Journal of Telecommunication Control and Intelligent System (JTCIS)
Volume 1, Issue 1, 2021
DOI: 11.11111/jtcis.xxxx

Particle Swarm Optimization Algorithm Based Optimization of Steam Turbine Generator and Gas Turbine Generator at Pt. Sriwidjaja Fertilizer

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***Abstract*—Electricity needs at PT. PUSRI is currently generated by four main generating units in the form of a Gas Turbine Generator (GTG). The three power plants are PUSRI-II (2006-J), PUSRI-III (3006-J), PUSRI-IV (4006-J) each with a capacity of 21.588kVA. PUSRI-IB (5006-J) with a capacity of 26.65kVA. Each unit is operated in parallel via a 13.8 kV syncronizing bus. However, for reasons of generator efficiency at PT. PUSRI with gas costs that are quite expensive will gradually be replaced by a Steam Turbine Generator – Coal (STG-BB) generator. The contribution of this paper uses the Particle Swarm Optimization (PSO) algorithm to find the optimum output (MW) from each generating unit. The results of the PSO calculation provide a better solution performance compared to the real system with the same generated power variation, namely 34.25 (MW) to 37.63 (MW). The cost savings obtained from the comparison between the PSO method and the real output of the system is Rp. 5,180.509 at load 34.25 (MW) and Rp. 6,416.864 at 37.63(MW) load.**

Keywords— Power Generation System Optimization, bus syncronizing, Turbine Generator, Particle Swarm Optimization

I. INTRODUCTION

Economic dispatch (economic dispatch) at power plants is an important aspect in power system management, the main objective of economic dispatch is to optimize power and minimize generation costs. A small percentage of fuel cost savings has a huge impact on operating cost savings. Research on economic disoatch has been studied by previous researchers. The evolutionary simplex adaptive Hooke-Jeeves algorithm for economic load delivery problems taking into account the effect of valve point loading was investigated by Farhan Tabassum [1]. Economical microgrid delivery taking into account the uncertainty of renewable energy and demand-side response was investigated by Xu [2]. Multi-energy Microgrid Reliability Evaluation: Effect Analysis of Energy Storage Devices studied by Ge [3]. The optimization of the cuckoo search algorithm for steady-state analysis of a self-excited induction generator was investigated by Hasanien [4]. Coordinated Operation of Electric and Natural Gas Systems with Bidirectional Energy Conversion researched by Zeng [5]

Optimal Operation of Integrated Heat and Electrical Systems: McCormick's Tightening Approach researched by Deng [6]. Multi-area economic delivery with stochastic wind power using the Salp Swarm Algorithm was investigated by Chaudhary [7]. Marginal cost pricing for a competitive wholesale district heating market: A case study in the Netherlands researched by Liu [8]. The cooperative model in the electrical energy market using bi-level optimization and Shapley value was investigated by Acuña [9]. The Memetic Computing Approach for Unit Commitment with Energy Storage Systems was researched by Salvini [10]. Data mining techniques for the characterization of electric customers were investigated by Ramos [11]. A generator model for mixed linear and integer linear optimization of energy systems was investigated by Krien [12]. Evaluating rotational inertia as a component of network reliability with high penetration variable renewable energy was investigated by Johnson [13]. The general framework for the opportunity constrained optimal power flow was investigated by Mühlpfordt [14]. Optimal Load Discharge in Electric Networks with Renewable Sources through Message Passing was studied by Harrison [15].

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The generation system where fuel consumption becomes a problem and needs serious attention considering that the largest component of the operating costs of generating an electric power system is the fuel cost. A small percentage of fuel cost savings has a huge impact on operating cost savings. To produce electricity in a power system, it is necessary to find a way to keep the generator fuel consumption costs or the operating costs of the entire system to a minimum. Previous researchers have researched about fuel economy. The EU HORIZON 2020 project on hydrogen-powered fuel cell utility vehicles using metal hydrides in hydrogen refueling and storage systems was investigated by Yartys [26]. Solid fuel users' perceptions of household solid fuel use in low and middle income countries: A scoping review researched by McCarron [27]. Air pollution interventions and life-saving effects in China were studied by Zou [28]. The development of fuel cells for New Energy Vehicles (NEV) and clean air in China was investigated by Kendall [29]. Optimization of Combined Control of Cooling and Power Systems with Solid Oxide Fuel Cell Turbine Prime Drive for Building Applications was investigated by Luo [30].

The validation of the coupled 3D CFD simulation model for a cross-fired oxy-fuel glass melting furnace with an electric amplifier was investigated by Raič [31]. A Bayesian approach based on a hybrid stochastic model for long-term energy demand management was investigated by Ahmadi [32]. The study of the potential of condensing boiler technology calculating various fuels was investigated by Bălănescu [33]. The estimation of the energy saving effect of introducing a single-loop hot spring water network system utilizing hot springs was investigated by Nabeshima [34]. Transport poverty and fuel poverty in the UK: From analogy to comparison researched by Mattioli [35]. Heat recovery in the actual LNG supply chain: A heat exchange network (HEN) retrofit designed for potential fuel economy was investigated by Othman [36]. The dataset of electrical energy consumption and its conservation in the cement manufacturing industry was investigated by Verma [37]. Impact of the China-Pakistan economic corridor on Pakistan's future energy consumption and energy saving potential: Evidence from sectoral time series analysis researched by Mirza [38]. A review of the properties of recycled and waste materials for energy repair of existing buildings according to NZEB requirements was investigated by Tallini [39]. Effect of Various Deflectors on Drag Reduction for Trucks investigated by Chowdhury [40]

The adoption and efficiency of mirt stove fuel use in Dilla district, southern Ethiopia was investigated by Yayeh [41]. Two-way prediction of structural characteristics and effective thermal conductivity of composite fuels through learning from finite element simulation results was investigated by Yan [42]. A numerical study of various heating options applied to swimming pools for energy saving was investigated by Jordaan [43]. Can Technical Advances in Private Vehicle Improvement Reduce Household and Total Fuel Use? investigated by Figus [44]. Application of Intelligent Devices and Methods to Detect Dynamic and Static Human Body in School Energy Saving Control was researched by Shao [45]. The first internationally adopted approach to quantifying life cycle GHG emissions for aviation fuels was investigated by Prussi [46]. The reduction in fuel wood and its implications for cooking and household meals in the three sub-counties of Kenya was investigated by Waswa [47]. An unconventional fuel path for decarbonization of power plants in Malaysia in 2050 was investigated by Haiges [48]. The emission performance and fuel use of the improved two furnaces and the determinants of their application in Dodola, southeastern Ethiopia were investigated by Mamuye [49]. Enersave API: An Android-based power-saving framework for mobile devices researched by Muharum [50]. The economical power scheduling problem is known as the economic distribution problem. The economical scheduling of the power plant takes into account the optimal economic conditions. In addition, it must meet the technical limitations in the operation of the generator in the power system.

To obtain optimal and economical results in the economical scheduling of power plants, a method or method is needed to minimize the fuel costs needed to operate the electric power system. The Particle Swarm Optimization (PSO) method is based on the behavior of a flock of birds or fish. The PSO algorithm mimics the social behavior of these organisms. Social behavior consists of individual actions and influences from other individuals in a group. The word particle denotes, for example, a bird in a flock of birds. Each individual or particle behaves by using its own intelligence and is also influenced by the behavior of its collective group. Thus, if one particle or a bird finds a short or short path to a food source, the rest of the group will also be able to quickly follow that path even if they are far away in the group.

II. LITERATURE REVIEW

A. Electric Power System

The electric power system consists of several components, namely an electric power generator, a transmission system, and a distribution system. In operation, the electric power system consists of many generator units that work alternately, so it is necessary to select a committed unit (used) to be able to serve the load every time. Ideally, the utilization of an electric power system must pay attention to technical factors and economic factors because these affect operating costs and profits during system operation. In general, the electric power system is divided into three main parts, namely power generation, distribution of electricity, and distribution of electric power. These three parts cannot be separated because it is a complex system that works to distribute power from the generating center to the load center.

The electrical energy generated by the power plant will be channeled through the transmission line and then from the transmission line through the distribution channel and then to consumers.

1. Power Plant (power plant)

The power plant center is the first place where electrical energy is generated or generated. Here there is an initial drive turbine and also a generator that converts turbine power into electrical energy. There are several types of power generation centers which are usually divided into two major parts, namely hydro power plants (PLTA) and thermal plants (PLTU, PLTG, PLTGU, PLTD, PLTP).

2. Electric Power Transmission

Electric power transmission is the process of distributing electricity from the power generation center to the electricity distribution channel so that it will eventually reach the consumers/users of electricity.

3. Distribution System

This distribution system is an electric power sub-system that is directly related to customers/consumers and functions in terms of distribution or distribution of electric power to several places. This sub-system consists of: central control / substation, substation, medium voltage line / primary network (6 kV and 20 kV) in the form of overhead lines or underground cables, low voltage lines / secondary networks (380 V and 220 V), a voltage distribution substation consisting of voltage control panels, both medium and low voltage, and a transformer.

In general, the main objective of the operation of an electric power system is to meet the needs of the electrical load efficiently (load is met with minimum cost), taking into account the objectives of the electric power operation (the system must be able to meet the standards in environmental safety, have good reliability, and can serve requests continuously from time to time).

B. Economic Operations (economic dispatch)

What is meant by economic operation of thermal generators is the process of sharing or scheduling the total load of a system to each of its generating centers, in such a way that the total operating costs are as minimal as possible. All generating centers in a system are continuously controlled so that power generation is carried out in the most economical way.

1. Input-Output Characteristics of Thermal Generators

The input-output characteristics of a thermal generator are characteristics that describe the relationship between fuel input (liters/hour) and the output produced by the generator (MW). In general, the input-output characteristics of thermal generators are based on:

$$H_i(P_i) = \alpha_i + \beta_i P_i + \gamma_i p_i^2 \tag{1}$$

where H_i is the $i-th$ thermal generator fuel input (liter/hour), P_i is the $i-th$ thermal generator output (MW), and $\alpha_i\beta_i\gamma_i$ is $i-th$ thermal generator input-output constant. Determination of parameters $\alpha_i\beta_i\gamma_i$ requires data related to fuel input H_i, and generator output P_i.

The input-output characteristics of the thermal unit in an ideal form are shown in Figure 1 as a continuous non-linear curve. The figure shows that the input from the generator is shown on the vertical axis, namely the heat energy needed in the form of Mbtu/h (million of btu per hour) because the British Temperature Unit is used (if using SI it becomes MJ/h or Kcal/H) which can be expressed as the total cost per hour (Rp/hour). The output of the generator is shown on the horizontal axis, namely electrical power which has limits in the form of maximum power and minimum power of the generator.

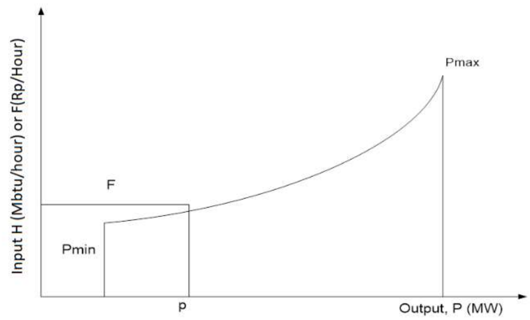

Fig. 1. Thermal Generation Unit Input-Output Characteristics

2. Heat-Rate Characteristics

The heat-rate characteristic shown in Figure 2 is a characteristic that indicates the efficiency of a system. The figure shows that the heat-rate characteristics of a generating unit indicate the heat input given to produce energy of 1 kW hour at the MW output of a unit. This heat rate characteristic shows the system work of the thermal generating system such as steam conditions, heat temperature, condenser pressure, and the overall water flow cycle. The curve shows that good efficiency lies at its maximum limit.

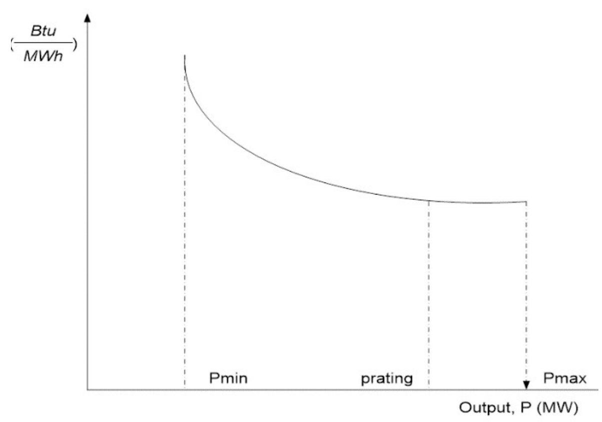

Fig. 2. Thermal Generation Unit Input-Output Characteristics

C. Basic Concepts of Particle Swarm Optimization (PSO)

Particle Swarm Optimization (PSO) is a population-based stochastic technique inspired by the social behavior of bird flocking or fish schooling. PSO technique was proposed by Russell C. Eberhart and James Kennedy in 1995. Together with ant Colony Optimization (ACO), PSO is classified into metaheuristic optimization of Swarm Intelligence (SI) in which socio-psychological principles that affect social behavior of living things are adopted. The PSO algorithm has the advantage of simple parameter settings so it is often used in solving optimization problems with a large solution space. In real conditions, the number of power plants in an electrical system consists of many units with different specifications and variants and there are many limitations in their operation.

There are several parameters in the PSO algorithm that can affect its performance. For certain optimization problems, multiple parameters and parameter selection have a large impact on the efficiency of the PSO method.

Swarm size

The swarm size or population size is the number of n particles in the swarm. A large flock will result in a larger share of the search space. The size of the selected swarm or population depends on the problem at hand.

Pbest (personal best)

Is the best individual position of a particle that is prepared to get the best solution.

Gbest (global best)

It is the best position among all the best positions (Pbest) that has been obtained by each individual.

Number of iterations

The number of iterations to get the best results also depends on the problem. Too low a number of iterations can stop the search process prematurely, while too large an iteration has the consequence of unnecessary additional computational complexity and more time required.

speed component.

The velocity component is very important to update the particle velocity. There are three terms of particle velocity, namely:

The term v_{ij}^{t} is called the inertial component which provides memory of the previous flight direction which means movement in the near future. This component is the momentum that prevents drastic changes in the direction of the particles and bias towards the direction of the current. The formula used in general to determine the directional velocity of particle movement is

$$0,5 * P_{max} - P_{min} * 1 \tag{2}$$

The term $c_1 r_{1j}^{t}\left[P_{best,i}^{t} - x_{ij}^{t}\right]$ is called the cognitive component that measures the performance of particle i. These components look like individual memories of the best positions for the particles.

$$Pos_{par}(t) - (p - \frac{\sum p}{np} \tag{3}$$

The effect of the cognitive component represents the individual's tendency to repeat a position that is better than the previous one.

The term $c_2 r_{2j}^{t}\left[G_{best} - x_{ij}^{t}\right]$ for Gbest PSO or $c_2 r_{2j}^{t}\left[L_{best,i} - x_{ij}^{t}\right]$ for Pbest PSO is called the social component that measures the performance of particle i relative to a group of particles

$$\begin{aligned} V_{par} = w * V_{par} + c1 * r1 * \left(P_{best} - pos_{par}\right) \\ + c2 * r2\left(G_{best} - pos_{par}\right) \end{aligned}$$

$$pos_{par(t+1)} = pos_{par}(t) + Vpar \tag{4}$$

The effect of the social component is that each particle flies at a controlled speed towards the best position found by the particle environment,

Acceleration Coefficient

In general the values for the acceleration coefficients c_1 and $c_2 = 2.0$. However, the value of the acceleration coefficient can be determined independently which is used in different studies, usually the values of c_1 and c_2 are the same and are in the range from 0 to 4.

Inertia Weight

The change in velocity in the PSO algorithm consists of three parts, namely, the social part, the cognitive part and the momentum part. These three parts determine the balance between global and local browsing capabilities, and therefore can provide good performance on PSO. The inertia weight parameter is combined with the social part in the standard PSO algorithm. The dynamic equation of PSO with inertia weight (w) is modified to be:

$$v_{id} = wV_{id} + c_1 rand_1(P_{id} - X_{id}) + c_2 rand_2(P_{gd} - X_{id}) \tag{5}$$

and

$$X_{id} = X_{id} + V_{id} \tag{6}$$

Both of the above equations are the same except for the addition of a new parameter, namely inertia weight (w). Inertia weight was introduced to strike a balance between global and local traceability. In general, the inertia weight (w) parameter is obtained using the following equation:

$$w = w_{max} - \frac{w_{max} - w_{min}}{Iter_{max}} Iter \tag{7}$$

with $w_{max} - w_{min}$ is start and end weight, $Iter_{max}$ is maximum number of iterations, dan ID is the number of iterations

A large inertia weight can make it easier for global searches while a small inertia weight makes it easier for local searches. The use of inertia weights can improve performance in some applications, some studies have shown that when using inertia weights the maximum velocity factor can be simple set with values in the dynamic range of each variable usually between 0.4 to 0.9.

III. METHOD

A. Time and Place of Research

This research was conducted starting from May 2018 which is located at PT. PUSRI Palembang.

B. Flowchart Diagrams

The research flow chart is shown in Figure 3. The figure shows that a literature study is needed to know about the PSO algorithm, economic dispatch. Input data in the form of loading data for each generator, the heart rate curve for each generator, the unit power limit for each generator, and data on fuel costs. Perform the initial generation calculation of a number of particles and determine the initial random velocity. Fitness evaluation of each particle based on its position. Determine the particle with the best fitness. Perform calculations to obtain optimum generator loading. Compare the results with the real system.

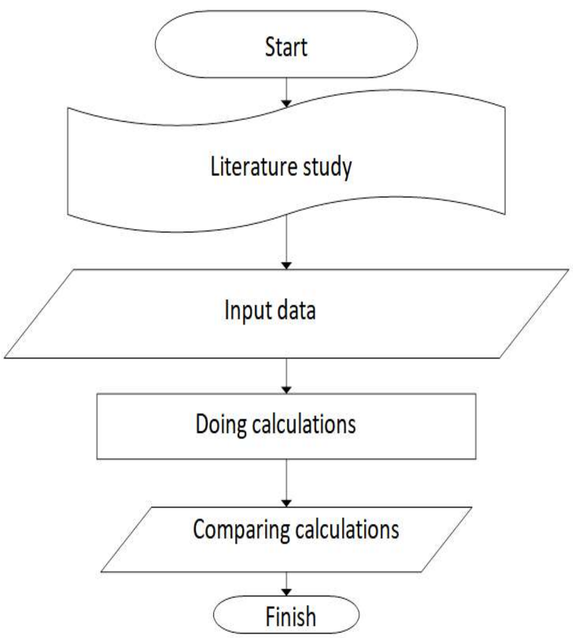

Fig. 3. Calculation flow chart

IV. RESULTS AND DISCUSSION

From the results of the calculations carried out, the optimization results for the five power plants using the PSO method are shown in table 1. The table shows that there are five power plants that are optimized using PSO, namely P-IB, P-II, P-III, P-IV, and STG-BB. From the table, it can be seen that five experiments were carried out for each generator.

TABLE I. TOTAL PSO METHOD GENERATION (MW)

P-IB	P-II	P-III	P-IV	STG-BB	Total load
7,9065	3,1309	3,1309	3,1309	16,9505	34,25
8,3924	3,6175	3,6175	3,6175	17,4350	36,68
8,4484	3,6735	3,6735	3,6735	17,4908	36,96
8,5024	3,7276	3,7276	3,7276	17,5446	37,23
8,5824	3,8077	3,8077	3,8077	17,6244	37,63

In the same way, but only 4 GTG pusri operating. The total generation for the real system is shown in table 2. The table shows that there are four power plants namely STG-BB, P-II, P-III, P-IV. Each generator was tested five times.

TABLE II. TOTAL REAL SYSTEM GENERATION(MW)

STG-BB	P-II	P-III	P-IV	Total load
11,2252	7,6749	7,6749	7,6749	34,25
12,0216	8,2194	8,2194	8,2194	36,68
12,1135	8,2822	8,2822	8,2822	36,96
12,2018	8,3427	8,3427	8,3427	37,23
12,3329	8,4323	8,4323	8,4323	37,63

Meanwhile, the total cost of generation using the PSO method and the real system is shown in table 3. The table shows that the higher the load, the higher the total cost. The total cost by optimizing the generator is cheaper than the total cost that does not use an optimization algorithm.

TABLE III. TOTAL PSO METHOD GENERATION COSTS AND SYSTEM REAL GENERATION

Total load (MW)	Optimize PSO (Rp/hour)	Real system (Rp/ hour)
34,25	21,318,678	27,735,542
36,68	23,164,415	28,344,924
36,96	23,371,718	28,682,718
37,23	23,570,566	29,014,169
37,63	23,863,258	29,565,607

Meanwhile, the total cost savings between the PSO method and the real system are shown in table 4.

TABLE IV. TOTAL SAVINGS OF PSO METHOD AND REAL SYSTEM

Total load (MW)	Real system (Rp/hour)	PSO Method (Rp/hour)	Total savings (Rp/hour)
34,25	27,735,542	21,318,678	6,416,864
36,68	28,344,924	23,164,415	5,180,509
36,96	28,682,718	23,371,718	5,311,112
37,23	29,014,169	23,570,566	5,443,602
37,63	29,565,607	23,863,258	5,702,348

The graph of the comparison of cost savings between the PSO method and the real system is shown in Figure 4. The figure shows that the PSO is shown in blue and the real system is shown in pink. By implementing the Particle Swarm Optimization (PSO) method to calculate generator optimization (economic dispatch), the results of the generation as shown in table 1. For the total cost of generation using the PT. PUSRI PSO method can be seen in table 3. The results of the calculation of the generation cost of the PSO method are then compared with the real data of the PT.PUSRI generation system which can be seen in Figure 4. The results of the PSO calculation provide a better solution performance compared to the real system with the same generated power variation of 34.25(MW) to 37.63(MW). The cost savings obtained from the comparison between the PSO method and the real system can be seen in table 5. The PSO method can save costs of Rp. 5,180,509 up to Rp. 6,416,864 at a load of 34.25(MW) to 37.63(MW).

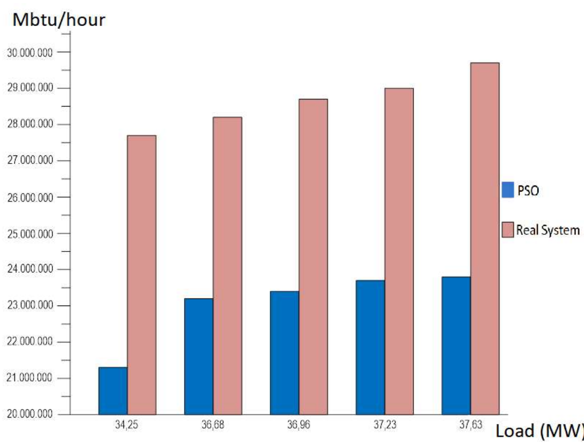

Fig. 4. Example of a figure caption. (*figure caption*)

V. CONCLUSION

Based on the calculations and analyzes that have been carried out, it can be concluded that the Particle Swarm Optimization (PSO) method can be used to solve the economic dispatch problem of optimal loading on the PT. PUSRI Palembang power plant unit. From the calculation results, the PSO optimization method shows better performance for economic dispatch optimization problems at PT. PUSRI Palembang. This can be seen from the results of the comparison with the real PT. PUSRI generation system. The cost savings obtained from the comparison between the PSO method and the real system is Rp. 5,180,509 up to Rp. 6,416,864 at loading 34.25(MW) to 37.63(MW).

REFERENCES

[1] M. Farhan Tabassum, M. Saeed, N. Ahmad Chaudhry, J. Ali, M. Farman, and S. Akram, “Evolutionary simplex adaptive Hooke-Jeeves algorithm for economic load dispatch problem considering valve point loading effects,” Ain Shams Eng. J., vol. 12, no. 1, pp. 1001–1015, Mar. 2021.

[2] H. Xu, Z. Meng, and Y. Wang, “Economic dispatching of microgrid considering renewable energy uncertainty and demand side response,” Energy Reports, vol. 6, pp. 196–204, Dec. 2020.

[3] S. Ge, H. Sun, H. Liu, J. Li, X. Zhang, and Y. Cao, “Reliability Evaluation of Multi-energy Microgrids: Energy Storage Devices Effects Analysis,” Energy Procedia, vol. 158, pp. 4453–4458, Feb. 2019.

[4] H. M. Hasanien and G. M. Hashem, “A cuckoo search algorithm optimizer for steady-state analysis of self-excited induction generator,” Ain Shams Eng. J., vol. 9, no. 4, pp. 2549–2555, Dec. 2018.

[5] Q. Zeng, B. Zhang, J. Fang, and Z. Chen, “Coordinated Operation of the Electricity and Natural Gas Systems with Bi-directional Energy Conversion,” Energy Procedia, vol. 105, pp. 492–497, May 2017.

[6] L. Deng, H. Sun, B. Li, Y. Sun, T. Yang, and X. Zhang, “Optimal Operation of Integrated Heat and Electricity Systems: A Tightening McCormick Approach,” Engineering, no. xxxx, Jun. 2021.

[7] V. Chaudhary, H. M. Dubey, M. Pandit, and J. C. Bansal, “Multi-area economic dispatch with stochastic wind power using Salp Swarm Algorithm,” Array, vol. 8, no. September, p. 100044, Dec. 2020.

[8] W. Liu, D. Klip, W. Zappa, S. Jelles, G. J. Kramer, and M. van den Broek, “The marginal-cost pricing for a competitive wholesale district heating market: A case study in the Netherlands,” Energy, vol. 189, p. 116367, Dec. 2019.

[9] L. G. Acuña, D. R. Ríos, C. P. Arboleda, and E. G. Ponzón, “Cooperation model in the electricity energy market using bi-level optimization and Shapley value,” Oper. Res. Perspect., vol. 5, no. June, pp. 161–168, 2018.

[10] C. Salvini and S. Monacchia, “A Memetic Computing Approach for Unit Commitment with Energy Storage Systems,” Energy Procedia, vol. 107, no. September 2016, pp. 377–382, Feb. 2017.

[11] S. Ramos et al., “Data mining techniques for electricity customer characterization,” Procedia Comput. Sci., vol. 186, pp. 475–488, 2021.

[12] U. Krien, P. Schönfeldt, J. Launer, S. Hilpert, C. Kaldemeyer, and G. Pleßmann, “oemof.solph—A model generator for linear and mixed-integer linear optimisation of energy systems,” Softw. Impacts, vol. 6, no. August, p. 100028, Nov. 2020.

[13] S. C. Johnson, D. J. Papageorgiou, D. S. Mallapragada, T. A. Deetjen, J. D. Rhodes, and M. E. Webber, “Evaluating rotational inertia as a component of grid reliability with high penetrations of variable renewable energy,” Energy, vol. 180, pp. 258–271, Aug. 2019.

[14] T. Mühlpfordt, T. Faulwasser, and V. Hagenmeyer, “A generalized framework for chance-constrained optimal power flow,” Sustain. Energy, Grids Networks, vol. 16, pp. 231–242, Dec. 2018.

[15] E. Harrison, D. Saad, and K. Y. M. Wong, “Optimal Load Shedding in Electricity Grids with Renewable Sources via Message Passing,” Energy Procedia, vol. 107, no. September 2016, pp. 101–108, Feb. 2017.

[16] F. Sun, R. Li, Y. Han, S. Liu, F. Liu, and H. Liu, “The IES dynamic time-scale scheduling strategy based on multiple load forecasting errors,” Glob. Energy Interconnect., vol. 4, no. 1, pp. 58–68, Feb. 2021.

[17] X. Wang, Q. Zhao, and Y. Wang, “An asynchronous distributed optimization method for energy saving of parallel-connected pumps in HVAC systems,” Results Control Optim., vol. 1, no. September, p. 100001, Dec. 2020.

[18] S. Guo, Y. Mu, H. Jia, N. Chen, T. Pu, and X. Yuan, “Optimization of AC / DC Hybrid Distributed Energy System with Power Electronic Transformer,” Energy Procedia, vol. 158, pp. 6687–6692, Feb. 2019.

[19] M. Sun, F. Teng, I. Konstantelos, and G. Strbac, “An objective-based scenario selection method for transmission network expansion

planning with multivariate stochasticity in load and renewable energy sources," Energy, vol. 145, pp. 871–885, Feb. 2018.

[20] M. Hogan, "Follow the missing money: Ensuring reliability at least cost to consumers in the transition to a low-carbon power system," Electr. J., vol. 30, no. 1, pp. 55–61, Jan. 2017.

[21] C. Li, Y. Yang, Z. Wang, N. Wang, L. Wang, and Z. Yang, "Energy hub-based optimal planning for integrated energy systems considering part-load characteristics and synergistic effect of equipment," Glob. Energy Interconnect., vol. 4, no. 2, pp. 169–183, Apr. 2021.

[22] M. Stüber and L. Odersky, "Uncertainty modeling with the open source framework urbs," Energy Strateg. Rev., vol. 29, no. November 2019, p. 100486, May 2020.

[23] J. Johnston, R. Henriquez-Auba, B. Maluenda, and M. Fripp, "Switch 2.0: A modern platform for planning high-renewable power systems," SoftwareX, vol. 10, p. 100251, Jul. 2019.

[24] U. Yüzgeç and M. Eser, "Chaotic based differential evolution algorithm for optimization of baker's yeast drying process," Egypt. Informatics J., vol. 19, no. 3, pp. 151–163, Nov. 2018.

[25] X. Jin, J. Wu, Y. Mu, M. Wang, X. Xu, and H. Jia, "Hierarchical microgrid energy management in an office building," Appl. Energy, vol. 208, no. July, pp. 480–494, Dec. 2017.

[26] V. A. Yartys et al., "HYDRIDE4MOBILITY: An EU HORIZON 2020 project on hydrogen powered fuel cell utility vehicles using metal hydrides in hydrogen storage and refuelling systems," Int. J. Hydrogen Energy, no. xxxx, pp. 1–14, Feb. 2021.

[27] A. McCarron et al., "Solid fuel users' perceptions of household solid fuel use in low- and middle-income countries: A scoping review," Environ. Int., vol. 143, no. March, p. 105991, Oct. 2020.

[28] B. Zou et al., "Air pollution intervention and life-saving effect in China," Environ. Int., vol. 125, no. 932, pp. 529–541, Apr. 2019.

[29] M. Kendall, "Fuel cell development for New Energy Vehicles (NEVs) and clean air in China," Prog. Nat. Sci. Mater. Int., vol. 28, no. 2, pp. 113–120, Apr. 2018.

[30] X. J. Luo and K. F. Fong, "Control Optimization of Combined Cooling and Power System with Prime Mover of Solid Oxide Fuel Cell-gas Turbine for Building Application," Energy Procedia, vol. 105, pp. 1883–1888, May 2017.

[31] J. Raič et al., "Validation of a coupled 3D CFD simulation model for an oxy-fuel cross-fired glass melting furnace with electric boosting," Appl. Therm. Eng., vol. 195, no. March, p. 117166, Aug. 2021.

[32] S. Ahmadi, A. hossien Fakehi, A. Vakili, M. Haddadi, and S. H. Iranmanesh, "A hybrid stochastic model based Bayesian approach for long term energy demand managements," Energy Strateg. Rev., vol. 28, p. 100462, Mar. 2020.

[33] D.-T. Bălănescu and V.-M. Homutescu, "Study on condensing boiler technology potential accounting various fuels," Procedia Manuf., vol. 32, pp. 504–512, 2019.

[34] M. Nabeshima, N. Koh, M. Nakao, and M. Mike, "Estimation of the energy-saving effect of introducing a heat source water network system with single-loop piping utilizing hot spring heat," Energy Procedia, vol. 149, pp. 519–528, Sep. 2018.

[35] G. Mattioli, K. Lucas, and G. Marsden, "Transport poverty and fuel poverty in the UK: From analogy to comparison," Transp. Policy, vol. 59, no. July, pp. 93–105, Oct. 2017.

[36] A. Othman, F. Almomani, E. I. Al-musleh, Z. Bouabidi, M. A. Katebah, and M. M. Hussein, "Heat recovery in an actual LNG supply chain: Retrofitting of designed heat exchange networks (HENs) for potential fuel saving," Chem. Eng. Process. - Process Intensif., vol. 166, no. March, p. 108477, Sep. 2021.

[37] Y. Verma, B. Mazumdar, and P. Ghosh, "Dataset on the electrical energy consumption and its conservation in the cement manufacturing industry," Data Br., vol. 28, p. 104967, Feb. 2020.

[38] F. M. Mirza, N. Fatima, and K. Ullah, "Impact of China-Pakistan economic corridor on Pakistan's future energy consumption and energy saving potential: Evidence from sectoral time series analysis," Energy Strateg. Rev., vol. 25, no. October 2018, pp. 34–46, Aug. 2019.

[39] A. Tallini and L. Cedola, "A review of the properties of recycled and waste materials for energy refurbishment of existing buildings towards the requirements of NZEB," Energy Procedia, vol. 148, no. Ati, pp. 868–875, Aug. 2018.

[40] H. Chowdhury, B. Loganathan, I. Mustary, H. Moria, and F. Alam, "Effect of Various Deflectors on Drag Reduction for Trucks," Energy Procedia, vol. 110, no. December 2016, pp. 561–566, Mar. 2017.

[41] T. Yayeh, A. Guadie, and S. Gatew, "Adoption and fuel use efficiency of mirt stove in Dilla district, southern Ethiopia," Clean. Eng. Technol., vol. 4, p. 100207, Oct. 2021.

[42] B. Yan et al., "Bi-directional prediction of structural characteristics and effective thermal conductivities of composite fuels through learning from finite element simulation results," Mater. Des., vol. 189, p. 108483, Apr. 2020.

[43] M. Jordaan and R. Narayanan, "A numerical study on various heating options applied to swimming pool for energy saving," Energy Procedia, vol. 160, no. 2018, pp. 131–138, Feb. 2019.

[44] G. Figus, J. K. Swales, and K. Turner, "Can Private Vehicle-augmenting Technical Progress Reduce Household and Total Fuel Use?," Ecol. Econ., vol. 146, no. May 2017, pp. 136–147, Apr. 2018.

[45] L. Shao, Z. Yang, and W. Zhang, "The Application of Intelligent Device and Method for Detecting Dynamic and Static Human Body in Energy-Saving Control of Schools," Procedia Eng., vol. 205, pp. 4017–4021, 2017.

[46] M. Prussi et al., "CORSIA: The first internationally adopted approach to calculate life-cycle GHG emissions for aviation fuels," Renew. Sustain. Energy Rev., vol. 150, no. August, p. 111398, Oct. 2021.

[47] F. Waswa, M. Mcharo, and M. Mworia, "Declining wood fuel and implications for household cooking and diets in tigania Sub-county Kenya," Sci. African, vol. 8, p. e00417, Jul. 2020.

[48] R. Haiges, Y. D. Wang, A. Ghoshray, and A. P. Roskilly, "Unconventional fuel pathways for decarbonizing the electrical power generation in Malaysia by 2050," Energy Procedia, vol. 158, pp. 4238–4245, Feb. 2019.

[49] F. Mamuye, B. Lemma, and T. Woldeamanuel, "Emissions and fuel use performance of two improved stoves and determinants of their adoption in Dodola, southeastern Ethiopia," Sustain. Environ. Res., vol. 28, no. 1, pp. 32–38, Jan. 2018.

[50] A. M. Muharum, V. T. Joyejob, V. Hurbungs, and Y. Beeharry, "Enersave API: Android-based power-saving framework for mobile devices," Futur. Comput. Informatics J., vol. 2, no. 1, pp. 48–64, Jun. 2017.