



# An assessment of Iran's natural gas potential for transition toward low-carbon economy



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## ABSTRACT

To mitigate climate change, low-carbon economy is introduced as a sustainable development strategy. Natural gas, as an alternative to pollutant fuels such as coal, which is now widely used, could facilitate global transition to the age of renewable energy. Iran is one of the major emitters of CO<sub>2</sub> in the world, and it is thus, crucial to move toward low-carbon economy in order to accomplish its commitment in reducing GHG emissions. This study evaluates Iran's natural gas industry development by reviewing reserves, production and consumption, infrastructures as well as natural gas agreements. The total proven natural gas reserves of Iran is estimated 33500 bcm by the end of 2015, where more than 60% of them are offshore. There exists 23 active fields in Iran and the largest of which is South Pars gas reservoirs in the Persian Gulf. The gross production of natural gas was 257623 million cubic meters in 2015 of which 80% was marketed. The current state of Iran's natural gas industry is assessed as an acceptable level due to massive reserves, high production capacity, wide transmission and distribution network and high penetration of natural gas in cities and villages. That is why natural gas has the highest contribution in the national energy mix, resulting in replacing petroleum fuels with natural gas to decrease CO<sub>2</sub> emissions. However, in recent years, delays in implementing development projects of the natural gas industry made supplying domestic demand difficult during cold seasons. Furthermore, it negatively influenced the nation's gas export potential. Iran's natural gas industry faces some challenges including growing domestic demand, high energy losses in residential and commercial sectors and low efficiency of energy systems in industrial and power generation sectors. If challenges are solved, natural gas could serve as a bridge for transition toward the low-carbon future of Iran.

## 1. Introduction

Industrialization in a country has significant effects on production and labor patterns, urbanization, lifestyle and family structure. Social-economic development because of industrialization is linked to growth in primary energy supply. Therefore, exploitation of sustainable and reliable energy resources is essential to maintain the growing economy and social development.

According to statistical data from the International Energy Agency (IEA), the total primary energy supply of the world rose from 10,359 Million tons of oil equivalent (Mtoe) in 2002 to 13,699 Mtoe in 2014. The share of various energy sources in the world primary energy supply in 2014 was oil, 31.3%; coal (including peat and oil shale), 28.6%; natural gas, 21.2%; bio fuels, 10.3%; nuclear, 4.8%; hydro, 2.4% and other sources (including solar, wind, geothermal), 1.4% [1].

However, increase in global energy consumption is generally associated with enhanced social welfare. Nevertheless, countries still lack sustainable development. Destruction of vegetation, depletion of

the ozone layer, melted glaciers and raised sea levels are consequences of global warming. Increasing social awareness about perilous consequences of climate change led to international treaties promoting reduction of greenhouse gas emissions. In order to respect countries' sovereignty in climate change agreements, selection of approaches to achieve GHG emission reduction targets are assigned to governments. This option led governments to different accomplishments in reducing GHG emissions, among them adopting various energy policies [2,3].

Since the early 90s, by the end of the Iran-Iraq war and beginning of the reconstruction of damaged areas and infrastructures, economic and industrial development efforts were accelerated. The growing energy demand resulting from development was obtained through increased exploitation of oil and gas fields.

In 1990, Iran's total final energy consumption was 402.2 Million barrels of oil equivalent (Mboe), which increased up to 687.8 Mboe in 2000, showing 71% energy growth within one decade [4]. The increasing social concerns about environmental degradation and emissions of hazardous pollutants resulting from consumption of oil

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products as energy carrier in power plants, industries, households and commercial sectors on the one hand, and discovery and utilization of South Pars gas-condensate field (the largest natural gas field in the world), on the other hand, convinced the Iranian government to accelerate implementing the oil products substitution policy with natural gas since early 2000 s. This political decision is included in sustainable energy development policies. As long as natural gas emits fewer greenhouse gasses, comparing other fossil fuels, substituting natural gas for coal and oil may be a more sustainable solution [5].

In Section 2, this research briefly studies Iran's energy policy (i.e. substituting natural gas for petroleum fuels). Then, it reviews the current state of Iran's gas industry development including reserves, production, consumption, infrastructures, as well as distribution networks and trade (Section 3). Carbon dioxide emissions in Iran and the role of power generation and reduction strategies are presented in Section 4. Finally, Section 5 presents the conclusion to our study.

## 2. Iran's energy transition toward low-carbon economy

Energy is a key factor in efforts for achieving sustainable development [6]. Global efforts in reducing greenhouse gas emissions and protecting the environment led governments to revise their energy policies and to consider deploying renewable and sustainable energies. Among sustainable energy development strategies, substituting fossil fuels with alternative renewable energy sources is of great significance [7]. However, there are many financial, technical, political, legal, social and environmental obstacles in the way of developing renewable energy [8]. According to the BP Energy Outlook report, it is predicted that by 2035, fossil fuels still provide the majority of the world's energy demand; though, it predicts reduction in oil and coal consumption. Generally, in the next twenty years, the energy mix shifts toward low-carbon fuels due to increased ratio of renewables and natural gas. It is expected that approximately one-third of increased energy demand be met by oil and coal, one-third by natural gas, and the remaining one-third by non-fossil fuels [9].

Given the obstacles to renewables development, transition from the fossil fuels age to renewable energies signals a long path ahead. The question raised here is what shall be done to energy supply in the transition age. Natural gas, as the cleanest fuel among all known fossil fuels so far, is assigned a unique place for supplying major global energy demands in the upcoming decades. It is considered a bridge for transition from fossil fuels to renewable energy. Economic, technical, and environmental advantages of natural gas comparing to other fuels led to its emphasized significance as a critical energy source. World natural gas consumption in 1984 and 2014 was 1588.5 Billion cubic meters (bcm) and 3393 bcm, respectively, indicating that world consumption has almost doubled over the past two decades [10].

Energy transition in a country is referred to a phase in which one energy carrier that is dominant in one period gradually decreases its share in the national energy mix due to development of a new energy source and finally is replaced by the new energy source [11–14]. Transition occurred because of the shift toward energy sources that are technically, economically and socially more efficient and high quality. Energy density, efficiency and conversion cost, GHG emissions, storage, financial risks, transportation convenience and human health risks are the determinant indicators of energy carrier desirability [13,15]. The socio-psychological factors may have a considerable effect on the acceptance of an energy source during energy transition in a country [16–18]. Gralla et al. (2017) examined energy transition in countries using nuclear energy. They investigated the development indicators including socio-economic, technological and environmental factors to determine that whether nuclear energy is a technological answer to global challenges like climate change [19].

Natural gas plays a critical role in Iran's energy transition toward low-carbon economy due to petroleum and petroleum products replacement policy with natural gas, which started two decades ago.

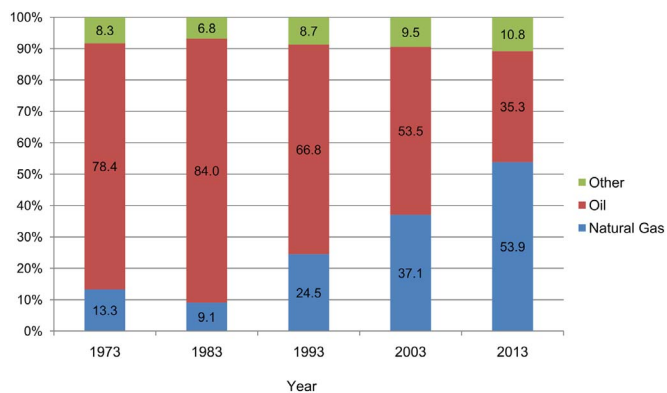


Fig. 1. Percentages of oil and natural gas in Iran's total final energy consumption. (source of data: [4,23]).

Considering economic, environmental and technical advantages such as massive gas reserves in Iranian territory, fewer CO<sub>2</sub> emissions and air pollution, higher efficiency of power generation technologies from natural gas, added revenues through exporting petroleum products compared to domestic usage has resulted in the preference of natural gas for domestic consumption over other primary energy sources.

Understanding the national energy transition requires analyzing energy consumption's long-term data [11]. The percentages of oil and natural gas in total final energy consumption (TFEC) for Iran from 1973 to 2013 are illustrated in Fig. 1. The share of natural gas has been constantly increasing since beginning of the 90s up to the present. In 2013, natural gas, constituting over 50% of national energy mix, turned into the main energy carrier demonstrating the Iranian government's achievement in implementing sustainable energy development policies.

## 3. Development of the natural gas industry

Since 1908 when the first oil well was discovered in the city of Masjed Soleyman, large volumes of associated gas was flared and lost due to the long distance between production and consumption sites as well as high investment costs and low natural gas consumption that was limited to southern areas of Iran. However, subsequent to increase in the number of exploited oil wells, utilizing natural gas was considered for supplying organizational households' energy demand in areas such as Masjed Soleyman, Aghajari and Abadan. Therefore, besides the main operations of production, transportation and refining of petroleum in southern areas, limited activities were performed for supplying and processing natural gas by agent firms.

A first, in Iran, only extracted petroleum was used; however, large volumes of associated gas were also produced. The produced gas was mainly flared from 1910 to 1960s. In early 1960s, the extracted gas was exported to the Soviet Union in exchange for constructing a steel manufacturing plant contract in Iran. At the same time, associated petroleum gas was commercialized for the first time, through transfer to the cement factory in Shiraz. Then, gas delivery to other cities gradually started. National Iranian Oil Company (NIOC) was responsible for the natural gas industry until independent gas fields were discovered. By discovering independent gas fields like Kangan and Pars, it was essential to establish a firm with differentiated responsibilities from NIOC. National Iranian Gas Company (NIGC) was founded in March 1966. Now, NIGC is one of the four large subsidiary companies of Iran's Ministry of Petroleum [21]. The President of Iran is the president of the General Assembly and the responsible Minister chairs the board.

Substituting natural gas for oil products requires development of the gas industry and its associated infrastructures. Therefore, as the share of domestic natural gas consumption increases and according to the national development outlook, the natural gas industry has always benefited from relevant growth in production, processing and dehy-

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