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Improving gas transmission networks operation using simulation algorithms: Case study of the National Iranian Gas Network

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ABSTRACT

Pipeline networks transmit gas between the source of natural gas and customers. The high cost of transportation is a challenge that must be addressed to decrease costs. Optimizing transmission operations can decrease energy consumption in compressor stations of the network. Considering significant fuel consumption in network, the present study examined common methods of optimizing fuel consumption in gas transmission networks and then simulated a simple network model using Simone simulation software. The theoretical effects of the methods were then applied to the National Iranian Gas Network, which currently transfers gas using 65 compressor stations and 33,000 km of high pressure pipeline. The methods studied were: use of maximum and balanced capacity of pipelines; adjusting the optimum inlet pressure at city inlets, industries and power plants; use of appropriate connections to assist gas transportation flow and decrease compressor load; and selecting appropriate numbers of in-service compressors to handle the volume of gas transferred. Results indicate that substantial cost savings can be realized from the decrease in gas consumption of turbo-compressors that will also postpone overhaul time by decreasing the hours of operation.

1. Introduction

Natural gas is becoming one of the most widely used sources of energy in the world due to it's low price and environmental friendly characteristics.

Based on latest BP review, Iran, Russia and Qatar hold around half of the worlds proved gas reservoirs (British Petroleum, 2014). Estimations indicate that Iran owns 16.8% of global gas reservoirs which is the largest one.

Usually the location of natural gas resources and the place where the gas needed for various applications are far apart. In order to overcome the problem of long distance two common ways are widely suggested: The application of pipeline networks and Liquefied Natural Gas (LNG). As reported in Ibrahim et al. (2000), short distances gas transportation by pipelines is more economical than LNG transportation. In this work pipeline networks are chosen.

Most gas reserves are located in the southern portions of Iran, with the exception of Khangiran field in northeastern Iran and several small fields in central and western Iran. The National Iranian Gas Company yearly transmits 170 billion m^3 of natural gas from gas plants in southern Iran to consumers across the country using 33,000 km of pipeline and 65 gas stations housing 233 turbo-compressor units. The main sources of consumption are:

- Residences, retail businesses, and small industry
- Power plants
- Large industry
- Injection into oil reservoirs or gas storage
- Export.

Fig. 1 shows that most gas is used in residences, retail businesses, and small industry (>50%). Large industry and power plants are the next largest users.

Residences, retail businesses, and small industry show different patterns of usage than the other consumers. For example, consumption increases from 110 MMSCMD in summer to 450 MMSCMD in winter in response to the need for heating. By contrast, peak consumption for power plants is in summer, when power is needed for cooling systems; consumption by power plants

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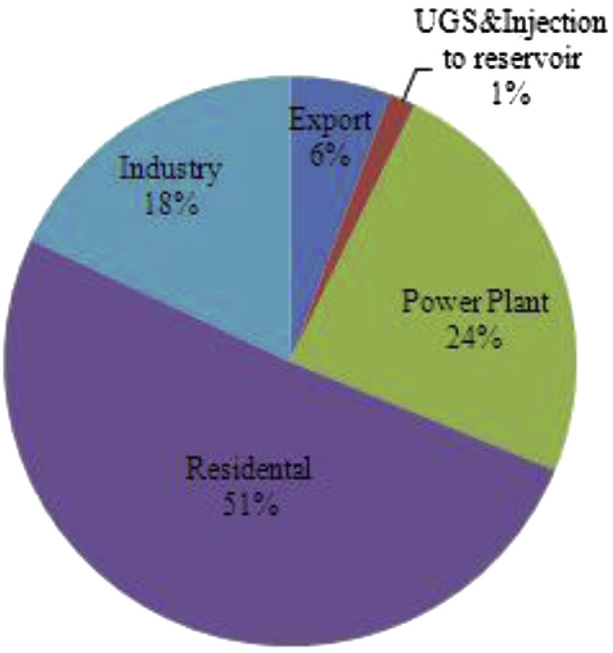

Fig. 1. Gas distribution in 2012.

decreases in winter. There is less fluctuation for other consumers by season, since there is no dependence on temperature. Fluctuation in residential consumption is shown in Fig. 2.

2. Energy conservation programs

The increasing number of natural gas consumers across the country requires construction and expansion of the gas transmission network. The complex system of high-pressure pipelines spanning the country requires compressor facilities to be installed at intervals to prevent drops in pressure. This extensive equipment uses a lot of energy.

It is estimated that 3–5% of the gas transported is consumed by the compressors in order to compensate for the lost pressure of the gas (Borraz-Sánchez and Rios-Mercado, 2005; Wu et al., 2000). This is actually a huge amount of gas especially for the network transmitting large volume of gas. Investigation on various pipeline network indicated that the overall operating cost of the system is highly dependent upon the operating cost of compressor stations which represents between 25% and 50% of the total company's operating budget (Rios-Mercado et al., 2006).

Energy subsidies are gradually being phased out at all levels of industry in line with government policies. This will require large industry, such as the National Iranian Gas Company, to implement energy conservation programs to conserve fuel and reduce costs. Decreasing fuel and power consumption requires optimal network performance, but methods of increasing efficiency must consider network limitations to prevent disruptions in the transmission and distribution of gas. If the capacity of the network is factored into its construction and expansion, it must be based on accommodating the maximum supply required for cold weather. This means that, although the system will not run at capacity for about 8 months of the year, it must be ready to meet the critical demand of heating residences and businesses during winter. This provides an opportunity to develop an effective energy conservation program.

2.1. Constraints and guidelines for energy conservation

The main network constraints for the expansion and energy conservation project are:

- To provide adequate pressure at delivery points
- Ability to meet maximum gas demand
- Maximum gas production at resource points
- Maintain compressor stations under peak operational conditions

When it is confirmed that no conflict exists between the project and the limitations, research must determine project efficiency to decrease energy consumption. Two methods exist to increase the overall efficiency of the networks. The first is to install equipment for optimization (hardware solutions). The second is to provide management scenarios (software solutions).

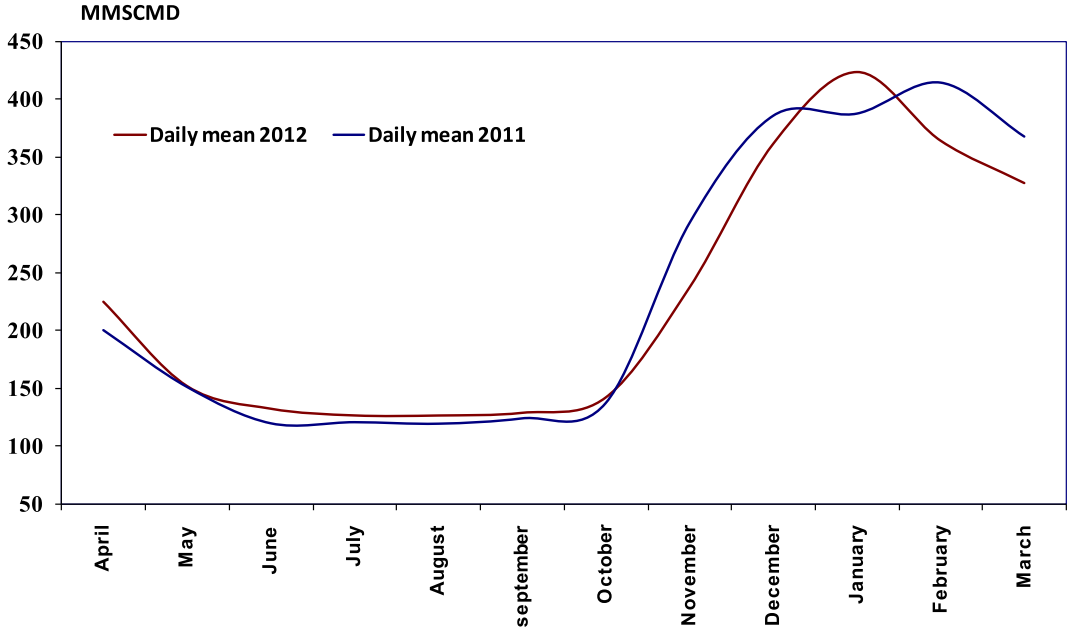

Fig. 2. Fluctuation in residential consumption.