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The future of Russian gas export

Abstract

For more than one decade, disputes between Russia and Ukraine have triggered Russia to build gas pipelines to Europe that circumvents Ukraine. The Russia-Ukraine disputes, which also affected countries farther west, caused the EU to consider reducing the dependence on Russian natural gas. This in turn gave Russia incentives to target new markets for its gas exports. The current paper examines potential implications of the Russia-Ukraine conflict on the Russian and European natural gas markets. Using a numerical energy market model (LIBEMOD), we find that if Russia stops using the pipelines to and via Ukraine, total gas export from Russia will drop by one third. The impacts on the European gas market are, however, moderate. Similar conclusions are reached if the EU decides to halve its gas imports from Russia. Further, building the planned pipeline to Turkey (“Turkish Stream”) has only modest effects on Russian gas exports, except in the case where trade to and via Ukraine is blocked. Finally, export of Russian gas to Europe is hardly affected by the new Russia-China gas trade agreement.

Keywords:

Russian gas export; Russia-Ukraine natural gas disputes; Turkish Stream; Russia-China natural gas trade agreement

JEL codes:

Q41; Q48; F10; C63

1. Introduction

Disputes between Russia and Ukraine spurred the construction of the Nord Stream pipeline, whereby Russia could bypass Ukraine by transporting some of its natural gas *directly* to Europe (Germany). More pipelines bypassing Ukraine are under construction or planned; one – Turkish Stream – to Turkey and Greece, and another – Nord Stream 2 – to Germany. While Russia repeatedly argued that its disputes with Ukraine should have no impact on its business reputation as a secure source of natural gas, the disagreements, which also affected EU member states, initiated political processes in the EU aiming at reducing the dependence on Russian natural gas. Therefore, Russia has a clear incentive to find additional markets for its natural gas, for example, piped gas to China and Turkey, or LNG.

This paper examines how the ongoing conflict between Russia and Ukraine may have powerful implications on the Russian and European natural gas markets. We discuss how

new pipes for Russian gas to Europe, and no transit of Russian natural gas through Ukraine, may affect the natural gas markets. We also investigate to what extent gas exports from Russia to China will have an impact on the European gas market.

Russia is the biggest exporter of natural gas to Europe. In 2014, approximately one third of natural gas imported to the EU came from Russia (BP, 2015). About 60 percent was delivered through Ukraine, 23 percent through Belarus, and the remaining 17 percent directly to the EU via Nord Stream. The dependence on Russian gas varies considerably between EU member states; Russian gas covers more than 40 percent of Italy's gas consumption and approximately one third of Germany's, but the share is significantly lower in other Western European countries. In Central Europe, Russia's share is much higher, but here the share of natural gas in primary energy consumption is smaller.

Although the EU is highly dependent on Russian gas imports, Russia's dependence on the EU export market is even bigger. In 2014, 60 percent of total Russian gas exports were delivered to the EU market. The remaining gas was exported to a number of countries; the biggest were Turkey, Belarus, Ukraine and Japan (LNG).

A substantial share of Russian gas exports to Europe is transported through Ukraine, a country that traditionally has been a big consumer of Russian gas. After the break-up of the Soviet Union, Ukraine enjoyed a low price for natural gas because of its historical ties to Russia. Later, the contractual price faced by Ukraine was raised, and in 2006 a dispute over the new commercial terms triggered a serious crisis where Russia turned off the gas supplies to Ukraine. Unexpected by Russia, also customers farther west were affected because some of the gas intended for transit through Ukraine was diverted to domestic use.

Although the conflict was resolved quickly, for Russia the lesson was to reduce transit through Ukraine, whereas for the EU the conflict changed the general perception of Russia as a secure supplier; the new goal of the EU was to reduce the vulnerability of the member states to imported fossil fuels, in particular to reduce the dependence on Russian gas. Such a response triggered Russia to look for additional markets for its natural gas exports.

Late in 2014, Russia announced a giant pipe project to Turkey and Greece – Turkish Stream. Turkey and the Balkans may be seen as alternative markets to the EU natural gas market, but Russia may build Turkish Stream partly to fend off potential competitors in the Caspian region; these are also aiming at supplying natural gas to Turkey and South-East Europe. Another new market for Russian gas is China: After years of negotiations, Russia and China signed an export agreement in 2014. The agreement involves a pipeline in Eastern Siberia – Power of Siberia – that is already under construction.

Russia's piped gas export is completely controlled by one company – Gazprom. Another key characteristic of the Russian natural gas market has been very low end-user prices. Whereas Gazprom has lobbied to bring domestic gas prices up to European net-back parity, a policy that was accepted and partly implemented by the Russian government in 2007-2013, the current policy is to increase end-user prices slowly. The aim is to establish a domestic industry gas price around 70 percent of the European net-back price. As part of this study, we will therefore examine how Russian exports of natural gas may change if domestic end-user prices for industry (large) customers are increased.

The present paper uses a well-established, numerical energy market equilibrium model (LIBEMOD) to analyze how new pipes – both to circumvent natural gas transport via Ukraine as well as to new markets – may have an impact on the Russian and European natural gas markets in 2030. LIBEMOD is well suited to explore these types of effects as it covers all European countries, including EU member states, Russia and Ukraine. It provides a detailed description of all major energy goods, including natural gas, through the entire energy value chain – investment, extraction of fossil fuels, production of electricity and bio energy, trade and consumption of energy – thereby offering a simultaneous and consistent determination of all prices and quantities in the energy markets. LIBEMOD takes into account different uses of natural gas (by sector and country), as well as inter-fuel competition between natural gas and other energy goods. Also the long distance between where natural gas is extracted in Russia and where natural gas is consumed in Russia, as well as the low and regulated end-user prices of natural gas in Russia, are integral parts of the model.

Our simulations suggest that if Russia no longer uses the pipelines to and via Ukraine, then total gas export from Russia drops by one third (compared to our 2020 reference scenario). Around half of this export reduction relates to Russian exports to EU-30 (via Ukraine), while the other half relates to Russian exports to Ukraine (which is not transported farther). The average user price of gas in EU-30 increases slightly. Similar results are found if the EU decides to halve its gas imports from Russia. The effect of building the “Turkish Stream” pipe is modest unless it is deliberately used by Russia to circumvent Ukraine. Cutting off Russian exports to Poland also have modest impacts, even for Poland. Finally, exports of Russian gas to Europe is not affected by the new Russia-China gas trade agreement, as gas reserves in the eastern part of Russia will be used to supply China.

Our paper contributes to the literature on Russian gas exports, in particular exports to the EU. Paltsev (2014) studies scenarios for Russia's natural gas exports to Europa and Asia until 2050, using a recursive-dynamic, multi-regional general equilibrium model of the world

economy – the MIT Emissions Prediction and Policy Analysis (EPPA) model. LIBEMOD differs significantly from the EPPA model along several dimensions. For example, LIBEMOD offers a more detailed modeling of the energy markets in each European country, but does not capture the interactions between the energy sector and the rest of the economy. Still, both studies find that (i) additional Russian pipeline capacity to Europa is not needed unless Russia wants to avoid transit via Ukraine and Belarus, and (ii) Europe’s reliance on LNG imports may increase. In contrast to Paltsev (2014), our study provides information also on how increased Russian export capacities have impact on the Russian natural gas market.

Richter and Holz (2015) use the Global Gas Model (GGM) to assess implications of Russian gas disruptions for the EU, finding that most of the EU member states are not severely affected even by a complete drop out of Russian exports. In our study, we do not examine implications of no Russian exports to Europe, but we investigate long-run effects of no sales of Russian gas to Ukraine. We find that Ukraine is moderately affected as long as it can compensate by importing natural gas from European countries.

Hirschhausen et al. (2005) analyze a game between Russia and Ukraine, where Russia decides gas volumes transported through Ukraine to Europe, and Ukraine decides the transit fee. The study highlights the importance of transit options through Belarus. Our study has similarities with this study, but considers a broader range of scenarios and applies a more detailed model for the energy markets in Europe and Russia.

Nagayama and Horita (2014) examine, using a network game model, how the Nord Sea pipeline has changed the relative power of Russia, Ukraine, Belarus and Western Europe. They challenge the traditional view that Russia is the player with the highest relative power; they find that prior to Nord Stream, Ukraine’s relative power was comparable to that of Russia. This may rationalize the development of Nord Stream by Russia. A related study is Chyong and Hobbs (2014), who examine the now cancelled South Stream project, which was not that different from the Turkish Stream project. Assuming non-competitive behavior among natural gas producers and transit countries (Ukraine), they find that neither expectations of high demand growth in Europe, nor risk of transporting Russian gas through Ukraine, can justify construction of South Stream; the project has a negative NPV. We reach a similar conclusion for Turkish Stream under alternative assumptions.

Another strand of literature has focused on regulatory changes in the Russian gas market and/or a shift towards competitive Russian gas exports, and how this may affect gas exports to Europe, see, for example, Sagen and Tsygankova (2008) and Tsygankova (2010, 2012). Another example is Aune et al. (2015), which, using the same numerical model

(LIBEMOD) as we do in the current paper, studies different liberalizations of the Russian natural gas markets under the assumption that export capacities are not altered. In the present study, we examine the partial effect of higher end-user prices of natural gas for industrial consumers when Russian natural gas export capacity to Europe is increased. Also Orlov (2015) studies implications of increasing domestic end-user prices for natural gas in Russia. Whereas his aim is to identify the optimal domestic price of natural gas, we explore how higher end-user prices work under alternative assumptions about the Russian natural gas export capacity.

Hartley and Medlock (2009) use the Rice World Gas Trade Model (RWGTM) to study how the development in the world natural gas market depends on which Russian fields are developed and the Russian export capacity to the Asian natural gas markets. They conclude that in the long run, Russia has limited ability to adversely affect the Western European natural gas market, which partly reflects the important role of LNG. This is in line with our findings. For geoeconomic studies on Russian natural gas, including how development of Russia's natural gas resources might be the key to Russia's revival as a global power and the potential of natural gas trade between Russia and China, see Baker Institute (2009), Jaffe and Medlock III (2013), Henderson and Pirani (2014), Henderson and Mitrova (2015), Vihma and Turksen (2015), Esen and Oral (2016), Henderson and Mitrova (2016), and Pirani and Yafimava (2016). Finally, also Goldthau (2008), IEA (2011), and Grimsrud et al. (2016) study the role of Russia in the future natural gas markets.

The rest of the paper is structured as follows. The numerical model LIBEMOD is presented non-technically in Section 2. In Section 3, first the 2030 scenarios are presented. Each scenario covers one extension of Russian gas export capacity – Turkish Stream, Nord Stream 2, or Power of Siberia – relative to our 2030 reference scenario. Next, we discuss how the outcome of each scenario differs from the reference scenario. The robustness of each scenario is also examined in Section 3, for example, with respect to the outcome of more Russian export capacity if Russia bypasses Ukraine, and how a moderate liberalization of the domestic Russian natural gas price policy may have impact on Russian natural gas exports. In Section 4, policy implications of our study are discussed, whereas Section 5 summarizes the main findings and points at other changes in the Russian gas industry that may materialize over the next decade.

Tekst som er tatt ut og som kanskje kan brukes andre steder:

These concerns have been particularly strong in Poland, which has feared that projects like the Nord Stream pipeline may allow Russia to cut off natural gas deliveries to Poland without affecting important EU customers located farther west.

The EU may replace Russian gas by imports from other countries, both piped gas (from Algeria and Norway, or from more distant sources) and LNG (from a number of potential countries, including Algeria). An alternative strategy is to reduce demand for natural gas in the EU by (i) replacing end-user demand for natural gas by electricity, and (ii) reducing the market share of gas fired power plants. If successful, such a strategy would lower demand for Russian gas, which in turn will give Russia an incentive to search for new export markets.

2. Prospects for the Russian gas industry

2.1 Background - organization and driving forces

The Russian gas sector is not fully market based. It is dominated by one company – Gazprom – which inherited the production and transportation infrastructure from the Soviet gas ministry, see Kryukov and Moe (2013) for an analysis of the evolution of Gazprom. Natural gas is distributed in a system more akin to the principles of a centrally planned economy than a free market. The organization of distribution fits well with the pipeline infrastructure, which again is closely integrated with production sites.

In the early 1970s, the Soviet Union started to export natural gas to Western Europe – Austria, West Germany and Italy – after the pipeline network supplying Eastern Europe had been extended. The big increase in exports came in the 1980s after deals had been signed to construct a pipeline between the Urengoy field in West Siberia and the Soviet border with Czechoslovakia, see Estrada et al. (1988). As part of the deal, Western European countries exported gas pipes and compressors to the Soviet Union. After the break-up of the Soviet Union, monopoly for Russian pipeline exports was by law granted to the operator of the trunk pipeline system – Gazprom.

Domestic Russian gas prices

A key feature of Russian gas policy has been to keep domestic gas prices low. Whereas the oil sector to a large extent has been de-monopolized, and thus petroleum product prices are market based, gas prices have been set much lower than the prices of alternative fuels,

measured in energy content. The rationale behind this policy was Russia's ample and cheap gas supplies, and perceived market limitations for gas exports. Encouraging gas consumption was therefore a state priority, which is reflected in the high share of gas in domestic energy consumption (55 percent in 2014). This strategy was intertwined with social concerns: distributing gas at a low price was also a social stabilizer. Furthermore, low gas prices tend to lower electricity and heat prices, which are also important for everyday life.

For Gazprom deliveries to domestic customers have been a secondary activity, an obligation to serve, even if they represent much larger volumes than exports. The other side of the 'contract' with the government has been that Gazprom retains a large share of its export revenues. The reasoning behind this 'contract' was that export revenues would compensate for losses in the domestic market, as well as provide funding for investments. Gazprom honored its obligation to serve domestic consumers even during difficult periods in the 1990s when non-payment of delivered gas was rampant.

The situation changed in the early 2000s. Until then Gazprom had enjoyed ample supplies from its own fields and low capital costs because huge investments in production and transportation infrastructure had been made by the Soviet state. Now Gazprom had to invest in new production capacity as well as upkeep of infrastructure. In addition, exports to the European market did not grow as before.

Gazprom started to lobby for a domestic price reform that would ultimately bring domestic prices up to European net-back parity. This was accepted by the Russian government in 2007,¹ and was followed up in 2010 when the government decided to increase gas prices by 15 percent annually until 2015. By 2013 the regulated gas price had reached USD 105 per 1000 m³, see IEA (2014, p. 107), but then the government froze gas prices until 2015. The current policy is to let real gas prices grow slowly over time, see Aune et al. (2015). The aim is to establish a domestic industry gas price around 70 percent of the European net-back price by 2030.

Although Russian natural gas prices have increased considerably after 2000, they are still significantly lower than the corresponding user prices in the European natural gas market (corrected for differences in cost of transport and taxes). Moreover, it seems that the current Russian policy is to increase the price to large customers – gas power plants and

¹ Government resolution No. 333, 28 May 2007, "On improving state regulation of gas prices"
<http://www.rg.ru/2007/06/02/a159632.html>

manufacturing firms – rather than the price to small customers – households and services. There is, however, much uncertainty about gas price development even though Gazprom argues that the present price is too low to cover long-term costs and investments.² Below, we therefore examine how higher natural gas prices to large Russian customers may have impact on the Russian and European natural gas markets.

Disputes between Russia and Ukraine

When the Soviet Union was dissolved, Ukraine became a transit country as well as the biggest importer of Russian gas. Due to its historical ties to Russia, Ukraine paid a much lower price for Russian gas than customers in the West, see Estrada et al. (1995).

The price was increased gradually, and raised tensions in the gas relations between the two countries. In 2006, a serious crisis erupted as Ukraine did not accept the newest Russian terms. Russia accused Ukraine for stealing some of the gas meant for transit and turned off the gas supplies. The conflict also affected customers further west and was a watershed in the perception of Russia as a reliable gas supplier. Both Gazprom and Russian authorities maintained that the crisis was a purely commercial dispute between Russia and Ukraine, and had no connection to its western customers. The immediate crisis was resolved quite quickly with Ukraine accepting a new price formula, but political processes were instigated in the EU with the goal of reducing Europe's dependence on Russian gas.

Three years later (spring 2009), a similar situation occurred with Gazprom cutting off supplies to Ukraine. This also led to supply disruptions to western countries (Stern, 2014: 91-2). The negative image of Russia as a gas supplier was reinforced.

The next phase came after Russia's annexation of Crimea in 2014 and the violent conflict in Eastern Ukraine. Negotiations about the conditions for gas deliveries were going on, but, supplied with credit provided by western countries, Ukraine was in a position to import gas from European countries – mainly Slovakia – via reversed flows. This supply option had emerged due to a more integrated European gas transport infrastructure, which was partly spurred by the earlier gas supply crises. Although Ukraine's dependence on Russian gas has

² Gazprom is challenged by other producers (especially Rosneft and Novatek) who can offer gas at a lower price than the regulated price. For this reason, Gazprom lobbies for the right to compete on price. If Gazprom gets this permission, prices may actually fall in the short term, but probably not in the longer term.

been reduced radically – in 2015 Ukraine’s import of Russian gas was almost fifty percent less than the year before (Gazprom, 2015) – Russia remains dependent on transit through Ukraine. Currently, approximately 60 percent of the Russian gas to Western Europe is transported through Ukraine. Below, we therefore explore how no exports of Russian gas to and via Ukraine has impact on Ukraine and the European natural gas market.

2.2 Natural gas export projects

The Nord Stream pipelines

The dispute with Ukraine spurred Russia to launch a pipeline under the Baltic Sea – Nord Stream – that would bring Russian gas directly to Germany (no transit via other countries). The last string of Nord Stream was completed in 2012, and the total capacity of the pipe is now 49 Mtoe. Nord Stream was financed as a joint venture between Gazprom and western companies, reflecting that also consuming countries had been upset by the risk of instability in natural gas deliveries via Ukraine.³

In September 2015, an extension of Nord Stream – Nord Stream 2 – with a capacity of 49 Mtoe was launched. The plan is that the new pipeline will use the same corridor as Nord Stream. The project was supported with letter of intention by several western companies. While an important Russian aim clearly was to reduce, or even abolish, dependence on transit through Ukraine, the western commercial participants see the project as a contribution to increased diversification and security of supply. The project is controversial, however, precisely because of the repercussions it may have for Ukraine (Riley, 2015). After a conflict with Polish authorities about the legalities of a joint venture, the project company Nord Stream 2 AG was reorganized with Gazprom as the only shareholder and the western companies as ‘sponsors’, committed to finance 50 percent of the total cost of 9.5 billion Euro.⁴

South Stream – Turkish Stream

³ The business partners in the Nord Stream project were: Gazprom (51 percent), Wintershall Holding and E. ON Ruhrgas (15.5 percent each), and Gasunie and GDF Suez (9 percent each), see:

<http://www.gazprom.com/about/production/projects/pipelines/active/nord-stream/>

⁴ The Western companies consist of ENGIE, OMV, Shell, Uniper and Wintershall. Nord Stream 2 AG and European energy companies have signed financing agreements, see: <https://www.nord-stream2.com/media-info/news-events/nord-stream-2-ag-and-european-energy-companies-sign-financing-agreements-47/>

After the first dispute with Ukraine, Gazprom also launched plans for a new pipeline under the Black Sea to Bulgaria – South Stream. The purpose of South Stream was also to fend off competition from gas producers in the Caspian region; these had worked out plans for competing projects, for example, the Nabucco pipeline.

Although there was considerable interest in the project in Southern Europe and the Balkans, the European Commission feared the project could establish a monopoly position for Gazprom in parts of Europe; it was deemed unrealistic that competing pipelines would be constructed once South Stream was operational. The European Commission therefore insisted that third party access had to be guaranteed. Preparations for start-up of the construction work continued as the wrangling over principles went on. The general atmosphere between the EU and Russia deteriorated after the crisis in Ukraine, but it was still a surprise when President Putin in December 2014 declared that the project was cancelled, blaming the EU and Bulgaria, see Financial Times (2014).

At the same time, Putin declared that an alternative pipeline – Turkish Stream – would be constructed, transporting gas to Turkey and southeastern Europe (via Greece).

Development of the plan was frozen after political relations between Russia and Turkey soured in the autumn of 2015. By October 2016, relations were reestablished, however, and the project reinvigorated. The revised project includes two strings with an annual capacity of 15.75 bcm each (about 14 Mtoe), one destined for the Turkish market and the other for Greece and southeastern Europe.⁵

Power of Siberia

Russia signed a gas export deal with China in May 2014, concluding many years of talks. The agreement involves construction of a pipeline in Eastern Siberia – Power of Siberia – which will ultimately bring about 34 Mtoe from two fields, Chayanda and Kovykta, to China.⁶ The China deal has been regarded as a political victory, showing that Russia is not totally dependent on western markets for gas exports. Construction of Power of Siberia has started,

⁵ Construction of TurkStream gas pipeline's offshore section commenced. Gazprom press release 7 May 2017. <http://www.gazprom.com/press/news/2017/may/article329932/>

⁶ <http://www.gazprom.com/press/news/2014/may/article191451/>

but has slowed down, apparently because Chinese forecasts for gas demand have been lowered.

The Chayanda and Kovykta gas fields are located far from the pipeline network that brings gas to the west. In fact, Russia would have preferred another gas corridor; the one via the Altai Mountains to western China. Such a project would be based on gas from West Siberia, and could have been linked to the trunk pipeline network. So far, China has not been much interested in this *additional* deal because it would require costly transport of gas from the western part of China, where demand for gas is low, to the booming eastern part of China. Still, there is a possibility that this pipeline is also built before 2030, in which case a capacity of 30 bcm has been discussed.

The future of Russian gas exports

The discussion above suggests that it is pertinent to explore how the upcoming increases in pipeline capacity from Russia will affect its gas export, as well as prices and consumption of gas in Russia and in Europe. In Section 4, we investigate the effects of respectively Nord Stream 2, Turkish Stream, and Power of Siberia, comparing with a scenario for 2030 where none of these are built. We will also examine how these effects are affected by potential changes in gas price regulations in Russia, and restrictions on gas sales to, and transit via, Ukraine. Finally, we assess the potential implications if a second gas pipeline is built between Russia (Western Siberia) and China.

3. The numerical model LIBEMOD

We use the numerical model LIBEMOD, which provides a detailed description of the energy markets in 31 European countries, including Russia, to examine different scenarios for Russian gas exports.

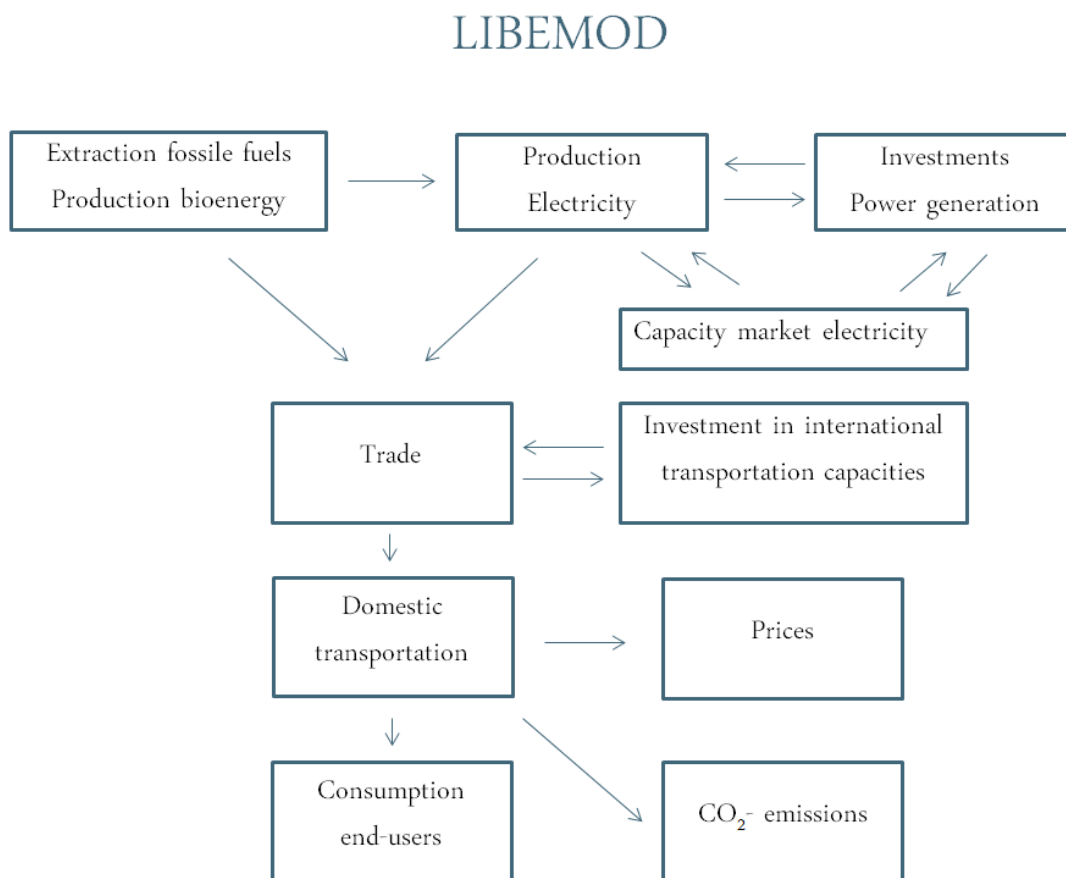
LIBEMOD is a deterministic, multi-good, multi-market, numerical, energy market model that covers EU-28 (except Croatia) along with Iceland, Norway, Russia and Switzerland. Because of long distances in Russia, and the fact that extraction of natural gas is located far from the main domestic consumption areas, Russia has been divided into three (LIBEMOD) regions; West, Middle and East Russia. Each Russian region is modelled as a

separate country. Henceforth, the set of 31 countries, including the three Russian regions, is referred to as EUROPE-31, whereas we refer to EU-30 as the group covering EU-28 (except Croatia) along with Iceland, Norway, and Switzerland. .

LIBEMOD determines *simultaneously* investment, extraction, production, trade, transport and consumption of all energy goods (prices and quantities) in EUROPE-31. In addition, LIBEMOD determines prices and quantities of the globally traded energy goods biofuel, coking coal, steam coal and oil. These equilibria are determined by global demand and supply, and hence all countries in the world (also EUROPE-31) are covered in this part of the model.

Figure 1 provides an overview of LIBEMOD. There are five types of fossil fuels – coaking coal, steam coal, lignite, natural gas and oil – and these are extracted in most of EUROPE-31, as well as in other countries. In addition, there is production of two types of bioenergy – biomass and biofuels. Bio energy is produced in EUROPE-31 as well as outside EUROPE-31.

Figure 1. Overview of the LIBEMOD model



In LIBEMOD, there are five big natural gas suppliers to the European market – Algeria, the Netherlands, Norway, Russia and the UK. For these countries, we distinguish between extraction from existing (“old”) fields in the data year of the model (2009), and (“new”) fields that may come on stream after 2009 if they are profitable. We use data from Rystad Energy to calibrate marginal costs of extraction from old and new fields in these five countries. There is also extraction of natural gas in (most of) the other EUROPE-31 countries, but the modeling is less detailed than for the five big natural gas extractors. Finally, there is price-sensitive export of natural gas to the European market from non-European countries, both piped gas and LNG.

Fossil fuels (except coking coal) and biomass are used as inputs to produce electricity in EUROPE-31. In LIBEMOD, electricity can also be produced in nuclear stations, by hydro (reservoir hydro, run-of-river hydro and pumped storage hydro), and there are two types of renewable electricity; wind power and solar. Each electricity producer solves a complicated optimization problem that determines investment in new capacity, the share of total installed capacity that is maintained for economic activity, and what share of maintained capacity that is used to produce electricity – the remainder capacity is sold to a (domestic) system operator who is to ensure that the electricity system does not break down.

Energy goods can be traded between countries. For piped natural gas, as well as electricity, trade requires infrastructure, that is, gas pipes or electricity transmission lines, running between two EUROPE-31 countries.⁷ In the data year of the model, there is a set of pre-determined capacities. These can be expanded through profitable investments where costs of investment are compared to the corresponding benefits – the arbitrage possibilities of international natural gas trade. However, investments in pipelines between West Russia and European countries are handled according to the scenarios specified in Section XX.

In order to transport piped natural gas (and electricity) between countries, a transport fee (per unit of energy) has to be paid to the owners of the transport facilities. All fees are determined by LIBEMOD in a competitive manner. Hence, if there is excess demand for transport services, the fee will increase until demand for services exactly equals the capacity of the pipe.

In each EUROPE-31 country, natural gas (as well as all other types of energy) is transported to the customers at an exogenous cost, which differs between countries, energy goods and user groups. In LIBEMOD, there are five types of energy users. First, there is

⁷ In LIBEMOD, imports of LNG require infrastructure as well.

demand for energy from electricity generating plants using fossil fuels or biomass as an input. Second, there are four groups of end users; households, services (including the public sector), transport and industry. For each of these groups (in each EUROPE-31 country), there is a (CES) system of demand relations that ensures that demand for all types of energy is handled in a theory-consistent way. Calibration of the associated (CES) parameters reflects national and sectoral differences in energy structure and preferences.

In LIBEMOD, prices and quantities of *all* energy goods are determined simultaneously in a competitive manner. The model determines both producer prices and consumer prices. The latter reflect energy taxes and subsidies, environmental taxes, as well as VAT (many of these are de facto zero).

There is, however, one exception from the assumption of competitive markets, namely natural gas in Russia. As explained in Section 1, domestic Russian gas prices are regulated and are far below hypothetical competitive prices. In LIBEMOD, this is handled by calibrating subsidies that reflect the difference (in the data year 2009) between (i) the real cost of supplying natural gas to a user, for example, gas power stations or households, and (ii) the price this user actually paid for the natural gas. The calibrated subsidies are in the range of 120 to 166 €/toe in 2009, see Aune et al. (2015) for more details. Below, we use these subsidies for the 2030 scenarios. For given subsidies, the model determines producer and consumer prices of natural gas in Russia, and hence also natural gas prices in Russia are endogenous in LIBMOD.⁸

We refer to Aune et al. (2008) for a more detailed and technical documentation of an earlier version of the model, and to Aune et al. (2015) and LIBEMOD (2015) for information about the latest version of the model, as well as data and calibration strategy.

4. Results

4.1 Alternative scenarios for 2020

⁸ Because Russia is a large exporter of natural gas to the European market, it may have market power. In earlier work, see Aune et al. (2015), we have calibrated the market power of Russian gas, expressed as a mark-up over marginal cost. We found this mark-up to be small (18 €/toe in 2009). In the present study, we assume there is no mark-up of Russian gas. First, the calibrated mark-up for 2009 is small and will therefore have negligible effect on the European market. Second, the mark-up may change over time due to a number of factors. Whereas we found sign of market power in the 2009 European natural gas market, we assume that by 2030 the European natural gas market can be characterized as being competitive – this is line with the ambition of the EU.

Table 1 shows the main scenarios; they are all for 2030. In addition, we have run some robustness scenarios, which we return to at the end of this section.

The reference scenario for 2030 differs from the observed 2009 outcome along several dimensions.⁹ First, while the 2030 demand system has the same parameters as the calibrated 2009 demand system, demand levels differ because the income levels differ. For each model country and end-user sector, demand for energy in 2030 reflects (exogenous) growth in GDP between 2009 and 2030 and the applied income elasticity. The latter differs between energy good and end-user group, and is calibrated to make the demand system consistent with IEA prediction for demand for energy in 2030, see IEA (2015).

Second, the 2030 predetermined capacities for old electricity plants and old international electricity transmission lines and gas pipes (that is, facilities that were established before 2010) are lower than in 2009 because of depreciation. On the other hand, there is expansion of a capacity if the corresponding investment project is profitable (except for transmission investments from Russia to other countries; these are assumed to be zero in the reference scenario).

Finally, we assume that the EU is successful in reaching its main 2030 climate and energy policy targets, that is, a 40 percent reduction in greenhouse gas emissions relative to 1990 (cf. the Paris agreement), and a renewable share in energy consumption of 27 percent. The EU imposes efficient EU-wide instruments to reach these targets in our scenarios, that is, a tradable quota system for the ETS sector, a uniform CO₂-price for the non-ETS sectors, and a uniform renewable subsidy. We also impose CO₂-prices to make emissions in non-EU member states in line with their Paris commitments.

In the three alternative scenarios, “Nord Stream 2”, “Turkish Stream” and “Power of Siberia”, we assume that the respective gas pipeline is built and in operation in 2030. This is the only difference between this scenario and the reference scenario. In the scenario “All three pipes”, we consider the effects of building all three pipelines by 2030.

Table 1. Alternative scenarios for 2030

⁹ Note that the reference scenario is not the scenario that seems most realistic, but simply a scenario where no new gas pipelines are built between Russia and Europe/China.

Reference	See description in the text
Nord Stream 2	Same as reference, but Nord Stream 2 is built
Turkish Stream	Same as reference, but Turkish Stream is built
Power of Siberia	Same as reference, but Power of Siberia is built
All three pipes	Same as reference, but Nord Stream 2, Turkish Stream and Power of Siberia are all built

4.2 Reference scenario

We start by comparing the reference scenario for 2030 with the historical base year 2009. Figure 2 shows the average user prices of natural gas in EU-30 and Russia, weighted over sectors and European countries/Russian regions. It is evident from the figure that the EU-30 user price was far above the Russian price in 2009 – around ten times higher on average. One important reason is that gas users in Russia are de facto subsidized, whereas gas users in the EU are taxed, see Table 2, which shows the cost elements of the end-user price of gas in the EU-30 and Russia. As seen from the table, Russian consumers also enjoy the fact that they are located closer to major gas fields, and hence the marginal cost of supply (sum of extraction and international transportation cost) is much lower in Russia than in the EU.

Table 2. End-user prices for gas in Russia and EU-30 in the reference scenario.
Euro₂₀₀₉/toe

	EU-30	Russia
Marginal cost of supply	144	74
Domestic energy losses	2	1
Domestic distribution costs	103	86
Energy taxes	36	0
Energy subsidies	0	-96
CO ₂ -taxes	114	0
Value added tax (VAT)	49	1
End-user price (sum)	447	66

Figure 2 shows that the average user price of gas in Russia is higher in the 2030 reference scenario than in 2009, which is due to a combination of several factors. First, we see from Figure 3 that Russian gas demand increases towards 2030, despite higher prices, and are on average 16 percent higher in the reference scenario than in 2009. This is caused by economic growth, which stimulates energy demand in Russia, putting upwards pressure on gas prices. Second, gas extraction costs in Russia increase as production expands and more expensive fields are extracted. Third, Russian gas export increases somewhat (see Figure 4), which is related to higher gas prices in Europe. The average user price of gas in EU-30 has increased by 25 percent in 2030 vis-à-vis 2009, cf. Figure 2. Economic growth towards 2030, although somewhat sluggish in Europe, stimulates energy demand. On the other hand, EU's climate and energy policy has significant impacts on the European energy market, and the combined effect of CO₂-prices and renewable support is to reduce demand for gas. Higher user prices of gas pull in the same direction. Higher gas prices in Europe are partly due to a significant reduction in own gas production towards 2030, which on the other hand is partly compensated by increased imports of LNG. The joint effect of all these factors is a minor increase in gas consumption in EU-30 compared to 2009, see Figure 3.¹⁰

Figure 5 shows the transport volumes of gas from Russia in the reference scenario for 2030, and the corresponding pipeline capacities in the base year 2009. We see that Russia exports 35 Mtoe directly to EU countries (Germany (31 Mtoe), Finland (2 Mtoe), Lithuania (1 Mtoe)

¹⁰ Gas consumption in the EU has in fact decreased by 20 percent from 2010 to 2015 (BP, 2016). Böhringer and Rosendahl (2010) shows that supporting renewables has particularly negative effects on gas consumption if an emission trading system like the EU ETS is already in place.

and Estonia (1 Mtoe)). In addition, 63 Mtoe is exported to Ukraine and 20 Mtoe to Belarus.¹¹ 60 percent of the export to Ukraine (38 Mtoe) is sent on to EU-30. Thus, Ukraine is an important transit country for Russian gas export to the EU.

In the following subsections, we will discuss the alternative scenarios shown in Table 1, and mainly compare them with the reference scenario.

Figure 2. Gas consumer prices in Russia and EU-30. Euro/toe

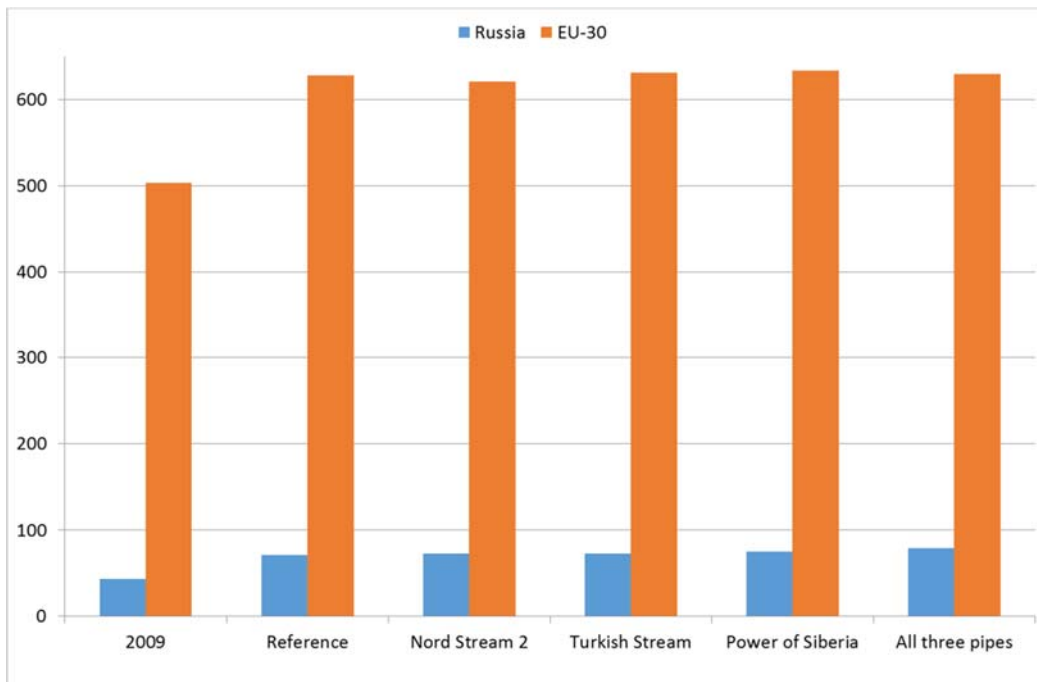


Figure 3. Gas consumption in Russia and EU-30. Mtoe per year

¹¹ Russia also exported 19 Mtoe to other non-EU countries (but this is not included in Figure 5).

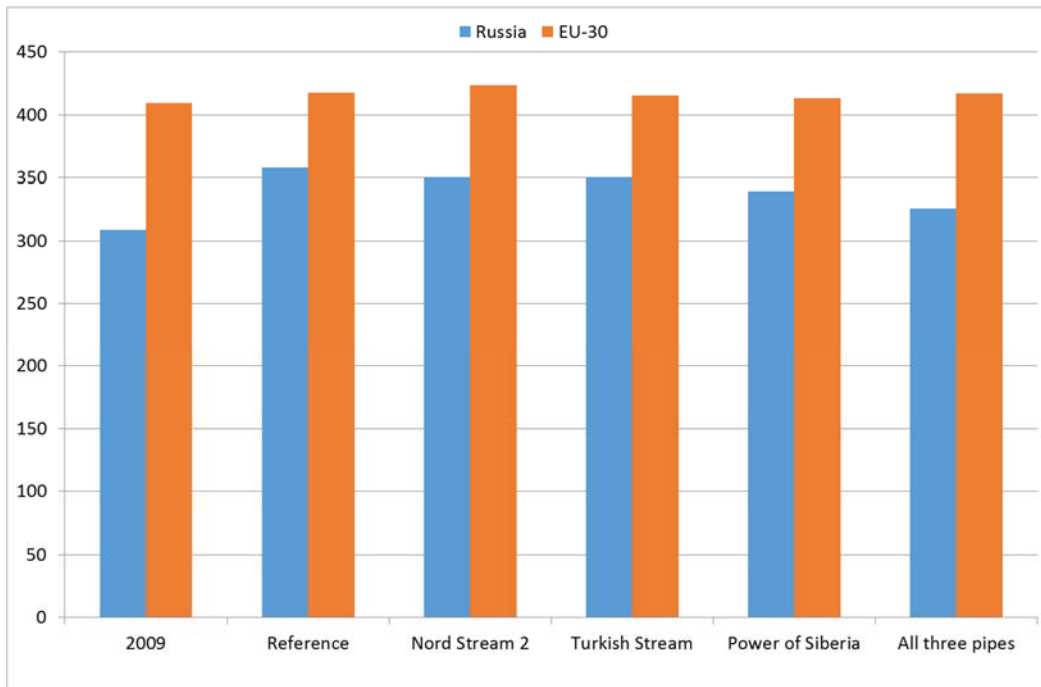
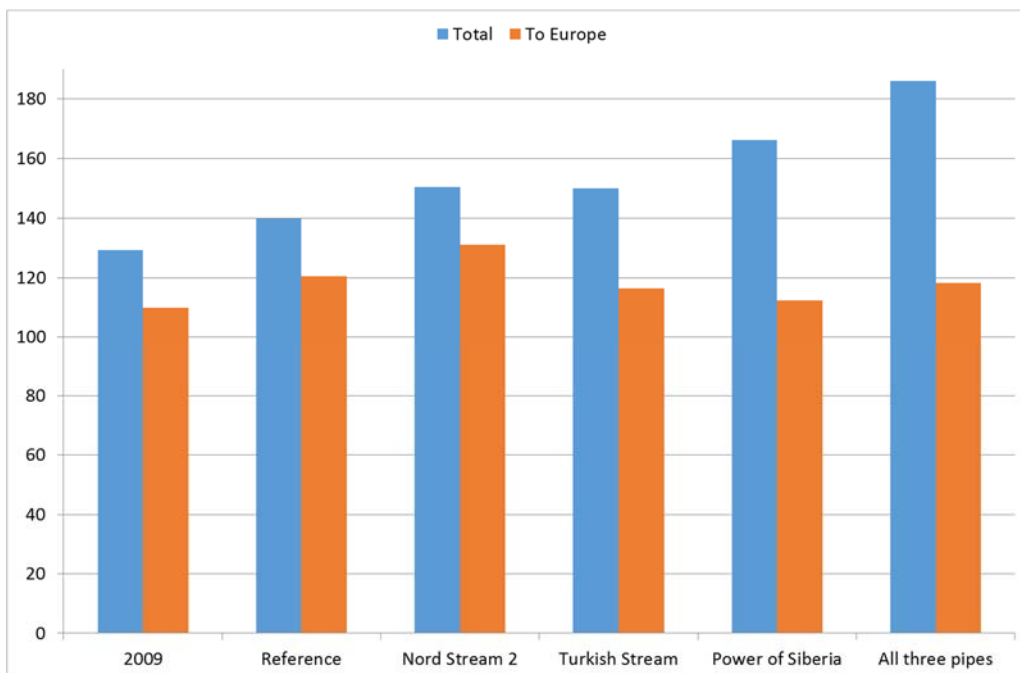


Figure 4. Net export of gas from Russia. Mtoe per year



Note: Europe includes here EU-30 (cf. model description in Sectin 3), Ukraine and Belarus

Figure 4

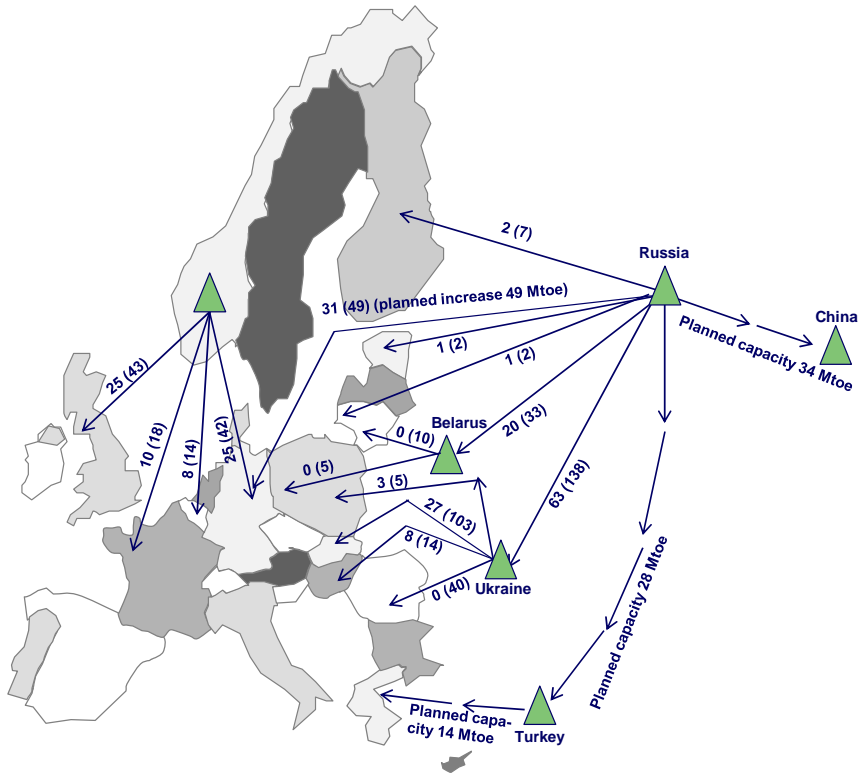


Figure 5. Transport of natural gas in the reference scenario (Transport capacities in 2009). Mtoe

Note: The numbers refer to transported gas (in Mtoe) in the reference scenario for 2030, with transport capacities in 2009 (in Mtoe per year) in parenthesis.

4.3 New gas pipeline through the Baltic Sea

Our first alternative scenario considers the effects of building an additional gas pipeline directly from Russia to Germany, i.e., the Nord Stream 2 pipeline. The capacity of the new pipeline is planned to have the same capacity as the first Nord Stream pipeline, i.e., 49 Mtoe per year. This is a significant increase in Russia's gas pipeline capacity – in the reference scenario Russian net gas export is 140 Mtoe.

The effect of the “Nord Stream 2” scenario is to increase Russia's (net) gas exports by 11 Mtoe per year. Given the substantial increase in capacity (49 Mtoe), the increase in export level is rather modest. Export directly from Russia to Germany increases much more, however, by almost 40 Mtoe, whereas exports via Ukraine to central Europe drop by around 25 Mtoe. Thus, the Nord Stream 2 pipeline will make Russia less dependent on gas transit via Ukraine.

The Nord Stream 2 pipeline has little influence on total gas consumption and average gas prices in EU-30 – prices fall by 1-2 percent while consumption grows by 1-2 percent. Gas prices and consumption in Germany do not react much more than in the rest of the EU. This is due to available pipeline capacity between German and neighboring countries. Hence, Germany imports less from other sources when Nord Stream 2 is built, and sends some of the imported gas to other countries. The effects on Russian gas consumption and prices are more or less the mirror image of the effects in EU-30, see Figures 1-2.

Note that the Nord Stream 2 project does not obtain a positive present value in this scenario, and thus it is not profitable. This finding reflects partly that it is costly to build pipelines, and partly that the existing capacity to the European market is high from a pure profitability point of view. This conclusion could change, however, with other assumptions about future policies and market development, which we come back to in Section 4.7.

4.4 Gas pipeline through Turkey

Our second alternative scenario examines the consequences of the Turkish Stream pipeline, i.e., building a pipeline from Russia to Turkey, and another pipeline via Turkey to Greece. Based on the announced plans for the project, we implement into our model a pipeline capacity from Russia to Turkey of 28 Mtoe per year, and a capacity from Turkey to Greece of 14 Mtoe per year, see Figure 5. The difference (14 Mtoe) is assumed exported from Russia to gas users in Turkey (Turkey is not a separate region in the model, but part of the region Rest of World).

The “Turkish Stream” scenario has almost the same effect on total Russian gas exports as the “Nord Stream 2” scenario, that is, an increase of 10 Mtoe compared to the reference scenario. That includes the assumed 14 Mtoe exported to Turkey, which means that exports to EU-30 in fact drop by 4 Mtoe (see Figure 4). In fact, none of the new capacity to Greece is being utilized. Hence, gas prices in the EU increase, gas consumption falls, and supply from other gas producers increases, but all these effects are only marginal.

Our conclusion is therefore that the Turkish Stream project, at least the second string into Greece, makes little sense when considering Russian exports to the EU, unless long-term strategic issues are taken into account. One such issue could be to prevent other proposed projects, such as the now abandoned Nabucco project. Ironically, realization of the Trans Adriatic Pipeline (TAP) - intended for bringing Azeri gas, pumped via Turkey, to Italy - could also become a channel for Russian gas via Turkish Stream.¹² Another issue could be to gradually become independent of transit through Ukraine. In a situation where the pipelines through Ukraine are not used, the effects of the Turkish Stream projects are bigger (see robustness analysis in subsection 4.7).

4.5 Gas exports to China

In 2014, Russia and China signed an agreement on exports of gas from Russia to China, called “Power of Siberia”. According to the agreement, Russia will deliver around 34 Mtoe by 2030, transported via Eastern Siberia into the northeastern part of China. In our “Power of

¹² TAP’s initial capacity will be 10 BCM, see <http://www.euractiv.com/section/energy/news/russia-can-use-trans-adriatic-pipeline-commission-confirms/>, and thus may have modest impact until its capacity eventually is increased radically.

Siberia” scenario, we assume that 34 Mtoe is exported from East Russia to China in 2030 (China is not a separate region in the model, but part of the region Rest of World).

We find that total exports of gas from Russia increase by 26 Mtoe compared to the reference scenario, i.e., somewhat less than the new export volume to China. This means that net exports to EU-30 decline by 8 Mtoe, as gas transit via Ukraine to central Europe decreases (see Figure 4). The increased gas export from Russia comes partly from increased Russian gas production (8 Mtoe), but mostly from reduced Russian gas consumption, which drops by 18 Mtoe or 5 percent (see Figure 3). Average user prices in Russia increase by 6 percent in this scenario, as higher extraction implies somewhat higher marginal costs of extraction. This is especially the case in East Russia, where user prices increase by 25 percent.

4.6 All three pipelines

As explained before, all three pipelines considered in the preceding subsections are expected to be in operation by 2030. Hence, it is natural to also model the effects of having all three pipelines available. This is done in the scenario “All three pipes”. In this case, net exports from Russia increases to 186 Mtoe in 2030, that is, 46 Mtoe higher than in the reference scenario (see Figure 4). However, as 34 Mtoe is exported to China, and 14 Mtoe to Turkey, net exports to EU-30 actually slightly declines. The new Nord Stream 2 pipeline is extensively used in this scenario, whereas the second part of the Turkish Stream pipeline (going into Greece) is still not used. Gas transit via Ukraine is substantially reduced due to the Nord Stream 2 pipeline, similarly as in the “Nord Stream 2” scenario.

As net Russian gas exports to EU-30 are almost unchanged vis-à-vis the reference scenario, gas prices and consumption in EU-30 are also quite unaltered in the “All three pipes” scenario compared to the reference scenario. The effects in Russia are more pronounced. Average user price of gas increases by 12 percent, while total gas consumption drops by 9 percent. Again, the impacts are biggest in East Russia.

4.7 Robustness analysis

There are a number of uncertainties about the future gas markets in Europe and Russia, both with regard to policies and market development. Hence, it is useful to do some robustness analysis with regard to some of the most important assumptions. In this subsection, we will

consider three important policy assumptions, and assess the impacts of the new pipelines given such alternative assumptions. As our main focus in this paper is on Russian gas exports to Europe, we will mostly focus on that in our robustness analysis.

First, as mentioned in Section 2, gas prices in Russia are highly regulated, with significant (implicit) subsidies to both small and large gas users. Previously, the Russian government intended to increase the regulated prices, but the process has been rather slow. It seems that the current Russian policy is to increase the price to large customers – gas power plants and manufacturing firms – rather than the price to small customers – households and services. Hence, we consider an alternative set of scenarios where the implicit subsidies to large customers are halved in 2030, while subsidies to small customers are unchanged (“Reduced subsidies”).

Second, as also mentioned in Section 2, there is a conflict between Russia and Ukraine, which periodically has affected gas exports from Russia via Ukraine to Europe. If the conflict escalates further, the export route via Ukraine could potentially be blocked. Although a full blockade of the gas pipelines via Ukraine may seem unrealistic today, it is of interest to consider the consequences. Thus, we investigate an alternative set of scenarios where Russia does not export any gas to or via Ukraine (“No transit via Ukraine”). Hence, Ukraine has to buy natural gas from other countries in order to supplement its domestic extraction of natural gas, and Russia has to use other routes than through Ukraine for its gas export to the EU.

Third, in Section 2 we briefly discussed the possibility of an additional pipeline from Russia (West Siberia) to China. Although China has not been particularly interested in such a pipeline so far, this could possibly change if Chinese gas demand grows strongly and other gas supply options seem less favorable. Hence, we investigate a scenario where Russian exports to China become 64 Mtoe in 2030, rather than 34 Mtoe as in the “Power of Siberia” scenario (“More gas to China”).

We start with the effects of reducing subsidies to large gas customers. This has significant impacts on Russian gas exports. In all scenarios discussed above (cf. Table 1), net exports from Russia increase substantially if subsidies to large gas customers in Russia are halved, see Table 3. The reason is that the use of gas in Russia decreases significantly, both in the manufacturing industries and especially in electricity generation. Hence, more gas is available for export.

From Table 3 we also see that the impacts of the new pipelines for Russian gas export are more pronounced when subsidies to large gas customers in Russia are halved. For instance, whereas the Nord Stream 2 pipeline increases Russian exports by modestly 11 Mtoe per year with the benchmark assumptions, with lower subsidies Russian exports increase by 37 Mtoe. Thus, gas transport via the Nord Stream 2 pipeline to a much lesser degree replaces gas transit via Ukraine. Further, whereas the Turkish Stream pipeline does not bring any gas to Greece with the benchmark assumptions, the capacity is fully utilized if subsidies to large Russian customers are reduced. Finally, Power of Siberia no longer leads to reduced gas exports to Europe.

Table 3. Net exports of gas from Russia in 2030 (Net exports to Europe in parenthesis). Mtoe per year

	Benchmark assumptions	Reduced subsidies	No transit via Ukraine	More gas to China
Reference	140 (120)	160 (141)	78 (59)	NA
Nord Stream 2	151 (131)	197 (178)	117 (98)	NA
Turkish Stream	150 (116)	190 (156)	107 (73)	NA
Power of Siberia	166 (112)	195 (141)	112 (58)	189 (105)
All three pipes	186 (118)	230 (162)	164 (96)	200 (105)

Note: Europe includes here EU-30 (cf. model description in Sectin 3), Ukraine and Belarus.

Next, we consider the impacts of blocking gas transit via Ukraine. This implies that the pipeline capacity to Europe is substantially reduced, and hence Russian gas exports drastically decline in the new reference scenario (see Table 3). This stimulates gas supply from other countries – gas production in Norway, the Netherlands, the UK, and Algeria increases by respectively 4 percent, 1 percent, 4 percent, and 2 percent (compared with the original reference scenario). Still, gas consumption in EU-30 declines by 9 percent, and the average user price of gas is now 7 percent higher in EU-30 than in the original reference scenario.

The effects of the new pipelines on Russian gas exports are much bigger than with the benchmark assumptions, and quite similar to the corresponding effects in the case with reduced subsidies. Thus, both the Nord Stream 2 pipeline and the Turkish Stream project seem more rational in a situation where Russia wants to be less reliant on gas transit via Ukraine, and might therefore be seen as strategic projects. However, we note that exports to

Europe are lower with all three pipelines built but no transit via Ukraine (96 Mtoe) than with transit via Ukraine but no new pipelines (120 Mtoe), and hence gas prices in EU-30 are slightly higher in the former case.

If gas exports from Russia to China are increased to 64 Mtoe per year, exports to Europe are reduced by 7 Mtoe compared to the “Power of Siberia” scenario, and by 15 Mtoe compared to the reference scenario. Hence, Russian gas sales to China shift some of its exports away from Europe, but the impacts are far from dramatic.

5. Concluding remarks

Russia is the biggest gas exporter in the world, and most of its exports go to EU member states. As all other natural gas suppliers, Russia puts great emphasis on security of demand, which reflects the huge costs of extracting and transporting natural gas. At the same time, Russia is the biggest supplier of gas to the EU, and the EU puts great emphasis on security of supply.

Traditionally, this mutual interest for security – security of demand for the supplier vs. security of supply for the purchaser – has been handled by long-term contracts. The development towards a more competitive European gas market has increased the share of spot trade in the European gas market, and thus affected both security of demand and supply. Also the disputes and conflicts between Russia and Ukraine have had impact on security of demand and supply.

In this paper we have used the numerical energy market model LIBEMOD to investigate long-run effects of specific moves by Russia, such as building new pipelines to Europe, Turkey and China, in order to increase its security of demand. Overall, the impacts on the gas market in the EU are either small or moderate.

We have also demonstrated that a reduction in Russian gas supply to the EU, caused by Russia not using the pipelines to and via Ukraine, will be followed by increased gas supply from other sources and switching from gas power production to other types of electricity generation in the EU. Again, these are long-run effects, that is, actors know several years in advance that there will be no transport of Russian gas to and via Ukraine, and this is taken into account when investments are determined. Needless to say, short-run disruption effects may differ significantly from the long-run effects. Yet, Bouwmeester and Oosterhaven

(2017) find that short-run effects of disruptions between Russia and EU are negligible for the EU economy.

Our modeling has assumed that Gazprom remains the sole exporter of natural gas from Russia. In the future, the organization of the Russian gas industry, including gas exports, may change radically. Although Gazprom has repeatedly argued that it would be dangerous to break up the well-integrated gas system, other gas producers have emerged with a production share of approximately 25 percent. So far, these companies, with the gas company Novatek and the oil giant Rosneft in the lead, have not been granted access to pipeline exports. However, in 2013 Rosneft and Novatek were given permission to sign export contracts for two LNG projects, provided they would not compete with Russian pipeline exports. It is the stated aim of Rosneft to make inroads into the prerogatives of Gazprom, in particular to get access to pipeline exports. If Russian gas exports should become more competitive than today, the result could be more aggressive export behavior by Russia than the response found in our analysis.

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