The Robustness of Natural Gas Energy Supply: System Dynamics Modelling

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ABSTRACT

This article describes how affordability, acceptability, and reliability of energy supply are three important concerns for government. Due to the crude oil restrictions and its environmental impacts, a replacement of other energy sources has become more important in recent years. Natural gas is one of the replacements as a cleaner source with a more suitable calorific value than oil in comparison with other renewable energy sources. Therefore, utilization of natural gas as the main source of replacement strategies in the energy system has accelerated at the national level. However, the natural gas energy system is a complex system including different influencing and influenced variables that affect social and economic factors. This research has developed a system dynamics model to understand the complexity of the natural gas energy systems at the macro-level. The model shows the effective sub-systems of energy system with their related variables. It helps to predict the effective factors of an energy supply system based on statistics approaches. After that, three scenarios are defined based on expert opinions and the behaviors of the sub-systems in each scenario is analyzed. The approach also helps to understand unknown consequences of a decision or scenario in the energy system.

KEYWORDS

Energy System, Natural Gas, Policy Implementation, Robustness, Scenario Planning

1. INTRODUCTION

Energy is a strategic commodity for societies. Due to increasing population and economic growth rate, the use of energy resources especially oil, gas, and water is rising. On the other hand, there exists prominent falling in the reserves of these resources. On the other hand, unfair distribution of these resources has made some countries as energy importer and exporter. Regarding these issues, energy security becomes more important (Kruyt et al., 2009) (Gholizad et al., 2017). Although countries have used renewables to reduce their dependency on fossil fuels, they have not yet decreased the strategic position of oil and other fossil fuels. Nonetheless, natural gas has a special position through other fossil fuels (Shahtemuri et al., 2016) (Khodayari and Aslani, 2018). Regarding natural gas positive aspects, it has a low price, and the technology related to conversion and transmission has developed widely in the world (Choen et al., 2011). At first, an analysis of supply system is needed to introduce natural gas behavior; however, the analysis shows that energy systems have complexities. One of the tools to analyze is system dynamics. The main target of this approach is learning how to analyze a supply system easily and rapidly. Unknown consequences of a decision or scenario are another aim

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as well. In this study, a system dynamics model is presented to analyze energy system in the natural gas sector. In this analyzed model, macro considerations on trends, supply, and energy demand, especially for natural gas, are reviewed. The desirable development scenarios are obtained in Iran as the case study. Iran stands the fourth regarding oil resources and is the first in case of natural gas in all over the world (British Petroleum, 2014). Iran’s energy system is highly dependent on oil and natural gas (Aslani et al., 2012). Further, more than 98% of energy supply consisted of oil and natural gas in 2012 which about 54% related to the natural gas. Besides, over 60% of electricity production in this country emerge from natural gas (IEA, 2014). Therefore, gas resources have a strategic role in the energy system of Iran.

First, the literature on energy supply and natural gas role is reviewed. Then, the energy system challenges and the need for system analysis are explained. Then, an overview of the case study is considered. System dynamics is introduced and the model is presented. Finally, the system dynamics model is simulated in the mentioned case study.

2. PROBLEM FORMULATION

Currently, fossil fuels (oil, gas, and coal) are the most important resources in the world. In 2012, about 86.5% of all supplied energy related to fossil fuels. According to IEA, total energy production and imports were 18609 million tons in 2012. Thus, 6497, 1137, 3712, 4746 million tons related to crude oil, oil products, natural gas, and coal respectively. Also, 14% of total supplied energy related to hydro, biomass, waste, and renewable energies (IEA, 2014).

Natural gas is kind of fossil fuel formed over millions of years. Methane is also called to this material composed of one carbon and four hydrogens. Today, natural gas has many uses in domestic, commercial, industrial and transportation. Natural gas industry in the United States began to boom in early 1900 and is progressing up to now (Kidney et al., 2011). Energy policy in today’s world is introduced in three general principles including supply security, social sustainability of supply, and the environment. While natural gas as an alternative energy source is cleaner, safer and cheaper than other fossil fuels, could well meet these goals (Frota, et al. 2010).

According to British Petroleum (2013), Iran has the largest proven gas reserves in the world. Proven reserves are said kind of reserves that have been discovered and are technically exploitable (British Petroleum, 2014). This amount was increased about 200 milliard m³ in comparison to the last year and comprised 18.2% of world’s gas reserves. While unconventional gas reserves have not yet been estimated exactly. After Iran, Russia has proven reserves of 31.3 trillion cubic meters, ranked second, equal to 16.8% of total proven reserves in the world. Figure 1 is shown 10 countries regarding natural gas reserves (British Petroleum, 2014).

![Figure 1. Natural gas reserves in 10 countries (2013) (British Petroleum, 2014)](image-url)
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