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Abstract

This article provides quantitative assessments of the impact of Russia's ongoing reform of domestic natural gas prices on the country's consumption of natural gas. The base assumption is that Russia could go through an adaptation process analogous to what occurred in more advanced transition countries. Empirical gas demand models are thus estimated for the transition countries of Central Europe for the period 1992-2006. The results are used to calibrate gas demand functions for the Russian Federation. Forward projections are then made up to 2020, separately for both industrial and residential consumption. This is complemented with estimates based on benchmarking for potential savings in generation of electricity and heat, and for gas transmission and distribution. The projected levels for total gas savings are large: in a range of 83 to 134 bcm per year by 2020 as compared to the 2007 level, provided price reform paths remain strong and assuming favourable conditions for rapid and large-scale investments in the electricity and heat generation sector. The results also suggest that Russia's net export potential should rise provided developments are favourable on the production side as well.

Keywords: Natural gas demand; Russia; price reform; gas demand projections.

Contents

1 Introduction, scope and structure

Russia is the world's leading producer and exporter of natural gas. It is however also a major consumer. For a production of 657 bcm in 2008, see IEA (2009a), consumption was 462 bcm, or 70% of production. The evolution of Russia's domestic gas consumption is therefore highly relevant for Russia's gas balance and its ability to fulfil its export commitments. As noted in Hartley and Medlock (2009), concerns over possible shortfalls were expressed by the Russian government in 2006 and a solution in terms of domestic price increases was formulated. Those initial plans were ambitious but suffered from repeated delays, while domestic demand rose sharply from 2005 to 2007. This led some researchers to assume annual demand levels close to or above 500 bcm by 2020, see e.g. Fernandez (2009). However domestic price increases above the rate of inflation have occurred in 2008 and 2009 and have been officially decided for 2010. These developments point to the need for a new quantitative assessment of the impact of gas price increases in Russia.

Econometric estimates of the price elasticity of demand for natural gas in the case of Russia are typically found to be not significant, see e.g. Solodnikova (2003) for an example and Sagen and Tsygankova (2008) for a brief review. Spanjer (2007) points out that Russian domestic gas prices have been at low levels for many years, so that the responsiveness to the (hitherto small) price fluctuations has been very limited. Estimating a gas demand model based on past Russian data therefore runs the risk of yielding results that would be misleading for future projections. A similar insight comes from work on the case of China, see e.g. Hang and Tu (2006) which assesses the pre- and post-energy price reform situations and finds significantly larger demand elasticities for the post-reform period.

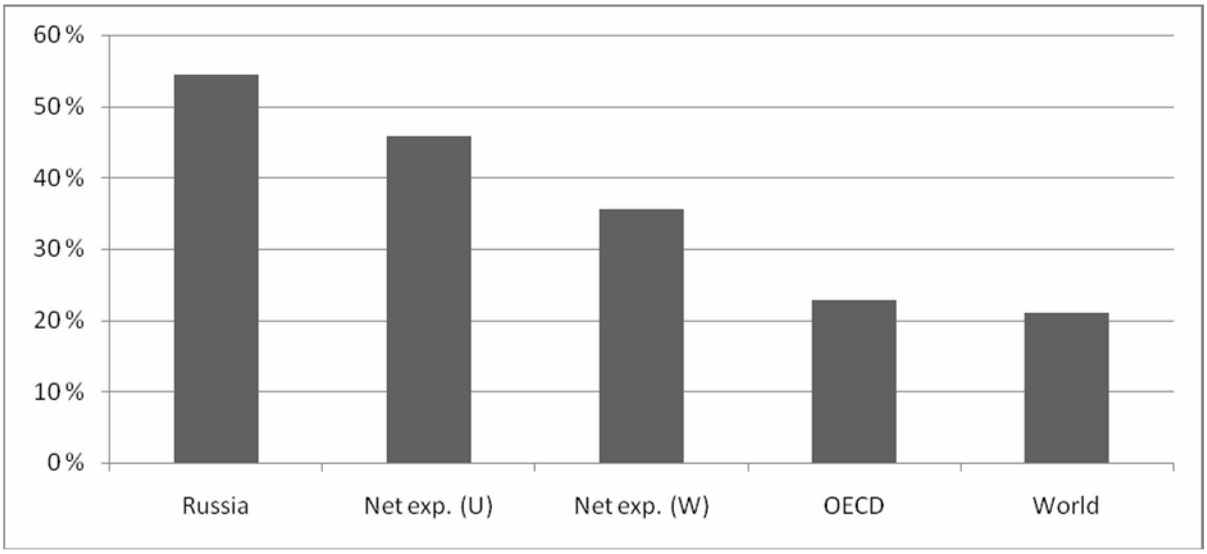
The approach in this paper is to start by estimating gas demand models for Central European transition countries instead. These countries have, to some extent, a similar structural legacy to Russia's but have already undergone episodes of structural change and energy price increases that may be analogous to what may unfold in Russia. The estimation results are then used to calibrate demand models for Russia, enabling out-of-sample projections up to 2020. This approach is used to assess both residential and industrial consumption. This is complemented with estimates of potential savings in generation of electricity and heat and in gas transmission and distribution based on benchmarking exercises. The results are then summed in order to yield scenarios for total potential gas savings that are caused by increases in domestic gas prices.

This article is structured as follows. Section 2 presents some stylised facts about Russian natural gas consumption and prices. Section 3 contains the estimation results for the empirical gas demand models for the residential and industrial sectors in Central Europe. The calibrated projection models are applied to the Russian case in Section 4. Section 5 covers estimates of potential savings in generation of electricity and heat. Section 6 contains the total consumption scenarios based on the results from the previous sections. Section 7 concludes.

2 Stylised facts

Natural gas consumption in 2008 was 658 bcm in the United States and 533 bcm in the European Union. Russia's level of 462 bcm therefore seems high both on a per capita basis and as compared to GDP. There are two main structural reasons for this difference which are not connected to energy efficiency. First, Russia's energy mix is more strongly based on natural gas than that of most countries, even if one compares Russia to other net exporters of natural gas, see Figure 1.

Figure 1. Share of natural gas in total primary energy supply, 2007



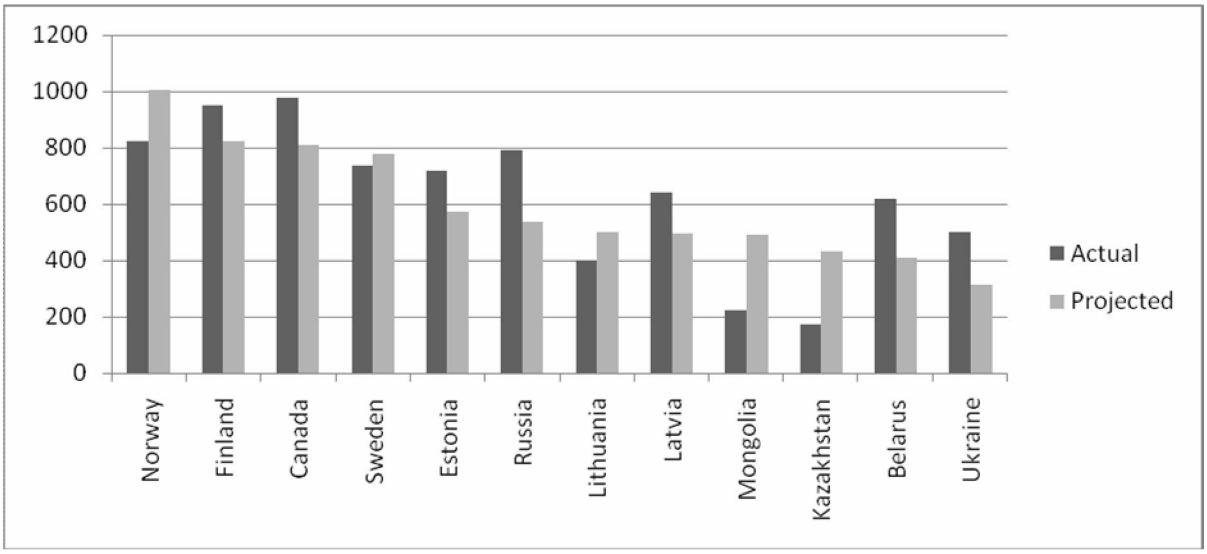
Source: IEA Energy Balances

Net exp. (U): unweighted average for all countries which had strictly positive net exports in 2007.

Net exp. (W): average weighted by total primary energy supply.

Second, Russia has the world's second coldest climate after Mongolia as measured in heating degree days (HDD), see Baumert and Selman (2003). Figure 2 presents actual versus projected levels of final energy consumption per capita in the residential sector for 12 of the world's coldest countries. The projected levels are based on a cross-section regression of the dependent variable on GDP per capita (at PPP) and HDD for the world's 40 coldest countries as measured by average national HDD for the year 2007 (see Annex A for the full results). Russia's per capita energy consumption in the residential sector was 790 kgoe in 2007 as compared to a baseline level of 538 kgoe, a difference of 47% as compared to the baseline. Russia is therefore quite strongly above the projected level, which suggests that quite large efficiency gains could be made in its residential sector.

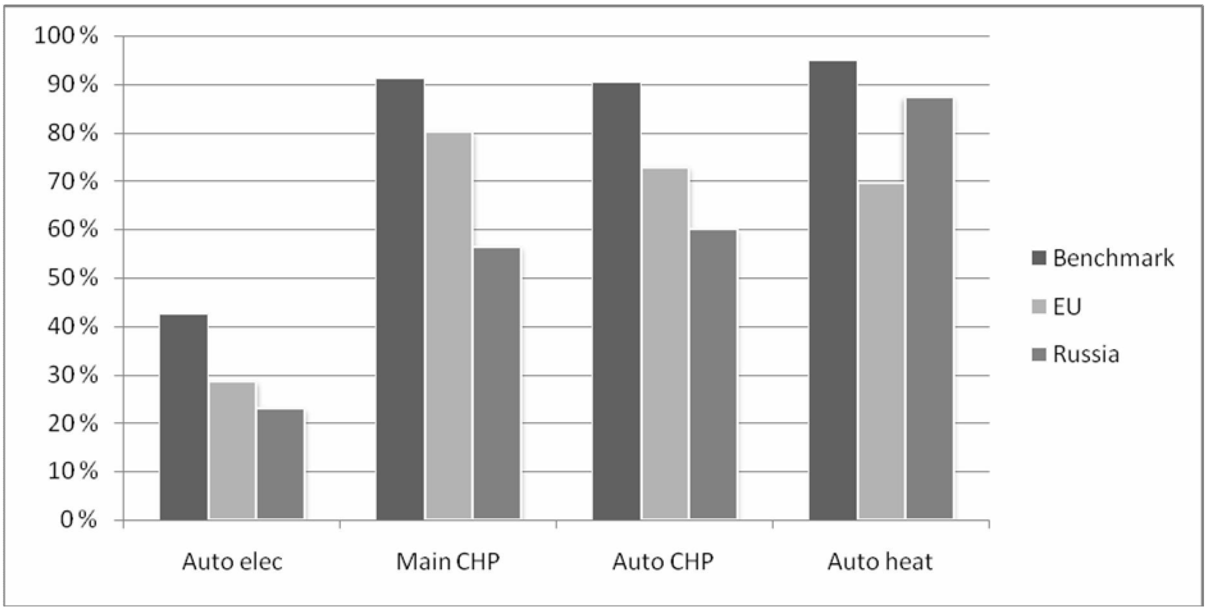
Figure 2. Actual versus expected residential energy consumption, 2007



Unit: kilograms of oil equivalent per capita

Electricity and heat generation accounted for 58.5% (265 bcm) of natural gas consumption in Russia in 2007. Figure 3 shows a comparison of thermal efficiencies by type of generation facility between Russia, the European Union average and a selected benchmark OECD country. The types of installation which are presented correspond to those that are in use in Russia, namely: autoproducer electricity plants (1% of natural gas used in generation), main activity producer CHP plants (63%), autoproducer CHP plants (8%) and autoproducer heat plants (28%). The benchmark efficiency levels for each type refer to Canada, Germany, the Netherlands, and again the Netherlands, respectively. These findings suggest that large efficiency improvements are possible in generation of electricity and heat as well.

Figure 3. Thermal efficiency of gas-fired plants by type, 2007



Source: IEA Energy Balances and own calculations

There are several reasons for Russia's high energy consumption levels. As suggested in Figure 2, GDP and temperature provide part, but only part, of the explanation. Industrial structure is also only a relatively minor explanatory factor for total consumption levels. In sum, and perhaps contrary to intuition, the combination of geography, climate and industrial structure might account for only around 3% of Russia's total energy consumption level, see World Bank (2008: 30). On the other hand, the same source attributes around 77% of total energy consumption to the GDP level, and just under 20% to other factors. As the estimate in World Bank (2008: 30) is based on a composite cross-country comparison, the 'other factors' include Russia's deviation from the world average in terms of energy intensity of GDP that is not explained by geography, climate or industrial structure. The reasons for that deviation are widely recognised to be explained, at least in part, by persistently low domestic energy prices in the Russian Federation.

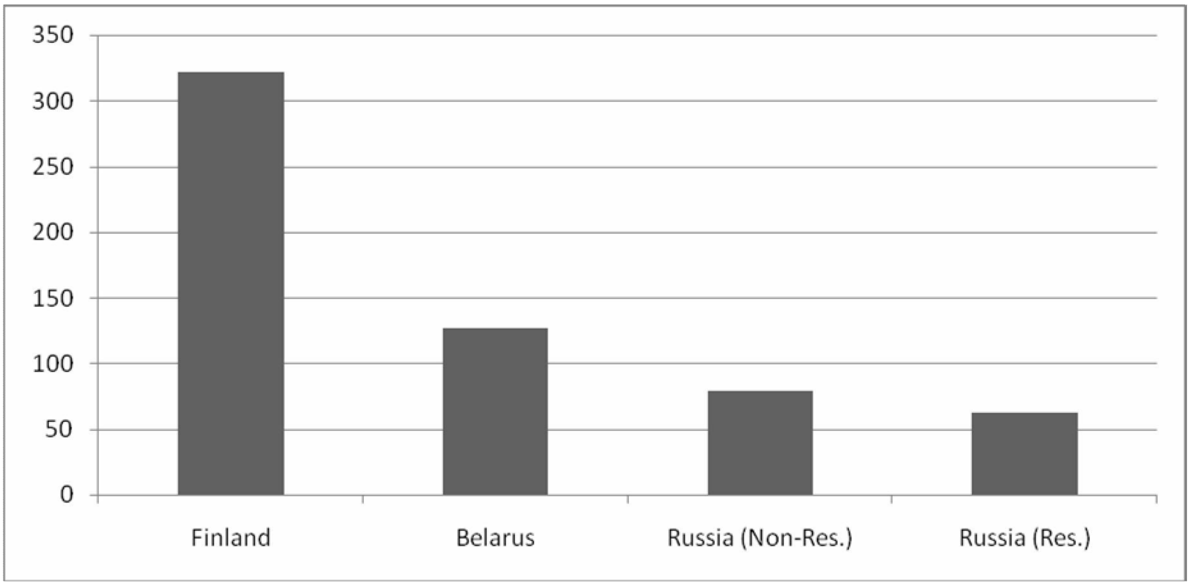
Looking only at natural gas prices, it is accurate to state that prices have been very low in international comparison for many years. Prices charged inside Russia differ for residential and non-residential customers as well as by region. Up to and including 2008, a system of 15 pricing zones, labelled 1 to 11, plus four additional zones labelled as 4a, 10a, P1 and P2, was in use. The unweighted arithmetic average across all zones is however not a bad indicator. It yields levels that are very close to those for zones 7 to 9 which account for a large share of Western Russia, including both

Moscow and St. Petersburg. In 2007 the average price, including VAT, was 1269 roubles per thousand cubic metre (RUR/mcm) for residential customers and 1623 RUR/mcm for non-residential customers. This was equivalent to 50 USD/mcm and 63 USD/mcm respectively. Prices rose in 2008, reaching 63 USD/mcm and 81 USD/mcm respectively[2]. Those price levels are of course still considerably lower than prices in European markets. The average import price paid by Finland (chosen as an example for Western Europe as it imports only Russian gas) was 322 USD/mcm, while even in the case of Belarus the import price was 127 USD/mcm, see Figure 4.

The idea of the Russian gas price reform is to bring prices closer to or at the netback price. The netback price is the average price on export markets minus all export-related costs. From the point of view of economic theory, this should make Gazprom exactly indifferent between selling an extra unit of gas at home or abroad. However the netback price fluctuates over time and its future value is uncertain: export prices are defined in export contracts based on a lagged function of a basket of petroleum products. Perhaps for this reason (or perhaps also out of administrative tradition) the Russian government chose to pre-define a transition phase with fixed nominal price increases over the period 2008-2011. In particular, plans announced by the Russian Ministry of Economic Development in 2007 foresaw nominal average increases of 25% in 2008, 25% in 2009, 30% in 2010 and 40% in 2011. What was to occur after 2011 was not precisely defined, but additional or final convergence to the netback price was thought possible.

[2] Prices rose, in nominal RUR terms, by 25% for both residential and non-residential customers in every pricing zone except P2 where the increases were 15% and 10% respectively. Zone P2 is very small, concerning only a part of the population of the Arkhangelsk region (itself not large) so that exception is ignored for the rest of this paper and the increase will be assumed to have been 25% for the whole country. All Russian gas price data for this section was taken from EEGas.

Figure 4. Average domestic and import prices for Russian natural gas in 2008 (USD/mcm)



Source: EEGas, UN COMTRADE, own calculations.

The economic crisis of 2008-2009 strongly impacted those plans. The average nominal increases in 2009 were 16.3% for residential customers and 16.1% for non-residential customers. For 2010 the Ministry of Energy announced on 18 December 2009 that the increase would be 15% for all customers. It was not fully clear at the time of writing (January 2010) what the increases will be in 2011 and beyond, and whether the slow-down in the price reform represents a temporary re-scheduling of the reform or a permanent lowering of the future target price. As a result of these uncertainties the projections which are made in this article are based on higher versus lower assumed price paths for the period 2011-2020.

3 Econometric modelling of final natural gas consumption in Central Europe

3.1 Residential consumption

The chosen empirical approach to modelling residential consumption of natural gas is based on Maddala et al. (1997) and Asche et al. (2008). The empirical model is shown in (1), where NGC represents total annual natural gas consumption of households in physical units, NGP denotes the real price of natural gas per physical unit, ELP denotes the real price of electricity per physical unit, FCH is real final consumption of households taken from national accounts, and HDD is heating degree days. All the variables are in logged form.

$$NGC_{i,t} = \alpha + \rho NGC_{i,t-1} + \beta_1 NGP_{i,t} + \beta_2 ELP_{i,t} + \beta_3 FCH_{i,t} + \beta_4 HDD_{i,t} \qquad (1)$$

The model is estimated on a panel data set of four Central European countries over the period 1990-2006, namely Poland, Slovakia, Hungary and the Czech Republic. NGC was taken from Eurostat and national sources. FCH was taken in nominal national currency terms from Eurostat and from WIIW databases. Energy prices were taken from the IEA Energy Prices and Taxes database. The price series used were the average annual prices in nominal national currency units per tonne of oil equivalent (toe), all taxes included. The series were deflated using the consumer price index. HDD data was taken from Eurostat.

Choosing the appropriate estimation procedure is not trivial. Asche et al. (2008) provide results for 12 European countries using both pooled and separate estimations, finding large country differences in the latter case. Maddala et al. (1997) reject both separate time series regressions (as too unstable) and pooled estimation (because the homogeneity hypothesis is rejected), and propose shrinkage estimators instead. In contrast, Baltagi et al. (2002) approach the issue from the viewpoint of out-of-sample forecast performance, and find that standard panel estimation methods such as pooled OLS, GLS and fixed effects perform well. Their findings on the poor performance of separate (fully heterogeneous) time series estimations are nevertheless in keeping with both Maddala et al. (1997) and Asche et al. (2008). The latter argue in favour of fixed effects if the goal is to assess the average response of a group of countries. Since this is also the goal in this article, and since out-of-sample projections are the ultimate application, fixed effects is the first choice. However the dynamic nature of the model would lead to biased parameter estimates due to correlation between the country effects and the error term. A solution to this problem was developed by Judson and Owen (1999) and extended by Bruno (2005) in the form of a corrected least squares dummy variable estimator (LSDVC). The latter is found to perform well on panel data sets with small N as discussed in Judson and Owen (1999) and Buddelmeyer et al. (2008).

Bruno's LSDVC estimator requires an initial estimate from standard dynamic panel estimators. Given that the series are highly persistent, and in keeping with Bruno (2005), the LSDVC estimator is initialised using the Blundell and Bond (1998) estimator. The estimation results are shown in Table 1. Bruno's LSDVC routine on Stata doesn't compute standard errors. However the standard LSDV estimates and the corresponding standard errors are shown for informational purposes. The estimation results are in line with comparable estimation efforts for other countries. A comparison with the results found by Asche et al. (2008), which covered 12 Western European countries[3] from 1978 to 2002, is provided in Table 2.

Table 1. Estimation results for residential consumption of natural gas

Estimation method	**LSDVC**	**LSDV**
Lagged nat. gas cons.	0.923	0.830 (0.049) (***)
Price of nat. gas	-0.220	-0.234 (0.053) (***)
Price of electricity	0.087	0.132 (0.070) (*)
Total consumption	0.108	0.152 (0.069) (* *)
Heating degree days	0.321	0.315 (0.148) (* *)

Note: Standard errors in parentheses; (*), (**), (***) denote significance at the 10%, 5% and 1% levels.

Table 2. Comparison with estimates for Western European countries

Region	**Central Europe**	**Western Europe**
Time period	***(1990-2006)***	***(1978-2002)***
Lagged nat. gas cons.	0.923	0.843
Price of nat. gas	-0.220	-0.242
Price of electricity	0.087	-0.010
Total consumption	0.108	0.329
Heating degree days	0.321	0.387

Source: own estimations for Central Europe, Asche et al. (2008) for Western Europe

[3] Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Spain, Switzerland, UK.

3.2 Industrial consumption

The empirical framework for modelling industrial consumption of natural gas is similar to what one finds for residential gas consumption. Huntington (2007) estimates a series of dynamic models using lagged natural gas demand, the price of natural gas, the prices of substitute energy products, and output and industrial activity indicators. He uses an indicator called ‘structural output’ which is an energy-intensity-weighted measure of industrial production, as well as capacity utilisation variables. Given data limitations however the current exercise is restricted to estimating the empirical model shown in (2).

$$NGC_{i,t} = \alpha + \rho NGC_{i,t-1} + \beta_1 NGP_{i,t} + \beta_2 ELP_{i,t} + \beta_3 COP_{i,t} + \beta_4 GVA_{i,t} + \beta_5 HDD_{i,t} \quad (2)$$

The model is estimated for Poland, Slovakia, Hungary and the Czech Republic over the period 1993-2006. The variable names are analogous to those used in (1), with the addition of COP, the real price of steam coal, and GVA which refers to real gross value added of the industry sector. Gas consumption data was taken from Eurostat. GVA was taken from Eurostat and from WIIW. Nominal energy prices as charged to industrial consumers (total price, all taxes included, in national currency units per tonne of oil equivalent) were taken from the IEA Energy Prices and Taxes database for natural gas, for electricity and for steam coal in the case of Poland. Complete steam coal price series are not available from the IEA for the other three countries, so estimated series were obtained from Cambridge Econometrics. Nominal price series were deflated using the producer price index of industry. HDD data was taken from Eurostat. The estimation results are shown in Table 3.

Table 3. Estimation results for industrial consumption of natural gas

Estimation method	**LSDVC**	**LSDV**	**Standard errors**
Lagged nat. gas cons.	0.762	0.641	0.116 (***)
Price of nat. gas	-0.203	-0.234	0.117 (*)
Price of electricity	-0.051	0.012	0.152 ( )
Price of steam coal	-0.007	-0.003	0.041 ( )
Gross value added	0.177	0.162	0.097 ( )
Heating degree days	0.337	0.337	0.187 (*)

Note: (*), (**), (***) denote significance at the 10%, 5% and 1% levels respectively.

The results are similar to those found for residential consumption, although initial significance levels are lower. The coefficient for lagged consumption is smaller than in the case of residential consumption, indicating faster adaptation to changes in current variable values. The results for the prices of electricity and of steam coal suggest that there are no significant inter-fuel substitution effects. The income effect is of higher magnitude than in the case of residential consumption, suggesting a stronger adaptation capability of industry as compared to the residential sector.

4 Forward simulation of Russia's final consumption of natural gas

4.1 Residential consumption

Equation (1) can be written in exponential form as shown in (3).

$$NGC_{i,t} = e^{\alpha} \cdot NGC^{\rho}{}_{i,t-1} \cdot NGP^{\beta 1}{}_{i,t} \cdot ELP^{\beta 2}{}_{i,t} \cdot FCH^{\beta 3}{}_{i,t} \cdot HDD^{\beta 4}{}_{i,t} \qquad (3)$$

It is however assumed that HDD remains constant over the projection period, i.e. that possible global warming effects will be negligible over the period. ELP is also dropped, given the low significance level that was found, see Table 1. Taking (3) as it holds for period t+1 and dividing that expression by (3) and then re-arranging terms yields the expression for future natural gas consumption (4).

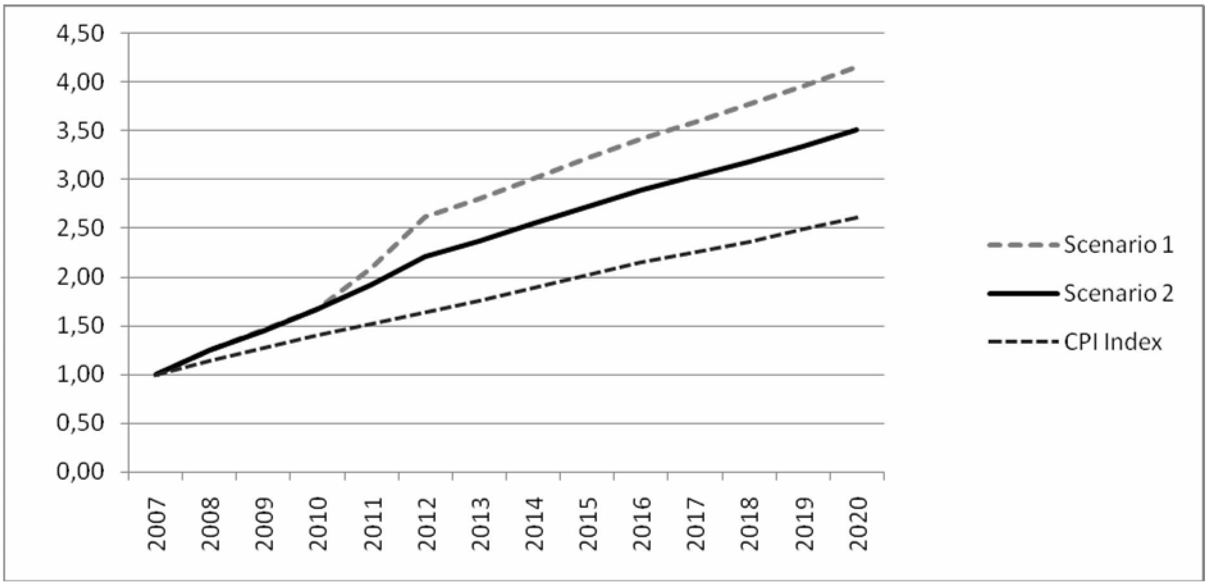
$$NGC_{i,t+1} = NGC_{i,t} \cdot \left(\frac{NGC_{i,t}}{NGC_{i,t-1}}\right)^{\rho} \cdot \left(\frac{NGP_{i,t+1}}{NGP_{i,t}}\right)^{\beta 1} \cdot \left(\frac{FCH_{i,t+1}}{FCH_{i,t}}\right)^{\beta 2} \qquad (4)$$

The use of (4) requires having consumption data (or estimates) for two consecutive years immediately prior to the projection period, and forecasts for the real price of natural gas and for real final consumption of households over the entire projection period. Residential consumption was 49.0 bcm in 2006 and 48.1 bcm in 2007. However this type of dynamic model is quite sensitive to the introduction of a trend at the beginning of the period. Since the difference between the 2006 and 2007 levels may not have any particular meaning for the longer term, the simulations are initialised using the average consumption level over the period 2005-2007 for the two initial periods.

The first price path is labelled Scenario 1 and assumes a relatively ambitious price reform. The second is labelled Scenario 2 and assumes a moderate price reform. Scenario 1 is based on nominal price growth rates for the years 2009-2012 of 16.3%, 15%, 25% and 25% respectively. For Scenario 2 the growth rates are 16.3%, 15%, 15% and 15%. Both scenarios then match consumer price inflation over the 2013-2020 period. The assumption for consumer price inflation is that it follows the forecasts from the IMF's World Economic Outlook, November 2009 edition, for the period 2009-2014.

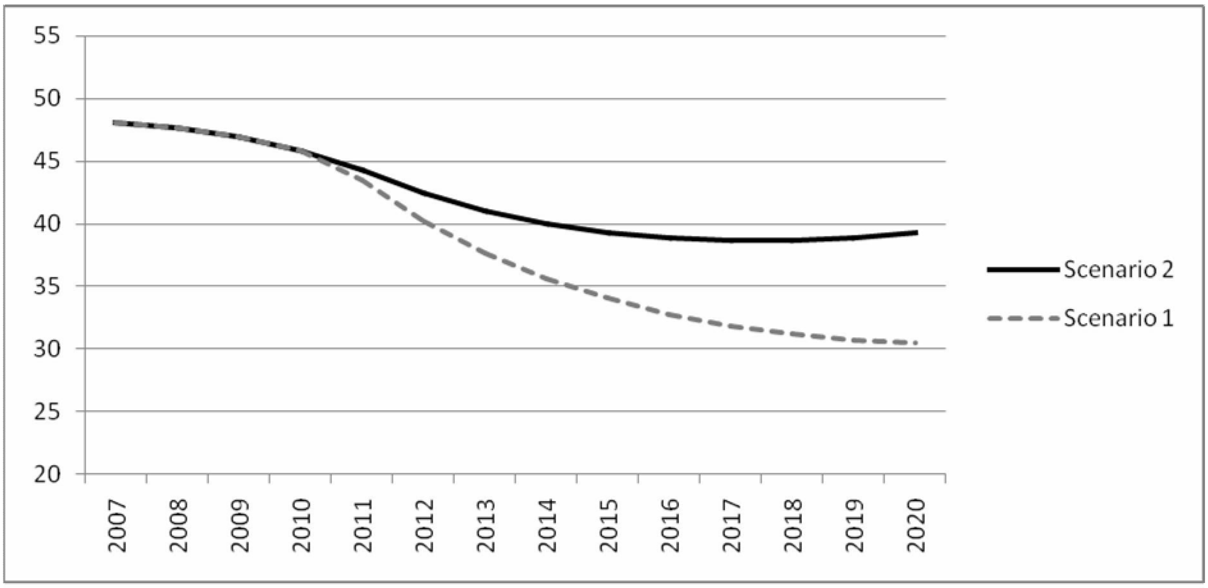
Thereafter a soft landing is assumed, with inflation stabilising at 5% towards the end of the period. As for real final consumption of households, the assumption is that it undergoes a significant slowdown in 2009 and an outright fall in 2010 (implicitly lagging both the oil price and GDP) before recovering and stabilising at 5% growth per year over 2014-2020. The scenarios are illustrated alongside the consumer price index in Figure 5.

Figure 5. Residential gas price index scenarios, 2008-2020 (Base 2007)



The resulting consumption projections are shown in Figure 6. Scenario 1 would lead to the stronger reduction in consumption, reaching 30.4 bcm in 2020 as compared to the starting level of 48.1 bcm, i.e. a fall of 17.6 bcm or 37%. Scenario 2 leads to a consumption level of 39.2 bcm in 2020, a fall of 8.8 bcm or 18%. With Scenario 2 the income effect would start to dominate the price effect starting from a trough of 38.6 bcm in 2017-2018. With Scenario 1 on the other hand this type of reversal would occur outside of the projection period. The complete assumption sets and results for each year are given in Annex B.

Figure 6. Residential gas consumption scenarios, 2008-2020, bcm



How does this range of 8.8 to 17.6 bcm compare to other possible approaches? In Section 2 we saw that, based on a simple regression of residential energy consumption on GDP and HDD, Russia was somewhat above the projected level. In particular, Russia's per capita energy consumption in the residential sector was 790 kgoe in 2007 as compared to a baseline level of 538 kgoe (see Annex A). Based on IEA Energy Balances, the share of natural gas in residential energy consumption was 34.6% in 2007. As a result, a per capita saving of 87 kgoe of natural gas seems feasible. Multiplying by Russia's population yields 12.4 Mtoe, or 15.3 bcm, which lies within the projected range.

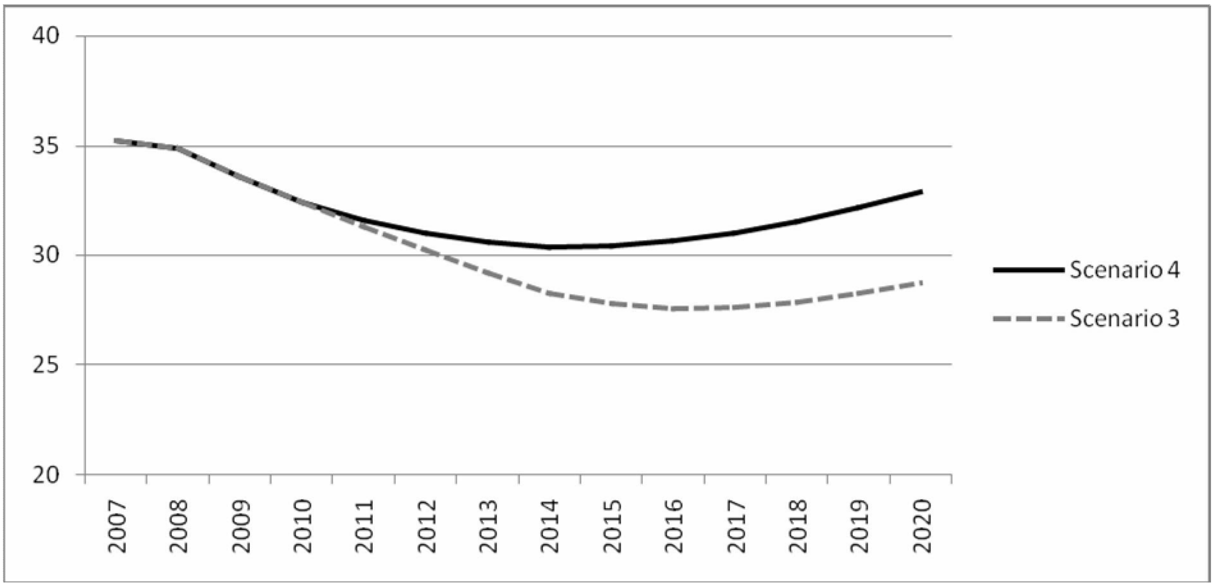
4.2 Industrial consumption

Industrial consumption of natural gas in the Russian Federation was around 32 bcm in 2007. That figure excludes mining and quarrying, so that industry in this sub-section refers to manufacturing and construction only. The framework for simulating industrial gas consumption is much the same as the one used for residential consumption. The initialisation of the simulation is carried out by assigning to the periods 2006 and 2007 the average industrial consumption for the period 2005-2007, namely 35.2 bcm.

The GVA variable is taken as an index of real GVA for manufacturing and construction together. The series was constructed for the years 2007-2008 based on data from Rosstat, complemented by preliminary estimates for 2009. For 2010-2012 industry

GVA is assumed to grow slightly more slowly than GDP and to then gradually converge to a growth rate of 4% per year. Prices and values are deflated using the same assumed consumer price inflation series as for the residential consumption scenarios. As for the nominal price paths, two scenarios are simulated: Scenario 3 and Scenario 4. Both scenarios take over the actual (national average) price increases that occurred in 2008 and 2009, namely 25% and 16.1%, both computed from EEGas data. For 2010 both scenarios follow the official announcement made by Russia's Federal Tariff Service on 18 December 2009 that the average increase would be 15% in 2010. In July 2009, Oil & Gas Eurasia (2009) reported the announced intention of the Ministry of Economic Development to raise gas prices for industry by 15% per year in 2011 and 2012. Similarly to the previous section, the choice is to focus on an ambitious scenario, namely Scenario 3, for which a 15% per year nominal average increase is assumed for the period 2011-2014. Scenario 4 in contrast is based on a 10% per year increase for 2011-2014. Both scenarios match consumer price inflation over 2015-2020. Heating degree days are assumed to be constant and equal to the initial level throughout the simulation period. In addition, no significant substitution effect is assumed to take place between natural gas and other energy sources. The results for the scenarios are shown in Figure 7. The projection results suggest relatively modest reductions of consumption, from 35.2 bcm to a range of 28.7 to 32.9 bcm in 2020, a decrease of 7% - 18%. Also, both scenarios suggest a recovery in gas demand growth before the end of the simulation period as the income effect starts to dominate over the price effect. The complete assumption sets and results for each year are given in Annex B.

Figure 7. Industrial gas consumption scenarios, 2008-2020, bcm



5 Power generation and other components of demand

This section contains estimates of potential savings for generation of electricity and heat and for transmission and distribution of natural gas. Estimates based on benchmarking exercises are provided and compared with recent estimates from the literature. The estimates are then analysed and set in relation with the price reform paths used in previous sections.

5.1 Shifts in the energy mix

According to Chubais (2007) Russia's fuel mix for electricity generation will undergo a relative shift in favour of coal up to 2015. Somewhat similar projections are presented in IEA (2009b), namely that the total volume of gas used in generation of electricity and heat could fall from 214 Mtoe in 2007 to 202 Mtoe in 2020. This is equivalent to 265 bcm for 2007 and to 250 bcm for 2020, i.e. a fall of 15 bcm. This shift can be interpreted as an additional demand component which should be taken into account for total consumption scenarios.

5.2 Generation of electricity and heat

In Section 2 we saw that thermal efficiency in generation of electricity and heat is somewhat lower in Russia than, e.g., the EU average for three out of four types of facilities. The easiest benchmarking exercise is therefore to assume that Russia would be able to replace existing facilities until it reaches the same average thermal efficiency as the EU for those three categories, i.e. autoproducer electricity plants, main activity CHP plants and autoproducer CHP plants. Autoproducer heat plants are assumed to reach the higher benchmark shown in Figure 2.3, i.e. the level found in the Netherlands which is 95%. Moreover it is assumed that final demand for gas-fired generated electricity and heat will grow in line with total final demand for electricity and heat as in the Reference Scenario in IEA (2009b). This assumption will be revisited in Section 6. Demand for gas-fired electricity would therefore grow from 41.8 Mtoe to 53.0 Mtoe, and demand for gas-fired heat would drop slightly from 97.4 Mtoe to 96.6 Mtoe, over the 2007-2020 period. The new amount of gas that is consistent with these assumptions can be determined using a standard linear optimisation approach. However doing so only with the assumptions above leads to the complete shut-down of both autoproducer electricity plants and autoproducer CHP plants owing to their lower efficiency levels. This prospect is not entirely realistic, as there may be some cases of autoproducer plants for which local circumstances would dictate a continuation of generation activities in spite of low efficiency and rising gas prices. A detailed assessment of this question would require an analysis of individual facilities and would be beyond the scope of the present article. However for simplicity it is assumed that half of the energy output currently produced by those facilities would still be produced in the same way in 2020, while the rest of the demand from autoproducers would be purchased from the market. The result of the linear optimisation as described is shown in Table 4. Potential savings amount to 42.9 bcm.

Table 4. Potential savings in gas-fired generation, ktoe

Variable / category	**Auto electricity**	**Main act. CHP**	**Auto CHP**	**Auto heat**	**Total**
Gas input	877	125,037	6,906	46,539	179,358
Electricity output	250	51,619	1,131	0	53,000
Heat output	0	48,517	3,901	44,212	96,630
Total output	250	100,136	5,031	44,212	149,630
New thermal efficiency	28.6%	80.1%	72.9%	95.0%	83.4%
Old thermal efficiency	22.9%	56.4%	59.9%	87.2%	65.1%
Input reduction	1,306	9,347	9,880	14,111	34,644
Input reduction (bcm)	**1.6**	**11.6**	**12.2**	**17.5**	**42.9**

World Bank (2008) contains bottom-up estimates based on work by CENEf, a Russian institute that specialises in energy efficiency analysis. CENEf distinguishes between energy savings that are viable technically, economically, or financially, see Table 5.

Table 5. CENEf categories of energy savings

CENEf categories	**Social return**	**Private returns**	**Output**	**Technology**
Technical	May be negative	May be negative	Upheld	Available
Economic	Positive	May be negative	Upheld	Available
Financial	Positive	Positive	Upheld	Available

The three categories differ in the treatment of who, notionally, would agree to cover the costs of the related investments. Technical savings is the maximum level of savings, regardless of economic or financial considerations, i.e. a solution that could cost the entire country (collectively) more than it gains from the change. Economic savings is the maximum level of savings which can be achieved without a negative social return, i.e. a solution which will typically require state intervention in order to occur. Financial savings, finally, is the maximum level of savings which can be achieved without any of the individual stakeholders experiencing a financial loss, i.e. without any negative private returns. Financial savings is therefore the best-case scenario in the absence of state intervention, while economic savings represents the best-case scenario if there is state intervention.

World Bank (2008) identifies savings for electricity and heat generation as shown in Table 6. The categories of electricity and heat generation are not directly comparable to IEA categories. There are some differences in the assumptions used between the assessment made earlier and the work presented in World Bank (2008). The latter base their calculations on demand levels of 2007, not for a particular future year under demand growth assumptions as above. Also, there is no simulation of possible shifts between types of generation. On the other hand, World Bank (2008) relies on a full bottom-up analysis of Russian plants. The total estimate for economic savings is however similar to the total estimate from Table 4, 45.4 bcm versus 42.9 bcm, suggesting that savings in that order of magnitude should be feasible economically.

Table 6. CENEf estimates of gas savings in electricity and heat generation

Generation type	**Economic savings**		**Financial savings**	
	Mtoe	bcm	Mtoe	bcm
Gas-fired boilers	5.1	6.3	0.6	0.7
CHP	13.7	17.0	3.1	3.8
Condensing plants	17.9	22.2	2.4	3.0
Total	**36.7**	**45.4**	**6.1**	**7.6**

Source: World Bank (2008)

The next question is the extent to which the ongoing energy price increases will raise the level of financial savings towards the level of economic savings. One way of looking at this is to compute the net present value (NPV) of the future gas savings, and then to compare that amount to possible capital investment costs to see if a notional investor would break even.

Table 7. NPV of gas savings in electricity and heat generation

Price path	**Discount rate**		
	5%	**7%**	**9%**
Scenario 3	78.0	64.0	53.5
Scenario 4	65.9	54.1	45.3

Units: USD billions at 2012 prices and exchange rates

The assumptions are as follows: a starting period of 2012; a financial time horizon of 25 years; a discount rate of 7% (with calculations made with rates of 5% and 9% as a sensitivity analysis); Scenario 3 or Scenario 4 for the evolution of gas prices to 2020; moderate price inflation of 2.5% per year over 2021-2037; and a RUR/USD exchange rate of 34.85 in 2012 (taken from the IMF World Economic Outlook database, November 2009 edition). Table 7 gives the corresponding NPV depending on which price scenario occurs and on what discount rate is chosen. Assuming capital costs of USD 800 per kW of new generation capacity at 2012 prices and exchange rates, Scenario 3 with a discount rate of 7% would allow for the commissioning of 80 GW of generation capacity (67.6 GW with Scenario 4). Russia's total installed gas-fired capacity was 97 GW in 2007 and it is reasonable to assume that the least efficient plants would be replaced first while some existing plants already have comparatively high thermal efficiency rates. For simplicity it is further assumed that the full economic savings can be achieved by replacing 85 GW of installed capacity, and that a correspondingly lower share of savings is achieved in proportion to that level. In other terms, Scenario 3 would enable 94.1% of the savings reported as economic in Table 6, while Scenario 4 would lead to 79.6% of the savings being made. This corresponds to 42.7 bcm and 36.1 bcm respectively.

5.3 Transmission and distribution of natural gas

Energy efficiency in natural gas transportation and distribution can also be improved, and a number of estimates exist. Among the most optimistic estimates, World Bank (2008: 62) suggest that up to 15 bcm could be saved annually (technical savings), while citing an estimate from Gazprom of 10 bcm annually (also technical savings). Since technical savings constitute the highest achievable level, a conservative (though admittedly debatable) range of possible reductions is preferred, namely 50% of the Gazprom estimate as a 'pessimistic' case, and 90% of the Gazprom estimate as an 'optimistic' case. This corresponds to a range of 4 bcm to 9 bcm, which is assumed to be fully achieved by 2020.

6 Total consumption scenarios and sensitivity analysis

The results so far are grouped under total savings scenarios that are labelled Low Scenario and High Scenario as shown in Table 8. The Low Scenario groups the findings for Scenario 2 and Scenario 4. The High Scenario groups the findings for Scenario 1 and Scenario 3. In addition the overall shift in the power generation mix described in Section 5.1 is assumed to hold identically for both the low and the high scenarios. For generation of electricity and heat the estimates from Section 5.2 are taken as indicated in the text. Finally, the low and high estimates assumed in Section 5.3 for transmission and distribution of natural gas are allocated to the Low and High scenarios respectively. The overall results are summarised in Table 8. Total potential savings by 2020 are large: in a range of 66.2 to 90.8 bcm, due to the effect of gas price increases only.

Table 8. Estimated direct gas savings in 2020 compared to 2007, bcm per year

	Low Scenario	**High Scenario**
Residential consumption	8.8	17.6
Industrial consumption	2.3	6.5
Input mix in generation	15.0	15.0
Efficiency in generation	36.1	42.7
Transmission and distribution	4.0	9.0
Total	**66.2**	**90.8**

The results presented in Table 8 concern only direct effects on gas demand that are due to increases in gas prices. It is assumed, in that context, that savings in transmission and distribution of natural gas would occur as Gazprom would find it in its interest to invest the necessary capital and labour costs to replace equipments in order to reduce losses. It is also assumed for simplicity that the relatively moderate shift in the generation mix, taken directly from IEA (2009b), is consistent with the price changes. One important element which was however not modelled so far concerns possible reductions in demand for electricity and heat as compared to the baseline used in Section 5.2 which is based on the Reference Scenario from IEA (2009b). Consumption of heat, e.g. municipal and district heating, is relatively high in Russia and it seems plausible that final consumption could fall quite strongly if households, businesses and municipal administrations carried out a number of energy-saving measures which would be encouraged by higher prices for heat, e.g. systematic metering. As for electricity, IEA (2009b) projects strong growth in demand for electricity as the Russian economy resumes a comparatively strong growth path in the medium-term. While the income effect should indeed go in that direction, electricity prices are also being increased in parallel with gas prices and this should moderate the effect if a relatively strong price path is chosen. The latter would incentivise a range of measures to reduce total use and would also raise the incentive for investments towards reducing network losses.

Without conducting a full analysis of the demand for electricity and heat, it is possible to use the framework developed in Section 5.2 and apply it to a lower demand profile. This is done both in order to take into consideration the indirect effect on natural gas consumption of different final demand levels on the generation sector, as well as in order to provide a sensitivity analysis for the results of Section 5.2. The following additional scenarios are formulated. The baseline used in Section 5.2 foresees growth of 26.7% for electricity demand and of -0.8% for heat demand. A moderate savings scenario is defined with growth over the period 15 percentage points below the baseline, and a high savings scenario is defined with growth over the period 30 percentage points below the baseline. The results in terms of reduction in natural gas use in the generation sector are shown in Table 9.

Table 9. Savings from lower demand for electricity and heat with high efficiency

	Baseline growth	**Moderate Savings**	**High Savings**
Electricity	26.7%	11.7%	-3.3%
Heat	-0.8%	-15.8%	-30.8%
Gas savings (bcm)	42.9	73.1	103.3

Given that some price increases are also occurring with respect to electricity and heat, it would be surprising if the baseline growth case were to occur, though as with previous scenarios much will hinge on the commitment to price increases for the medium-term. What the results also illustrate is the sheer scale of Russia’s gas-fired generation sector, and how different demand profiles (admittedly strongly divergent ones) can lead to large falls in natural gas use. Of course, the scenarios in Table 9 assume that full convergence to the higher average thermal efficiency levels will have been completed by 2020, which is a strong assumption. Levels of investment in the sector would have to rise very fast and this could pose a number of practical challenges and generate additional costs. A complete assessment of the likelihood (and likely timing) of such a large shift in the generation sector would require scenario-building based on a bottom-up analysis of the generation sector and a detailed rendering of financing options and constraints. Such an analysis would be beyond the scope of this paper and is also not undertaken in World Bank (2008). The issue would however merit close attention. For the purposes of this paper, one final estimation which can make sense is to assume that only a share of the thermal efficiency improvements is achieved. This could be explained due to a piling up of delays and cost overruns for the commissioning of new generation capacity as well as due to costs of decommissioning existing facilities (an issue not taken into account in Section 5.2). Other structural economic barriers could also explain some of the difficulties. The problematic levels of corruption and bribery that prevail in the Russian Federation would likely become a cost factor as well. In addition, a rapid boost in tendering for generation facilities could have strong inflationary effects at the sector level, also leading to higher commissioning and decommissioning costs and/or to rescheduling of certain investments in order to reduce costs. Re-estimations of the simulations shown earlier are therefore made, assuming that Russia manages to close 60% of the gap in thermal efficiency as compared to the benchmark used in Section 5.2 by 2020. While this is inevitably a judgment call, it seems reasonable to believe that the new central value of 52.5 bcm is eminently achievable by 2020, provided electricity and heat prices rise quite strongly, and provided that relatively strong and rapid investment occurs in the generation sector. That value may therefore be taken as a prudent estimate for savings from the generation sector achievable by 2020.

Table 10. Savings from lower demand for electricity and heat with moderate efficiency

	Baseline growth	Moderate Savings	High Savings
Electricity	26.7%	11.7%	-3.3%
Heat	-0.8%	-15.8%	-30.8%
Gas savings (bcm)	19.4	52.5	85.6

To conclude, while the results from Table 10 do not rely on explicit price scenarios, the assumptions concerning both demand for electricity and heat and concerning improvements in thermal efficiency seem more persuasive than those made initially. It is therefore chosen to use the results from Table 10 for the generation sector, while keeping on board the other simulation results that were summarised in Table 8. These combined results are shown in Table 11. They represent estimates of total (direct and indirect) reductions in consumption of natural gas for the Russian Federation for the year 2020 as compared to the 2007 level. The resulting level of consumption is also indicated. As a final note, the estimates for direct gas savings, i.e. those that are estimates as a consequence of only the gas price increases, may be amended according to the results from Table 10, namely by replacing the range of estimates for the generation sector by a point estimate of 19.4 bcm. This yields a range of 49.5 to 67.5 bcm per year by 2020 for the two groups of price scenarios and may be seen as a more cautious estimate for direct savings.

Table 11. Estimated total gas savings in 2020 compared to 2007, bcm per year

	Lower Bound	**Upper Bound**
Residential consumption	8.8	17.6
Industrial consumption	2.3	6.5
Input mix in generation	15.0	15.0
Generation efficiency and demand	52.5	85.6
Transmission and distribution	4.0	9.0
Total savings	**82.6**	**133.7**
Consumption in 2020	379.4	328.3

7 Conclusions

Taking all the results together, it is found that an economically feasible and relatively plausible range for savings in Russian gas consumption could be in the order of 82.6 to 133.7 bcm per year by 2020 as compared to the 2007 level, i.e. Russia's total gas consumption could be in a range of 328 to 379 bcm per year by 2020 as compared to 462 bcm in 2007. These estimates account for savings in residential and industrial consumption, as well as in power generation and in transmission and distribution of natural gas. However the estimates exclude the issue of flaring of associated petroleum gas.

As a comparison, Russia's net exports of natural gas were around 195 bcm in 2008, so the potential savings are in a range of 42% to 69% of 2008 export volumes. In value terms, the potential savings would represent a gross market value on Russia's European export markets of roughly 25 to 40 billion US dollars per year assuming a price of 300 USD/mcm. Such savings would contribute very favourably to Russia's overall natural gas balance and to its net export potential, provided developments in production are reasonably favourable.

The strongest channel through which gas consumption is reduced is in gas-fired generation of electricity and heat, through a combination of possible reductions of demand for electricity and heat and of thermal efficiency improvements in the generation sector. Under some strong assumptions, total savings as compared to the 2007 level could even exceed 100 bcm per year for the generation sector alone. However this would require strong reductions in demand for electricity and heat as compared to baseline projections, as well as rapid and large-scale commissioning (and corresponding decommissioning) in Russia's generation sector, effectively replacing a very large share of the existing gas-fired capacity in a time-frame of less than a decade. In a more moderate scenario it is assumed that Russia could close 60% of the gap between its current average thermal efficiency in gas-fired generation and a benchmark of European countries. As a result of that assumption, and assuming smaller (but still plausible) demand reductions for electricity and heat by 2020, a relatively prudent estimate for the generation sector would still amount to 52.5 bcm per year by 2020.

The main estimates found are thought to be feasible and within reach provided a number of important assumptions are met. Much will depend on upholding the commitment towards higher energy prices over the medium-run. In addition, the speed, extent and financial constraints of large-scale investment in the generation sector should be carefully analysed as well. A related policy recommendation would be to offer more clarity (and more certainty) concerning future prices. From that point of view it is not necessarily desirable to track the netback price given that it generates its own uncertain profile due to oil price and dollar exchange rate fluctuations, thus making energy-saving investments more risky and therefore less likely to occur.

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Annex A – Regression results for Figure 2 (Section 2)

The HDD data from Baumert and Selman (2003) is based on daily temperature records by weather station covering the period 1977-1991. The data is weighted according to the population distribution within each country, thus yielding national average HDD. The implicit assumption made for this article is that those levels have not changed substantially since the measurement period, and/or that the changes are systematic across the sample used. The full sample is shown in Table A.1. It covers 38 of the 40 countries with the highest HDD levels according to Baumert and Selman (2003). North Korea was excluded due to lack of data for other variables, while Iceland was excluded as an outlier after a first estimation. However the inclusion of Iceland also leads to Russia being above the regression line. GDP per capita at PPP and population figures were taken from the IMF Economic Outlook database. Final consumption of energy of the residential sector was taken from IEA Energy Balances. All the data except HDD are for 2007.

The regression is a standard OLS regression of residential energy consumption per capita ('Actual' in Table A.1) on GDP and HDD. The variables were taken in levels, not in logs. The regression results are summarised in Table A.2. The resulting in-sample projections are shown ('Proj.') in Table A.1.

Table A.1. HDD and actual and projected residential energy consumption for 2007

Country	HDD	GDP	Actual	Proj.	Country	HDD	GDP	Actual	Proj.
Mongolia	6,681	3,238	221	492	Moldova	3,317	2,719	215	220
Russia	5,235	14,766	790	538	Slovenia	3,290	27,957	521	568
Finland	5,212	35,277	952	821	Armenia	3,282	5,324	54	253
Estonia	4,605	20,886	716	574	Germany	3,252	34,326	697	653
Kazakhstan	4,575	10,859	174	432	Kyrgyzstan	3,161	2,010	46	198
Norway	4,535	52,229	822	1,003	Romania	3,157	11,479	348	329
Canada	4,493	38,561	979	810	Hungary	3,057	18,989	551	425
Sweden	4,375	36,733	736	775	Netherlands	3,035	39,138	556	703
Belarus	4,299	10,937	616	411	Belgium	3,009	35,434	760	650
Latvia	4,237	17,472	639	497	Ireland	2,977	43,334	670	757
Lithuania	4,218	17,943	399	502	Bosnia	2,949	7,095	148	252
Ukraine	3,752	7,002	498	314	Serbia	2,813	10,039	438	282
Poland	3,719	16,371	478	441	UK	2,810	35,512	665	635
Denmark	3,621	37,163	810	722	Macedonia	2,647	8,578	228	248
Czech Rep.	3,569	24,182	566	538	Bulgaria	2,624	11,603	276	289
Slovakia	3,498	20,355	385	479	South Korea	2,480	26,576	380	485
Luxembourg	3,467	81,222	1,208	1,321	France	2,478	33,563	670	582
Austria	3,446	38,332	747	724	Bolivia	2,399	4,091	81	167
Switzerland	3,419	41,618	776	768	Croatia	2,289	17,768	387	348

Table A.2. Regression results

Variable	Coef.	Std. err.	t-stat
Intercept	-79.2313	93.7008	-0.85
HDD	0.0788	0.0239	3.30
GDP	0.0139	0.0013	10.55
R-squared	0.7765		

Annex B – Detailed assumptions and results for Sections 4.1 and 4.2

Table B.1. Assumption sets for residential consumption

	Nominal price index assumptions		Economic assumptions	
Year	**Scenario 1**	**Scenario 2**	**CPI (%)**	**Real income (%)**
2007	1.00	1.00	9.01	13.90
2008	1.25	1.25	14.11	10.70
2009	1.45	1.45	12.27	2.00
2010	1.67	1.67	9.90	-3.00
2011	2.09	1.92	8.45	3.00
2012	2.61	2.21	7.73	4.00
2013	2.80	2.37	7.23	4.50
2014	3.01	2.55	7.48	5.00
2015	3.22	2.73	7.00	5.00
2016	3.41	2.89	6.00	5.00
2017	3.59	3.03	5.00	5.00
2018	3.76	3.19	5.00	5.00
2019	3.95	3.35	5.00	5.00
2020	4.15	3.51	5.00	5.00

Table B.2. Scenario projections for residential consumption (bcm)

Year	Scenario 1	Scenario 2
2007	48.1	48.1
2008	47.6	47.6
2009	47.0	47.0
2010	45.8	45.8
2011	43.4	44.2
2012	40.2	42.4
2013	37.7	41.1
2014	35.6	40.0
2015	34.0	39.3
2016	32.8	38.8
2017	31.8	38.6
2018	31.1	38.6
2019	30.7	38.8
2020	30.4	39.2
Change 2007-2020 (%)	*-37%*	*-18%*
Change 2007-2020 (bcm)	*-17.6*	*-8.8*

Table B.3. Assumption sets for industrial consumption

	Nominal price index assumptions		Economic assumptions	
Year	**Scenario 3**	**Scenario 4**	**CPI (%)**	**Real GVA (%)**
2007	1.00	1.00	9.01	9.85
2008	1.25	1.25	14.11	5.07
2009	1.45	1.45	12.27	-12.00
2010	1.67	1.67	9.90	1.00
2011	1.92	1.84	8.45	2.00
2012	2.21	2.02	7.73	3.00
2013	2.54	2.22	7.23	4.00
2014	2.92	2.44	7.48	4.00
2015	3.12	2.61	7.00	4.00
2016	3.31	2.77	6.00	4.00
2017	3.48	2.91	5.00	4.00
2018	3.65	3.06	5.00	4.00
2019	3.83	3.21	5.00	4.00
2020	4.02	3.37	5.00	4.00

Table B.4. Scenario projections for industrial consumption (bcm)

Year	Scenario 3	Scenario 4
2007	35.2	35.2
2008	34.9	34.9
2009	33.6	33.6
2010	32.4	32.4
2011	31.3	31.6
2012	30.2	31.0
2013	29.2	30.6
2014	28.3	30.4
2015	27.8	30.4
2016	27.6	30.6
2017	27.6	31.0
2018	27.9	31.6
2019	28.2	32.2
2020	28.7	32.9
Change 2007-2020 (%)	*-18%*	*-7%*
Change 2007-2020 (bcm)	*-6.5*	*-2.3*

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