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# Solution of Combined Heat and Power Economic Dispatch Problem Using Direct Optimization Algorithm

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**ABSTRACT :** Combined Heat and Power (CHP), also known as cogeneration, is a highly efficient method of generating electricity and useful heat simultaneously from a single fuel source. This process involves capturing and utilizing waste heat produced during electricity generation, which would otherwise be wasted in conventional power plants. CHP systems can be deployed across various sectors, including industrial, commercial, and residential, offering significant energy savings, reduced greenhouse gas emissions, and enhanced energy resilience. The integration of CHP technologies into energy systems contributes to the transition towards more sustainable and resilient energy infrastructure worldwide. This abstract provides an overview of the key principles and benefits of Combined Heat and Power systems

**KEYWORDS**: Economic Dispatch, Lagrange Multiplier Algorithm, Combined Heat and Power, Constraints and Objective Functions, Optimal Dispatch

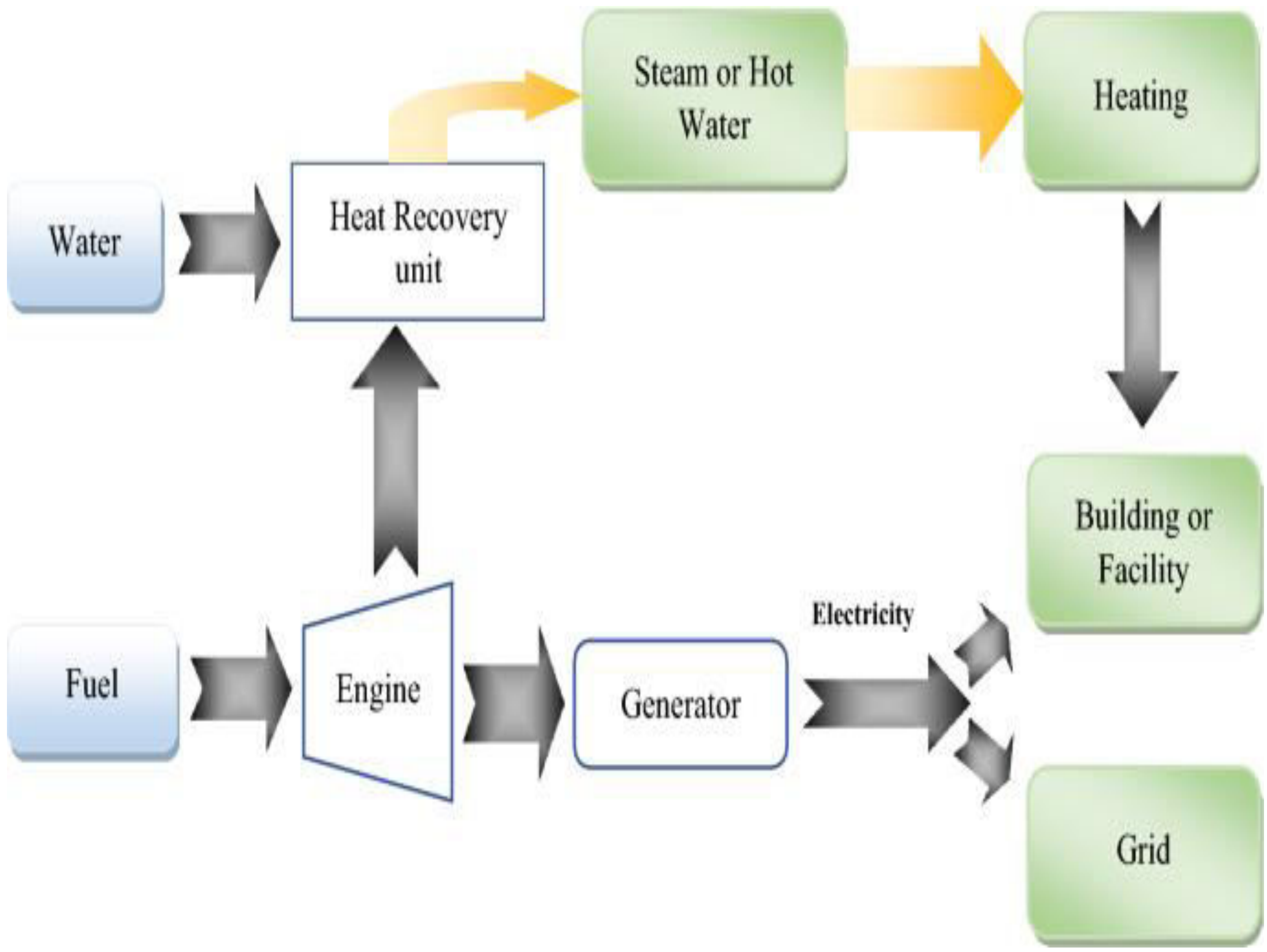
## I. INTRODUCTION

Combined Heat and Power (CHP), also known as cogeneration, is a transformative approach to energy production that maximizes efficiency by simultaneously generating electricity and capturing waste heat for various heating, cooling, or industrial processes. Unlike conventional power generation, which typically discards a significant portion of heat produced during electricity generation, CHP systems harness this thermal energy, resulting in substantially higher overall energy efficiency. This introduction provides an overview of the fundamental principles, advantages, and applications of CHP, highlighting its potential to revolutionize energy generation and contribute to sustainability and energy resilience goals. Combined Heat and Power (CHP), also known as cogeneration, is a highly efficient method of generating electricity and useful heat simultaneously from a single fuel source. This process involves capturing and utilizing waste heat produced during electricity generation, which would otherwise be wasted in conventional power plants

## II. BRIEF LITERATURE REVIEW

Combined Heat and Power (CHP) systems simultaneously generate electricity and useful heat from a single fuel source, typically natural gas, biomass, or waste heat CHP systems offer higher efficiency compared to conventional separate production of heat and power, as they capture and utilize waste heat that would otherwise be wasted Optimization Techniques for CHP Systems Traditional optimization techniques for CHP systems include mathematical programming, genetic algorithms, and particle swarm optimization Direct optimization algorithms, such as model predictive control (MPC) and dynamic programming, offer advantages in real-time optimization and control of CHP systems. Despite the advantages of direct optimization algorithms, challenges remain in implementing these techniques in real world applications, including computational complexity, model accuracy, and system integration Future research directions may focus on developing advanced optimization algorithms, incorporating uncertainty analysis

**BLOCK DIAGRAM**




**Combined Heat and Power Economic Dispatch Problem Formulation**

The CHPED problems are constrained optimization problems, which consists of decision variables i.e. (heat, power dispatch values) and objective function. The objective function indicates how much each decision variables contributes to the value of the function (cost) to be optimized in the problem statement and its duty is to minimize the total generation cost in a system that consists of the conventional thermal power and heat units plus the cogeneration unit with feasible operation region. The two power units, a cogeneration unit and a heat-only unit in the research have quadratic cost functions. The limit on the outputs of the cogeneration unit is specified by listing the co-ordinates of the corners of the feasible operating region of the unit as shown in Table 4. The objective function also represents the input fuel cost while the constraints are inequality, equality and other operational constraints that matches load and heat demands with power generation. In this research, the system transmission losses were neglected leaving power and heat loads plus the machine operation bound as the only available constraints. The research first shows that it is possible to solve CHPED problem using direct method [1]. Furthermore, artificial bee colony, genetic, particle swarm optimization and differential evolution algorithms can also be employed to this class of optimization problem and results from the various algorithms were compared to determine the algorithm with optimal result and best operational costs. Firstly, we developed a formula for the system lambdas which correspond to the power and heat demands in terms of the coefficients of the generator cost functions for the most common form of this problem formulated assuming that

**Numerical Result from Direct Solution (Lagrange Multiplier) Technique**

| Corners | $(p_1, q_1)$ | $(p_2, q_2)$ | $(p_3, q_3)$ | $(p_4, q_4)$ | |
|---|---|---|---|---|---|
| Unit 3 | | (20, 0.1) | (200, 0.5) | (195, 120) | (15, 110) |

**Table** . Coordinate of the corners of the feasible region of the co-generation unit

| | Lagrange Multiplier Algorithm |
|---|---|
| $P_1$ (MWth) | 173.0654 |
| $P_2$ (MWth) | 186.9926 |
| $P_3$ (MWth) | 141.931 |
| $Q_3$ (MWth) | 195.6136 |
| $Q_4$ (MWth) | 104.3884 |
| Cost (₦) | 18336 |

## III. CONCLUSION

In proposing a new algorithm for the solution of the CHP dispatch problem, this research has explored a novel formula derived for calculating the optimum marginal costs (λ-s) corresponding with a specified heat and power demand. The optimum λ-s obtained using the formula gives the final dispatch if none of the units violates their limits. On the other hand, in case of violations, this step facilitates the identification of the violating units. The final dispatch is obtained by recalculating the λ-s, considering only the non-violating units when all the violating units are identified and set at their limits. The effectiveness of the proposed algorithm has been demonstrated by considering a 4-unit test system. The performance of the new algorithm has been critically assessed in comparison with the artificial bee colony algorithm in order to highlight its merits. The formulation of the CHP dispatch problem considered here conforms to the prevailing practice of using quadratic cost functions for the units. The possibility of extending the proposed solution scheme for cases where the cost functions are not quadratic is currently being explored.

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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