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How does a natural gas supply interruption affect the EU gas security? A Monte Carlo simulation

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ABSTRACT

Nowadays, the European natural gas production has declined having, as a consequence, increased import dependence, which is estimated to reach 85% by 2030. Therefore, the implementation of a European energy policy, towards the viability, competitiveness and security of energy supply, is more than essential. Necessary parameter for the elaboration of such a policy is the diversification of natural gas supply sources and corridors, in order to eliminate growing dependences. Moreover, the recent cases of natural gas supply interruptions to the EU, due to international geopolitical conflicts, further underline the above, indicating the necessity towards an assessment of the potential impact that a natural gas supply disruption would cause to the European natural gas security. To this end and, given the political uprising in the area of North Africa, main objective of this paper is to investigate how a natural gas supply interruption from Algeria, the EU's third largest supplier, would affect the European natural gas security, in terms of natural gas demand satisfaction. Monte Carlo simulation was applied, producing results on the more affected countries and underlining the importance of supplies diversification, reserves and production, when applicable, towards the enhancement of natural gas security.

Contents

1. Introduction

Security of energy supply is of crucial importance to the European Union, as the EU has declared that security of supply constitutes one of the three main pillars in its energy policy [1]. Especially, as regards natural gas supply, the increased EU import dependence has been highlighted several times, adding a greater impetus in the development of viable alternatives to petroleum-based fuels [2] such as biogas. Despite the fact that biogas and natural gas are two energy gases with similar properties and can be distributed in the same distribution systems, the current utilization of biogas is still low, compared to its technical potential [3]. Thus, the significance of a safe natural gas supply is even more fundamental.

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The importance of natural gas is highlighted by the International Energy Agency's estimations, which indicate that by 2030, 25% of the world energy needs will be covered by natural gas, while the global natural gas consumption will be double by then [4]. At a European level, natural gas comprises 25% of the primary energy supply, contributing to the sectors such as electricity production, heating, industry and transport [5]. Natural gas production in the EU reached a peak in 1996, following a steady pattern until 2004, when it started declining [6]. Nevertheless, natural gas demand followed an increasing course. The registered EU natural gas customers, during the period 2006–2007, were increased around 1%, reaching the number of 110,171,000 users by the end of 2007 [7,8].

In 2011, 33% of EU's total net supplies were covered by indigenous production (the Netherlands and UK), 19% from Norway, 24% from Russia, 9% from Algeria, 8% from Qatar, while 7% was covered by the countries such as Nigeria, Trinidad and Tobago, Egypt, Libya etc. [9].

However, several recent studies further underline the European Union's (EU) declining natural gas production [10,11]. A number of scenarios indicate that the natural gas production in the EU, within 2008–2035, declines by 100 bcm (billion cubic meters) to 210 bcm, as the North Sea production in the UK and the Netherlands decreases, outweighing the natural gas production growth in Norway [12].

As Europe's natural gas production has declined in recent years, its dependence on imported natural gas has increased [11]. The natural gas import dependence in EU amounted around 64% in 2011, while it is expected to reach 85% until 2030 [13].

Furthermore, several cases of natural gas supply disruptions have been recorded over the past few years. Until 2006, a few natural gas supply disruptions were recorded, caused mostly due to accidents, terrorism incidents and monopolistic practices [14]. From 2006 and on, disruptions, affecting the European economy and the smooth natural gas flow, were caused mostly due to non-European geopolitical, interstate conflicts. The most important cases involve Russia's use of natural gas to politically compel Ukraine (according to Ukraine), or Russia's problems with Ukraine on gas terms, which led to halting the gas flow to Europe in January 2006 [8], while in January 2009 the transits via Ukraine were interrupted for almost two weeks, due to failure of agreement on new gas purchasing and gas transit contracts and the settlement of outstanding debt of previous imports in Ukraine [15]. Finally the political uprising in Libya at the beginning of 2011 severely affected the country's pipeline exports, as the Greenstream pipeline from Libya, supplying 9 bcm of natural gas to Italy each year, stopped operations on 22 February 2011 and deprived the Italian gas market of significant volumes for 8 months [16].

The above-mentioned information highlight the imperative need towards diversification of natural gas supply sources, amplification of security of natural gas supply and the importance of a European natural gas supply system that is able to withstand any disruption. To this end, several studies have attempted to evaluate the security of natural gas supply by constructing appropriate indexes and by assessing the vulnerability of natural gas supply through various models.

Cohen et al. constructed a global diversification index, using each producing country's share of total production and have computed a country-specific diversification, in order to measure the risk of disruption to an individual country's natural gas and oil supplies [17]. Gnasnounou designed a composite index for energy vulnerability, based on several indicators such as energy intensity, oil and gas import dependence, CO_2 content of primary energy supply, electricity, supply weaknesses and non-diversity in transport fuels, for the assessment of industrialized countries [18], while Cabalu, following Gnasnounou, used the gas supply security index to measure the natural gas vulnerability of seven Asian countries [19] and Reymond utilized the same index to measure vulnerability to natural gas supply shocks in countries of the South America [20]. Within the framework of the European project "REACCESS—Risk of Energy Availability: Common Corridors for Europe Supply Security", funded by the 7th Framework Programme, a socio-economic risk index was developed to calculate security of supply, taking into account economic, intrinsic energy, political and social parameters affecting the smooth supply [21]. The particular index was used for the Greek energy corridors assessment, through Graph Theory [22], while also Doukas et al. based the construction of a web tool, providing the opportunity to assess the socio-economic risk of supply, for 158 countries, on the particular index [1]. Le Coq and Paltseva constructed a Transit Risk Index (TRI), combining standard supply security factors, such as gas dependency, with a set of physical and political aspects of pipeline transit risk, in order to evaluate the EU Member States' exposure to risks associated with the Russian gas supply [23]. Monforti and Szikszai used the MC-GENERCIS model (Monte-Carlo based Gas Energy Network for Europe, Russia and the Commonwealth of Independent States) in order to assess the adequacy of the European transmission system, under supply crisis conditions caused by lacking of gas reaching Europe through the Ukrainian pipelines [24]. The Transport Infrastructure for Gas with Enhanced Resolution (TIGER) model, a linear network flow model consisting of nodes and edges, was used by Lochner and Bothe to demonstrate the effects of a new pipeline focusing on its impact on existing import pipelines with respect to utilization, a possible change in supply structure and gas flows within the whole of Europe [25], while Lochner applied it to an ex-post investigation of the security of supply situation in January 2009 by replicating the disruption scenario in the model [15].

Within the above framework, the main scope of this paper is to present and evaluate the natural gas supply reliability of EU-states, members of the European Transmission System, under the scenario of a natural gas supply disruption from EU's third largest exogenous natural gas supplier, Algeria. The Monte Carlo method was used in order to simulate each country's natural gas supply strategy, under the scenario of a disruption of natural gas supply from Algeria and determine the natural gas supply success, need for enhancement or failure. The particular study has been structured along five sections. Apart from the introductory section, this paper is structured along four sections. Section 2 presents the current situation of the European natural gas supply, in terms of major suppliers and recorded supply interruption incidents. Section 3 provides a detailed analysis of the adopted approach, while Section 4 contains the application of the Monte Carlo simulation. Section 5 provides an in-depth analysis of the obtained results and finally, Section 6 includes the paper's results and discussion.

2. European natural gas supply

According to EU regulation 994/2010, "The diversification of gas routes and of sources of supply for the Union is essential for improving the security of supply of the Union as a whole and its Member States individually" while "In order to reduce the impact of potential crises triggered by the disruption of gas supplies Member States should facilitate the diversification of energy sources and gas delivery routes and supply sources" [5].

In 2011, 33% of EU's total net supplies were covered by indigenous production (the Netherlands and UK), 19% from Norway, 24% from Russia, 9% from Algeria, 8% from Qatar, while 7% was covered by countries such as Nigeria, Trinidad and Tobago, Egypt, Libya etc. [9]. In 2011, liquefied natural gas (LNG)