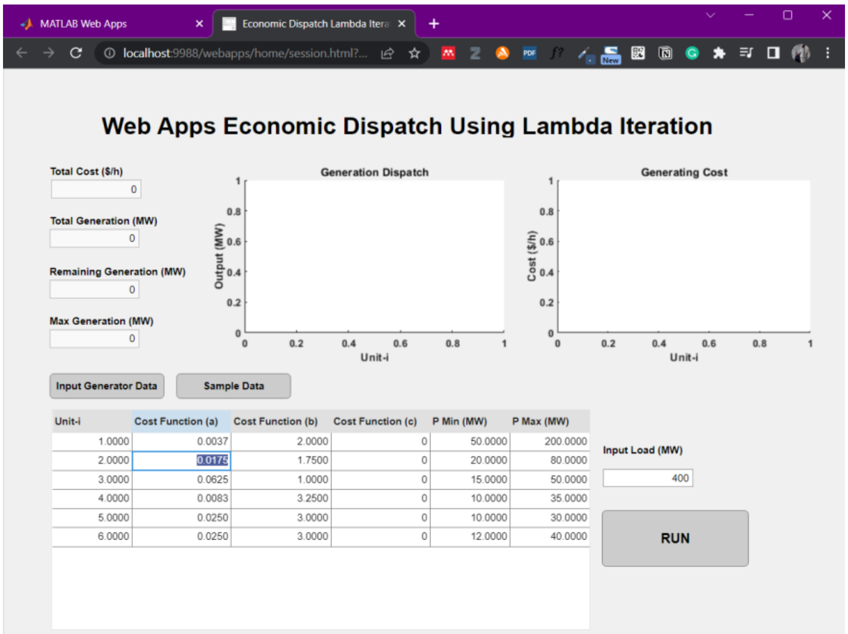

Figure 5. Web apps economic dispatch user interface

Web Apps Testing

In the testing phase of this web app, three tests were conducted with loads of 200MW, 300MW, and 400MW respectively. The results of testing with the web app can be seen in Figures 6, 7, and 8. A summary of this simulation can be found in Table 2, 3, and 4.

Based on simulation results, The results showed that the web app was effective and accurate in solving the economic dispatch problem. The web application can operate well and meet the specified specifications. The proposed web application can be used as a tool for optimizing generation dispatch in power systems. Hopefully, this web application will contribute to the efficient and cost-effective operation of power systems.

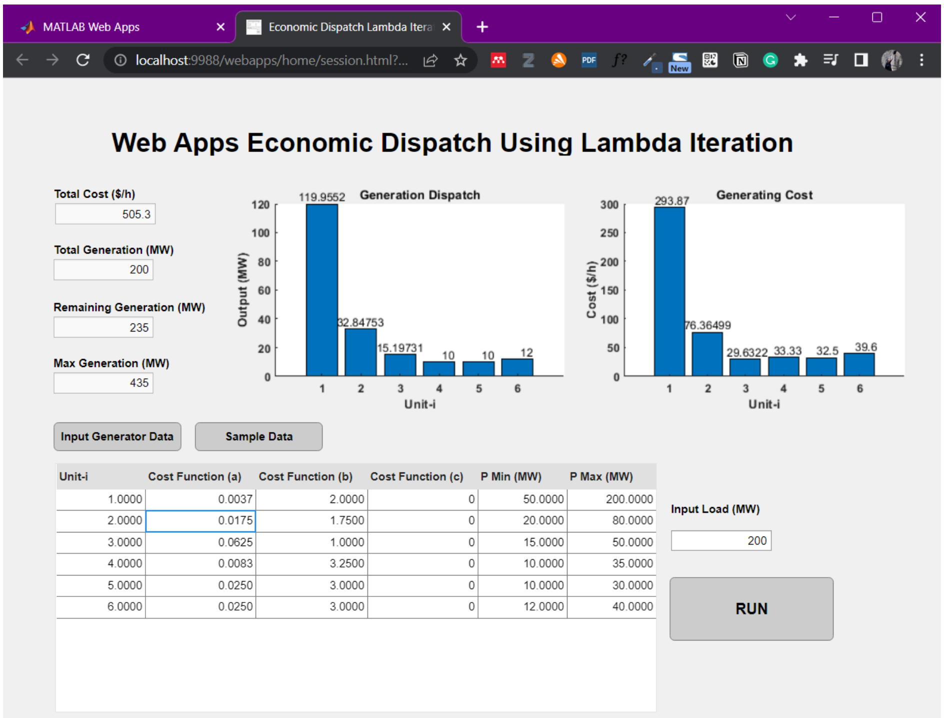

Figure 6. Web apps testing with a load of 200 MW

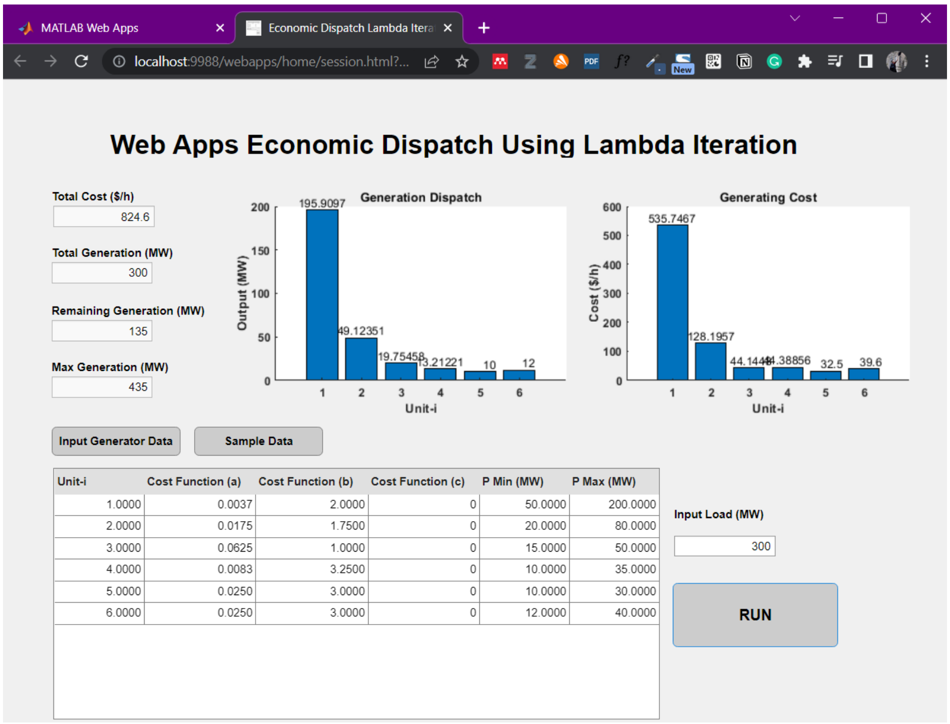

Figure 7. Web apps testing with a load of 300 MW

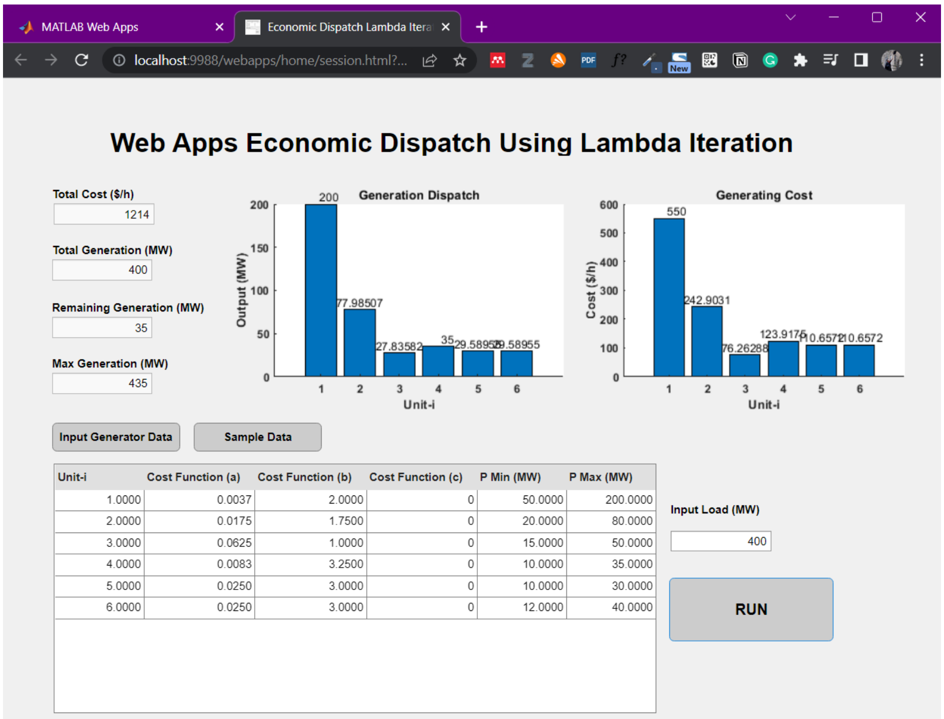

Figure 8. Web apps testing with a load of 400 MW

Table 2. Testing case 1 with a load of 200 MW

Unit	Power Output (MW)	Cost ($/h)
Generator 1	119.96	293.87
Generator 2	32.85	76.36
Generator 3	15.20	29.63
Generator 4	10.00	33.33
Generator 5	10.00	32.50
Generator 6	12.00	39.60
Total	**200.00**	**505.30**

Table 3. Testing case 1 with a load of 300 MW

Unit	Power Output (MW)	Cost ($/h)
Generator 1	195.95	535.87
Generator 2	49.13	128.22
Generator 3	19.76	44.15
Generator 4	13.17	44.23
Generator 5	10.00	32.50
Generator 6	12.00	39.60
Total	**300.00**	**824.58**

Table 4. Testing case 1 with a load of 400 MW

Unit	Power Output (MW)	Cost ($/h)
Generator 1	200.00	550.00
Generator 2	77.99	242.90
Generator 3	27.84	76.26
Generator 4	35.00	123.97
Generator 5	29.59	110.66
Generator 6	29.59	110.66
Total	**400.00**	**1214.45**

IV. CONCLUSION

Economic dispatch web application can be used as a tool for more efficient and effective economic dispatch processes. Users can run the app in web browsers without having MATLAB installed on their devices. The application can be optimized by adding more comprehensive and user-friendly features.

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