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# A system dynamic model for production and consumption policy in Iran oil and gas sector

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ABSTRACT

A system dynamic model is presented, which considers the feedback between supply and demand and oil revenue of the existing system in Iran considering different sectors of the economy. Also the export of the oil surplus and the injection of the gas surplus into the oil reservoirs are seen in the model by establishing a balance between supply and demand. In this model the counter-effects and existing system feedbacks between supply and demand and oil revenue can be seen considering different sectors of the economy. As a result, the effects of oil and gas policies in different scenarios for different sectors of Iran's economy together with the counter-effects of energy consumption and oil revenue are examined. Three scenarios, which show the worst, base and ideal cases, are considered to find future trends of major variables such as seasonal gas consumption in power plants, seasonal injected gas in oil reservoirs, economic growth in the industrial sector, oil consumption in the transportation sector, industrial gas consumption and exported gas. For example, it is shown that the exported gas will reach between 500 and 620 million cubic-meter per day in different scenarios and export revenues can reach up to $500 billion by 2025.



## 1. Introduction

Iran owns the second largest oil and gas reservoir in the world. Iran is also the fourth largest producer and consumer of gas and the fourth largest producer and exporter of oil in the world.

A strong dependency has been created between the oil and gas sectors and the economic growth in the country during the hundred years of oil production and the forty years of development of gas consumption network. Oil revenue is also the biggest provider of the government's budget and the growth of all sectors of the economy directly and indirectly is effected by petro-dollars (Central Bank of Iran Report, 2009).

The original idea to use system dynamic models in energy discussions came to existence by Naill (1973) who developed a model for United States gas industry. Sterman (1981) also developed a system dynamic model with mutual relationship between energy and economy in his doctorate thesis.

The other works done in this field were mainly based on Nail and Sterman's efforts. For example New Zealand's dynamic energy model by Bodger and May (1992) and the model for discovery and extraction in India by Chowdhury and Shau (1992). Recently, Chi et al. (2009) developed the system dynamic model for gas industry in England in the year 2008.

Numerous elements have caused the nature and structure of the relationships in our energy sector to be different from other countries. For example Pandey (2002) has mentioned some of the characteristics of some developing countries that should be taken into account when modeling energy policies. Another study was carried out by Urban et al. (2007) on modeling of Energy systems for developing countries. They have indicated how to improve energy models for increasing their suitability for developing countries and have given advice on modeling techniques and data requirements.

The structural difference in Iran's energy sector is different from the industrialized countries that most energy models have been developed for. In Iran the causal relationships that Chi et al. (2009), Naill (1973) and Sterman (1981) have seen in their models have some major differences for countries like Iran. For example, the energy price for consumers is not a function of production costs or the rate of exploration and oil production is not a function of global oil price but is according to OPEC's share. Therefore the energy model for Iran must be developed based on particular relationships that exist in this country and the relationships and dynamism available in the country must be used as the base for developing an energy model based on the system dynamics simulation method (Sterman, 2000). The system dynamics model can establish the necessary causal relations and their feedbacks

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that specifically show the case for Iran, which will be discussed in Section 3 in brief but within the limits of this paper.

Some of the specifications of Iran that makes the energy relationships structure different from industrial countries are as follows:

1- Governmental management of oil and gas production and its particular decisions and policies.
2- Low energy prices and very high energy intensity and the existence of illogical and uneconomical relation in consumption because of low energy prices.
3- Lack of technical and financial abilities for developing the oil and gas production due to political sanctions, difficulties caused by war, etc.
4- Existence of huge undeveloped resources and the slow development of the resources regardless of their final production capacity.
5- A high potential for oil and gas export in the future with the realization that there is a limit on these resources in the world.
6- Existence of high potential for energy conservation and possibility of decrease in domestic consumption due to the high amount of waste in various stages of oil and gas consumption since long ago, which has been continued to the present.
7- Very low final production costs of oil and gas in comparison to other countries and the possibility of competition with low world oil prices.
8- High effectiveness of oil revenue on the economy and the effects of oil revenue on investments in oil and gas productions.

Knowing the above facts, there are some weaknesses and strengths that affect the energy sector of Iran. Major policies should go towards demand side management and optimal production strategies.

The relationship framework and priorities used in the model are based on major policies to increase the productivity in the country. Based on this fact, gas consumption has been prioritized as follows:

1- Domestic consumption.
2- Injection into the oil reservoirs in order to increase oil production.
3- Gas and LNG export.

Oil production is based on the country's share in OPEC and OPEC's share of oil production is related to global demand. The policy to substitute oil consumption by gas in different sectors depends on the trend in gas production and the peak demand in the cold season of the country.

The policies defined in this model can be considered in the following groups:

- How to increase the productivity of energy in different sectors of economy and decrease the energy intensities of these sectors.
- How to introduce policies related to improving the efficiency of production, refining and distribution of oil, gas and electricity.
- Policies to introduce nuclear energy, hydroelectric power, decrease the associated flare gas.

In this model the counter-effects and existing system feedbacks between supply and demand and oil revenue can be seen considering different sectors of the economy. As a result, the effects of oil and gas policies in different scenarios for different sectors of Iran's economy together with the counter-effects of energy consumption and oil revenue are examined. Three scenarios, which show the worst, base and ideal cases, are considered to find future trends of major variables such as seasonal gas consumption in power plants, seasonal injected gas in oil reservoirs, economic growth in the industrial sector, oil consumption in the transportation sector, industrial gas consumption and exported gas. The authors are trying to show the evolution of those variables that accept the most effects from "today's policies", as well as others such as gas exports that on the contrary are not very much affected by policy making.

This paper is supposed to reflect mostly future gas trends, but as oil and gas are much related to each other, both are seen in the model. The paper is organized as follows. The model assumption is introduced in Section 2. In Section 3 the model's main negative and positive feedback loops are explained. In Section 4 the dynamic behavior of the model and its validation are presented. In Section 5 the results of alternative scenarios analysis are introduced and Section 6 discusses the major conclusions from the model.

## 2. Model assumptions

In this model it is assumed that the trend of increase in oil and gas production will not be much affected by technology innovation and it is assumed that the existing technology will only be used for possible development of oil and gas resources. Also domestic energy prices and its effect on consumption are not seen in the model, because energy price has always been introduced by the government and is not a function of final production costs. So decrease in energy consumption is assumed to be encouraged by policies that can be divided to price and non-price policies. Also certain measures, such as substitution of oil by gas and low gas price relative to oil together with high level of availability of gas wherever there is gas network, result in higher energy intensity and energy consumption. Although this effect has been seen in the model with energy intensity parameter as a whole, its effect has not been seen according to the energy carriers. Thus, in this model, the rate of fossil energy consumption in different sectors of economy has been figured out without considering the effect of change in energy intensity of each energy carrier.

The proven relationships obtained from the former patterns in energy consumption are the basis for future predictions and the possibility of changes in the components of the consumption structure has not been seen. Therefore, these predictions are based on the current energy structure and the continuation of present conditions in the country. Of course, it is possible that the result obtained from the model could change the executive managers and decision-maker's perception towards correcting the current structure and creating new structures and relationships.

The possibility of importing energy in the future has not been applied in the model either, and the assumption is that the rate of production will always be more than the domestic consumption, which with the current conditions it is a logical assumption (at least for the next 20 years' forecast seen in the model).

## 3. Explanation of the main causal loops of the model

In the developed model, there are numerous causal loops inside the energy sector and also linked with the economy sector. Some of the main loops are explained here and ultimately a model that includes all major relationship of causal effects is presented.