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Evaluating the options to diversify gas supply in Ukraine

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Evaluating the options to diversify gas supply in Ukraine

Executive Summary

Ukraine is economically dependent on natural gas imports from Russia. This allows Russia to arbitrarily set the price or demand for economic (and political) concessions. In the past, Ukraine was able to use its significant role as a transit country for Eurasian gas to Europe to, nevertheless, negotiate relatively moderate prices. But this role is vanishing. After the completion of the first two strings of Nord Stream, 64% of the exports to Europe could circumvent Ukraine. If either South Stream or the next two strings of Nord Stream are completed, Ukraine could be fully circumvented. Consequently, Ukraine could choose between three strategies:

Strategy 1: Paying a very high price for natural gas (in the order of 400-500 USD/tcm under current market conditions)

Strategy 2: Obtaining lower prices in return for political and economic concessions

Strategy 3: Reducing the price of gas imports by reducing its unilateral dependence

In this paper we review main technical and economic options to reduce dependence, and thus to implement Strategy 3. Concretely, we look at three possibilities: i. diversify supplies, ii. increase domestic production and iii. reduce demand. We quantify the individual options in terms of available volume, investment needs, variable cost and implementation time (see overview table on the following page).

Obviously, implementing all available options independently from each other is not wise as the combined volume would substantially exceed the demand of Ukraine and the costs of many of the options are quite substantial. This implies that a simple 'all of the above' approach (i.e. implementing all options at the same time without taking into account interdependencies) would not be economic. Consequently, Ukraine must determine an optimal portfolio of options under political, technical and economic uncertainties. Thereby, timing is important, as some of the options can be implemented quickly, while others might take up to ten years.

The private sector can help to shoulder the (often) substantial investment cost. However, private investors require a firm commitment of the government to a sourcing and pricing strategy. Increasing transparency in the setting of import prices and domestic prices based on supply and demand would substantially reduce the political/regulatory risk for investors. On the other hand, a volatile strategy towards price discounts for concessions risks shying off private investors. And without transparent and non-discriminatory access to infrastructure is also an issue.

In some cases, investments that are beneficial for Ukraine will not be conducted by the private sector. For example, investing in new import infrastructure (LNG or pipeline) could help to create competition for gas imports to Ukraine and hence might also force the incumbent supplier to lower prices in order to maintain its market share. This might be hugely beneficial for Ukraine, but might at the same time render the investment in new import infrastructure uneconomic. Consequently, private investors will at best underinvest, unless they are given the right incentives (for example, in the form of option contracts with the government).

Finally, we caution that an import price below the European price will be difficult to achieve, as all potential exporters to Ukraine would reroute their volumes to Europe in case the price there is substantially higher.

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Summary of the different options [indicative values]

	Max capacity (bcm/y)	Fix cost (bn USD/ bcm/y)	Variable cost (USD/tcm)	Implemen-tation time (y)	Remarks
Diversify imports					
o Physical reverse flows	o	o	o	o	o
▪ Poland	1.5	0	400	0	
▪ Slovakia	10-30	0	400	0-0.5	Full reverse capacity requires a by-pass pipeline
▪ Hungary	2-6.5	0	400	0	
▪ Romania	5	0	400	0	
▪ Moldova	0	0	400	0	Technical: 27 bcm, but Moldovagaz = Gazprom, and lack of gas in SEE
o Virtual reverse flows	0	0	400	0	Technical: >80 bcm, legally unclear
o LNG terminal	-	-	-	-	Turkish straits traffic
▪ Floating	5	0.2	400	2	
▪ On-shore	10	0.2	400	4	Deepen the sea for port
o New pipelines					
▪ Azerbaijan-Georgia-Ukraine	8	>1	300	10	Extremely unlikely
▪ Connection to Adria LNG	5	1	400+	3-7	Includes cost share in Adria LNG
Increase domestic production					
o Shale gas	0-15	<1	120-282	7-10	High uncertainty before exploration drillings
o Off-shore	7-9	>1	75-125	7-10	
o CBM	2-4	0.5-1	290-410	7-10	
o Conventional	18-24	0.5-1	80-115	3-7	
Reduce consumption					
o Fuel switching: coal->gas					
▪ Electricity	0-2	1-2	100	3-7	Some gas units needed for system stability
▪ Heat (incl CHP)	18	1.5-3	100	3-7	
▪ Coal gasification	4	1	140	3-7	
o Energy efficiency	30	0-…	0-1000	0-10	Wide continuum of options
▪ Ex.: Residential building	?	0.45	0	1-3	

The numbers in this table are collected/deducted from various sources and are subject to substantial uncertainties.

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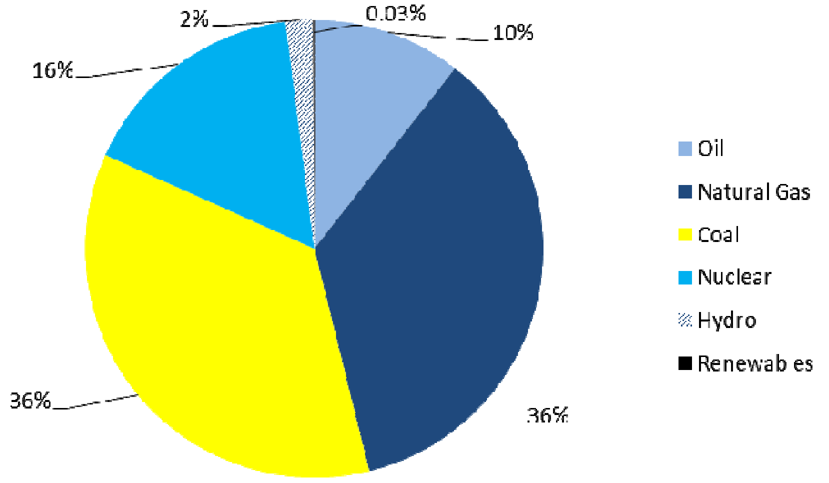
1. Introduction

Ensuring inexpensive gas supplies is economically and politically pivotal for Ukraine. Natural gas is the most important energy carrier in Ukraine. According to British Petroleum 36 percent of total energy supply in 2012 came from natural gas. More than half of this gas is imported from Russia and imports of natural gas account for about 8 percent of Ukrainian GDP in 2012[1].

Figure 1

Energy supply by fuel in Ukraine in 2012



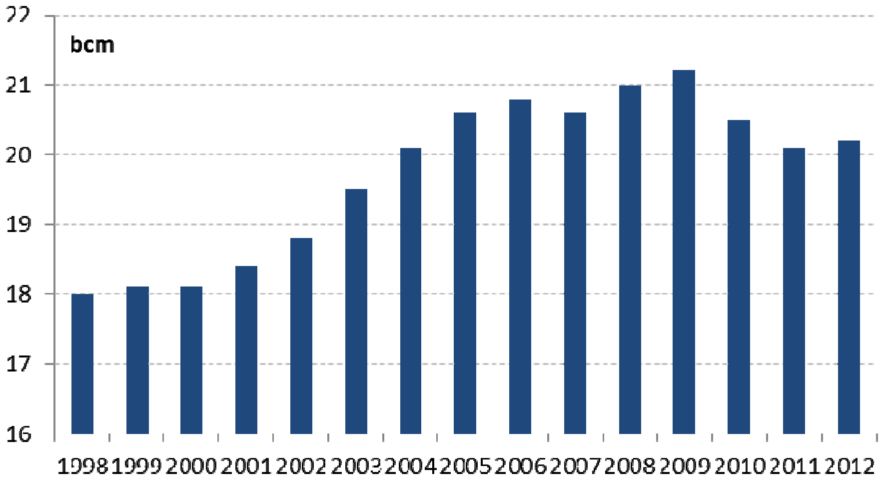
Source: BP Statistical Review of World Energy June 2013

In 2012 Ukraine consumed 55 billion cubic meters (bcm) of natural gas. About 20 bcm (or 36%) of this were produced domestically while 33 bcm (or 60%) where imported. The share of imports in consumption will likely increase as natural gas consumption is expected to recover with the Ukrainian economy, while domestic natural gas production will fall unless substantial investments are undertaken.

[1] (426 USD/tcm * 32,900,000 tcm) / 176 bn USD.

Figure 2

Natural gas production in Ukraine 1998-2012



Source: Naftogaz[2]

Until 2012 Ukraine imported all natural gas from/through Russia[3]. This one-sided provisioning strategy was caused both, by the comparatively low price offered by Russia as well as the lack of infrastructure that would have allowed alternative imports.

At the same time Ukraine had some leverage when negotiating the gas import price with its monopoly supplier Russia, as Ukraine was a pivotal transit country. But natural gas transit through Ukraine is declining. While 2011 104 bcm were transported through Ukraine, transit decreased to 84 bcm[4] in 2012 and remained low at 86.1 bcm in 2013[5]. In addition to the 140 bcm that currently can be transited through Ukraine[6], 35 bcm of Eurasian gas can be imported through Belarus and 55 bcm through Nord Stream 1 & 2. Thus, technically Ukraine is only pivotal for 36 percent[7] of the current European imports from Eurasia (2012: 140 bcm) and if either South Stream (63 bcm) or Nord Stream 3 & 4 (55 bcm) are completed Ukraine could be quasi fully circumvented[8] – even though

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[2] Note: IMF 2012 p.8 claims a substantially lower production in 2012 (~16 bcm).

[3] Even though, for several years Ukraine contractually bought natural gas in Turkmenistan, volumes and prices were determined by Russia as the gas had to be transited through Russian pipelines.

[4] As a consequence Ukraine is considering to mothball parts of its pipeline system to save cost (see http://www.europarl.europa.eu/meetdocs/2009_2014/documents/d-ua/dv/dua_20131009_12/DUA_20131009_12EN.pdf p.14).

[5] http://www.utg.ua/uk/press/site-updates/у-2013-році-україна-збільшила-транзит-при/

[6] There is some uncertainty on the technical transit capacity of Ukraine. Hafner (2012) assumes a low 115 bcm:

"The annual initial gas transit capacity via Ukraine totalled 175 bcm. Deterioration of the Ukrainian GTS led to declining real transportation capacity, which is estimated currently at around 115 bcm", while Ukrtransgas still speaks of 140 bcm (www.utg.ua/en/activities/) and declares that it actually pumped about 140 bcm of transit gas in 2010 (http://www.utg.ua/uk/press/publications/газотранспортна-система-україни-над/).

[7] (140 bcm – (35 bcm + 55 bcm))/140 bcm = 36%.

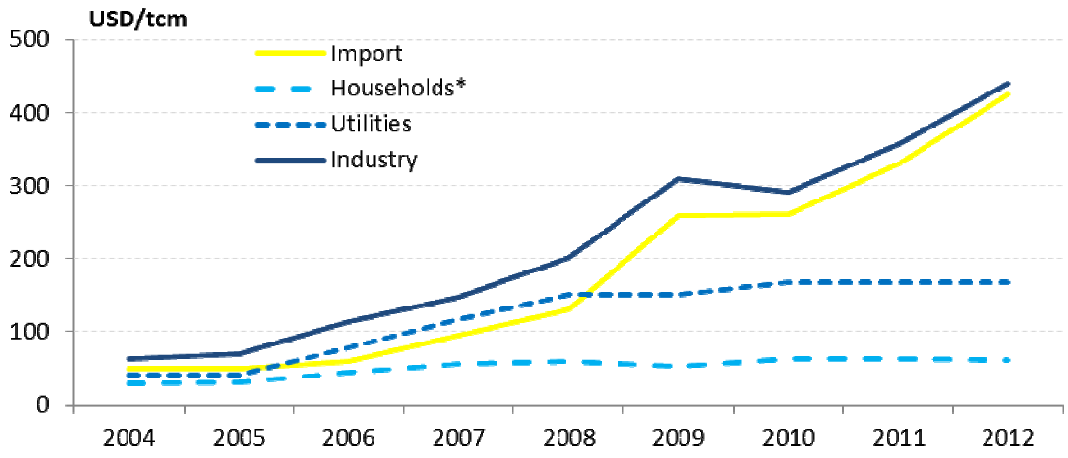
[8] This will not mean that the pipelines will not be used any more, but Russia can negotiate the transit tariffs/gas prices much more aggressively. So far, Ukraine remains the main transit route for Russian gas sold to Europe, which earns Kyiv about USD 3 bn a year in transit fees (USD 2.97 bn in 2012)http://economics.unian.net/rus/news/168069-naftogaz-v-1-m-kvartale-sokratil-dohod-ot-tranzita-gaza-na-18.html.

storage-wise Ukraine might still be important for gas-transit. [9] Consequently, the Ukrainian gas transit lost its transit-monopoly[10] and hence the negotiation position of Ukraine vis-à-vis Russia substantially deteriorated.

The declining importance of Ukraine as a transit country as well as other factors allowed and encouraged **Russia to move away from preferential pricing for Ukraine to exercising its monopoly power.** Consequently, natural gas import prices from Russia to Ukraine increased from below 100 USD/tcm before 2005 to about 400 USD/tcm in 2013. This is more than Germany currently pays for Russian gas (~350 USD), even though the cost for delivering gas to Germany are substantially higher. In addition, the 400 USD/tcm Ukraine paid in 2013 already include a 100 USD/tcm discount[11] granted by Russia to compensate Ukraine for the right to harbour the Russian Black Sea Fleet in Ukraine.

Figure 3

Gas prices in Ukraine



* Households consuming up to 2,500 cm a year (majority of end users)

Source: Naftogaz, NERC

Russia could essentially decide between three gas-pricing schemes for Ukraine.

In a <u>preferential</u> setting – as applied to Ukraine before 2009 and still applied in Belarus for example – Russia might ask prices that are below the profit it can make from selling

[9] Ukrainian storages were built in Soviet time to provide seasonal flexibility for export flows and until now cannot be replaced by the Russian storages. According to the Russian official statistics the summer/ winter flexibility of Russian gas supplies is something like 60/40 (% winter vs summer offtake). Russia needs this storages for reliable supplies to Europe: gas supplies shortfall in February 2012, when Gazprom failed to meet European demand for gas during an unprecedented cold snap, which led to at least eight EU members - including Italy, France, Germany and Austria - reporting a cut in gas supplies from Russia, resulted from a lack of agreement on the Ukrainian UGSs utilization by Gazprom in 2010 and in 2011. Theoretically, building storages in Europe and inside Russia close to the western border could help Russia to modulate without Ukraine in the longer term, but it does not seem feasible until 2025-2030.

http://www.bloomberg.com/news/2012-02-22/gazprom-sees-zero-need-for-ukraine-gas-transit-with-new-links.html

[11] On 21 April 2010 in Kharkov, presidents Yanukovych and Medvedev signed the Russian Ukrainian Naval Base for Gas treaty, widely referred to as the Kharkov Accords. According to this treaty, the Russian lease on naval facilities in Crimea was extended beyond 2017 by 25 years (to 2042) with an additional 5 year renewal option (to 2047) in exchange for a multiyear 30% discounted contract to provide Ukraine with Russian gas. As a result in June 2010, Ukraine paid to Gazprom around 234 USD/tcm instead of 330 USD/tcm (according to initial formula). Kiev says this deal signed in January 2009 is unfairly favorable to Russia. In October 2011, Tymoshenko was sentenced to seven years in prison for abusing authority while negotiating the gas agreement with Russia.

the gas elsewhere. The preferential price for Belarus is currently at 165 USD/tcm. Preferential prices come in return for political or other concessions, for example, the right to use the gas transport system or to participate in the Customs Union.

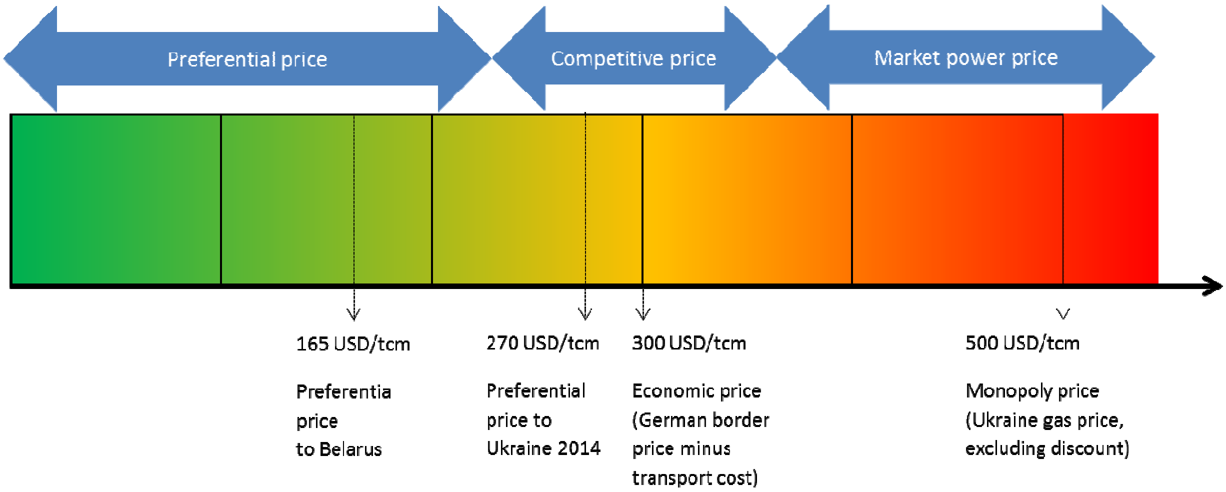
In a <u>competitive</u> setting Russia would ask Ukraine the lowest price at which it sells this gas elsewhere plus the differential in supply/transport cost (i.e. the opportunity cost of selling gas not to Ukraine but elsewhere). Currently, this is should be around 300 USD/tcm.[12] This price would only materialise if sufficient volumes of alternative supplies would be offered at a similar price.

In a <u>market power</u> setting, Russia's price maximisation is only constraint by Ukraine's ability to pay[13]. Thereby, the price not only includes the 'face value' - i.e., the price paid per thousand cubic meters - but also the value of political concessions. Currently, this price[14] seems to be in the range of 500 USD/tcm[15].

In December 2013 Ukraine was granted a temporary price of 268.5 USD/tcm. Policy-makers and media are speculating about what promises Russia obtained in return for this discount that was granted shortly before Ukraine rejected to sign an Association Agreement with the European Union. Thus, even though this price is below the price one would expect in a fully competitive market, there is likely hidden political cost so that the full cost of the deal reflects the market power Russia has.

Figure 4

Schematic price range for Russian gas imports to Ukraine



Source: Own illustration

That is, given that Ukraine is still strongly dependent on Russian gas the full price Ukraine has to pay is the 'market power price'. As a consequence, any price reduction by Russia will only be given in return for valuable political concessions. With a decreasing value of gas transit through Ukraine, Ukraine must offer additional concessions to Russia or accept higher prices.

Ukraine is aware of this issue and in 2012 the government embarked on a three-step policy to reduce Ukraine's gas dependence: first, domestic gas production should

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[12] German gas border price minus transit cost through Ukraine and Slovakia.

[13] Russia would maximise its profit at the price at which the volume effect (price-related reduction in long-term demand of Ukraine) does not dominate the price effect (increase in the price-cost margin).

[14] If Russia would not care about the long-term demand but only the short-term price relation this monopoly price might be substantially higher.

[15] Russian full price without discount.

increase; second, there should be a shift from gas-based to coal-based technologies in the country's power plants; and third, gas imports should be diversified.

Beyond this macro-view, understanding the status quo and development options of Ukrainian gas supply requires understanding at least five overlapping layers: (i) the physical picture of existing and potential production, transport and consumption infrastructure, (ii) the economic picture of the cost of the different options, (iii) the foreign policy picture that depicts how gas supply and transit is used as an item in international political negotiations, (iv) the interest group picture of who controls which assets and institutions and therefore favours certain solutions, (v) and the contractual picture about which contracts have been concluded and what do they allow/disallow.

In this piece we will focus only on (i) and (ii). That is, we will not discuss Ukraine-Russia-EU foreign relations, neither will we discuss the internal relations between Ukraine's largest gas importers Naftogaz and the Ostchem holding nor whether it is legally possible to challenge the 2010 Kharkov accord between Putin and Yanukovitch on gas prices.

In the following we want to answer the question whether Ukraine has technical and/or commercial options to improve its negotiation position. That is, do options (or a combination thereof) exist to reduce Russia's price setting power that are technically feasible and viable from an economic and business perspective.

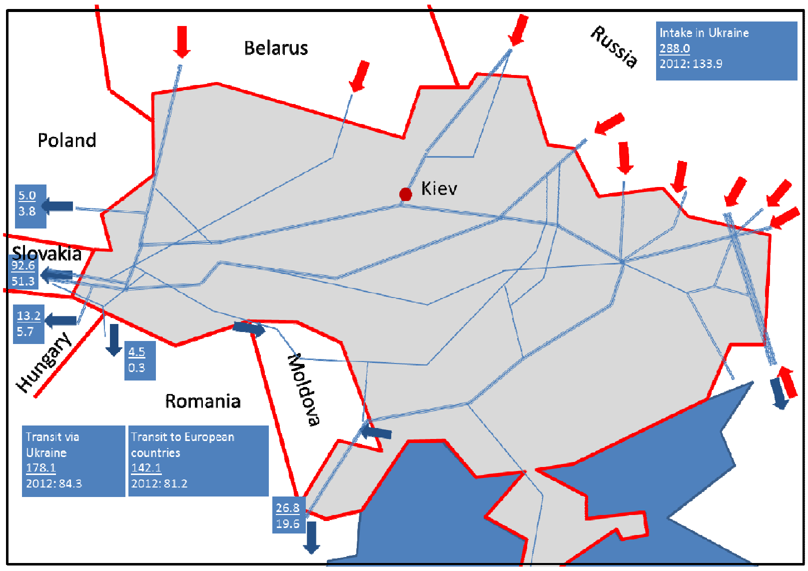
2. Ukraine has a number of options

2.1 Diversify imports

Ukraine is currently (almost) only able import gas from the East, which is the direction the existing system was initially designed for. However, various alternative options have been theoretically explored (contractual reverse flows, alternative pipelines, LNG terminal) or even practically tested (physical reverse flows). These options will be discussed in the following.[16]

Figure 5

Ukraine Gas Transport system (designed exit capacity and exit flows 2012, in bcm)



Source: Own illustration based on Ukrtransgaz and Naftogaz

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[16] As indicated in the introduction we will not discuss contractual issues, such as how existing long-term 'take or pay' volumes in the contracts between Naftogaz and Gazprom can be adapted in case Ukraine replaces imports from Russia by other sources.

2.1.1 Physical reverse flows

Physical reverse flows refer to the import of natural gas from the West, reverse to the originally designed flow direction of the existing pipelines. While the pipeline diameters would allow the import to equal the export capacity (142 bcm) actual imports from the West would be technically much more constraint by a number of factors.

First, compressors and automatic control from the dispatch centre were originally designed for unidirectional flows. Hence, software and hardware would need to be updated in order to allow 'reverse flows'. Corresponding upgrades have been conducted in Central Europe in the aftermath of the 2008/09 gas crisis and costs were comparatively limited – Slovakia speaks about only "over a million Euros"[17].

Second, Gazprom insists that the agreed amount of gas physically leaves Ukraine. This is monitored in measuring stations at the border. As a partial physical fix to this contractual issue an alternative "interconnector", bypassing Gazprom's metering station, has been proposed, and priced at just EUR 20 mn[18]. Gazprom, however, disputes that Gazprom gas can at all be reimported into Ukraine.[19] At the extreme the legal question would be whether a 'gas carousel' at the Western border - in which European gas is imported into Ukraine, relabelled into Gazprom gas exported to Europe, relabelled again and imported again into Ukraine and so forth - is legal.

Third, reverse flows would arrive in Western Ukraine. However, the most important gas demand is in the industrial East of the country. Corresponding West-East flows would again require technical upgrades to the existing infrastructure and dispatching. Inner-Ukraine swapping of Western and Eastern imports might be a more elegant (and cheaper) solution. It, however, poses again the legal question whether Gazproms transit contract foresees that a certain amount of gas is imported from Russia and the same amount is exported to the EU or whether it is exactly this gas that has to be transported from East to West.

Fourth, supply from the West might be limited, both regionally and from an exporting company perspective. Regionally, it might be difficult to make sufficient gas available for exports to Ukraine in times of high domestic consumption. In an extreme crisis, when Gazprom would curtail exports to Slovakia and Ukraine, it will be already difficult to supply Slovakia with gas from other sources and probably impossible to ensure exports to the (non-EU member) Ukraine. Furthermore, large European gas companies might be unwilling to enter into contracts with Ukrainian importers as this might prompt Gazprom to offer corresponding companies less favourable terms than companies that abstain from such business.[20]

Fifth, some of the European gas transmission system operators (TSO) are (partly) owned by Gazprom. While EU legislation (and Energy Community legislation in the case of Moldova) is supposed to ensure that TSOs perform all network access in a non-discriminatory fashion, there is reason to believe that the corresponding TSOs might be less eager to resolve technical difficulties when this is not in the interest of their owner.

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[17] http://www.eustream.sk/en_media/en_press-releases/reverse-flow-project-is-completed/10

[18] EUR 20 m according to http://www.economist.com/blogs/schumpeter/2013/11/gazprom or €15 m according to http://www.icis.com/heren/articles/2013/11/19/9727107/gas/esgm/mou-near-on-physical-gas-reverse-flow-from-slovakia-to-ukraine.html.

[19] http://blogs.euobserver.com/popescu/2013/07/16/ukraines-gas-loop/

[20] Currently, the two European suppliers that operate(d) reverse flows to Ukraine (RWE and PGNiG) are both in negotiations with Gazprom over price-discounts. The Czech arm of Germany's RWE, and Polish state PGNiG are not satisfied by Gazproms proposal to reduce price by 10% and trying to obtain larger discounts. So the exports might be more a tactical negotiation-chip with Gazprom, than a long-term business-building.

Table 1

Reverse flows

	Poland	Slovakia	Hungary	Romania	Moldova
Design export capacity to Europe (bcm/y)	5	93	13	5	27
Existing arrangements	RWE-Naftogaz, PGniG-DTEK	Not signed yet	RWE-Naftogaz VETEK DTEK	MoU[21]	Not considered as a reverse corridor
Max imports (mcm/d)		27[22]-80[23]	12[24]	5	
Actual max imports (mcm/d)	4.5	2.9 (test volumes)	6-9[25]- (max. 8.6 in October)[26]		
Gas price	400	400	400		
TSO ownership	Gaz-System S.A.	Eustream	FGSZ Ltd	Transgaz S.A.	Gazprom

Source: Various sources (see footnotes)

Despite these difficulties, reverse flows have been operated since 2012. The German gas company RWE supplied natural gas to Naftogaz from November 2012 via Poland and Hungary. The Polish gas company PGniG signed a natural gas supply contract with DTEK in October 2013.

However, the price for gas in reverse flow mode is comparatively high. Furthermore the fiscal treatment of these transactions (VAT tax refund) in Ukraine is an issue. Given the high European price and the significant transaction cost prices of about 400 USD/tcm are quoted, which is only slightly below what Ukraine has been paying to Russia in 2013. Private companies might find it quite difficult to engage in reverse flows on low margins as the regulatory risks (e.g. access to the Ukraine pipeline system is not yet ensured on a transparent and non-discriminatory basis) associated are quite substantial. Given the Russian price discount from December 2013 that brought the Ukrainian import price down to 270 USD/tcm, imports in reverse flow mode become uncommercial.

Consequently, using the revers flow option is not commercial. Nevertheless, the ability to re-inaugurate (and possibly expand) reverse flows can be extremely valuable, as it constrains Russia’s ability to exercise market power.

2.1.2 Virtual reverse flows

In physical terms transporting Russian gas from the East to the West and at the same time bring European gas into Ukraine sounds absurd as it involves moving an indistinguishable commodity forth and back. It would be much more straightforward to swap some Russian gas in the East with some European gas in the West (‘virtual reverse flows’). That is, Ukraine would buy Russian gas from Gazproms European customers, before this gas is actually shipped to the Ukrainian/EU border.

[21] ”Ukrtransgaz has also signed a memorandum of understanding with Romanian TSO Transgaz, the Ukrainian operator said. The TSOs are looking at exporting up to 5.0mcm/day via the Mediesu Aurit border point. Talks are also under way about reversing flow on the other point of Isaccea.” http://www.icis.com/resources/news/2013/04/02/9655154/european-natural-gas-flows-to-ukraine-rise-again-with-start-of-new-season/

[22] One of the four pipelines (i.e. 10 bcm/a=27mcm/d) in reverse mode.

[23] http://www.icis.com/heren/articles/2013/10/07/9713002/eu-pushes-for-information-on-slovakia-ukraine-natural-gas-reverse-flows.html

[24] http://en.itar-tass.com/old-top-news/699077

[25] http://en.itar-tass.com/old-top-news/699077

[26] http://dt.ua/ECONOMICS/ukrayina-skorotila-revers-gazu-cherez-ugorschinu-na-58-131276_.html

Such a move is strongly opposed by Gazprom as it would undermine its ability to ask for different prices in different markets. Consequently, Gazprom insists that it owns the gas that is transited through Ukraine to Europe. Hence, it can effectively block the swapping of gas volumes[27].

While the European Commission is of the opinion that virtual reverse flows are in line with European legislation[28], Gazprom argues that "Virtual reverse supplies without the involvement of the supplier cannot be carried out faultlessly from a legal point of view."[29] It essentially boils down to the question which legal title prevails (1) existing contracts between Gazprom and Ukraine or (2) Ukraine's Energy Community obligations.

The introduction of virtual reverse flows would have significant repercussions. Gazprom would then only be able to set one single price for Europe[30]. This price would still reflect the dominant position of Gazprom in the European gas supply. Hence, the optimal price for Gazprom might actually be higher than the one currently charged to countries that have advantageous contracts with Gazprom (e.g. Germany)[31]. Consequently, abolishing price discrimination will not be favoured by all European countries. Allowing virtual reverse flows might also change who owns all gas transited through Ukraine. There is some concern that a change in ownership of the gas might have an impact on the security of supply to Europe and/or encourage intermediaries to seek additional rents from transiting gas from the Russian to the European border.

Consequently, not only Gazprom, but also some EU countries might oppose a corresponding arrangement.

2.1.3 LNG terminal

Liquefied natural gas (LNG) has increased the geographic flexibility of natural gas supply dramatically in the past decade. In the EU there are currently 19 regasification plants in operation that allowed Europe in 2011 to import 82 bcm from overseas. Also, Ukraine government has identified LNG as one option to diversify its supplies. In August 2012, the Ukrainian Government approved a feasibility study for the construction of an LNG regasification terminal in the Odessa region. For the first stage (2016) the project is to use a 5 bcm floating terminal. Floating terminals have the advantage of lower capital cost and faster installation[32]. However, they are less efficient than on-shore terminals. Hence, for the second stage (by 2018) an on-shore 10 bcm LNG-regasification terminal should be built. Ukraine is providing state guarantees for the project. The capital cost assumptions for regasification plants are freight with substantial uncertainty. European on-shore regasification plants did cost between 80 m USD and 200 m USD per bcm[33] and

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[27] The contract between Naftogaz and Gazprom stipulates that Gazprom is permitted to fulfill the functions of the operator of transportation network on transit routes where Gazprom acts as a shipper.

[28] Öttinger: 'Also virtual reverse flows are perfectly in line with the EU and the Energy Community. They are a way of optimizing gas transport and trading within the EU's (and Energy Community's) internal market, and can be executed as swaps between different downstream buyers. This is possible all over the EU and has for example also been implemented in Poland on the Yamal Europol pipeline.' http://en.interfax.com.ua/news/interview/151789.html

[29] http://www.gazpromexport.ru/content/file/bf/Blue_Fuel_June2013_FINAL.pdf

[30] In fact, Gazprom can only charge different prices in case infrastructure bottlenecks prevent the free flow of gas inside Europe.

[31] Gazproms strategy to charge lower prices to countries that have alternative sourcing options is in line with a profit maximising price discrimination strategy.

[32] According to Reuters a recent 3 bcm floating facility in China was reported to cost 180 m USD per bcm/y.

[33] See Lochner (2011, p.93).

take 2-2.5 years (in the best case, given that all permission documentation is provided).[34]

Table 2

LNG terminals

	Floating	On-shore
Design capacity (bcm/y)	5	10
Capital cost (USD m/ bcm/y)	~180	80-200
Gas price (USD/tcm)	350-425	350-425

Source: Indicative values based on sources quoted in the text

The cost of liquefied gas is expected to stay high (in 2013 about 350 USD/tcm in Europe and 425 USD/tcm in Asia[35]) and volatile, given rising demand from Asia. In addition there are serious technological challenges including Turkish straits traffic[36] and the need to deepen the sea for the port.

One alternative to sourcing gas from the global LNG market and shipping it through the Turkish straits is developing the infrastructure to liquefy Azeri gas at the Georgian Black Sea coast and sending it to Ukraine. There are high risks due to the involvement of three pivotal actors (Azerbaijan, Georgia, Ukraine) that each might have an incentive to renege on their part of the deal. Ukraine might not take gas if it is too expensive, thus rendering the pipeline and liquefaction investments uneconomic. Georgia and Azerbaijan might reroute the gas to higher bidders – such as Turkey and Europe, rendering the regasification infrastructure in Ukraine futile. This risk can probably not be compensated as the economics of such a project would be anyway very tight.

Optimistically assuming a 10 percent interest rate, a capital cost of 180 m USD per bcm, an LNG import price of 400 USD/tcm and a 75 percent utilisation rate an LNG terminal would only break even at a domestic price of 424 USD/tcm.[37]

Consequently, again (as in the case of the revers flow) the LNG option is currently not commercial. Nevertheless, the ability to source alternative imports can be quite valuable strategically, as it constrains Russia’s ability to exercise market power.

2.1.4 New pipelines

A further option for Ukraine to diversify its import routes is investing in import pipelines from different sources. The most prominent project that has been discussed is the White Stream project that was supposed to bring gas from Azerbaijan through Georgia and then through an off-shore pipeline crossing the Black Sea[38]. Despite some interest from policymakers in Brussels and Kiev in the late 2000s the project now seems to be on hold for political, technical and economic reasons. Azeri gas has been largely committed to other pipeline projects, crossing the very deep black-sea is technically more challenging

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[34] Hafner (2012).

[35] http://www.ferc.gov/market-oversight/mkt-gas/overview/ngas-ovr-lng-wld-pr-est.pdf

[36] “We have problems with the construction of a terminal for receiving liquefied natural gas. The problems are related to the fact that Turkey is reluctantly considering passage of tankers with liquefied gas through its straits”, Mykola Azarov said. [Feb 5th, 2013]

[37] 18 USD/tcm = (domestic price - 400 USD/tcm) x 75percent

[38] Route: Turkmenistan (Dauletabad-Turkmenbashi)-Caspian Sea (Turkmenbashi -Apsheron peninsula, near Karadag)-Azerbaijan (Karadag-Kazi Magomed-Agdash-Kazakh)- Georgia (Saguramo -Kutaisi-Poti/Supsa)-Black Sea (Poti-Feodosiya)-Ukraine (Feodosiya- Maryivka-Talne)

and expensive than other routes and so far there has been a lack of interested private investors.

Table 3

Ukrainian branch of White Stream Pipeline

Design capacity – branch to Ukraine (bcm/y)	8
Length off-shore	630 km
Length onshore: Sangachal-Black Sea	658 km
Depth	2150 m
Capital cost (bn USD / bcm/y)	1.2
Gas price (USD/tcm)	300
Gas source	Turkmenistan, Azerbaijan

Source: Indicative values based on sources quoted in the text

Costs for the Ukrainian supply branch are difficult to estimate. Mott McDonald (2010) estimates about 10 m EUR per km offshore and about 0.8 m EUR per km onshore for a 24 inch pipeline which would be able to transport about 8 bcm per year. For White Stream the cost is probably higher given the unfavourable elevation-profile of the pipeline. According to these figures only building the Ukrainian supply arm would cost about 7 bn EUR (9.5 bn USD). Obviously, cost for Ukraine could be lower if the pipeline system would be dimensioned larger and shared with other importers.

In any case, unless Azerbaijan would be willing to sell gas at Shah Deniz significantly below 300 USD/tcm the pipeline would not be competitive with Russian gas at 400 USD/tcm[39] even at optimistic assumptions on the interest rate (10%).

An alternative to a pipeline directly from a supplier (e.g., Azerbaijan) would be pipelines to import gas from a gas hub. In particular connections to the Balkans might help reducing Ukraine's import dependence on Russia. One option that has been considered by Naftogaz is participation in the construction of the 10-15 bcm Adria LNG Terminal in Krk (Croatia)[40]. Compared to a domestic LNG terminal there are several advantages: sharing the infrastructure cost with partners, possibly lower interest rates given the lower country risk of Croatia and a more competitive construction sector might reduce the cost for the import capacity. Furthermore, the Turkish strait issue would not exist. Compared to a pipeline from a supplier, a trunk onshore pipeline (or partial strengthening of the existing system) connecting the Adria LNG with Ukraine would be substantially cheaper. However, not having a direct access to a supplier will put Ukrainian imports at competition with European consumers. Consequently, the gas price from the Adria LNG (or similar projects) will be the European gas plus some cost component for the additional infrastructure.

2.2 Increase domestic production

Ukraine currently produces about 20 bcm of natural gas which is insufficient to meet its current domestic demand of about 55 bcm. However, at its peak in the 1970s production reached almost 70 bcm and Ukraine's energy strategy foresees a substantial increase in domestic production. In terms of geology at least four options are available. First, Ukraine could increase the production from existing fields using new technologies.

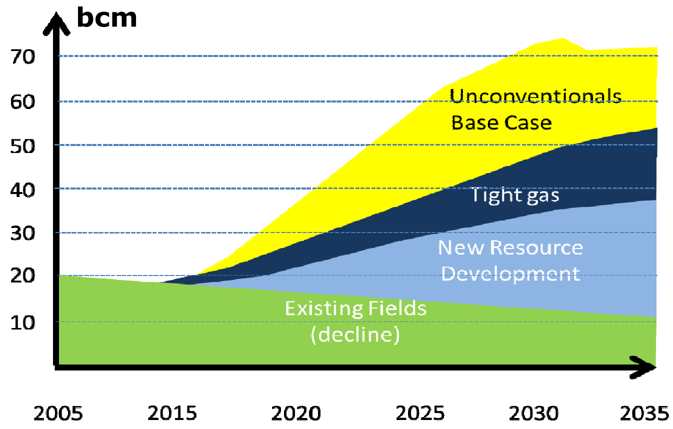
[39] 9.5 bn USD x 10% interest rate = (400 USD/tcm for Russian gas – 280 USD/tcm for Shah Deniz gas) x 8 bcm

[40] http://powermarket.seenews.com/news/croatia-in-talks-with-mvm-naftogaz-on-krk-lng-terminal-capacity-deals-media-393878

Second, production from shallow and deep-water off-shore gas fields could be increased. Third, Ukraine probably possesses significant untapped shale gas and tight gas resources. Fourth, the production of coal bed methane could be increased.

Figure 6

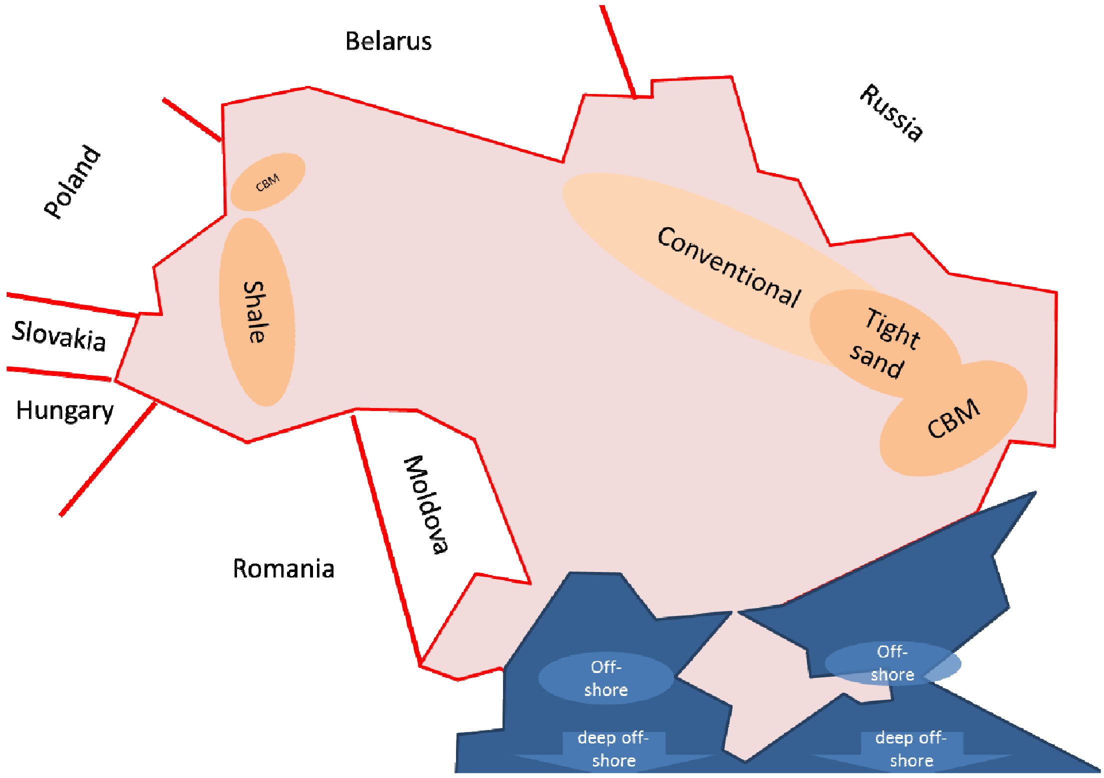
Gas production forecast



Source: IHS CERA

Figure 7

Natural gas deposits in Ukraine



Source: Own illustration based on

http://shalegas.in.ua/en/karta/,

http://www.ukrainian-energy.com/en/oil_gas_map

Ukraine has substantial gas reserves, both conventional and unconventional, which are mostly unexploited. Only proved conventional gas reserves from already discovered fields are estimated between 600 bcm by BP[41] and 1100 bcm by the Ministry of Energy of Ukraine[42] complemented by prospective reserves tapped in off-shore gas fields, coal bed methane and vast unconventional gas resources, mainly shale gas. The estimates for non-conventional natural gas reserves vary widely from 1.2 trillion cm (EIA) to 20-50 trillion cm (draft Energy Strategy) and are to be clarified after the first exploration drillings. In the most optimistic scenario (IHS CERA) cumulative domestic production of gas in Ukraine could reach about 70 bcm annually.

2.2.1 Shale and tight gas

Estimation of reserves: In its recent study the EIA[43] ranked Ukraine at the 4th place in Europe followed after Russia, Poland and France in terms of estimated shale gas reserves with cumulative reserve of 3.6 trillion cm.

According to averaged estimate in the draft Energy Strategy till 2030 technically recoverable reserves of shale gas in Ukraine are estimated between 1 and 1.5 trillion cm. Taking into account existing barriers for shale gas production (lack of investments and technologies, the need to reduce environmental risks, the need to take local concerns into account etc.) commercial production of shale gas can be estimated to start in the first half of the 2020s with a potential level of production of 6-11 bcm annually. The necessary investments are estimated between USD 4-6 bn.

Signed product-sharing agreements: In January 2013 Ukraine granted the first 50-year shale gas product-sharing agreement (PSA) to Shell at Yuzovska in the eastern Dniepr-Donets Basin covering an area of 7,886 sq. km and assigns oil and gas rights to all strata up to a depth of 10 km, including tight and basin-centered gas. Its estimated reserves are 4 trillion cm. In September the second PSA was granted to Chevron to Oleska field in the West. The estimated shale gas reserves there are 3 trillion cm.[44]

Estimates for production volumes and costs: Ukraine (and Europe generally) has completely different internal conditions for unconventional gas production compared to the US (geological conditions, level of infrastructure development, abundance of service companies, industrial regulation, pricing and hedging system, land and environmental regulation). According to Wood MacKenzie estimates, shale gas production in Europe will have much higher costs than in the North America – about 10 USD/MBtu compared to 4-7 USD/MBtu. There are no detailed cost estimates for Ukrainian shale production, but anyway this is going to be an expensive gas. Moreover there were no profound studies on Ukrainian shale gas reserves estimation, so far it`s mainly speculation without real drilling.

The report from IHS CERA "Natural Gas and Ukraine's Energy Future" (2012) indicates that industrial production of unconventional gas in Ukraine including Yuzivska and Oleska fields and the achievement of annual production levels at 25 bcm (in aggregate: shale gas, gas from non-porous sandstone formations and coal bed methane) is possible, on condition that investments into new fields reach USD 2-3.5 bn, and in some periods even USD 10 bn.[45] The projected wellhead supply costs for unconventional gas are estimated

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[41] Statistical Review of World Energy 2013 (http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy-2013.html)

[42] The draft Updated Energy Strategy of Ukraine to 2030 as of 7 June 2013

[43] http://www.eia.gov/conference/2013/pdf/presentations/kuuskraa.pdf

[44] http://www.kreschatic.kiev.ua/ua/4084/art/1337021639.html

[45] However, this did not refer only the two fields mentioned above; they also took into account the launch of gas production in other areas of Ukraine.

between USD 176 and USD 282 per tcm.[46] The Ministry of Energy estimates annual amount of extraction at these fields at 15 bcm annually in the base case scenario and about 50 bcm in optimistic scenario with the costs of USD 120 – 130 per tcm.[47]

The draft Energy Strategy of Ukraine till 2030 provides the comparative analysis of production data in similar production areas that shows rough numbers for extraction costs for shale gas will probably vary between USD 260 and 350 per tcm.

Recently, a discussion started on the environmental impact that Ukrainian shale gas production might have on Russian territory. Some observers claim that the Russian concerns are also driven by the motive to avoid competition in gas production[48].

2.2.2 Off-shore

Off-shore gas production in Ukraine develops at the Black Sea shelf. The exploration and production now concentrated at shallow waters (depth less than 350 m) as deep-shelf waters gas development requires significant investments and technologies.

According to draft Energy Strategy to 2030, the reserves in deep waters of the Black Sea shelf (maximum depth is 2000 m) are preliminary estimated at 4-13 trillion cm. In case the exploration works will be successful the production can start in 2022 and reach 7-9 bcm per annum by 2030. For reaching this level it's necessary to invest about USD 11 bn. The average costs are estimated at USD 75-125 per 1000 cm.

A consortium of investors led by ExxonMobil won a tender for a PSA agreement for Black Sea off-shore development at Skifska field with potential production of up to 3-4 bcm. The investor is expected to invest about USD 10 – 12 bn and will pay an additional one-time payment to the budget of USD 325 mn. Due to ongoing negotiations between the consortium and Ukraine no agreement has been signing up to now (January 2014).

Another PSA for offshore oil and gas was signed in November 2013 with the Italian group Eni and France's EDF. The project could draw up to USD 4 bn of investments for exploring for oil and gas on the 1,400 square-km western Black Sea's shallow shelf which includes the Subbotina, Abikha, Mayachna and Kavkazka blocks. It could provide Ukraine with up to 3 million tonnes of oil a year while the expectations for gas production remain unknown.[49]

2.2.3 Coal bed methane

Ukraine has considerable unconventional gas potential in the form of coal bed methane in the main coal mining areas of eastern Ukraine and in two shale gas basins: a portion of the Lublin Basin, which extends into Poland and the Dnieper-Donets Basin in the east. Coal bed methane resources are estimated at close to 3 trillion cm. So far in Ukraine there were only few pilot projects for coal bed methane extraction by coal mining companies and smaller private companies (e.g. Iskander, Donestkstal). A serious problem is posed by the fact that coal deposits in Ukraine – that are not also interesting for coal mining – lie rather deep, at between 0.5 km and 5 km, and are quite thin (0.5–2 m). As a result, production requires considerable expenditures. According to the comparative analysis the average costs of coal bed methane extraction in Ukrainian conditions may vary between USD 290 and 410 per tcm and potential production would

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[46] IHS CERA & Ministry of Energy and Coal Industry of Ukraine. Natural Gas and Ukraine's Energy Future, February 2012

[47] http://dt.ua/ECONOMICS/azarov-ociniv-vartist-slancevogo-gazu-ukrayinskogo-vidobutku-v-130-dolariv-za-tisyachu-kubometriv-128420_.html

[48] See: http://en.ria.ru/world/20131031/184458703.html

[49] http://www.reuters.com/article/2013/11/27/us-ukraine-energy-deal-idUSBRE9AQ0JX20131127

reach 2-4 bcm annually till 2030 if about USD 2 bn will be invested in exploration works and infrastructure.[50]

2.2.4 Conventional

As stated in draft Energy Strategy to 2030 domestic production of conventional gas in Ukraine gradually deteriorates due to high depletion of existing large production fields, low activity in search and exploration of new gas fields, lack of technologies and investments for deep drilling (more than 6 km below the surface). It's estimated that investments around USD 14 bn in new fields development and bringing new technologies into enhancing existing large fields will allow to reach annual production of 15-24 bcm of conventional gas in base case scenario. The costs of production are estimated at USD 80-115 per 1000 cm depending on field type.

[50] The draft Updated Energy Strategy of Ukraine to 2030 as of 7 June 2013

Table 4

Exploration and production agreements with international energy companies for unconventional gas resources

International oil company	Deposit	Type of unconventional gas	Status	Capex disclosed (USD bn)	Resources estimate (bcm)	Production estimate (bcm)
ExxonMobil, Shell, OMV Petrom	Skyfske	DSG	Signing PSA still pending in winter 2013 /14	10-12	--	8-10
Chevron	Olesske	Shale gas	PSA signed in November 2013	25	3	8-10
Shell	Yuzivske	Tight gas	PSA signed in January 2013	4	10	15-40
Shell	Pavlivsko-Svitlivske, Melekhivskiy, Gersevanovskiy, Novo-Mechebilovskiy, Shebelinskiy, West Shebelinskiy	Tight gas	JAA signed in September, drilling of the 1st exploration well started in October 2012	0,8	--	--
Eni, EDF	Subbotino, Abikha, Mayachen, Kavkazska	DSG	PSA signed in November 2013	4	--	--
Eni, Cadogan Petroleum	Reklynetska, Zhuzhelianska, Cheremkhivsko-Strupkivska, Debeslavetska Exploration, Debeslavetska Production, Baulinska, Filimonivska, Kurinna, Sandugeyivska and Yakovlivska	Shale gas	LLC Westgasinvest holding the respective licenses was established in 2012, where Eni holds 50,01% and Cadogan holds 15%. An exploration program worth USD 55 mn was approved for 2012-15	--	--	--

Source: ICU (2013)

2.3 Reduce consumption

A third strategy to reduce the market power of Russian supplies in Ukraine is by reducing gas consumption. In the past, modernisation, fuel switching and deindustrialisation have already contributed to a reduction in Ukrainian gas demand from 76 bcm in 2003-2005 to 55 bcm in 2012. While a further reduction through deindustrialisation is neither desirable nor likely[51], switching from gas to other energy sources and using energy more efficiently would allow reducing natural gas demand.

2.3.1 Fuel switching

Heat and electricity can be produced from different sources than natural gas. In the past decade, Ukraine already reduced its use of natural gas in power plants by 2.6 m toe (79 percent) and increased its use of coal in power plants from coal by 4 m toe (33 percent) between 2004 and 2010[52]. Thus, additional switching away from natural gas in power plants is barely possible.

Between 2004 and 2010 the consumption of natural gas in heat plants has been halved from more than 20 to less than 10 mn toe. A small part of this was achieved by using

[51] According to the October 2013 World Economic Outlook, the IMF expects Ukraine to grow at an average of 1.5 percent per year between 2013 and 2018.

[52] Source: IEA (2012) and IEA (2005).

more coal (1 m toe) for heat production[53]. The same is true for Combined Heat and Power Plants (CHP). Despite rising electricity and heat production in CHPs the consumption of natural gas stayed about constant. This was both, due to increasing efficiency but also due to using more coal (1.7 m toe) in CHPs. In heat plants and CHPs, that consume together about 15 m toe (around 18 bcm) of natural gas, additional fuel switching is possible but implies substantial cost.

Conversion of existing (often inefficient) natural gas fired CHPs to state-of-the-art coal fired CHPs is essentially equivalent to the new-build of a corresponding plant. The investment cost of fluidized bed combustion CHP plants based on coal or solid biomass ranges from 3000 to 4000 USD/kWe[54]. That is for, enabling to switch one bcm/y of gas used in a gas fired CHP[55] to coal in a modern coal fired CHP would require investment cost of about USD 1.5 – 3 bn[56]. In addition to the investment cost, the CHP would also incur fuel cost. These will, however, be significantly lower than that of the gas unit it replaced, given the lower price of coal (~100 USD/tcm)[57] and also because a state-of-the-art plant is quite efficient.

Fuel switching is also possible for industrial processes. For example, pulverised coal injection for blast furnaces allows switching steel production from gas to coal and delivering significant energy savings[58].

Furthermore, based on a 3.65 bn USD deal with China Development Bank Corporation, Ukraine plans to gradually work towards the gasification of coal to reduce its dependency on natural gas by about 4 bcm/y[59]. At a coal price of about 60-70 USD/mt and an efficiency in the order of 70 percent the variable cost of as from coal gasification would be in the order of 140 USD/tcm. Currently, the Ministry of Energy and Coal Industry studies the feasibility of three options: (1) local coal gasification to fuel CHPs, (2) production of syntetic gas to replace natural gas in the chemical industry and (3) centralised coal gasification to feed gas into the existing gas pipeline system. The Ministry of Fuel and Energy foresees that corresponding investments would be carried out publicly.

2.3.2 Energy efficiency

Based on support from international financial institutions, obligations under the Energy Community and domestic political will Ukraine put significant efforts into increasing energy efficiency in the last years. However, progress has been somewhat limited as legislative projects got stalled (e.g., the Draft law "On energy efficiency of residential and public buildings" that passed its first reading in the Verkova Rada in May 2012 is still not adopted) and key issues such as reducing price-subsidies have not been tackled.

According to BEST (2013) the energy saving potential in Ukraine is in the order of 30 bcm. The three main sectors of natural gas consumption in Ukraine are electricity and

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[53] Largest part was achieved by reducing the heat produced in pure heat plants (more has been produced in CHPs) and increasing efficiency of the transformation.

[54] http://www.iea-etsap.org/web/e-techds/pdf/e04-chp-gs-gct_adfinal.pdf.

[55] That is about 10 m MWh of gas input which produced about 4.3 m MWh of heat and 4.3 m MWh of electricity output in Ukraine in 2010.

[56] To produce 4.3 m MWh of heat and 4.3 m MWh of electricity an installed electric capacity of about 500 to 1000 MWe is required. At 3000 USD/kWe this translates into USD 1.5 – 3 bn.

[57] As 1.5 m mt of coal has approximately the calorific value of 1 bcm natural gas, a price of 60-70 USD/mt is roughly equivalent to 100 USD/tcm.

[58] The pulverised coal injection at Zaporizhstal Steel Plant reduced natural gas consumption by about 0.3 bcm/y. See BEST(2013,p21)

[59] http://oilprice.com/Energy/Coal/China-Invests-in-Ukraine-Coal-Gasification.html

heat production (17 percent), industry and commercial customers (46 percent) and households (34 percent).

For *industry* IHS CERA (2012) sees "substantial further potential for greater increases in energy efficiency. In particular, the chemicals sector (consuming 8 to 8.5 bcm annually at present) could reduce its use of gas by 2 bcm per year while maintaining its current output, and the metals sector (with consumption of roughly 9 bcm annually) could similarly cut consumption by nearly 4 bcm per year."

According to BEST (2013, p.28) the energy saving potential in the *residential* sector is about 11 bcm. Of course, unlocking energy efficiency potential requires investment. Many of these investments are economic at the prices Ukraine had to pay for gas in the last years. As, however, these prices were not passed through to a number of customers[60], the private and public actors had limited /or no incentive to invest in energy savings.

Quantifying which amount of energy efficiency investment would allow which amount of natural gas savings is quite complex as there is a multitude of potential saving investments (e.g., isolation of public buildings), each of which allows for many options (e.g., double-glassed vs. triple-glassed windows). Obviously, the first saved bcm is pretty cheap (<450 mn USD/bcm)[61], while the last saved bcm will be prohibitively expensive.

3. Need for a strategic view

The true price Ukraine pays for natural gas is higher than in most other countries as a single supplier – Russia - can set it without any competition. Even though at face value the price was very volatile in the past two decades, the fluctuations largely reflected the value of the (political or economic) concessions that Ukraine was willing to offer. Before 2009, the value of using the transit system was sufficiently high, to allow Ukraine to negotiate face-value gas prices that were substantially lower than those in Europe. With the decreasing importance of the transit route through Ukraine, the value of this concession decreased. Hence, the face value price reached more than 400 USD/tcm and even this price involved concessions (somewhat arbitrarily) valued at 100 USD/tcm.

Ukraine can continue to sell concessions to keep the face value price below the price which its supplier might ask it. But that will not help avoid that the true economic cost to the country are higher. The only alternative is to reduce the market power of the main supplier by enabling alternative supply routes. Thereby, it is not so important that these alternatives are actually used but only that they are credibly available. If a significant volume of the Ukrainian gas imports can be replaced by other imports, domestic production or reduced consumption, Ukraine might improve its negotiation position with its main supplier.

We show in this paper that there are plentiful options to replace gas imports from the East. However, we also demonstrate that none of the options is going to reduce the price in Ukraine below the European price and that some of them require substantial investments. One big problem is that large scale private investments in the described options might render themselves uneconomic. If the main supplier reduces the price to react to the new competition (be it from an LNG terminal or a new pipeline) this might kill the business model of the private investment even though the project might make sense from a national economic standpoint as the import price decrease it stipulated

[60] The price of gas for households consuming up to 2,500 m3 a year (which accounts for the majority of end users) is equivalent to 91-100 USD/tcm (depending on the presence of gas meters), i.e. less than 25% of the cost of gas imported by Naftogaz from Russia.

[61] The two residential building efficiency projects presented in Kiva (2009) feature an investment cost of 50 USD/Gcal. This implies investments of around 450 m USD to save one bcm each year.

exceeds the cost of the privately built infrastructure. Consequently, public support to well-chosen projects might be beneficial. However, implementing too many options at the same time will be hugely expensive and at worst a disincentive to private investments in gas supply. In a follow-up paper we want to evaluate whether certain portfolios of options can be identified that are optimal in terms of timing, volume, capital and gas cost.

From an economic point of view, one often proposed option sticks out as a 'no-brainer'. Increasing the domestic tariffs for gas is at the same time increasing incentives to invest in energy efficiency and energy production, do away with the most wasteful uses of natural gas[62] and relax the state budget. In addition, the impact of reduced demand and increased domestic supply might put pressure at the Russian price[63].

Europe is a prime example of how to unwind from the market power of its major supplier. With gas demand decreasing due to the crisis, increased shares of renewables and additional imports available through LNG, Gazprom was forced to renegotiate its contracts with all mayor European gas importers. As one observer put it "Russians unwillingly had to foot the bill of German renewables by lowering gas price".

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[62] According to the IMF: "in response to a 20 percent tariff increase households would react by reducing consumption by around 5 percent for gas and 3 percent for heating".

[63] If in the optimistic (pessimistic) scenario domestic gas consumption decreases from 25 bcm to 15 (20) bcm and production increases by (5) 10 bcm. Hence, import demand would drop by 20 bcm (10 bcm). This would make Ukraine almost independent of gas imports. Hence, the price might drop to the 350 USD/tcm. Consequently, instead of 7.5 percent of GDP (33 bcm x 400 US/tcm) Ukraine might than only have to pay about 3 percent of GDP (13 bcm x 350 USD/tcm) for natural gas imports in the optimistic scenario. In the pessimistic scenario this would be 4.6 percent (23 bcm x 350 USD/tcm).

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