Natural gas demand and supply in Italy

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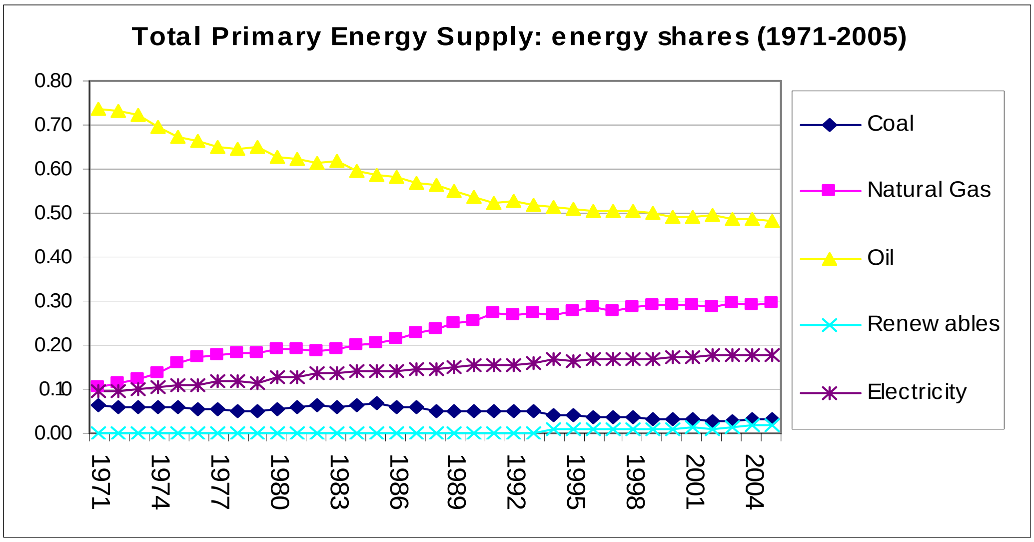
Abstract
This article explores the dynamics between natural gas supply and demand in Italy. In order to supply Italy with increasing volumes of gas, several new pipelines and regasification plants are expected in the next future, but their implementation is uncertain. Thus, there exist the possibility of natural gas shortage in the future. On the other hand, if all the expected projects will be implemented, situations of oversupply cannot be excluded. In order to study the dynamics between supply and demand of natural gas a system dynamic model has been built. The model core consists of a stock representing the transport network, with the total natural gas supply acting as inflows, and the total natural gas demand as an outflow. A key role in the model is played by the natural gas storage system. The model allows to explore future scenarios, make sensitivity analysis and verify which are the key variables in the determination of situations of gas shortage or oversupply.

Energy in Italy: main features

A simple reading of Italy's energy balances represents an interesting exercise that provides plenty of information about key trends, so offering useful insights for a reflection about Italy's energy future. A first relevant point is represented by the strong variations in the shares of energy sources that affected Italy since the beginning of the '70s. Fig. 1 shows the deep penetration of gas due to the fact that the decrease in oil use was offset by increased use of natuarla gas. The two curves are almost symmetrical: in the period 1971-2005 their correlation is almost perfect (-0.98) and, if we take as a reference shorter periods since 2005 backward, it is never larger than -0.94. In end uses, the gas-oil substitution process is less stronger, the correlation coefficient being between -0.37 and -0.77. In tab. 1, the strong process of oil-gas substitution is clearly showed: in the years 1971-2005, the gas share increased from 0.09 to 0.36, while the oil share decreased from 0.75 to 0.43. Such a substitution occurred mainly in the domestic sector (correlation -1), in the energy and industrial sectors (correlation -0.98 and -0.96), and is weaker in the transportation and agricultural sectors (correlations -0.63 and -0.62).

Fig. 1 - Trends in energy sources' shares (1971-2005)

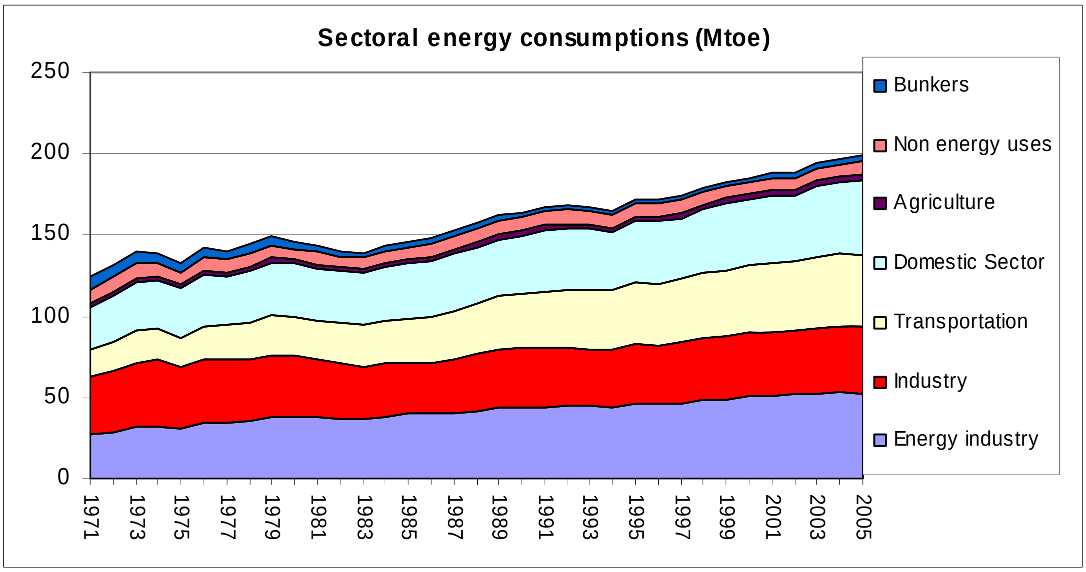


Tab. 1 - Energy sources' shares (1971-2005)

	1971	1980	1990	2000	2005
Coal	0.08	0.09	0.10	0.07	0.08
Natural gas	0.09	0.16	0.24	0.32	0.36
Oil	0.75	0.67	0.57	0.49	0.43
Renewables	0.00	0.00	0.00	0.07	0.07
Electricity	0.08	0.09	0.10	0.05	0.05

Sectors changes were not so strong as energy share ones. Fig. 2 shows the trends since 1971 to 2005. The average annual increase in energy consumptions was as follows: 3.1% (transportation), 2.7% (energy sector), 1.6% (domestic sector, which includes residential and commercial sectors), 0.4% (industry), 1.4% (agriculture). Altogether, the transport and domestic sectors expansion did not compensate the industry decline and this translates into a total primary energy supply average annual increase larger than that occurred in end uses (1.4% vs. 1.2%).

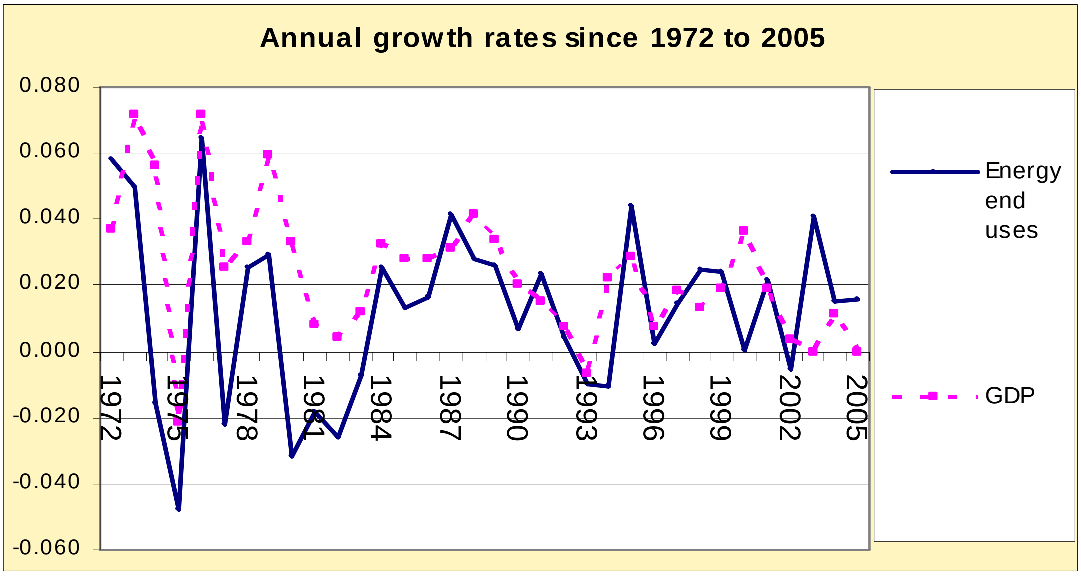
Fig. 2 - Energy consumptions by sectors (Mtoe; 1971-2005)



Given such trends, two points must be stressed:

- as a whole, the growth in energy consumptions tends to decrease in the recent years. This is particularly true for transportations, where the increase in the stock of vehicles tends to become weak, and less true for the domestic sector in which the highest average annual growth rate (around 2%) occurs in the period 2001-2005. Such a growth is the result of the combination of two phenomena: hot summers, springing from climate change, not sufficiently compensated by warm winters; the diffusion of conditioning air equipment. This is confirmed by the strong annual increase in electricity demand (3.7%) in the same period. It is worth noting that, for the first time in the considered periods, the growth of the domestic sector is larger than that of transportation and energy sector.
- The growth in energy consumption is strictly related to economic growth, as fig. 3 shows. Nevertheless, the degree of correlation decreases. In particular, in the years since 1995 onwards, the correlation becomes negative, and this means that, due to changes in life styles, energy consumptions grow up in spite of the low economic growth.

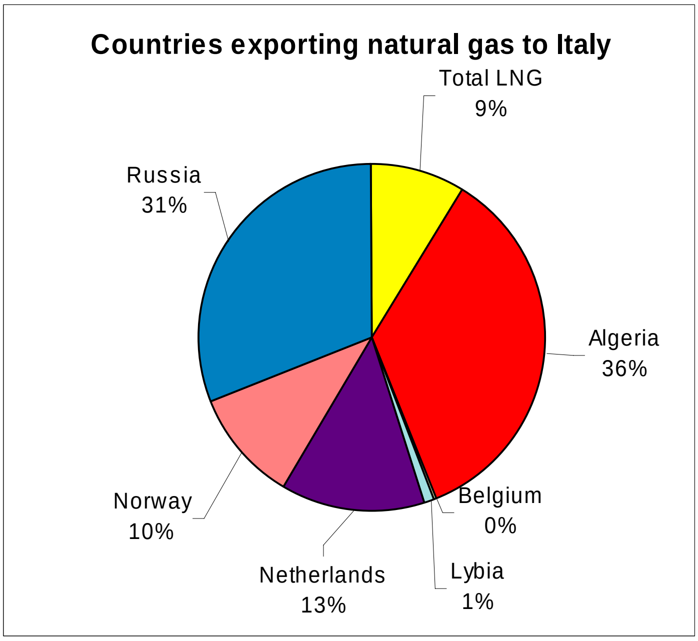
Fig. 3 - Annual growth rates in GDP and end uses (1972-2005)



The natural gas issue

The strong increase in natural gas share represents a deep transformation of the Italian energy system. Since 1971 to 2005, gas consumptions annual average increase is equal to 5.7% while oil consumptions decreases by 0.2%. However, if we look at per-capita consumptions, Italy's is similar to other European countries, its value being close to the average European one. On the other hand, Italy is one of the largest energy importing countries in the world: 7th with reference to oil and 4th with reference to natural gas. The natural gas shortage occurred in the 2005-2006 winter shows that there is a problem related to the concentration of natural gas import. Since the different economy sectors make use of natural gas to different extents, they are differently damaged by the natural gas dependency. In particular, the energy and domestic sectors, where the natural gas share is equal to 49% and 54% are more affected by natural gas shortage phenomena. As far as gas exporting countries are concerned, Fig. 4 shows the key role played by Russia and Algeria which offer to Italy 67% of its natural gas import, this having effects on prices and security. New LNG plants can weaken such a strong natural gas import concentration by widening the number of supplier countries.

Fig. 4 - Italy's natural gas imports by country



Since 1995 to 2005 natural gas consumption has grown by 59%, and there are no signs that this trend will change: in the next 3-4 years natural gas consumption is expected to exceed that of oil. The main reason for this expansion is the growing use in the energy sector, while in the domestic sector there is only a limited increase.
The supply of natural gas consists of national production and imports from different countries. Using the information reported in Eni's World Oil and Gas Review 2006 (Eni 2006), it is clear that from the 90s onwards national production is constantly decreasing and its share in covering total demand is in decline. Based on the trend from 1995 to 2006 there appears to be an annual decrease of 11%, with production in 2014 predicted to be about 6 Gm3. Thus, because of the depletion of the Italian reserves, imports will play an ever-more vital part in satisfying national demand, intensifying the dependence on external resources.

Natural gas can be imported in two ways: as LNG and through pipelines. At present the main gas pipelines that link Italy to production areas are:

- TAG to import from Russia (total length 1,108 Km);
- TENP and Transitgas (respectively 924 and 291 Km length) to import from Holland and Norway;
- TTPC and TMPC (742 and 775 km length, mainly underwater) to import from Algeria and Libya.

The only working regasification plant is located in Panigaglia (La Spezia) and it receives natural gas mainly from Nigeria, Algeria, Abu Dhabi and Egypt. In 2005, Italy imported about 2.5 Gm^3 of LNG from Algeria, a very little fraction considering that the remaining 70 Gm^3 of national demand came from only 7 countries through pipelines, and that Russia and Algeria alone cover about 67% of gas import.

To ensure a suitable supply, there are several projects of construction of both pipelines or regasification plants that will be completed in the next few years. As reported by the Italian Energy Authority for Electricity and Gas, the most probable will be the following:

Table 2 : expected new pipelines and regasification plants

	Country	capacity [Gm^3/y]	completion
Increasing the potential / new pipelines	Algeria	3.2	2008
		3.3	2011
	Russia	3.3	2008
		3.2	2011
	Greece – Turkey IGI	9.0	2010
	GALSI	8.0	2011
Regasification plants	Livorno	4.0	2008
	Rovigo	8.0	2008
	Porto Empedocle	8.0	2010
	Gioia Tauro	12.0	2011
	Adriatico	9.0	2012

Natural gas storages represent one of the most important parts of a country's national gas infrastructure. As previously highlighted, gas consumption during the year is characterized by remarkable variability, mainly because of climatic factors, whereas the supply varies less. For the Italian market the most convenient way of balancing supply and demand is through natural gas storages, built close to areas of major consumption, with national production maintained roughly constant and imports moderately modulated. At present in Italy the total storage capacity is about 13.2 Gm^3 and an addition of 3.5 Gm^3 is expected in 2010. Stogit manages 8 gas storage fields with a total capacity of 12.9 Gm^3, while the remaining 0.3 Gm^3 are in 2 deposits managed by Edison.

The model

The strong expansion of natural gas consumptions and the recent tensions in the supply of natural gas from Russia to Europe gave rise, in Italy, to a wide debate about the security of natural gas supply. The basic issue is whether the future expected pipelines and regasification projects will be able to satisfy the increasing natural gas demand. Since many of the expected plants are still uncertain, there exists the possibility of natural gas shortage in the future. On the other hand, if all the expected projects will be implemented, situations of oversupply cannot be excluded. In order to study such dynamics between supply and demand of natural gas, explore future scenarios and verify which are the key elements in the determination of situations of gas shortage or oversupply, a simple system dynamics model has been built. It analyses the stream of natural gas in Italy assuming a time horizon of 96 months for simulation. The model allows one to make forecasts for the Italian situation but also enables to focus on variations in certain key variables in order to make a sensitivity analysis for the future supply-demand balance.

The model core consists of a stock representing the transport network, with the total natural gas supply (sum of imports from various countries, national production and LNG) acting as inflows, and the total natural gas demand as an outflow. Another biflow is attached to the network stock, representing the natural gas storage system and its capacity to inject or extract natural gas from the network, in order to create a perfect matching between supply and demand.

On the supply side, a slightly modulated curve of natural gas is assumed, due to the relative rigidity of gas imports in a market dominated by long term contracts. Considering this characteristic of natural gas market, annual import from each country has been assumed to follow the same monthly pattern as current imports, and therefore has been distributed to reflect the varying levels of imports throughout the year. In addition, the new projects are assumed to come online in June of the year of completion. The model allows to control the percentage of imports from each country, in order to simulate losses of import capacity due to different causes. Obviously, it is possible to exclude one or more countries from the set of gas exporting countries to Italy. As seen above, a list of possible capacity addition has been identified, and inserted in the model in the respective completion years. Each capacity addition is associated with an on/off button that enables or disables the realization of each project. The same mechanism works also for the LNG regasification plants forecasted to be built in Italy. Such a variety of parameters generates multiple scenarios that will be analysed in the following paragraph of this paper. In the i-think system dynamics software a routine has been programmed that automatically determines the time of new regasification plants with an annual import capacity of 4 Gm^3, depending on the demand and supply gap, or due to the shortage of stored gas. The construction time and number of plants are taken as input in the above programme. Moreover there is the possibility to consider only the 85% of the capacity planned: this is a security margin that ensures flexibility to the system.

As far as the demand is concerned, the model identifies the principal sectors requiring gas (industrial, energy and domestic) and incorporates a forecast of monthly demand for the next 8 years. The forecast to 2014 was done, through statistical procedures, using data reported in the National Energy Balance for the years 2000 to 2006. Moreover, it takes into account the strong seasonality of demand depending on temperature variations: in particular, the demand peaks in winter and declines in August, as it results by the analysis of data by Snam Rete Gas (the owner and manager of the Italian gas transport network). In the base case, the forecast shows a general growth of 2.74% per year, with relevant differences between each sector. Because of the diffusion of 'combined gas cycle' in electric generation, the energy sector's demand will grow at an annual rate of 5.55%, while domestic and industrial demands are predicted to grow at, respectively, 1.77% and 0.64%. The model allows to modify the growth rate of one or more sector and generates the resulting aggregate and sectorial demand growth.

The program provides as an output the filling/emptying profile of the natural gas storage system, and shows natural gas crisis (due to insufficient supply) or oversupply situations. Natural gas is prevalently injected into the storages during summer and extracted in winter, but it is also possible to go against the flow. The model assumes a maximum daily extraction or injection of 0.16 Gm3, resulting a monthly value equal to 4.8 Gm^3.

The model allows several possibilities of implementing sensitivity and scenario analyses thus giving rise to a clear picture of the future developments in the natural gas supply and demand game, enlightening the critical forces and variables, as well as the key role of the storage system in presence of high new pipelines' investment costs and strong seasonal demand.

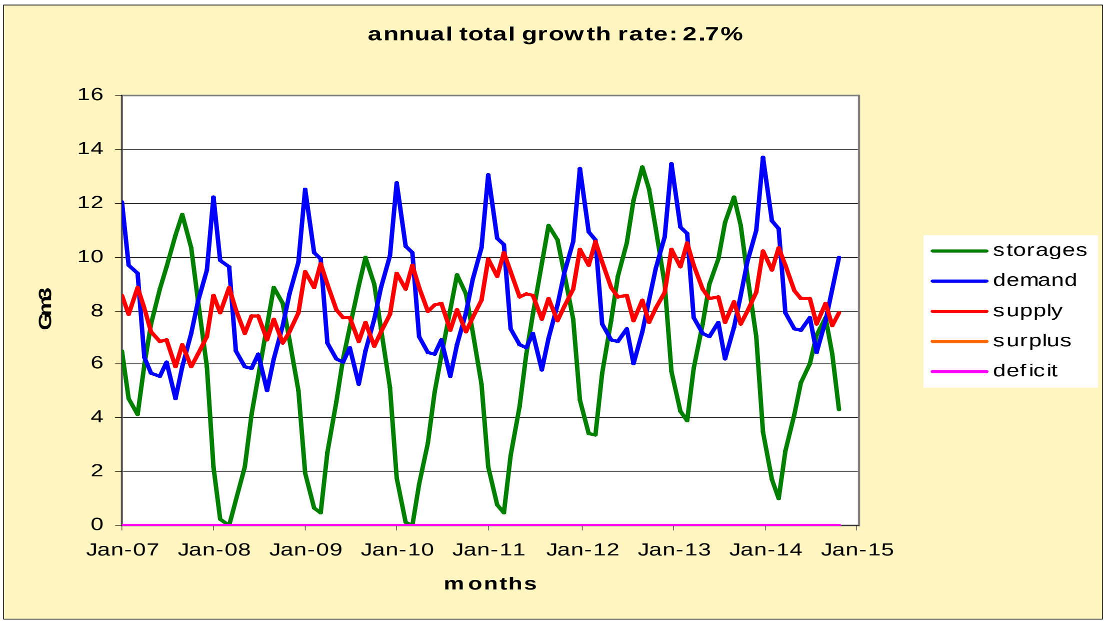
Future scenarios

The main target of the scenarios analysis that will be showed in this paragraph is to individuate under which conditions a balance between natural gas supply and demand will exist in Italy in the next future, and under which key events such a balance ceases to exist. We assumed three possible trends in natural gas demand: base case, low growth, high growth.

Base Case Scenario

In this scenario, the aggregate natural gas demand is assumed to growth by 2.7% a year. The sectors' growth is as follows: domestic, 1.8%; industry, 0.6%; energy industry, 5.6%. In fig. 5, the supply-demand dynamics and the key role of storages in determining balance is showed. Under the above mentioned demand growths, a balance exists if the upgrades of the pipelines from Algeria and Russia are implemented by 2008 and 2011, and the Rovigo and Porto Empedocle new regasification plants are built. In this and the following scenarios, the model runs with the security margin button on, that is assuming 85% of the planned capacity, and with storage capacity addition. Such a balance seems to be quite weak. The removal of a regasification plant or a pipeline expansion in 2008 brings about severe shortage in gas supply. For instance, not implementing the Rovigo regasification plant would give rise to 5 months winter crises starting in the winter 2009-2010, with a deficit in December 2009 equal 4 Gm^3, that is 40% of the demand. Similarly, if the upgrade of the Russian pipeline in 2011 is not implemented, 3 months winter crises occur starting in the winter 2013-2014. The natural gas gap would be equal to 3.7 Gm^3 in December 2013 (30% of demand). On the other hand, if we add either the Galsi or the Caspian pipeline to the balance scenario, we face oversupply. The implementation of the Galsi would generate a 2.2 Gm^3 oversupply (37% of the demand) in August 2012 and weaker supply excesses in the next two summers, due to the increase in demand.

Fig. 5 - Balance trends in the base case scenario

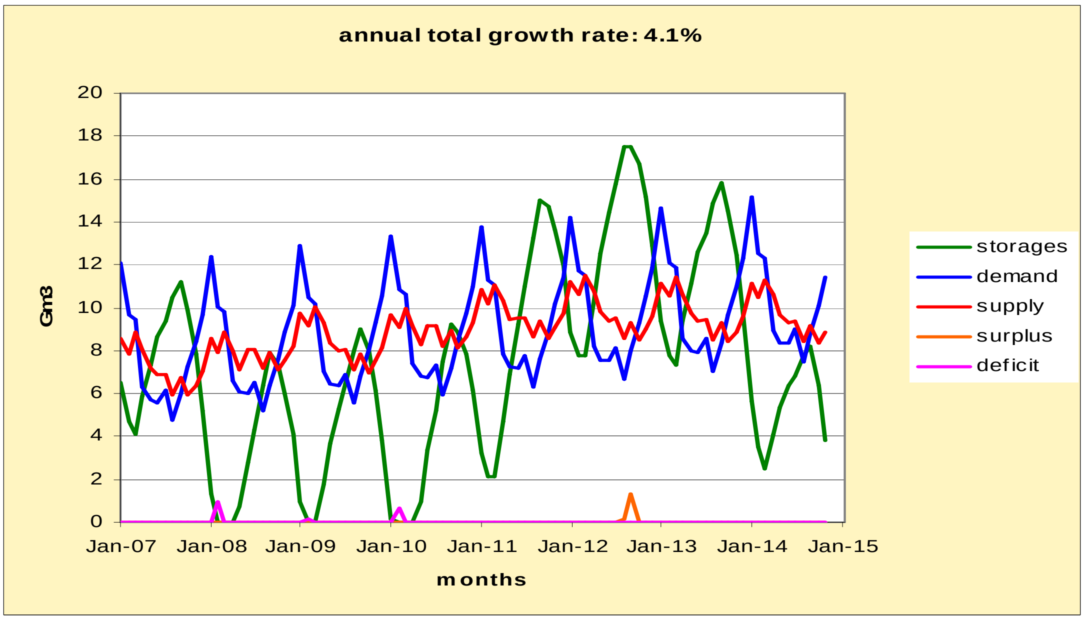


On the other hand, if both the Galsi and Caspian pipelines are added, a first oversupply situation occurs in August 2011 (50% of demand) and lasts until the end of 2014, affecting the period June-October. Finally, if all the regasification plants and new pipelines are implemented, supply excess occurs starting in August 2011 until 2014, it never being inferior to 2.2 Gm^3 in the period April-September.

High Scenario

The natural gas demand is assumed to increase at a rate which is 50% higher than the base case one. In particular, the growths are: domestic, 2.7%; industry, 0.9%; energy industry, 8.4%. Fig. 6 shows the balance trends.

Fig. 6 - Balance trends in the high scenario

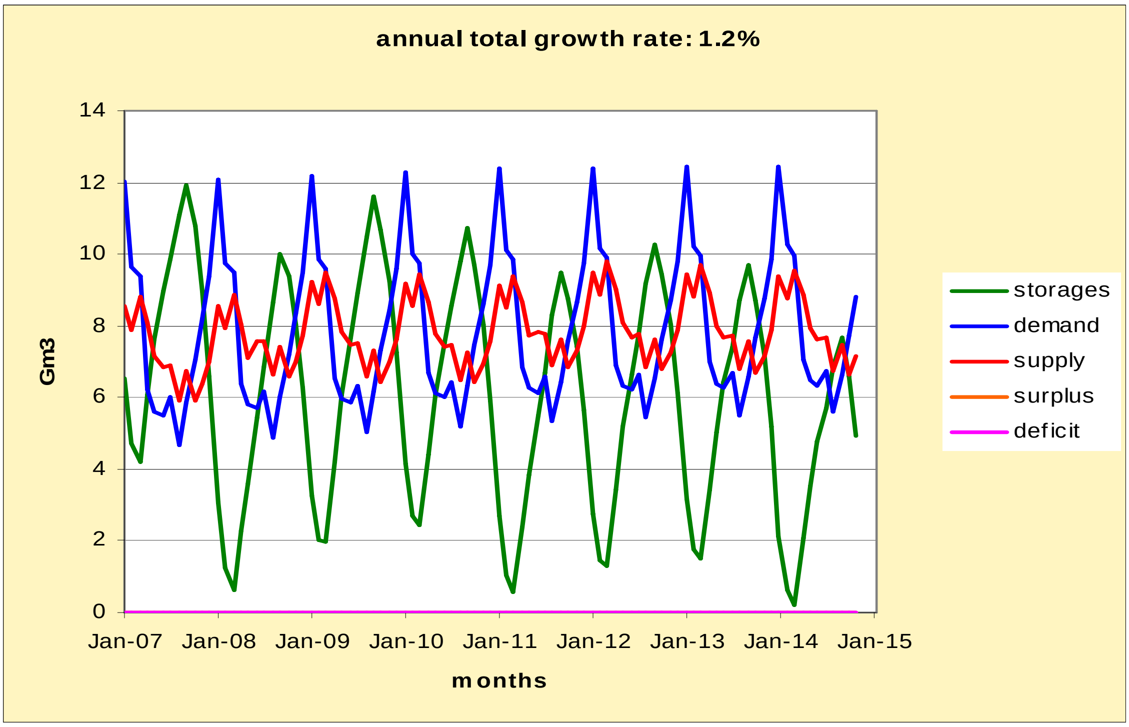


The balance exists if the upgrades of the pipelines from Algeria and Russia are implemented by 2008 and 2011, and the Rovigo and Porto Empedocle new regasification plants are built, as in the base case scenario. Moreover, the Caspian pipeline and Livorno regasification plant are implemented. The removal of one of the aforesaid plants brings about natural gas supply shortage. For instance, the removal of the Caspian pipeline gives rise to a shortage equal to 1.73 Gm^3 (10% of demand) in 2011. Due to the increasing demand, such a shortage rises in the winter of the following years reaching 34% of the demand in November 2014. Avoiding the implementation of the Caspian pipelines and the upgrades of the Russian and Algerian pipelines renders the crises stronger. The first crises occurs in January 2011 and in the following years the situation worsens: the natural gas deficit reaches 56% of demand in November 2014. On the contrary, if the Caspian pipeline or the Central Adriatic (or Gioia Tauro) regasification plant is built, the shortage situation is avoided but oversupply can occur. Building the Gioia Tauro plant would mean to face a first surplus in September 2011 (0.94 Gm^3) which increases and becomes equal to 40% of demand in May 2012, and finally decreases due to the demand expansion (1.23 Gm^3 in 2014, i.e. 18% of demand). The joint implementation of the Gioia Tauro, Central Adriatic plants and Galsi pipeline generates a marked supply surplus: 3.18 Gm^3 (42% of demand) in September 2011; larger than 3.4 Gm^3 in the period April-September 2012; 35% of demand in the period May-September 2014.

Low Scenario

The natural gas demand is assumed to increase at a very low rate, i.e. 50% lower than the base case one. In particular, the growths are the following: domestic, 0.9%; industry, 0.3%; energy industry, 2.8%. Fig. 7 shows the balance trends.

Fig. 7 - Balance trends in the low scenario



There is a balance between natural gas supply and demand if the upgrades of the pipelines from Algeria and Russia are implemented by 2008 and 2011, and the Rovigo regasification plant is built. If, for instance, the Russian pipeline is not upgraded, a first deficit occurs in January 2010 (1.67 Gm^3, 14% of demand). In the following years, stronger and longer crises happen. Even if the demand increase is quite low, not implementing the upgrades of the Algerian (2011) and Russian (2008 and 2011) pipelines would imply a shortage situation starting in January 2010 (deficit equal to 1.67 Gm^3, 14% of demand) which worsens in the following years reaching its peak in December 2013 (deficit equal to 3.74 Gm^3, i.e. 36% of demand). In order to have an oversupply situation, the Livorno plant should operate in addition to plants active in the base case. The oversupply starts in September 2009 (1.42 Gm^3, 23% of demand) and reaches its peak in August 2012 (1.69 Gm^3, 30% of demand). The surplus increases if also the Caspian pipeline is added and affects the whole period May-September 2012 (2.66 Gm^3, 42% of demand).

Conclusions

The scenarios showed in the previous paragraph are just some among the many that the model is able to generate. Other and more complex sensitivity analyses could be performed. Nonetheless, we believe that what showed provides a quite clear picture of what could happen in the future years in Italy in the natural gas sector. The range in the growth of natural gas demand that we hypothesised is realistic and exclude extreme situations, in particular in the high scenario. Certainly, stronger increases in natural gas demand can be assumed, so rendering situations of natural gas shortage more probable. We tried to perform judicious simulations, so avoiding extreme cases that, nevertheless, the model can easily generate. Thus, the main conclusions of our analysis can be summarised as follows:

- In the case of medium growth of demand (base case), assuming that the pipelines from Algeria and Russia will be upgraded, the realisation of at least two new regasification plants (e.g. Rovigo and Porto Empedocle) become crucial in order to guarantee balance between demand and supply.
- When the demand growth is higher (high scenario), a third new regasification plant, as well as the Caspian pipeline, play a key role. Without them, natural gas shortage occurs.
- In the case of low demand growth, oversupply is more probable. Nevertheless, also in this case, a new regasification plant is necessary in order to avoid shortage situations.

Now, given such scenarios, the key questions are: will Italy be able to upgrade its pipelines? Will Italy be able to build new regasification plants. If we look at Italy's past energy history, we should answer positively to the first question and negatively to the second one. In the past years, Italy demonstrated a strong capacity of building pipelines, upgrading them and bringing natural gas into the country from very far places. On the other hand, it must be recognised that in several decades Italy was able to build just a single regasification plant (La Spezia). New projects (e.g. Monfalcone) were proposed several times but they were always rejected. Until now, the main enemy of this kind of projects was the so called Nimby effect, that is the opposition of local population that did not want to have risky and anaesthetic plants in their area. However, it is also worth noting that the natural gas shortage crisis in the winter 2005-2006 had an impact on policy makers sensitivity. Nowadays, inside the political parties, it seems that there is a push to remove all kinds of obstacles to the realisation of plants supplying energy to the country. The future will show whether or not such a push really exists, is strong enough and will be successful. On the other hand, the past natural gas crisis raised the problem of the need of a national energy policy capable of planning and coordinating actions whose target is supplying energy to the country. Such a coordination need becomes greater if we think of the possibility of having too many regasification plants in the future. Such a possibility exists if we look at the list of the planned plants. In fact, if the political climate has really changed, it is possible that Italy passes from regasification plants deficit to excess. So, the target of such a policy action should be the coordination of the many projects that private companies have planned and the removal of local opposition to new plants: such a coordination should balance natural gas demand and supply in the medium and long term.

We believe that our model, even if simple, was able to provide a quantitative interpretation of the natural gas issue, enlightening its key aspects. Certainly, the structure of our model can be improved and a certain number of variables could be made endogenous. For instance, the demand could be linked to income, the role of people aptitude towards environment could be made explicit and affecting the new plants building. The progressive opening of the natural gas price, in Italy and Europe, could be taken into account by assigning some role to prices. These are some of the possible, future improvements. Nevertheless, with reference to the main aim of our analysis, namely the specification of the conditions that balance natural gas supply and demand, we believe that our model clearly showed the crucial elements of the issue and the forces at stake.

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