AGH DRILLING, OIL, GAS • Vol. 31 • No. 1 • 2014

http://dx.doi.org/10.7494/drill.2014.31.1.11

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# ROLE OF UNDERGROUND GAS STORAGE IN THE EU NATURAL GAS MARKET

## 1. INTRODUCTION

One of the main objectives of the European Union is to create a common liberalised natural gas market in Europe. Action in this regard hasbeen taken for several years, but the results achieved are not always consistent with the establishedgoals. Over the past few years, the consumption of natural gas in the EU has been characterised by a downward trend. The use of gas for power generation is decreasing, mainly at the expense of dynamic growth in electricity production in the RES-based facilities (Renewable Energy Sources);due to limited economic growth, the industrial sector is not increasingthe demand for gas; higher temperatures in the autumn-winter months, particularly noticeable in the last season 2013/2014, translate into a reduction of the demand for gas in households. In 2012 it was equal to 444 bcm, and in 2008, for instance,reached 497 bcm. Regulations for the natural gas market cover all the elements that affect the establishment of a liberalised single market, i.e.: transmission, distribution and LNG storage. In this paper, the authors wish to draw attention to the special role of underground gas storage, and want to show how the functions to be fulfilled by storage facilities are changing on the liberalising natural gas market in Europe (e.g. arbitrage). The purpose of this paper is to present the current situation in the market of storage services, i.e. available storage capacity, its capacity utilisation rate, and plans for the development or creation of new capacities.

The EU demand for primary energy in 2004-2012 decreased by about 8% (from 1,807.5 to 1,673.4 Mtoe). The main products covering this demand in 2012 were: oil, covering 36.5% of the demand, natural gas 23.9%, coal 17.6%, nuclear energy 11.9%, and RES 10.1% [1]. Figure 1 shows the change in the consumption of individual energy products in the European Union, in 2004 – 2012.

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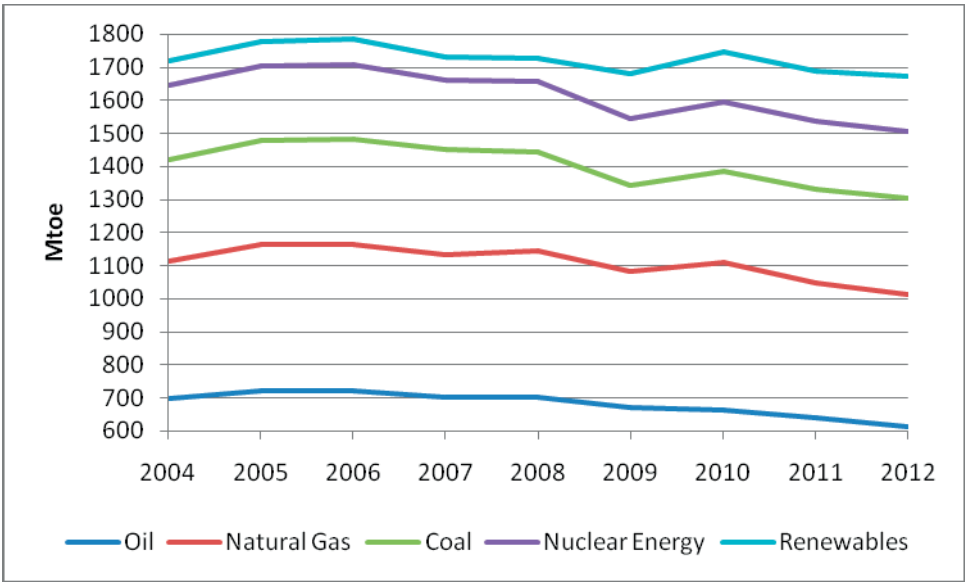


**Fig. 1.** Consumption of energy sources in the EU, 2004-2012
[Authors on the basis of 1]

## 2. DEMAND FOR GAS IN THE EU

Natural gas is one of the essential energy sourcesto cover the demand for energy in the European Union. In 2012 its consumption was equal to 443.9 bcm, and compared to 2011, it decreased by more than 2%. This means another year of decline in demand for gas in Europe. From 2004 to 2012,the consumption of natural gas decreased by nearly 9% [1] [8]. The decline resulted primarily from low economic growth (the analysis of the cumulative growth in the EU countries in the years 2008-2012 shows that the EU recorded a drop of 0.5%; the highest increase of 18.8% occurred in Poland and 10.4% in Slovakia, while the largest drops were in Greece, 18.6% and in Latvia, 15%), which led to a lower demand for energy products and electricity. Lower demand for gas in the power sector was the consequence of an increasing usage of renewable energy sources and an increasing competitiveness of coal, the supply of which in the global market is high, given additional growth in coal exports from the US, stimulated by the shale gas revolution and the shift to gas-powered electricity generation in several plants [7] [20]. Table 1 shows the evolution of natural gas consumption in the European Union and in selected EU countries. Preliminary data from Eurogas inform that in 2013, compared to 2012, there was a slight decrease in natural gas consumptionby 1.4% in the EU-28. As in previous years, this decline was mainly due to lesser use of gas in power generation. [2].

**Table 1**

Consumption of natural gas in the European Union [bcm]

| Country | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Austria | 9.5 | 10.0 | 9.4 | 8.9 | 9.5 | 9.3 | 10.1 | 9.5 | 9.0 | -4.7% |
| Belgium | 16.2 | 16.4 | 16.7 | 16.6 | 16.5 | 16.8 | 18.8 | 16.6 | 16.9 | 4.6% |
| Bulgaria | 2.8 | 3.1 | 3.2 | 3.2 | 3.2 | 2.3 | 2.6 | 2.9 | 2.7 | -1.6% |
| Czech Republic | 9.1 | 9.5 | 9.3 | 8.7 | 8.7 | 8.2 | 9.3 | 8.4 | 8.2 | -10.1% |
| Denmark | 5.2 | 5.0 | 5.1 | 4.6 | 4.6 | 4.4 | 5.0 | 4.2 | 3.9 | -24.6% |
| Finland | 4.3 | 4.0 | 4.2 | 3.9 | 4.0 | 3.6 | 3.9 | 3.4 | 3.1 | -28.9% |
| France | 45.1 | 45.4 | 44.0 | 42.6 | 44.3 | 42.6 | 47.4 | 40.9 | 42.5 | -5.7% |
| Germany | 85.9 | 86.2 | 87.2 | 82.9 | 81.2 | 78.0 | 83.3 | 74.5 | 75.2 | -12.4% |
| Greece | 2.7 | 2.7 | 3.1 | 3.8 | 4.0 | 3.4 | 3.7 | 4.5 | 4.2 | 58.0% |
| Hungary | 13.0 | 13.4 | 12.7 | 11.9 | 11.7 | 10.2 | 10.9 | 10.4 | 9.7 | -25.1% |
| Republic of Ireland | 4.1 | 3.9 | 4.5 | 4.8 | 5.0 | 4.8 | 5.2 | 4.6 | 4.5 | 10.0% |
| Italy | 73.9 | 79.1 | 77.4 | 77.8 | 77.8 | 71.5 | 76.1 | 71.3 | 68.7 | -7.1% |
| Lithuania | 3.1 | 3.3 | 3.2 | 3.6 | 3.2 | 2.7 | 3.1 | 3.4 | 3.3 | 7.4% |
| Netherlands | 40.9 | 39.3 | 38.1 | 37.0 | 38.6 | 38.9 | 43.6 | 38.1 | 36.4 | -10.8% |
| Poland | 13.2 | 13.6 | 13.7 | 13.8 | 14.9 | 14.4 | 15.5 | 15.7 | 16.6 | 25.5% |
| Portugal | 3.8 | 4.2 | 4.1 | 4.3 | 4.7 | 4.7 | 5.1 | 5.2 | 4.7 | 24.7% |
| Romania | 17.5 | 17.6 | 18.1 | 16.1 | 15.9 | 13.3 | 13.6 | 13.9 | 13.5 | -22.9% |
| Slovakia | 6.1 | 6.6 | 6.0 | 5.7 | 5.7 | 4.9 | 5.6 | 5.2 | 6.0 | -2.1% |
| Spain | 27.4 | 32.4 | 33.7 | 35.1 | 38.6 | 34.6 | 34.6 | 32.2 | 31.4 | 14.5% |
| Sweden | 0.8 | 0.8 | 0.9 | 1.0 | 0.9 | 1.1 | 1.6 | 1.3 | 1.1 | 33.8% |
| United Kingdom | 97.4 | 95.0 | 90.1 | 91.1 | 99.3 | 91.2 | 99.2 | 82.8 | 78.3 | -19.7% |
| European Union | 486.7 | 496.1 | 489.7 | 482.1 | 497.3 | 465.1 | 502.9 | 453.1 | 443.9 | -8.8% |

Source: [Authors on the basis of 8]

As can be seen in Table 1, the highest relative increases in gas consumption have been recorded in Greece and Sweden, but in terms of absolute values these increases are minimal, 1.5 and 0.3 bcm respectively. For comparison, in the analysed periodPoland saw an increase of 3.4 bcm,one of the highestgrowth in the EU. The reasons for the increased natural gas consumption should probably be sought in the growing Polish economy, as mentioned previously, as well as in a lowerper unit cost of gas in Poland, as compared to other EU countries. For example, in 2012the level of natural gas consumption per capita was equal to 411 $m^3$in Poland, 1,242 $m^3$ in the UK,925 $m^3$ in Germany, while the average value for the EU was 881 $m^3$ [20]. Growth in demand for natural gas in Polandwill further depend, i.a., on the development of gas-fired power generation. The construction of CCGT units is currently underway in StalowaWola, Włocławek and Gorzów Wielkopolski [18]. Assuming only the completion of these units, the natural gas consumption will increase by more than 1 bcm within two years.

Also, when analysing the access of households to natural gas distributionnetworks,wide variations can be seen in this regard; in the case of Małopolskaand Podkarpackie provinces this access is of approximately 70%, and for the province ofPodlasie it is less than 30% [6].

In recent years, a growing dependency of the EU on natural gas imports has been observed. In 2000, the imports of this raw material covered approximately 61% of the annual demand, while in 2012 the imports already covered 85% of the annual consumption of this fuel [1] [8]. Figure 2 shows the increasing imports of natural gas to the European Union against the gas consumption in 2000-2012. In 2013 the largest natural gas imports into the EU were delivered from Russia: 27% of total EU demand for natural gas, 23% from Norway, and 8% from Algeria[2].

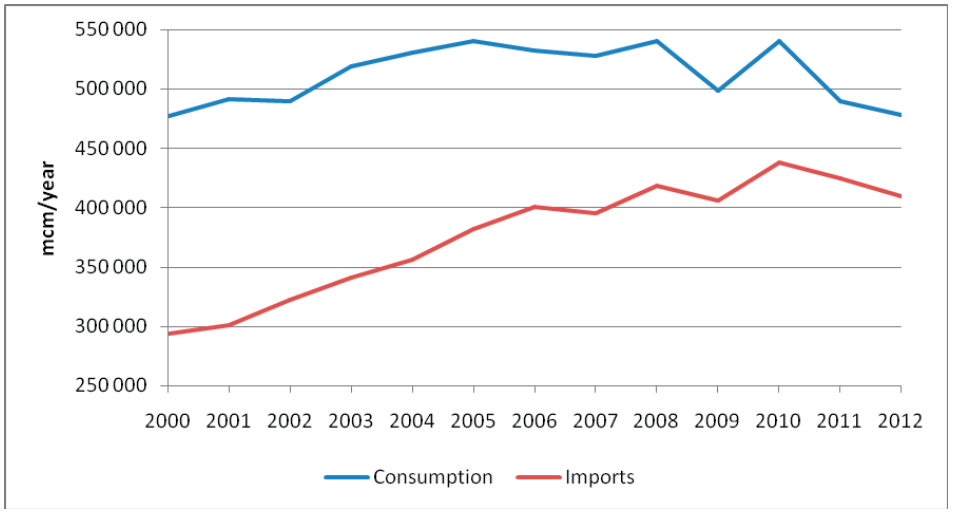


**Fig. 2.** Consumption and imports of natural gas to the EU in 2000-2012
[Authors on the basis of1]

## 3. THE ROLE OF UNDERGROUND GAS STORAGE (UGS)

Taking into account, inter alia, an increasing dependency on natural gas imports, the European Union has taken steps to create a single market for natural gas. This is to be understood as the creation of a market that will allow the operation of multiple providers, the creation of mechanisms to guarantee price stability while ensuring non-discriminatory and equal access to the network infrastructure. The European Union aims to create a single market for natural gas, where the flow of this fuel would not be liable to distortions, and itspricing would solely and exclusively be market-based. The main objective of the liberalisation of markets for fuels and energy is to achieve a reduction in the prices of energy sources for end users, by increasing the efficiency of resource allocation [14]. One of the essential elements of the

European natural gas market is underground gas storage. Along with the changing market environment, the tasks to be fulfilled by storage facilities are different. The main purposes that underground gas storage facilities serve are [14]:

- create strategic reserve in case of disruption of supplies (this especially applies to countries depending on imports mostly),
- provideseasonal load balancing in order to meetdemand peaks;
- enable daily balancing;
- sustain transmission by eliminating local bottlenecks or critical pressure constraints.

Progressive liberalisation of natural gas market in the European Unioncausesthe purposes currently served by underground gas storage facilities to be extended to new functions, among which are:

- enable arbitrage of gas prices, or commercial optimisation of variations in gas prices;
- overall system optimisation including facilitating swaps.

Along with the liberalisation of the EU gas market, regional natural gas exchanges have been established where this fuel is sold and its pricing ismarket-based. Figure 3 shows the variations in natural gas prices from 2010 to 2014. First, i.e. in 2010, a considerable difference can be seen in the price of natural gas on different exchanges, reachingup to approximately 90 USD/1000 $m^3$. However, along with progressive liberalisation, the differences in gas prices on individual markets are decreasing up to a maximum of 6%[23].

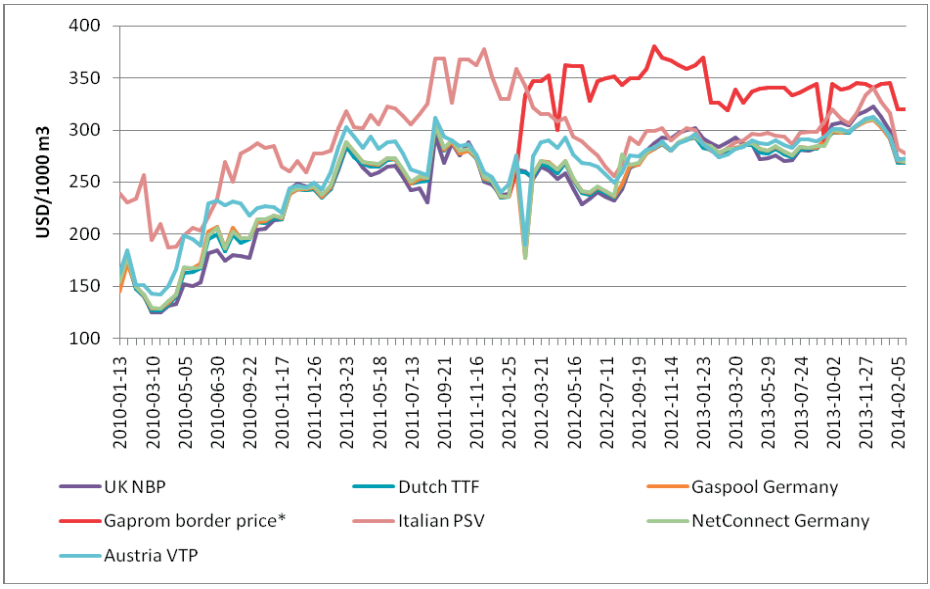


**Fig. 3.** Natural gas price evolution on regional exchanges in the EU, 2010-2014
[Authors on the basis of 23]
* estimated price

Given the situation on European markets, together with its traditional role as a guarantee of energy security, storage facilitiesare growing in importance as an asset that may be used to generate an extra margin. Over the last few years the Europe's gas markets have been characterised by dynamic fall in the gas price differential in the summer and winter seasons. The main reason for this is an overall development of storage capacities in Europe resulting from ongoing investments. As a result of enhanced available storage capacities, a growing supply of gas in winter months (withdrawal period) is being observed, which inhibits the rise in gas prices. In summer months (injection period), in turn, a rising demand for gas is being observed, which translates into increased gas prices. As a result, the seasonal trends are smoothed [15].

In 2012 the European Union had 132 underground gas storage facilities with aggregate working volumes of over 92 bcm. Compared to 2000, the number of storage facilities has grown by 23%. Most storage facilities have been located in salt caverns, a rise of 68%. In the analysed period the aggregate storage capacity increased by 48%, from 62.3 bcm in 2000 to 92.1 bcm in 2012. The highest growth in working capacity could be seen in storage facilities located in salt caverns: 68%, then in depleted gas fields: a growth of 49%, and in aquifers: a rise of 34%. Table 2 provides an overview of the number of underground gas storage facilities in the EU, in 2000 and 2012 [8].

**Table 2**

UGS in Europe

| Type of UGS | Number of facilities | | | Workingvolumes [mcm] | | | Offtake capacity [mcm/day] | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2012 | Change | 2000 | 2012 | Change | 2000 | 2012 | Change |
| Depleted gas field | 57 | 68 | 19% | 41,987 | 62,681 | 49% | 714.78 | 987 | 38% |
| LNG | 4 | 1 | -75% | 616 | 386 | -37% | 122.1 | 86 | -30% |
| Aquifer | 24 | 24 | 0% | 12,432 | 16,652 | 34% | 195.5 | 261.5 | 34% |
| Salt cavern | 22 | 37 | 68% | 7,363 | 12,365 | 68% | 292.32 | 478.7 | 64% |
| Rock cavern | 0 | 2 | | | 73 | | | 6.6 | |
| TOTAL | 107 | 132 | 23% | 62,398 | 92,157 | 48% | 1,324.7 | 1,819.8 | 37% |

Source: [Authors on the basis of 8]

Germany has the highest working volumes in underground gas storage facilities in the European Union:over 23% of available capacity in the EU in 2012. Italy follows with almost 17%, then France 14%, Austria with over 8%, Hungary 6.8%, the Netherlands 5.7%, the United Kingdom 5%, Romania 3.4%, Slovakia 3.2%, Czech Republic 2.8%, Spain and Latvia, both 2.6%, Poland 2.2%, Denmark 1.1%, and other countries with less than 1% [8].

As already indicated, in 2000-2012 the EU recorded a growth of 48% in working capacity of underground gas storage facilities. But in individual countries the situation was as follows: a growth of 263% in Romania, 225% in Austria, 125% in the Netherlands, 97% in Poland, 90% in Spain, 82% in Bulgaria, 70% in Hungary, 39% in Czech Republic, 27% in the United Kingdom, 24% in Denmark, 22% in Italy, 21% in Slovakia, 20% in France, 13% in Germany, 10% in Croatia. Table 3 shows the growing working capacity of underground gas storage facilities in individual EU countries.

**Table 3**

Growth inworking capacity of underground gas storage facilities in individual EU countries, from 2000 to 2012, [mcm]

| Country | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | 2 295 | 2 820 | 2820 | 3020 | 3020 | 2820 | 2820 | 2849 | 4099 | 4249 | 4639 | 4639 | 7451 |
| Germany | 18 353 | 18 556 | 19 099 | 18 830 | 19 547 | 18 934 | 18 934 | 19 135 | 19 138 | 19 866 | 19 866 | 20 804 | 20 693 |
| Italy | 12 402 | 12 747 | 12 747 | 12 747 | 12 747 | 12 743 | 12 792 | 13 250 | 12 900 | 12 870 | 14 295 | 14 417 | 15 150 |
| France | 10 490 | 10 490 | 10 490 | 10 840 | 10 840 | 10 840 | 10 840 | 10 840 | 10 840 | 12 143 | 12 395 | 12 395 | 12 595 |
| Hungary | 3 610 | 3 180 | 3 290 | 3 340 | 3 380 | 3 380 | 3 400 | 3 500 | 3 820 | 4 190 | 6 280 | 5 780 | 6 130 |
| Netherlands | 2 128 | 2 478 | 2 478 | 2 478 | 2 478 | 2 478 | 2 478 | 2 478 | 2 478 | 5 078 | 5 078 | 5 078 | 5 078 |
| United Kingdom | 3562 | 3562 | 3627 | 3645 | 3597 | 3586 | 3759 | 4364 | 4364 | 4523 | 4310 | 4290 | 4530 |
| Romania | 840 | 840 | 1568 | 2012 | 2500 | 2500 | 3004 | 3590 | 3694 | 3162 | 3228 | 3003 | 3048 |
| Slovakia | 2 380 | 2 670 | 2 740 | 2 740 | 2 740 | 2 740 | 2 740 | 2 740 | 2 600 | 2 770 | 2 786 | 2 786 | 2 875 |
| Czech Republic | 1 804 | 2 047 | 2 059 | 2 059 | 2 185 | 2 245 | 2 285 | 2 285 | 2 285 | 2 501 | 2 501 | 2 501 | 2 501 |
| Spain | 1 247 | 1 274 | 1 414 | 1 414 | 2 121 | 2 121 | 2 366 | 2 366 | 2 366 | 2 726 | 2 726 | 2 366 | 2 366 |
| Latvia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2300 | 2300 | 2300 | 2300 |
| Poland | 982 | 1 200 | 1 255 | 1 460 | 1 715 | 1 715 | 1 795 | 1 652 | 1 660 | 1 660 | 1 630 | 1 719 | 1 939 |
| Denmark | 815 | 810 | 810 | 700 | 700 | 760 | 810 | 840 | 760 | 497 | 1 001 | 970 | 1 013 |
| Belgium | 712 | 712 | 712 | 636 | 636 | 635 | 655 | 635 | 655 | 655 | 709 | 709 | 700 |
| Croatia | 500 | 500 | 500 | 500 | 500 | 500 | 550 | 550 | 500 | 550 | 558 | 550 | 550 |
| Bulgaria | 200 | 200 | 200 | 500 | 550 | 550 | 410 | 502 | 600 | 350 | 647 | 509 | 450 |
| Ireland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 198 | 198 | 198 | 198 | 230 |
| Portugal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 134 | 124 | 180 | 180 | 181 |
| Sweden | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 9 | 9 | 9 | 9 |

Source: [Authors on the basis of 8]

As can be seen from Table 3, in the case of Poland underground gas storage working volumes have grown in the last few years. In the near term, when the works related to the expansion of the Wierzchowice Underground Gas Storage facility have been completed, the capacity of this storage facility will increase from 575 mcm to 1,200 mcm, which will decisively translate into an aggregate capacity of underground gas storage facilities[4].

One of the fundamental objectives to be attained by underground gas storage is to ensure a strategic reserve in the event of disruptions in gas supplies. Considering the EU as a whole, the change in the coverage ratio of annual natural gasconsumption from underground gas storage in 2012 was equal to 20%. From one country to the other, the situation is much more complex.The highest coverage ratio of annual natural gas consumption from underground gas storage in 2012 was observed in Latvia and accounted for 153%.But it is necessary to bear in mind that the volumes of natural gas consumption in Latvia account for approximately 1.5 bcm/year. Table 4 shows how this ratio has been shaped in selected EU countries. Figure 4 shows daily consumption of natural gas from the start of 2009 until mid-2013, and, at the same time, it illustrates how supplies from UGS are important during periods of increased gas demand. As can be seen, disparities in gas consumption between summer and winter months have significantly increased in recent years. Minimum natural gas consumption in the analysed period accounted for 16.2 mcm/day while the maximum consumption was equal to 72.3 mcm/day[14].

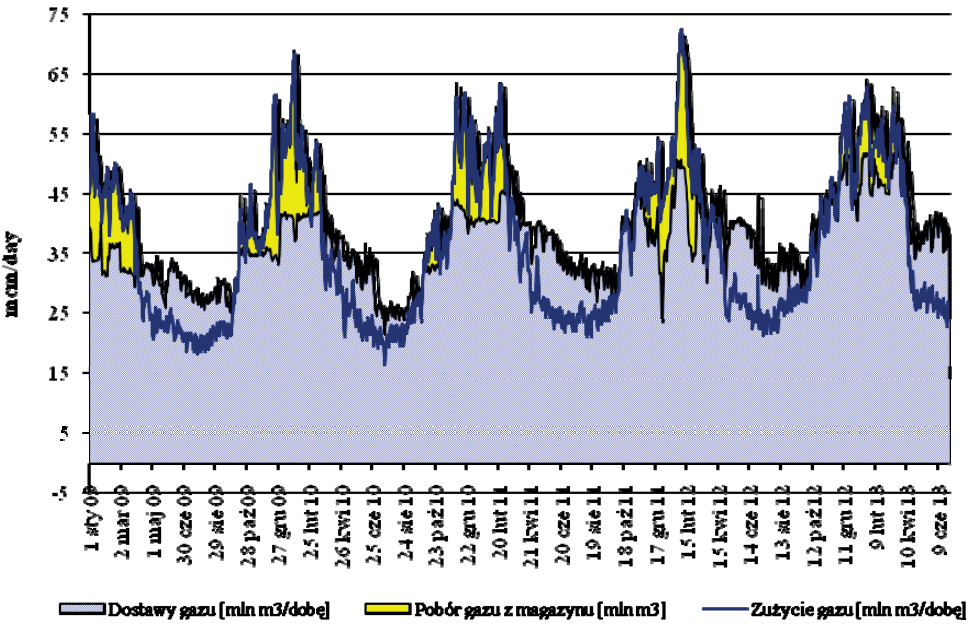


**Fig. 4.** Dailyconsumption of natural gas from 1 January 2009 to 31June 2013[14]

**Table 4**

The coverage ratio of annual natural consumption from underground gas storage facilities in 2012

| No | Country | Ratio [%] | No | Country | Ratio [%] |
|---|---|---|---|---|---|
| 1. | Austria | 82 | 10. | Croatia | 18 |
| 2. | Hungary | 60 | 11. | Bulgaria | 16 |
| 3. | Slovakia | 54 | 12. | Netherlands | 11 |
| 4. | Czech Republic | 30 | 13. | Poland | 11 |
| 5. | France | 29 | 14. | Spain | 7 |
| 6. | Denmark | 26 | 15. | United Kingdom | 6 |
| 7. | Germany | 24 | 16. | Ireland | 5 |
| 8. | Romania | 22 | 17. | Belgium | 4 |
| 9. | Italy | 20 | 18. | Portugal | 4 |

Source: [Authors on the basis of 8]

Table 5 provides an overview of changes in the coverage ratio of annual natural gas consumption from underground gas storage in individual EU countries from 2000-2012.

It appears that in the case of certain countries the investments involving the extension of underground gas storage facilities could have been influenced by the Russian-Ukrainian gas conflict in early 2009. A detailed development of this crisis has beendiscussed in the publication [11] [12]. Among the countries to be affected by this serious crisis in recent years arei.a. Slovakia, Hungary, and Austria. As can be seen from Table 5 these countries developed UGS capacities after 2009, as illustrated by the ratio value in Table 5.

In the context of the liberalisation of natural gas market, peak underground gas storageis gaining in importance. The major role of underground gas storage is to ensure the continuity of gas supplies in the period of increased gas consumption. But on the liberalised natural gas market, peak underground gas storage may generate additional revenues through arbitrage.

A decreasing attractiveness of UGS built in depleted gas fields can be seen in Europe today, while cavern storage is gaining in importance. This is a result of the following factors [3]:

- due to the narrowing of the seasonal spread, the classic summer-winter arbitrage, possible to be carried out with the use of gas field storage, is becoming less and less profitable and more risky (sometimes even impossible);
- there are also short-term demand/supply shocks on the gas market, which results in significant market price fluctuations. The storage characteristics (i.e. relatively low deliverability and injectability) do not allow to react to short-term demand/supply shocks;
- gas field storage does not show any flexibility in terms of changing directions of the gas flows, which means that it is impossible to inject gas in the winter or deliver it in the summer;
- cavern storage has several times higher gas injectability and deliverability than gas reservoir storage, which enables a faster adaptation to changing market conditions;
- cavern storage makes it possible to benefit from short-term price fluctuations in order to gain an additional margin.

**Table 5**

The coverage ratio of annual natural gas consumption from underground gas storage in individual EU countries[8]

| Country | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | 28% | 34% | 34% | 34% | 34% | 29% | 33% | 32% | 44% | 46% | 46% | 49% | 82% |
| Romania | 5% | 5% | 9% | 11% | 14% | 14% | 17% | 22% | 23% | 24% | 24% | 22% | 22% |
| Netherlands | 4% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 10% | 9% | 11% | 11% |
| Bulgaria | 6% | 6% | 7% | 16% | 17% | 16% | 11% | 14% | 17% | 13% | 23% | 16% | 16% |
| Poland | 7% | 9% | 9% | 10% | 11% | 11% | 11% | 10% | 10% | 10% | 10% | 10% | 11% |
| Spain | 7% | 7% | 7% | 6% | 8% | 7% | 7% | 6% | 6% | 8% | 8% | 7% | 7% |
| Hungary | 30% | 24% | 25% | 23% | 23% | 23% | 24% | 26% | 29% | 37% | 52% | 50% | 60% |
| Czech Republic | 20% | 21% | 22% | 21% | 23% | 24% | 25% | 26% | 26% | 31% | 27% | 30% | 30% |
| United Kingdom | 3% | 4% | 4% | 4% | 4% | 4% | 4% | 5% | 4% | 5% | 4% | 5% | 6% |
| Denmark | 17% | 16% | 16% | 14% | 14% | 15% | 16% | 18% | 17% | 11% | 20% | 23% | 26% |
| Italy | 18% | 18% | 18% | 16% | 16% | 15% | 15% | 16% | 15% | 16% | 17% | 19% | 20% |
| Slovakia | 33% | 35% | 38% | 39% | 41% | 38% | 42% | 44% | 41% | 51% | 46% | 49% | 54% |
| France | 26% | 24% | 25% | 24% | 24% | 23% | 24% | 24% | 24% | 27% | 25% | 29% | 29% |
| Germany | 21% | 20% | 21% | 19% | 19% | 19% | 19% | 20% | 20% | 23% | 21% | 24% | 24% |
| Croatia | 18% | 18% | 17% | 17% | 17% | 17% | 19% | 17% | 16% | 19% | 17% | 17% | 18% |
| Belgium | 5% | 5% | 4% | 4% | 4% | 4% | 4% | 4% | 4% | 4% | 4% | 4% | 4% |
| Latvia | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 151% | 126% | 143% | 153% |
| Ireland | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 4% | 4% | 4% | 4% | 5% |
| Portugal | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 3% | 3% | 4% | 3% | 4% |

As a result of an increasing attractiveness of cavern storage, a vast majority of investments being carried out in Europe concern cavern storage – Figure 5. They better meet the needs of market participants and allow an additional profit to be produced.

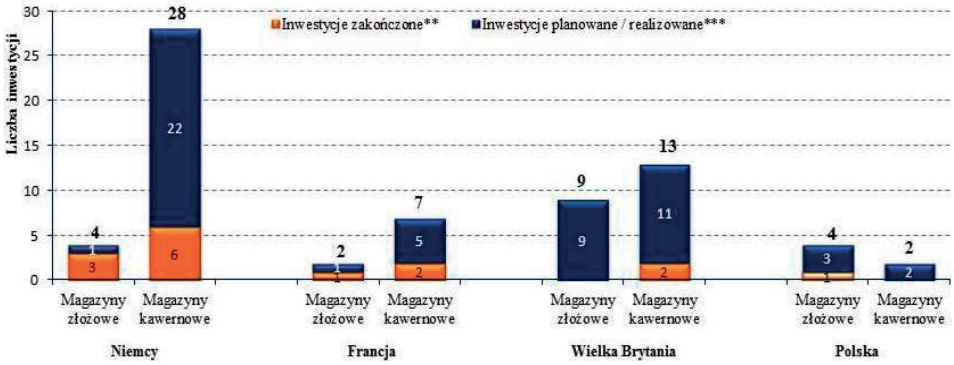


**Fig. 5.** Planned extension of storage capacities in selected EU countries [15]

## 4. SUMMARY

Over the past four years, as a result of underground gas storage expansion, its working capacity has grown by 17%. However, as analysed in this paper, despite the investments carried out in the UGS area, the comparison made between the internal coverage ratio of annual gas consumption from underground gas storage, and the equivalent ratios for EU countries with developed gas markets illustrates an advantage for these EU countries and induces further expansion of UGS at domestic level.

It is also supported by recent development of domestic natural gas market, that is the period in which the EU saw a decline in gas consumption. It is necessary to bear in mind that the extension of storage capacity will be necessary for plans associated with growth in the volume of natural gas production, both from conventional and unconventional gas deposits[5] [17]. Changes occurring in the electricity market, i.a. significant growth of the capacity inRES-based facilities, will also require investments in units with high operating flexibility, for example gas-powered units, which will necessitate extra use of UGS[21]. Moreover, further development of the market for natural gas in Poland and its liberalisation will result in the use of advanced gas storage objectives, such as transmission adjustment and commercial optimisation of prices (arbitrage) [16]. However, the situation that arose as a result of the Russian-Ukrainian conflict in March 2014 and its possible repercussions in terms of disrupted natural gas supplies into the European Union causes the fundamental objective of UGS (i.e. securing role in the event of gas supply disruptions) to be still valid. Changes observed on the markets for natural gas in EU countries point out that investments in gas storage facilities with high operating flexibility are to be preferred. Such requirements are met in the case of cavern storage, and work is currently underway at domestic level in terms of enhancing

storage capacity of such storage facilities. It should be stressed that the expansion of UGS and, in particular, the expansion of cavern UGS is characterised by high investment costs; therefore, the use of EU funds materially affects both the scope and speed of investment in the UGS sector.

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