Economic Dispatch Problem Considering Integrated Natural Gas System

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Abstract – **In recent years, electricity generation using natural gas has been increased by considering the electric network and natural gas system as a single energy system, the economic operation of the system can be determined. This paper presents a solution to economic dispatch problem by considering the natural gas system. This solution is developed based on lambda iteration method. The approach is tested on a three unit generation systems. The results show that the economic dispatch solution can be obtained by integrating the natural gas system.**

Index Terms - Natural gas systems; economic dispatch

I. INTRODUCTION

The integration of electricity and natural gas has grown considerately in the last decade as an effect of combined cycle thermal power plants. It has been a main factor in the overall growth of natural gas usage in many countries [1]. Anticipated by the numbers of unexplored natural gas reserves, the usage of natural gas should be more widely because of its low environmental impact and its economic competitiveness compared with other fossil fuels [2].

When the gas and electric network are in the same authority, the optimization of this combined networks operation considered as the economic advantages compared to the optimization of the two networks separately. In natural gas plants, the fuel cost can be divided into two parts which are the cost of production and cost of transportation [3]. The gas transportation is conducted using gas pipeline systems that have common characteristic of the electricity transmission network. Gas transportation cost depends on the consumer in the gas network and topology of the pipeline network.

Based on the natural gas and electric networks that have been studied thoroughly by Gedra, Qing Li and Seungwon An, they suggested a technique to solve natural gas load flow problems using the electric load flow technique. They also presenting a combined natural gas and electricity optimal power flow [4]. Ohishi and Mello proposed an integrated dispatch model of a gas power flow and natural gas supply system where a set of natural gas power plants considered by the model supplied by a gas pipelines network. The objective of this model is to reduce the cost power generation and natural gas production subject to system requirements [5]. While for Wiedman, Fu and Shahidepour, they included the core of the natural gas infrastructure for supplying gas-fired units which are increasing in numbers in their studies. They also discuss about using the security constrained unit commitment to examine the impacts of natural gas price on power generation scheduling [6].

The main objective of this project is to reduce the total operation cost while fulfilling the constraints of both natural gas and electric system and to satisfy the demand.

II. PROBLEM FORMULATION

Electric and gas networks are interconnected at gas fired generation stations. The characteristics of the power plant can be used to relate the two networks. The economic dispatch's objective is to minimize the operation cost, which is expressed as:

$$Min \sum_{i=1}^{n} F_i(p_i) + \sum_{j}^{m} c \, . \, \tau_j \tag{1}$$

Subjected to:

(a) Power balance

$$\sum_{i=1}^{n} P_i = P_D \tag{2}$$

(b) Unit limits

$$P_{imin} \leq p_i \leq P_{imax} \tag{3}$$

Where:
$F_i(p_i)$: generator fuel cost function
τ_j : the amount of gas used by each compressor
c : gas price
m : numbers of compressors
n : numbers of gas-fired power plant
P_{imin} : the minimum generating limit
P_{imax} : the maximum generating limit

$$F_T = \sum_{i=1}^{n} F_i$$
$$= \sum_{i=1}^{n} a_i + b_i P_{i+} c_i P^2{}_i \qquad (4)$$

Where:
a, b ,c : compressor coefficients

III. METHODOLOGY

The proposed solution to solve economic dispatch problem considering integrated natural gas system is developed using MATLAB. The steps taken in solving the problems can be described as shown in flowchart of Figure 1.

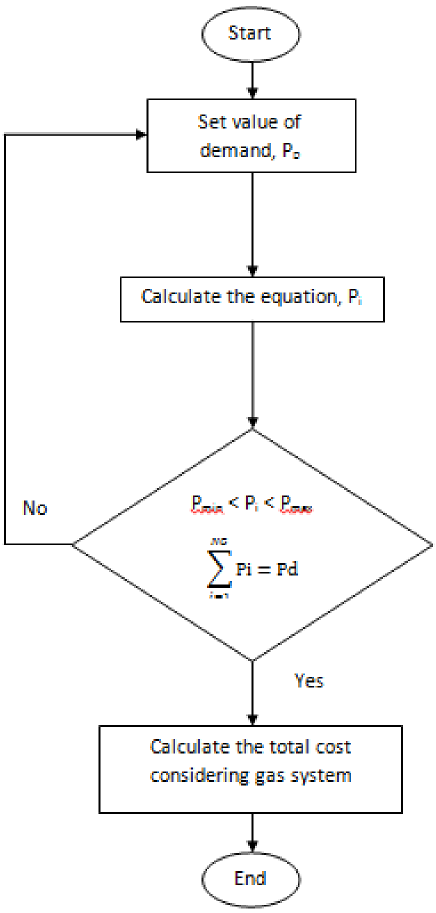

Fig. 1: Flowchart of the project

IV. RESULT AND DISCUSSION

In this study, a three generating unit systems are used as the case study. The generation data is given below [7].

Gas-fired plant:

$P_G = 200 + 5.8P_T + 0.009P_T^2$ MBtu/h
$100 \leq P_T \leq 225$

Generation of remaining units:

$P_1 = 500 + 5.3P_1 + 0.004P_1^2$ MBtu/h
$200 \leq P_1 \leq 450$
$P_2 = 400 + 5.5P_2 + 0.006P_2^2$ MBtu/h
$150 \leq P_2 \leq 350$

Table 1 show the result of the dispatch and generation cost for the system with the gas constraint based on the power demand.

Table 1: Total generation cost with gas constraints

Demand (MBtu)	**Total cost ($/h)**
500	7465.00
600	8740.67
700	10118.25
800	11561.67
900	13070.90
1000	14727.47

Table 2 show the comparison between the cost when the natural gas is or not considered.

Table 2: Comparison between cost with gas constraint and cost without gas constraint

Total cost with gas constraint (MBtu/h)	**Total cost without gas constraint (MBtu/h)**
7465.00	7175.00
8740.67	8430.48
10118.25	9752.40
11561.67	11137.50
13070.90	12585.75
14727.47	14122.50

The result obtained for this study shows that the solution is able to meet the demand while satisfying the constraint of the electric and natural gas system. Comparing the cost when the gas constraint is ignored, it is noted that that the cost is higher as shown in Table 2.

V. CONCLUSION

In this study, the proposed technique can be used to solve economic dispatch problem considering integrated natural gas system. The cost of the integrated system can be lower if the system is properly scheduled.

VI. RECOMMENDATION

Future recommendation that could be considered for this project is to consider more constraints of thermal and natural gas system.

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