Geopolitical Instability in Ukraine and Security of Energy Supply. The Effects on Natural Gas Supply to Italy under Different Scenarios

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Abstract

The Italian energy system is characterised by a high level of import dependency, especially regarding natural gas supply. A dominant role in the NG imports is played by Russia, that in 2013 accounted for 43.6% of the total. As a consequence, the political and institutional crisis between Russia and Ukraine could have significant effects on the energy supply to Italy. In order to analyse these effects, a forecasting scenario analysis was performed by using the TIMES-based optimisation model developed under the 7th Framework Programme REACCESS, able to fully represent the energy corridors (both captive and open sea) supplying the European Union and to evaluate, in a quantitative manner, the risk related to each supply. The analysis was focused on the consequences of a disruption in the supply through the Dolina physical natural gas hub (located in Ukraine) by means of two scenarios: one considering the closure of the hub from 2015 and the other describing a 50% NG flow reduction through it in 2015. The assumed time horizon was 2010-2040, and the effects on the supply composition, on the total system costs, on the marginal costs of natural gas and on the CO₂ emissions level were investigated. The results show that the unavailability of the Dolina physical hub causes more significant effects on the mid-long term supply composition than the reduction of the NG flows through it in 2015. In particular, a strong reduction of the Russian contribution in comparison with the baseline one, a simultaneous increase of the import of LNG from Qatar and a decrease in the total amount of the NG supply by corridors, due to a fuel shift phenomenon, can be noticed. In the same way, the Dolina closure scenario leads to major negative effects also from the economical and environmental point of view. This study highlights the main problems of a high import dependency from a major supplier (as in the case of natural gas imports from Russia to Italy, but the modelling tool allows for the assessment of any EU country security of supply) and underlines the need of a strong diversification in the supply composition.

Keywords: Energy modelling, Infrastructures, Supply security, Natural gas

1. Introduction

The high import dependency in the energy field is one of the major issues affecting the European Union and having large effects on the level of its security of supply. According to Eurostat data [1], in 2012 more than half (54.8%) of the Gross Inland Consumption of energy commodities was satisfied by imports, with significantly high values of dependency for oil products (93.4%) and natural gas (65.8%).

Focusing in particular on Italy, the import dependency results higher than the average value for the EU28, and this fact is particularly relevant in the case of natural gas supply, as it can be noticed in Figure 1, where the historical trends for the total supply and the gas supply from 1990 to 2012 are shown.

Generally speaking, the diversification in the supply sources is important in order to increase the security of the receiving country. Referring to natural gas import composition in Italy, it can be observed that a dominant role is played by Russia, which accounted for 43.6% of the total gas supply in 2013 (Figure 2).

As a consequence of such a dependency, geopolitical instabilities like those that are affecting the relationships between Russia and Ukraine can have several negative influences on the security and the affordability of natural gas supply, with possible effects on the availability and/or on the price of this commodity.

The assessment of the implications of different energy import policies and strategies thus becomes increasingly important, also taking into account the mismatch between an energy market that is progressively more dynamic and global and the inertia of policy makers, that are often strongly influenced by the geopolitical criticalities among different countries or areas in the world (like those involving Russia, European Union and United States on the Ukrainian situation) [3].
In order to compare in a quantitative and objective manner different options for the supply, a modelling framework is necessary. Especially during last year, some scenario analyses focusing on the natural gas supply from Russia to the EU28 have been performed, trying to compare the role of the countries crossed by the energy infrastructures and the possible alternative routes. Among these, the one proposed by Nagayama and Horita [4] involves an application of the Network Game Model, in which the pipelines linking Russia and Europe are treated like graphs. The implementation of the Link-based Flexible Network Allocation Rule allows to evaluate the way in which the considered players (Russia, Ukraine, Belarus and Western Europe, which in turn is mainly composed by Italy and Germany) are connected. The results obtained under the assumed scenarios underline the different relative power of Russia before and after the construction of the Nord Stream pipeline, showing that the availability of this pipeline causes a strong increase in Russian role at the cost of Ukraine [4].

This kind of analysis, however, does not allow to directly estimate in a numerical way the risk related to each import and the effects of different scenarios on the level of energy supply security in European high dependent countries like Italy, but only to evaluate the relative weight of the considered countries. For this reason, in the present study the optimization TIMES model [5] developed during the REACCESS project has been adopted to compare the consequences on the Italian supply of two scenarios involving the Ukrainian physical natural gas hub in Dolina.

2. Methodological approach

The model used to perform the analysis mentioned in the Introduction was developed under the 7th Framework Programme REACCESS, focused on the detailed description and technical-economical characterisation of the energy corridors (both open sea and captive) supplying the European Union and on the assessment – by using numerical indexes related to the geopolitical risk – of the security of the related supply.

One of the main features of this model is to link three different optimization models, two existing (the Pan
European TIMES model, describing the energy system of 36 European countries, and the KanORS TIMES Integrated Assessment Model, modelling the energy system of 15 world macro-areas) and one – the REACCESS CORridor (RECOR) model – newly implemented during the project and including the whole description of the energy infrastructures and the risk parameters [6].

2.1. The RECOR model and the risk implementation

The RECOR model transfers the information on all the analysed corridor (for the main energy commodities: natural gas, crude oil, refined petroleum products, hard coal, biomass, nuclear material, hydrogen, electricity from CSP), collected into a wide set of wide Excel-based databases, into a TIMES-based model structure. In particular, each corridor is described as a chain of branches (modelled as processes), each one of them linking two significant points (i.e. the extraction field and the border of the production country, two borders of a crossed country, a border between two countries and an internal hub, etc.). Each branch is characterised by a series of technical and economical parameters, including investment costs, fixed and variable operating and maintenance costs, fuel in input and related consumption, start year of the infrastructure, capacity, activity carried in the model Base Year. The specific code system adopted and the introduction of two kind of processes – in the case of commodity delivered by a series of technical and economical parameters (like the marginal costs of each commodity in output from each supply process. The value of this commodity is calculated by multiplying the risk indicator by the total activity delivered by the analysed corridor, as shown in Eq. (2).

\[
Risk_C = RL_C \cdot Activity_C
\]

Furthermore, in order to estimate the risk related to the single PJ/y supplied by corridors in a certain country, the Specific Risk parameter – defined by Eq. 3 as the ratio between the total risk and the total supply – has been introduced.

\[
Specific\ Risk_r = \frac{\sum_C Risk_C}{\sum_C Activity_C}
\]

where:

- \(C\) identifies the corridors supplying the country \(r\)
- \(r\) identifies the crossed country
- \(ORI\) is the Overall Risk Index for the country \(r\)
- \(RL\) defines the Risk Indicator for the energy corridor \(C\)
- \(Activity\) is the total activity delivered by the analysed corridor

2.2. Scenarios

The analysis was focused on the effects on the Italian natural gas imports of a disruption in the supply through the natural gas physical hub of Dolina, located in Ukraine (Figure 3), over a mid-long term time horizon (from 2015 to 2040).

In particular, this hub involves the Trans Austria Gas (TAG) pipeline, that allows natural gas import to Italy through the Tarvisio interconnection. Table 1 lists all the possible present/future alternative supply routes via pipeline implemented into the RECOR model.

Two scenarios on the availability of the Dolina hub were defined, one assuming a complete closure of the hub starting from 2015 and the other hypothesising a 50% reduction of the natural gas flowing through it in 2015 in comparison with the Baseline value. In both the scenarios the time horizon was 2010-2040. The main assumptions of the performed runs are summarised in Table 2.
3. Results

First of all, the effects of the assumed scenarios on the composition of the NG supply to Italy were investigated; Figures 4, 5 and 6 show the results for each run.

As it can be noticed, in the Baseline run (i.e. without specific constraints; Figure 4) the forecast highlights a strong increase in the role played by Russia, which in the mid-long term will become the dominant supplier (also taking into account the reduction in the imports from Algeria), accounting for about 80% of the total in 2040. This situation is negative from the point of view of the security of supply, because it does not allow the diversification of sources, which is one of the key elements for the achievement of a sufficient level of security. Furthermore, at the end of the time horizon, a large part of the supply from Russia (corresponding to 73.1% of the total) is planned to be delivered via the TAG pipeline and only 26.9% of the natural gas exported to Italy is flowing through the South Stream pipeline, so bypassing Ukraine.
Figure 4: Composition of the natural gas supply in Italy – Baseline scenario

Figure 5: Composition of the natural gas supply in Italy – Close Dolina scenario

Figure 6: Composition of the natural gas supply in Italy – Dolina Reduction scenario
In the Close Dolina scenario, the future evolution of the NG supply is instead quite different from the Baseline one. As it can be seen in Figure 5, the closure of the Dolina natural gas hub causes a strong reduction in imports from Russia (coupled to an increase in the supply of LNG from Qatar) and – more in general – a reduction in the global import of natural gas, due to fuel shift phenomenon. This trend underlines the importance of the TAG pipeline, as the model prefers to modify the import composition rather than to increase the capacity and the use of the South Stream corridor.

In the case of a 50% reduction in the NG flow through Dolina, a little reduction in the supply from Russia is observable (Figure 6) in comparison with the Baseline value, but the composition trend remains quite similar to the Baseline one.

Referring to the Specific Risk (SR) evaluation, Figure 7 shows that both the Dolina scenarios cause a decrease in the SR value, which is more relevant in the Close Dolina run. In the Dolina Reduction scenario it is possible to notice a value lower than the Baseline one in 2015, while in the next milestone years the SR remains more or less the same. This means that the effects of the NG flow reduction in 2015 are a local perturbation and are rapidly absorbed by the system, thus not spreading over the whole time horizon.

Analysing the consequences in terms of environmental aspects, it can be seen (Figure 8) that both the assumed scenarios cause an increase in CO2 emission in comparison with the Baseline value in 2015. After this milestone year, a reduction in the percentage difference is observable; from 2025 the level of emissions tends to become similar to the Baseline one.

Eventually, taking into account the economical effects and focusing, in particular, on the marginal cost of natural gas (Figure 9), a strong increase (higher than 100% in the case of Dolina closed) in 2015 with respect to the Baseline run can be noticed in both the scenarios. As for the Specific Risk, also in this case there is a rapid absorption of effects deriving from the 50% flow reduction in 2015: in fact, from 2020 the marginal cost is quite equal to the Baseline value. Instead, in the case of complete unavailability of the Dolina hub, major consequences in the mid-long term can be observed.

Furthermore, both the scenarios cause an increase in the total system cost of Italy, which is higher in the case of a closure of the Dolina hub (+0.31% in comparison with the Baseline value versus +0.02% calculated in the Dolina Reduction scenario).

4. Conclusions

This study highlights the role played by the natural gas infrastructures crossing Ukraine and supplying Italy, showing in particular the issues related to the high import dependency from a major supplier like Russia. If a disruption in the Dolina physical hub happens, a significant variation in the composition of the Italian NG imports can be noticed, with corresponding higher system costs, gas marginal cost and CO2 emissions in the mid-long term.

On the contrary, the unavailability of the Dolina hub has positive consequences on the risk related to the energy supply by corridors, with a reduction in the specific risk related to each PJ/y imported in Italy in comparison with the Baseline value.

This fact is mostly due to the higher diversification in the NG supply, with a greater contribution related to “safer” countries like Qatar.

![Figure 7: Specific Risk for the total supply by corridors in Italy](image_url)
Instead, the reduction of the NG flowing through Dolina only in 2015 causes less effects on the natural gas supply and on the energy system; moreover, these effects – in general – affect only the period between 2015 and 2020 and do not spread over the whole time horizon.

These results put in evidence the need for policies (at National or European scale) focused on the diversification of the supply, in order to avoid criticalities that can derive from geopolitical instabilities like those related to the present crisis between Russia and Ukraine.

References


