Elusive Potential: Natural Gas Consumption in the CIS and the Quest for Efficiency

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Preface

Most publications on CIS gas focus on supply and trade issues. But with consumption greater than any geographical region other than North America, CIS gas demand is an important and much neglected research issue. A major reason for this lack of attention is the statistical difficulty confronting researchers of this subject. Lack of public domain data, and major differences between published sources (Russian and western), possibly relating to definitions and/or measurement, means that discovery and selection of historical data is a large part of the research task. Accordingly, much of this paper is focussed on trying to establish a statistical basis from which analysis can proceed, along with identification of gaps in data, disagreements between different sources and the extent to which reconciliation is possible.

Given the fact that when the Soviet Union broke up it was one of the least energy efficient economies on the planet, for the two post-Soviet decades the generalisation that conservation and efficiency measures should yield huge energy and gas savings has been uncontroversial. The problem is that the actual results have been modest both in absolute terms and certainly in relation to theoretical potential. Simon Pirani's study investigates the reasons for this relative failure and what may need to happen to produce greater success in future.

This is the most recent paper on CIS gas issues from the OIES Gas Research Programme following Simon Pirani's edited book covering the entire region, Simon's subsequent paper on the impact of economic recession and financial crisis, and papers on various gas contract and crises between Russia and western CIS countries. It is the first piece of research to focus on the detail of gas demand, a hugely important part of the complex matrix of CIS gas issues which forms an important part of the global gas picture.

Jonathan Stern
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Simon Pirani.

Abbreviations and acronyms

APBE	Association for Forecasting Energy Balances (Russia) (*Agentstvo po prognozirovaniiu balansov v elektroenergetike*)
APG	Associated petroleum gas
bcm	billion cubic metres
CCGT	combined-cycle gas turbines
CDM	Clean Development Mechanism
CHP	Combined heat and power
ERU	emissions reduction units
g/kwh	grammes (of fuel) per kilowatt hour (of electricity)
Gcal	Gigacalories (of heat energy)
GW	Gigawatts (of electricity)
IEA	International Energy Agency
kg/Gcal	kilogrammes (of fuel) per Gigacalorie
kwh	Kilowatt hour
LPG	Liquefied petroleum gas
mcm	thousands of cubic metres
mmcm	millions of cubic metres
mtoe	millions of tonnes of oil equivalent
musf	millions of units of standard fuel
MW	Megawatts (of electricity)
OGKs	Wholesale generating companies
RAB	Regulated asset base
TGKs	Territorial generating companies
toe	tonnes of oil equivalent
TPES	Total primary energy supply
UES	United Energy Systems
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
usf	units of standard fuel
ZhEK	housing deployment bureau (*zhilishno-ekspluatatsionnaia kontora*)

1. Introduction and overview

This study aims to provide an overview of natural gas consumption in Russia and the Commonwealth of Independent States (CIS), and to determine the factors that will shape demand over the next decade. It surveys the economic sectors that account for gas consumption, and discusses the current and future impact of factors such as energy policies, including energy saving measures; the expansion and upgrading of power and district heating systems; and the move away from regulated pricing towards price-setting by markets.[1]

The former Soviet Union, which accounts for just under one quarter of global gas production and just under one third of proved reserves,[2] is usually first thought of as a producing region. But it also accounts for just under one fifth of world gas consumption, despite having less than one twentieth of the world's population. The share of gas in the energy balance of the former Soviet countries is substantially higher than in other parts of the world – in the view of many of their governments, unreasonably high. Moreover, the gas is consumed inefficiently: energy use is more than twice as inefficient as the international average by one common measure.[3]

Discussion of the gas supply-demand balance often focuses on Russian supply and European demand. This approach ignores other crucial elements, including Russia's own demand – which accounts for more than twice the volume of gas that it exports to Europe – and demand from its CIS neighbours. The OIES Natural Gas Research Programme has frequently presented the "Russian gas matrix" as follows:[4]

[1] The study was conducted for the Natural Gas Research Programme at the Oxford Institute for Energy Studies. Previous relevant publications on the dynamics of production, consumption and trade of gas by former Soviet countries include Jonathan Stern, *The Future of Russian Gas and Gazprom* (London, Oxford University Press, 2005); Simon Pirani (ed.), *Russian and CIS Gas Markets and Their Impact on Europe* (London, Oxford University Press, 2009); and James Henderson, *Non-Gazprom Gas Producers in Russia* (London, Oxford University Press, 2011).

[2] In 2010, 23.7% of production and 31.3% of reserves. BP *Statistical Review of World Energy*, June 2011.

[3] The common measure is total primary energy supply (in tonnes of oil equivalent (toe)) per unit of Gross Domestic Product (GDP) (at purchasing power parity) (per $2000), which in the former Soviet Union is 0.4, compared to a world average of 0.19, and levels of 0.14 in Europe and 0.19 in China). Energy consumption in the CIS region is more inefficient than in most other countries by any measure. For example, TPES per unit of GDP (not adjusted for PPP), is 1.59 in the former Soviet Union, compared to 0.30 (world average), 0.18 (EU) and 0.75 (China). IEA web site, Selected 2008 Indicators.

[4] See also: Jonathan Stern, *Future Gas Production in Russia: is concern about lack of investment justified?* (OIES, Oxford, 2009), p. 4.

Table 1: The Russian Gas Matrix

2009 actuals, 2010 estimates in brackets	
Supply	**Demand**
Gazprom production 462 bcm (508 bcm)	Russian demand 430 bcm (495 bcm)
Non-Gazprom production 120 bcm (142 bcm)	Russian exports to the CIS 63 bcm (60 bcm)
Central Asian imports 36 bcm (33 bcm)	Russian exports to Europe 140 bcm (140 bcm)

Source: Russian ministry of energy, Gazprom, OIES estimates

The table presents only the major building-blocks of supply and demand. It excludes, for example, gas consumed in the Russian Far East, gas exported from Sakhalin to Pacific countries and storage inflows and outflows. Nevertheless, it highlights the interconnectedness of the three major sources of supply and the three major sources of demand. It underlines that the availability of Russian gas for Europe, for example, needs to be considered not only in the light of production by Gazprom, Russia's dominant producer; non-Gazprom production; and central Asian imports to Russia – but also in the light of Russian and CIS demand that makes a call on these same three sources of supply.

This study will argue that Russian and CIS demand is more likely in the coming years to grow slowly, or even remain flat, than it is to grow rapidly. The implication is that the volumes required from Gazprom and other producers for Russian and CIS markets would be smaller than is usually presumed, freeing up additional gas for export. Or, put another way, the timing of development of new producing fields needed to supply both domestic and export markets – including the Yamal peninsula project, the largest Russian gas development – may be adjusted to allow for more gentle demand growth than has been projected. There are significant implications for investment – even more so if lower-than-expected demand in Russia and the CIS is combined with lower-than-expected demand for Russian gas in Europe.

The sheer scale of Russian and CIS demand, and of the potential for demand reduction through energy saving, is a central theme of the paper. The IEA has recently stated: "A concerted effort to realise this [energy saving] potential [in the former USSR and eastern Europe] would have major implications for the global gas balance."[5] Each 1% of CIS consumption that can be saved, e.g. by energy saving, amounts to 6-7 bcm/year of incremental supply (since the region's consumption runs at around 650 bcm/year). Price increases and market liberalisation will not only re-shape domestic demand, but will also give rise to changed conditions for non-CIS energy companies to work in CIS markets. For all these reasons, Russian and CIS demand is very much an international gas industry concern, rather than a local one. While the potential for energy saving and consequent gas demand

[5] IEA, *Special Report: Are We Entering a Golden Age of Gas?* (IEA, Paris, June 2011).

reduction has been emphasised in a wealth of commentary, less has been said about progress so far and the reasons that it has been so slow. This paper aims both to present a general survey of gas consumption, and also to identify as far as possible the reasons why energy efficiency gains have been slow in coming, i.e. why the potential is elusive.

This introduction provides an overview of Russian and CIS demand. It then considers the sources of gas supply in the region; the place of gas in the energy balance; changes in consumption trends since 1998; future demand trends, and the effect of energy policies, pricing and market reform; and the situation with gas consumption statistics. The paper then covers gas consumption in, respectively, the power and heat sector (Section 2); industry (Section 3); households (Section 4); and production, transportation and distribution (Section 5). Section 6 suggests subjects for further research. Section 7 discusses factors impacting demand outlook and presents some conclusions.

In each Section, considerable space has been devoted to discussing the statistical data. Good data is scarce, and the lack of it means that only Russia and Ukraine have been covered in any sense comprehensively. Often, available sets of data appear to contradict each other. Although the discussion of data makes the paper hard to read in places, it is necessary to include it: this issue has to be tackled head-on before serious research on this subject can progress.

1.a. Overview

The study covers the 11 CIS states (Russia, Ukraine, Belarus, Moldova, Azerbaijan, Armenia, Kazakhstan, Turkmenistan, Uzbekistan, Tajikistan and Kyrgyzstan) and Georgia, which left the CIS in mid 2009 – in other words, all the former Soviet countries except the three Baltic states (Latvia, Lithuania and Estonia) that are members of the European Union. This geographical area has been chosen because, despite the way that the former Soviet states have moved away from each other politically, culturally and economically over the last 20 years, the links and the similarities between their economies remain strong. In the case of the natural gas sector, all the countries covered in the study remain closely bound together not only by their common origins in the Soviet Union, but also physically, by a transport network that remains integrated to a large extent. (The 12 states covered will sometimes be referred to collectively as the CIS region.) A summary of gas consumption in the region in 2008, the year for which the most recent information for all countries is available, is given in Table 2.

Table 2 is abbreviated from statistics compiled by the International Energy Agency (IEA), on the basis of information from national statistics agencies or ministries, which are the most detailed available. (Conversion factors used are explained in Appendix 1. An unabbreviated version of the table is presented in Appendix 2, Table 39.)

Table 2: Summary of Gas Consumption in the CIS, 2008

TABLE 2. SUMMARY OF GAS CONSUMPTION IN THE CIS, 2008

Bcm	Total	Russia	Ukraine	Belarus	Moldova	Armenia	Azerbaijan	Georgia	Kazakhstan	Turkmenist	Uzbekistan	Kyrgyzstan	Tajikistan
DOMESTIC SUPPLY	**662.961**	**453.435**	**66.771**	**21.311**	**2.385**	**2.222**	**10.954**	**1.317**	**32.832**	**16.933**	**53.514**	**0.745**	**0.543**
Transfers & statistical differences	-1.898	0.003	0.042	0	0	0	0	0	-1.938	0	0	0	0
TRANSFORMATION, including	**339.797**	**264.556**	**26.389**	**15.503**	**1.31**	**0.547**	**5.753**	**0.379**	**2.56**	**7.163**	**14.95**	**0.41**	**0.275**
Electricity plants	16.181	2.574	1.546	4.869	0.789						6.403		
CHP plants	209.032	188.166	6.653	7.279	0.387						6.546		
Heat plants	95.531	71.893	18.147	3.354	0.134						2.001		
Heat & power, unspecified	17.088					0.547	5.753	0.379	2.56	7.163		0.41	0.275
Other transformation	1.966	1.923	0.043	0	0	0	0	0	0	0	0	0	0
ENERGY IND. OWN USE	**28.334**	**16.48**	**1.409**	**0**	**0.36**	**0**	**0.506**	**0.099**	**5.618**	**1.683**	**2.18**	**0**	**0**
DISTRIBUTION LOSSES	**11.68**	**6.538**	**1.048**	**0.154**	**0.075**	**0**	**0.736**	0.099	**0.985**	**0**	**2.045**	**0**	**0**
PIPELINE TRANSPORT	**49.466**	**43.669**	**3.528**	**0.54**	**0.008**	n/a	**0**	0	**0**	**0**	**1.706**	**0**	**0**
INDUSTRY, including	**100.695**	**66.716**	**17.024**	**3.535**	**0.241**	**1.037**	**0.701**	0.218	**0.93**	**0**	**8.123**	**0**	**0**
Iron & steel	21.789	16.243	5.374	0.127	0		0.006	0.039			0		
Non-metallic minerals (incl. cement)	17.673	13.462	2.808	1.231	0		0.139	0.033			0		
Chemical & petrochemical	3.577	2.13	0.672	0.489	0		0.223	0.062			0		
Chemical feedstocks	36.5	29.408	5.705	1.387	0		n/a	0			2.17		
Other industry	21.156	5.473	2.465	0.301	0.241		0.333	0.083			5.953		
RESIDENTIAL	**89.343**	**49.408**	**16.483**	**1.443**	**0.274**	**0**	**3.114**	**0.234**	**0**	**0**	**18.387**	**0**	**0**
COMMERC. & PUB. SERVICES	**9.441**	**4.852**	**0.65**	**0.044**	**0.101**	**0**	**0.051**	**0.066**	**0**	**0**	**3.678**	**0**	**0**
OTHER/ NON-SPECIFIED	**32.323**	**1.213**	**0.284**	**0.092**	**0.016**	**0.638**	**0.093**	**0.222**	**20.8**	**8.087**	**0.275**	**0.335**	**0.268**

Note. The row "Other transformation" includes consumption defined by the IEA as "Other transformation" and "Liquefaction". The row "Chemical industry feedstocks" is presented as an industrial sub-sector rather than as "non-energy use" as the IEA does. The row "Other industry" includes ten industrial sub-sectors defined by the IEA (see Appendix 2). The row "Other/non-specified" includes gas consumed in road transport and other/unspecified transport uses, agriculture/forestry and other unspecified uses, and non-energy use outside industry, which is negligible. Most of the volumes in this row comprise consumption in Kazakhstan and Turkmenistan denoted by the IEA as "Other" but likely to include consumption in pipeline transport and the residential, commercial and public services and industrial sectors.

Table 2 should be read as follows. The first row, "Domestic Supply", is the total of natural gas consumed; the second row notes transfers and statistical differences. The remaining rows present a breakdown of consumption in each of the 12 countries in the region, into eight categories presented in bold type: (i) transformation (more than 99% of which is for the heat and power sector); (ii) energy industry own use (mainly natural gas consumed by upstream oil and gas operations); (iii) distribution losses; (iv) pipeline transport; (v) industry; (vi) residential consumption; (vii) commercial and public services; and (viii) other/non-specified. Further breakdowns are provided, in a lighter typeface, of the transformation and industry sectors. In the transformation sector, a breakdown by different types of heat and power plants is available for only five countries, but fortunately these include the three largest consumers.

The other eight countries report to the IEA a single statistic for electricity and CHP plants, and give no other breakdown of transformation sector consumption; in these cases a figure is given for “heat & power, unspecified” and the rows for electricity plants, CHP plants and heat plants are left blank. In the industry sector, seven countries provide the IEA with a more detailed breakdown into sub-sectors, the most important of which are shown in the table.

There are substantial differences between the methodologies used by the IEA and some national agencies and companies, and also differences in the volumes counted. Most significantly, in Russia, statistics used by Gazprom indicate much higher levels of consumption by industry, and lower levels of consumption by households, than do the IEA’s. These two sets of statistics are compared in Table 46 in Appendix 6, along with a discussion of the possible reasons for the differences. Information published recently by Azerbaijan’s statistical agency is very similar to, but more detailed than, that published by the IEA. Some very limited information on Turkmenistan has been published by the United Nations Development Programme (UNDP). Statistics used in Russia, Kazakhstan, Azerbaijan and Turkmenistan, and those published by the IEA, are compared in Appendix 6.

Table 2 illustrates some outstanding features of gas consumption. It is dominated by three of the 12 countries – Russia, Ukraine and Uzbekistan – which together account for more than 86% of total consumption. The heat and power sector (including electricity plants, CHP and heat plants (i.e. gas-fired boilers)), are overwhelmingly dominant, accounting for more than half of the gas consumed. Other significant consumers are the residential sector (13%), industry (15%, including 6% for chemical feedstocks) and the gas transport system (9%, including the rows “pipeline transport” and “distribution losses”). It is probably higher, given obvious statistical lacunae, e.g. zero for pipeline transport in Kazakhstan and Turkmenistan).

Table 2 refers to 2008, the most recent year for which comprehensive data are available. In 2009, gas consumption fell sharply in Russia, Ukraine and Belarus – but, apparently, less sharply elsewhere in the region – as a result of the impact of the world economic crisis. Consumption trends following the crisis are discussed in Section 1.d below, page 11.

Russian regional demand

Any detailed study of Russian demand will need to take into account regional consumption patterns. There is a dearth of statistical information on this. Table 3 shows the most recent available information on levels of demand in the seven federal districts of Russia in 2004, including sectoral breakdown within the districts.

Table 3: Natural Gas Consumption in Russia: Regional Breakdown

2004 consumption, bcm	Russia total		Federal regions						
			Central	NW	South	Volga	Urals	Siberia	Far East
TOTAL	**383.84**		**100.46**	**35.052**	**50.528**	**106.77**	**74.88**	**15.337**	**3.517**
Statistical differences	-0.109		0.818	-0.023	-0.099	-0.300	2.199	0	-0.001
TRANSFORMATION (ASSUMED)	**197.56**		**52.076**	**15.642**	**22.164**	**59.309**	**44.495**	**4.077**	**2.108**
Electrical power production	149.2		42.108	11.244	11.529	48.286	33.238	3.089	1.704
Municipal services	30.156		9.838	2.469	4.544	8.05	3.931	0.932	0.404
Gazprom	18.206		0.13	1.929	6.091	2.973	7.326	0.056	0
ENERGY IND OWN USE (ASSUMED)	**13.927**		**0.063**	**1.072**	**1.007**	**2.704**	**7.937**	**0.421**	**0.721**
Oil industry	13.927		0.063	1.072	1.007	2.704	7.937	0.421	0.721
INDUSTRY (ASSUMED)	**78.267**		**19.041**	**7.881**	**6.567**	**22.085**	**13.851**	**9.205**	**0.141**
Metallurgy	29.423		4.664	3.757	0.839	2.585	11.771	5.254	0.056
Cement industry	20.431		6.526	3.056	1.83	8.699	0.001	1.319	0
Agri-chemical	6.346		2.239	0.057	1.258	1.633	0.674	0.44	0.065
Petrochemical	8.506		0.768	0.168	0.726	4.847	0.275	1.728	0
Auto and agri machinery	3.582		0.914	0.086	0.212	1.918	0.437	0.025	0
Agri-industrial complex	9.979		3.93	0.757	1.702	2.403	0.693	0.439	0.02
RESIDENTIAL	**44.807**		**12.184**	**1.338**	**15.634**	**13.555**	**1.648**	**0.183**	**0.165**
OTHER CONSUMERS	**49.277**		**17.091**	**9.119**	**5.255**	**9.116**	**6.949**	**1.451**	**0.382**

Source: Gazprom

The information in the table appears to show volumes as measured by Gazprom at the point of sale, and therefore gas consumed by the gas transport system and distribution losses (about 50 bcm/year in recent years), and some other volumes, are not included.[6] It is not clear to which type of consumption the categories “municipal services” and “Gazprom” refer. The former most likely includes district heating companies (they are indeed municipal services, and no other municipal service consumes the large volumes of gas listed in that row); the latter may refer to gas used by Gazprom to produce electrical power for its own use or for sale. These statistics are compared with the IEA’s in Appendix 6, in Table 46.

The importance of regional consumption trends stands out, notwithstanding the statistical uncertainties. The Central and Volga regions each consume more gas than Germany; the Urals, not much less than Italy; and the Southern region, more than the Netherlands. These four regions each consume more gas than any CIS country except Russia and Ukraine.

[6] Gazprom has more recently released sales information broken down by the 60-plus different subjects of the Russian federation (i.e. smaller geographical units than the federal districts) in which it is sold. See for example *Interfax Russian Oil and Gas Report*, 22 April 2010.

1.b. Gas supply for the CIS region

Natural gas consumption needs to be considered with a mind to the sources of gas supply and how they may change. More than 99% of the natural gas consumed in the CIS region is produced in Russia, Turkmenistan, Uzbekistan, Kazakhstan, Ukraine and Azerbaijan, and supplied domestically or to other CIS countries by pipeline. No gas is imported into the region from outside it,[7] although there is considerable cross-border trade within the region (exports from Russia to Ukraine, Belarus and Moldova, from the central Asian countries to Russia, from Russia to Georgia and Armenia and small trades between central Asian and Caucasian countries).

Of the gas produced in the region, about nine-tenths is natural gas and about one-tenth is associated petroleum gas (APG). There are no comprehensive data on the level of APG production, but in Russia, APG made up 54.7 bcm of the 582 bcm of gas produced in 2009; in Azerbaijan, it made up 4.9 bcm of the 6.6 bcm produced in 2006; and in Kazakhstan, 0.9 bcm of the 7.2 bcm supplied in 2009.[8]

An important trend with implications for consumption in the region is that, due to the exhaustion of old gas fields in Russia and the development of new ones, there will be a significant increase in the proportion of wet gas, i.e. gas containing high levels of petroleum liquids (propane, butane, ethane, etc) that requires additional processing before being admitted to the gas transport system. Gazprom projects that gas with high liquids content, which in 2008 comprised 24% of total Russian production (159 bcm out of 664 bcm), will in 2016-2030 comprise 46% of total output (389 bcm/year out of 845 bcm/year on average).[9] (Propane and butane are marketed as liquefied petroleum gas (LPG), and serve areas of demand – e.g. transport fuel and small heating appliances in rural areas – that have little in common with those served by natural gas, and so are not covered in this study.)

Central Asian gas also requires processing, but for different reasons: much of it contains high concentrations of sulphur, carbonic acid and other toxic chemicals, rather than comparatively valuable petroleum liquids. Most of the gas produced currently by Uzbekistan, the region's third largest producer after Russia and Turkmenistan, is extracted in the form of unstable concentrate that requires a significant amount of processing.[10]

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[7] Except for infintesimal quantities of Iranian gas imported by Azerbaijan (0.03 bcm in 2006) and Georgia (0.008 bcm in 2006) in recent years. Julian Bowden, "Azerbaijan: from gas importer to exporter", in Pirani (ed.), *Russian and CIS Gas Markets*, p. 223; and Micheil Tokmazishvili, "Georgia's Gas Sector", in Pirani (ed.), *Russian and CIS Gas Markets*, p. 265.

[8] James Henderson, *Non-Gazprom Gas Producers in Russia* (London, Oxford University Press, 2010), p. 44; Julian Bowden, "Azerbaijan", op. cit; Statistical Agency of the Republic of Kazakhstan, *Toplivno-energeticheskii balans Respubliki Kazakhstana* (Astana, 2010), pp. 62-72. Some sets of statistics for Kazakhstan appear to record APG flared and reinjected at oil fields in the gas balance, contrary to the standard practice of the IEA and other agencies, and the approach of this paper. See Appendix 3, table 41, and Appendix 6, table 48.

[9] Gazprom presentation, *Gaining Momentum: Gazprom Investor Day* (February 2010).

[10] Stanislav Zhukov, "Uzbekistan", in Pirani (ed.), *Russian and CIS Gas Markets*, p. 362.

Another significant source of gas in Russia, Ukraine and Kazakhstan is manufactured gases, i.e. coke oven gas and blast furnace gas produced in the course of steelmaking.[11] These gases account for 3.6% of Russia's gas supply (by energy content), 10.7% of Ukraine's and 11% of Kazakhstan's, according to the most recent available statistics, which are set out in Appendix 3. Most of these gases are used in the steel industry, and their role – which reduces the dependence of the steel industry on natural gas – will be discussed below in Section 3 on industrial consumption. A smaller proportion of them is used in the power and district heating sector in steel-producing areas.

1.c. Natural gas in the energy balance

The economies of most countries in the CIS region are heavily dependent on natural gas, significantly more so than most other economies (with the exception of Middle Eastern countries, Bangladesh, and some others). For example, gas's share in the total primary energy supply (TPES) is 25.2% in the EU, but significantly greater than that across the CIS region, except in Kyrgyzstan and Tajikistan. Table 4 shows the volumes of gas consumed as a proportion of (i) the TPES; (ii) the total energy inputs for the power and heat sector (including electricity plants, CHP and boilers); (iii) the supply of gas to industry (excluding gas used as feedstock in the chemical industry); and (iv) the energy supplied to the residential sector. The energy balances of the countries covered by the study are summarised in Table 42 in Appendix 4.

There is no mistaking the heavy gas dependence of the economies listed, and the discussion that follows will touch on the constraints on gas consumers – whether gas-fired power stations, district heating systems, industrial or residential consumers – switching easily or quickly away from gas. Russia, the largest consumer, is among the most gas-dependent economies in the world. But Russia is not as gas-dependent as several other CIS countries, and is supplied mainly by its own gas. So too are the two large central Asian producers, Uzbekistan and Turkmenistan, the most gas-dependent economies in the CIS by far. Kazakhstan, like those countries, and Azerbaijan, which relied on significant levels of imports until 2006, are net exporters. But the other seven CIS countries are net importers. The largest importer by volume is Ukraine. It is less gas-dependent than Russia overall, and has substantial coal and nuclear electricity generation capacity – but its district heating and residential sectors, as well as its chemical plants and other industrial sectors, are to a considerable degree captive markets. Belarus, Armenia and Moldova are significantly more gas-dependent than Russia, and – apart from a negligible amount of local production in Belarus – 100% dependent on imports. The remaining net importers have significant energy sources apart from gas: hydro and renewables in Georgia; hydro, coal and oil products in Kyrgyzstan; and hydro in Tajikistan.

[11] Coke oven gas is a by-product of the process of transforming metallurgical coal into coke. Its components are hydrogen, carbon monoxide, methane and volatile hydrocarbons, with small amounts of non-calorific gases (carbon dioxide and nitrogen). Blast furnace gas is a by-product generated when iron ore is reduced with coke to metallic iron. It has a low calorific value: it consists of about 60% nitrogen, 18-20% carbon dioxide and oxygen, and flammable carbon monoxide.

Table 4: Gas in the Energy Balance

Gas as % of energy supplied (2008, net calorific value)				
	TPES	Power	Industry	Residential
Russia	53.3	58.7	24.1	35.0
Ukraine	41.1	33.5	30.8	59.1
Belarus	62.8	91.4	30.6	20.1
Moldova	62.9	97.6	49.6	30.1
Azerbaijan	67.9	88.3	42.5	76.5
Armenia	60.1	35.7	87.5	0
Georgia	36.2	33.5	56.8	21.9
Kazakhstan	38.8	9.3	4.2	n/a
Turkmenistan	72.9	100	n/a	n/a
Uzbekistan	86.3	84.1	79.5	95.7
Kyrgyzstan	21.8	24.3	0	n/a
Tajikistan	17.8	14.2	0	n/a

Source: IEA energy balances, author's calculations.

Table 5: Gas in the Energy Balance: Comparisons

2008, millions of tonnes of oil equivalent, net calorific value basis								
	FSU		**CEE**		**EU27**		**China**	
	mtoe	% of TPES	mtoe	% of TPES	mtoe	% of TPES	mtoe	% of TPES
Gas	544.4	52.4%	101.6	34.7%	440.5	25.2%	70.9	3.3%
Coal	194.4	18.7%	77.6	26.4%	304.1	17.4%	1413.3	66.3%
Nuclear, hydro & renewables	102.1	9.8%	52.5	17.9%	397.6	22.7%	278.1	13.1%
TPES	1038.2	100.0%	293.1	100.0%	1750.7	100.0%	2130.6	100.0%
	Russia		**Ukraine**		**Uzbekistan**			
	mtoe	% of TPES	mtoe	% of TPES	mtoe	% of TPES		
Gas	366.2	53.3%	56.0	41.1%	43.6	86.3%		
Coal	117.1	17.0%	40.8	29.9%	1.2	2.5%		
Nuclear, hydro & renewables	63.6	9.3%	25.3	18.6%	1.0	1.9%		
TPES	686.8	100.0%	136.1	100.0%	50.5	100.0%		

Source: IEA energy balances 2008, author's calculations

Tables 5 and 6 show that the dominant role of gas in the former Soviet Union is in many ways exceptional: they compare the place of gas in the energy balance, and the proportion of that gas supplied to the heat and power sector, in the former Soviet Union (FSU), central and eastern Europe, the EU (27 countries) and China. Aside from the Middle East and North Africa, the only region that comes close to the FSU in terms of gas dependence is central and eastern Europe, under which the IEA includes the gas-intensive former Soviet states of Ukraine, Moldova, Belarus and the three Baltic states, overlapping with its "FSU" category.[12]

Table 6: Gas for the Heat and Power Sector: Comparisons

2008, millions of tonnes of oil equivalent, net calorific value basis								
	FSU		**CEE**		**EU27**		**China**	
	mtoe	**% of total gas supply**	**mtoe**	**% of total gas supply**	**mtoe**	**% of total gas supply**	**mtoe**	**% of total gas supply**
Gas for electricity plants	14.1	2.6%	6.9	6.8%	77.9	17.7%	9.2	12.9%
Gas for CHP	184.1	33.8%	17.4	17.2%	63.0	14.3%	0	0.0%
Gas for heat plants	78.6	14.4%	20.2	19.9%	8.1	1.8%	1.8	2.5%
Gas, total domestic supply	544.4	100.0%	101.6	100.0%	440.5	100.0%	70.9	100.0%
	Russia		**Ukraine**		**Uzbekistan**			
	mtoe	**% of total gas supply**	**mtoe**	**% of total gas supply**	**mtoe**	**% of total gas supply**		
Gas for electricity plants	2.1	0.6%	1.3	2.3%	5.2	12.0%		
Gas for CHP	152.0	41.5%	56.3	4.1%	5.3	10.6%		
Gas for heat plants	58.1	15.8%	15.2	27.2%	1.6	3.2%		
Gas, total domestic supply	366.2	100.0%	56.0	100.0%	43.6	100.0%		

Source: IEA energy balances 2008, author's calculations

Gas accounts for more than half of the FSU's total primary energy supply, compared to a little more than a third in central and eastern Europe, about a quarter in the EU27 and 3.3% in China. The power and heat sector accounts for 50.8% of FSU consumption, according to this method of calculation, compared to 43.9% of consumption in the CEE, 33.8% in the EU27 and just15.4% in China.

The tables also include columns for the three largest former Soviet gas consumers. Russia, by far the largest consumer, is also striking for the preponderance of CHP in gas consumption: it accounts for 41.5%, with a further 15.8% going to heat boilers and 0.6% to electricity-only generating plants. (Note that the IEA definition of CHP includes not only the heat-power

[12] Under the IEA's methodology, the FSU comprises the 15 former Soviet countries, i.e. the 12 covered by this study plus the Baltic states. Central and eastern Europe comprises Albania, Bulgaria, Cyprus, Malta, Romania, Bosnia and Herzegovina, Croatia, Former Yugoslav Republic of Macedonia, Montenegro, Serbia, Slovenia, Belarus, Estonia, Latvia, Lithuania, Moldova and Ukraine. China comprises the People's Republic of China and Hong Kong.

centres characteristic of former Soviet urban heating systems, but also condensing power plants that produce smaller amounts of heat as a by-product. This issue is discussed below in Section 2.a, page 35, and Section 2.b, page 39.) Ukraine by contrast relies heavily on coal and nuclear power for electricity generation, but uses a large amount of gas, 27.1% of its total consumption, supplying boilers. Uzbekistan consumes a smaller proportion of its gas in the power and heat sector than Russia or Ukraine – about a quarter – but is far more dependent on gas overall.

1.d. Changes in consumption over time 1998-2010

The study will focus mainly on the period since 1998. That year marks the turning-point between the economic crisis of the 1990s – during which Russia, Ukraine and other post-Soviet countries suffered the worst slump ever experienced in peacetime – and the years of economic growth that followed. The next dividing-line is 2008, when two sharp economic changes – on one hand the international financial and economic crisis and on the other the peak and rapid fall in the prices of oil and other commodities – combined to return many of the former Soviet economies to recession. The available information on the way that that recession, and the subsequent recovery, was reflected in gas consumption is also reviewed.

In this Section, the impact on gas consumption of changes in the economy and population are considered. Rising prices, market reform and energy efficiency policies – which have only recently begun to have any discernible effect, but will become increasingly important – are discussed in Section 1.e below, on future demand trends.

The effect of temperature variations has not been considered. This is a significant omission, because of the considerable effect that temperature variations are known to have on gas consumption, particularly in countries where temperatures vary over a wide range during the year, including most of the CIS region. The reason for this is simply the total absence of data: to the author's knowledge no-one has tried to correlate gas consumption data with temperature data, or to compile temperature-corrected data.[13]

The decade up to 2008

Table 7 shows total natural gas consumption, by sector, in the CIS region in 1998-2008.

[13] On correlating data, see Anouk Honore, *European Natural Gas Demand, Supply and Pricing*, pp. 39, 193-199 and 234-235.

Table 7: Total Natural Gas Consumption in the CIS, 1998-2008

bcm	1998	1999	2000	2001	2002	2003
DOMESTIC SUPPLY	**554.8**	**568.8**	**574.0**	**586.5**	**588.1**	**610.5**
Transfers & statistical differences	0.0	3.0	0.0	0.0	0.0	0.0
TRANSFORMATION, incl:	**276.2**	**293.8**	**295.2**	**312.9**	**314.6**	**325.0**
Electricity plants	20.9	22.4	22.7	28.3	28.7	29.4
CHP plants	163.6	169.9	172.0	173.0	176.3	181.5
Heat plants	67.9	87.1	85.2	93.3	93.6	95.7
Heat & power, unspecified	9.8	10.4	11.6	12.9	12.0	12.4
Other transformation	14.1	4.0	0.0	5.5	3.9	6.0
ENERGY IND. OWN USE	**17.6**	**17.0**	**7.4**	**19.1**	**19.8**	**23.0**
DISTRIBUTION LOSSES	**11.1**	**4.5**	**4.5**	**10.8**	**10.8**	**10.4**
PIPELINE TRANSPORT	**18.0**	**39.6**	**35.1**	**35.3**	**37.0**	**40.6**
INDUSTRY, incl:	**95.6**	**79.8**	**82.7**	**82.8**	**80.4**	**81.6**
Iron & steel	21.3	13.3	14.7	14.9	15.0	15.8
Non-metallic minerals (incl. cement)	6.0	5.7	7.1	7.4	7.8	8.6
Chemical & petrochemical	8.3	4.4	3.6	4.0	3.9	3.9
Chemical feedstocks	16.7	19.7	20.8	24.1	20.9	22.6
Other industry	42.5	36.0	35.7	31.6	31.9	29.4
RESIDENTIAL	**92.4**	**95.5**	**95.5**	**91.4**	**90.8**	**93.5**
COMMERCIAL & PUBLIC SERVICES	**14.5**	**18.1**	**17.7**	**15.7**	**15.5**	**14.8**
OTHER/ NON-SPECIFIED	**27.8**	**16.3**	**17.5**	**18.4**	**19.2**	**21.7**
Table 7, continued						
bcm	**2004**	**2005**	**2006**	**2007**	**2008**	
DOMESTIC SUPPLY	**624.9**	**635.3**	**643.6**	**654.5**	**663.0**	
Transfers & stat differences	0.0	-2.6	-0.7	-1.2	-1.9	
TRANSFORMATION, incl.:	**333.8**	**332.9**	**335.2**	**339.9**	**339.8**	
Electricity plants	16.1	16.1	15.3	16.5	16.2	
CHP plants	190.5	197.8	201.7	208.1	209.0	
Heat plants	106.4	101.4	99.8	96.4	95.5	
Heat & power, unspecified	13.7	15.0	15.9	16.7	17.1	
Other transformation	7.2	2.6	2.5	2.1	2.0	
ENERGY IND. OWN USE	**22.6**	**23.6**	**24.8**	**28.5**	**28.3**	
DISTRIBUTION LOSSES	**11.3**	**11.5**	**11.6**	**10.3**	**11.7**	
PIPELINE TRANSPORT	**47.9**	**47.5**	**47.0**	**48.1**	**49.5**	
INDUSTRY , incl:	**86.7**	**96.6**	**98.7**	**96.3**	**98.5**	
Iron & steel	23.9	25.3	23.3	22.5	21.8	
Non-metallic minerals (incl. cement)	12.1	15.6	16.2	15.4	17.7	
Chemical & petrochemical	3.7	4.4	4.9	3.5	3.6	
Chemical feedstocks	29.2	36.3	36.5	39.4	38.7	
Other industry	16.4	13.4	15.8	13.7	14.8	
RESIDENTIAL	**90.7**	**85.9**	**89.0**	**86.2**	**89.3**	
COMMERCIAL & PUBLIC SERVICES	**8.0**	**8.6**	**9.0**	**11.1**	**9.4**	
OTHER/ NON-SPECIFIED	**21.9**	**24.5**	**25.7**	**29.7**	**32.3**	

Source: IEA energy statistics, author's calculations

Note: The table has been summarised from IEA statistics, in a manner similar to Table 2. Details in the note to Table 2. For 1998-2003 volumes used as chemical industry feedstocks in Belarus, Russia and Uzbekistan, and included by the IEA under “chemical and petrochemical industry” and presented as a sub-category, have been moved to the “chemical feedstocks” row.

Total consumption by the 12 countries rose each year, and by 2008 was 19.5% higher than in 1998. By 2008 consumption by the transformation sector (almost entirely comprising power and district heating) was 23% higher than in 1998, and by industry (including the energy industry's own use) 12% higher, while consumption by the residential sector was 3.5% lower. Steady GDP growth and the recovery of economic activity after the 1990s clearly played a big part. Attention is drawn to the the non-metallic minerals sector (which mainly comprises cement manufacture), which consumed nearly three times as much gas in 2008 as it had in 1998, and to the use of gas as chemical feedstock, mainly to produce fertilisers, which more than doubled. The reduction in gas consumption in the residential sector probably reflects the decline in population in some countries in the region, among other factors.

Figure 1 shows the relative changes in GDP, population, total primary energy supply (TPES) and gas consumption in the three largest gas consuming countries, Russia, Ukraine and Uzbekistan. Values are shown by comparison with 1998, i.e. as percentages, with 1998 measured as 100%.

Figure 1: GDP, Population, TPES and Gas Consumption Measured in %: 1998=100

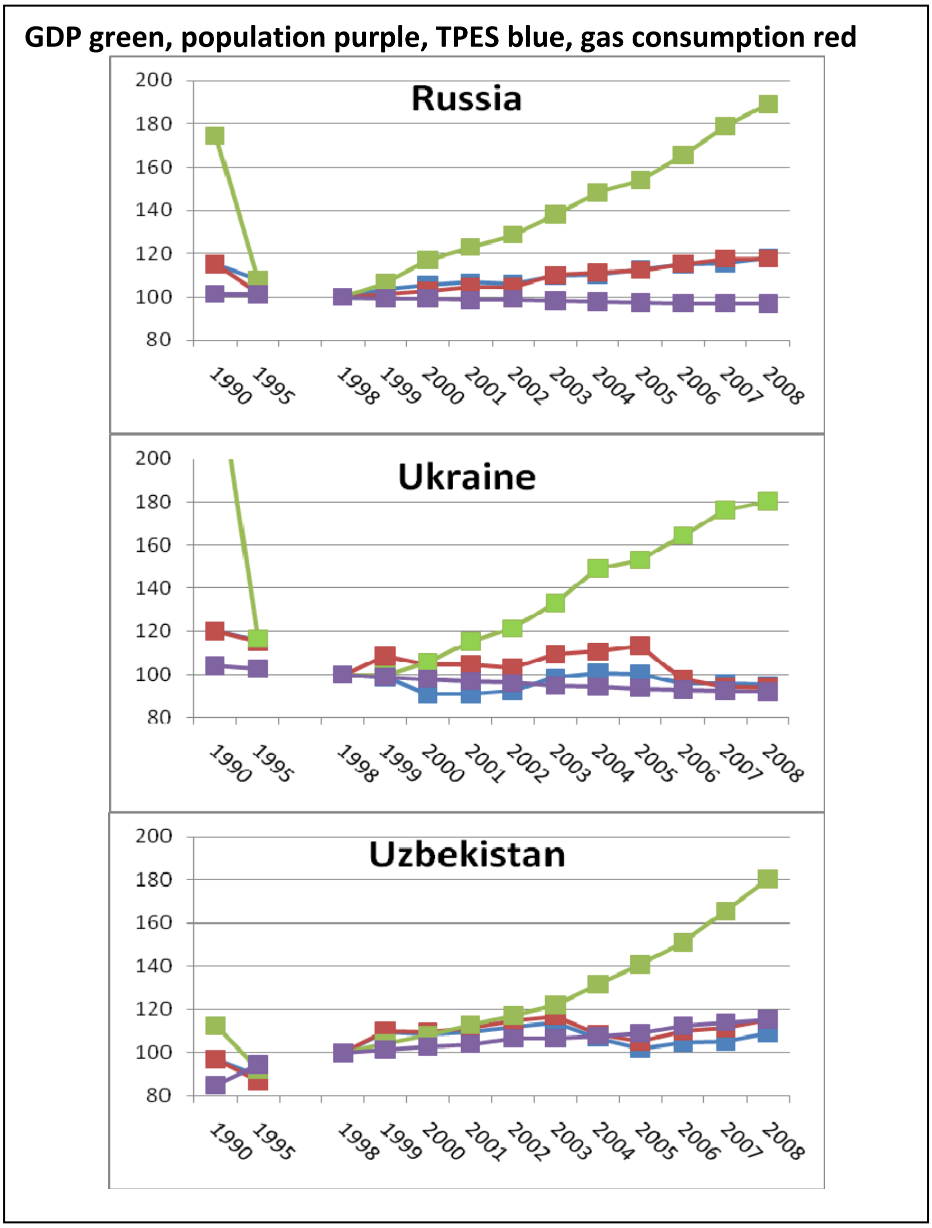


Figure 1 shows, firstly, the constant improvement in energy efficiency – from a very low base – i.e. GDP rose more rapidly than TPES in all three countries. A large part of this is attributable to structural change, i.e. the fact that, in the recovery of the 2000s, the previously small service sectors grew far more rapidly than energy-intensive industries.

Another significant point is the relationship between gas consumption and TPES. In Russia and Uzbekistan, the two grew more or less in tandem. In Ukraine, gas consumption grew more rapidly than TPES in the early 2000s, but fell sharply both absolutely and in comparison to TPES in 2005-08. This is probably due to the increase in the price of gas imported by Ukraine: import prices rose more rapidly only in Georgia and Moldova. The statistical evidence is still too thin to reach any firm conclusions, but it does seem that reduced consumption of gas in Ukraine in 2005-08 – at a time when the economy continued to grow, and TPES declined only very slightly – was the first sign of a response to changing price trends. This issue is further discussed below in Section 1.e.

As for the impact of demographic changes – falling population in Russia and Ukraine, rising population in Uzbekistan – Figure 1 leaves us none the wiser. While gas consumption fell in Ukraine in 2005-08, as population fell, it rose not only in Uzbekistan – which is the only one of the three countries where the population was growing – but in Russia too. Part of the answer to this question may be found in Table 8, which compares GDP and population trends with gas consumption by the transformation sector (i.e. power and district heating), industry and residential consumers.

Table 8: GDP, Population and Natural Gas Consumption in Russia, Ukraine and Uzbekistan, 1998-2008

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
RUSSIA											
GDP, % (1998 = 100)	**100**	**106.4**	**117.0**	**123.0**	**128.8**	**138.3**	**148.1**	**154.1**	**165.5**	**178.9**	**188.9**
Population, % (1998 = 100)	**100**	**99.4**	**99.2**	**98.6**	**99.0**	**98.5**	**98.0**	**97.5**	**97.1**	**97.1**	**97.0**
Gas for transformation, bcm	219.1	233.8	234.5	240.4	242.5	251.6	255.3	254.8	261.7	266.8	264.6
Gas for industry, bcm	63.9	46.6	49.9	53.8	51.0	53.5	54.0	63.8	66.0	63.1	66.7
Gas for residential, bcm	51.5	52.4	53.4	53.3	52.2	56.3	52.9	47.2	49.0	48.1	49.4
UKRAINE											
GDP, % (1998 = 100)	**100**	**99.8**	**105.7**	**115.4**	**121.4**	**133.1**	**149.2**	**153.2**	**164.4**	**176.4**	**180.1**
Population, % (1998 = 100)	**100**	**99.1**	**98.0**	**97.1**	**96.2**	**95.1**	**94.4**	**93.7**	**93.1**	**92.4**	**91.9**
Gas for transformation, bcm	19.6	21.3	20.5	30.6	30.7	31.0	34.4	32.9	26.5	25.1	26.4
Gas for industry, bcm	17.4	18.9	18.2	14.6	14.3	12.7	19.9	19.7	18.4	19.1	17.0
Gas for residential, bcm	19.7	21.4	20.6	16.5	16.2	14.4	15.9	17.1	17.7	15.9	16.5
UZBEKISTAN											
GDP, % (1998 = 100)	**100**	**104.3**	**108.3**	**112.7**	**117.2**	**122.1**	**131.5**	**140.7**	**151.0**	**165.4**	**180.2**
Population, % (1998 = 100)	**100**	**101.3**	**102.7**	**103.9**	**106.5**	**106.5**	**107.8**	**109.3**	**112.4**	**114.0**	**115.4**
Gas for transf’mn, bcm	14.0	14.2	14.2	14.4	14.8	15.0	14.0	13.6	14.2	14.3	15.0
Gas for industry, bcm	9.4	9.6	9.5	9.7	10.0	10.1	7.6	7.4	7.7	7.8	8.1
Gas for residential, bcm	17.3	17.6	17.5	17.8	18.4	18.5	17.3	16.8	17.5	17.7	18.4

Source: EBRD and IEA statistics, author's calculations

Table 8 shows that consumption by residents peaked in 1999 in Ukraine and in 2003 in Russia, and fell thereafter, albeit not uniformly. There is a major caveat regarding Russia: the author understands that statistics compiled internally by Gazprom indicate a net *increase* in residential consumption in the decade to 2008, rather than the decrease recorded by the IEA – which underlines how substantial the differences between sets of data are. In Uzbekistan it peaked in 2003 but then bucked the trend, rising each year between 2005 and 2008. The most one can say from this uncertain evidence is that population growth *may* be one of the factors supporting demand in Uzbekistan. In Russia and Ukraine, falling population *may* have reduced demand, and price increases for domestic consumers may also have played a part; on the other hand, rising average living standards (implying an increase in living space per person, purchase of more electrical appliances, etc) may have supported rising demand. There are simply too few data to be sure.

The rows showing consumption by the transformation sector and by industry are more revealing. The most important trend, and one of the most consistent, was the steady year-on-year growth of consumption by the Russian power and district heating sector – which consumes more gas than the total consumed by all the 11 other CIS countries. Russian industry, consumption by which fell steeply between 1998 and 1999, presumably at least partly due to the aftershocks of the 1998 financial crisis, grew – albeit erratically – thereafter. In Ukraine the transformation and industry sectors in the table trended downwards from 2005, albeit not uniformly or steadily, again suggesting that price increases may have had an effect.

Overall, however, given the difficulties of separating out the relative weight of such factors, it would be hazardous to draw any more than these tentative conclusions. Instead, this study will focus on the changes discernible in the various consuming sectors in order to try to put more flesh on the bones of the statistics.

The effect of the 2008-09 economic crisis

In the period following the financial and economic crisis, the pattern of steady economic growth of the previous decade was interrupted in some, but not all, CIS states, and there was a corresponding effect on gas consumption.

Of the six largest CIS economies, Russia and Ukraine (the first- and second-largest) went into deep recession in 2009; Kazakhstan and Belarus (the third and fourth) stagnated; and Azerbaijan and Uzbekistan (fifth and sixth) continued to grow. It could be said that Russia and Ukraine paid the price for their relatively high level of integration with international financial markets and their dependence on exports to Europe. The crisis impacted their revenues from commodities exports (above all oil and gas for Russia, and steel for Ukraine), froze domestic credit flows and severely impacted manufacturing industry. By contrast, the effect of the crisis on central Asia was ameliorated by its expanding trade links with China.

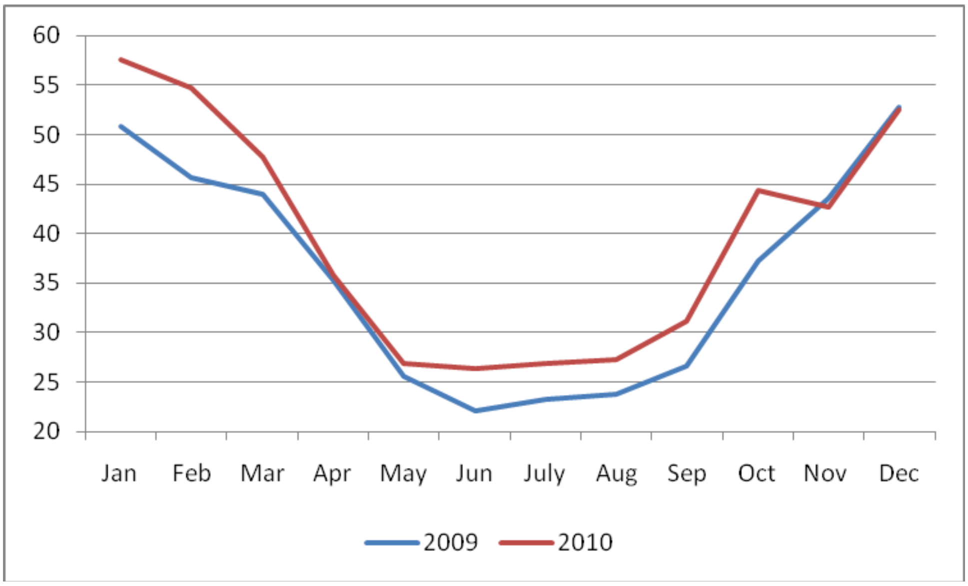
As a result of the crisis, gas consumption fell extremely sharply in Ukraine, and sharply in Russia and Belarus. Little statistical data is available for the rest of the CIS, but it appears that, just as the Caucasian and central Asian economies were in many respects shielded from the crisis, so their level of gas consumption was less significantly impacted. The available information about total consumption (by country, without any sectoral breakdown) is summarised in Table 9.

Table 9: Reported Natural Gas Consumption, 2007-2010

bcm		2007	2008	2009	2010	Source of information
Russia	(Gazprom)	467.1	462.5	432.2	460.3	Gazprom financial reports
	(energy ministry)	n/a	n/a	430.5	495.4	Ministry of energy web site
Ukraine		70.8	67.3	52.8	57.6	Ministry of energy/*Energobiznes*
Belarus		20.6	21.1	17.6	n/a	Beltransgaz web site
Moldova	(imports, including Pridnestrovye)	2.7	2.7	3.0	3.2	Gazprom
	(deliveries to customers, right-bank only)	1.21	1.13	1.03	1.09	National Agency for Energy Regulation (ANRE)
Azerbaijan		9.2	10.8	9.8	n/a	State statistics committee of Azerbaijan
Kazakhstan		n/a	7.4	7.2	n/a	Statistical Agency of the Kazakh Republic/ author's estimates

The main points are that in 2009, consumption fell by comparison with 2008 sharply in Russia (by about 6.5%) and Belarus (by about 8%), but even more sharply in Ukraine (by about 21.5%). In 2010, demand in Russia recovered, and, according to the energy ministry's data, substantially exceeded 2007-08 levels; in Ukraine it rose by 9.1%, remaining far short of 2008 levels. In the first quarter of 2010 in particular, exceptional weather conditions – an unusually long, cold winter, followed by an exceptionally hot summer and more cold weather at the end of the year – will certainly have impacted demand in Russia and Ukraine. Kazakhstan experienced only a negligible fall in gas demand as a result of the crisis, and when statistics become available from Uzbekistan, they may follow a similar pattern.

Figure 2: Monthly Gas Consumption in Russia, 2009-2010



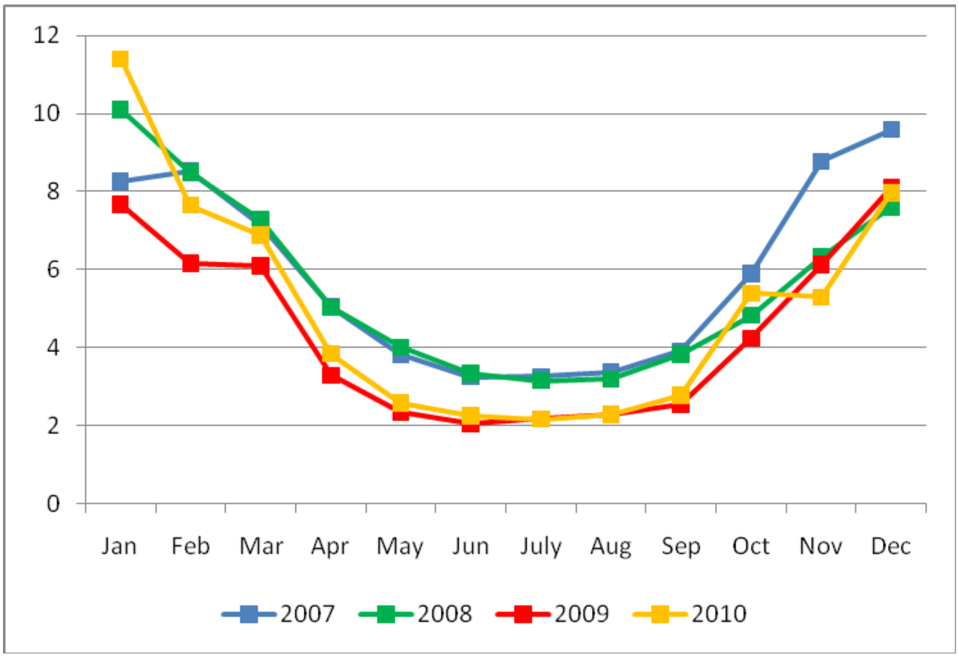
Source: ministry of energy web site

The data on which Figure 2 is based are presented in Table 43 in Appendix 5.

Figure 2, based on monthly demand statistics published by the energy ministry, shows that 2010 demand significantly outpaced 2009 demand in January-March and June-October. The return to 2009's unusually low level in November-December, though, raises at least the possibility that the demand recovery in 2010 was driven as much by the unusual weather in the first quarter, and during the summer – which was unusually hot – than by underlying economic factors.

Monthly consumption statistics for Ukraine are shown in Figure 3.

Figure 3: Ukrainian Gas Consumption, 2007-2010

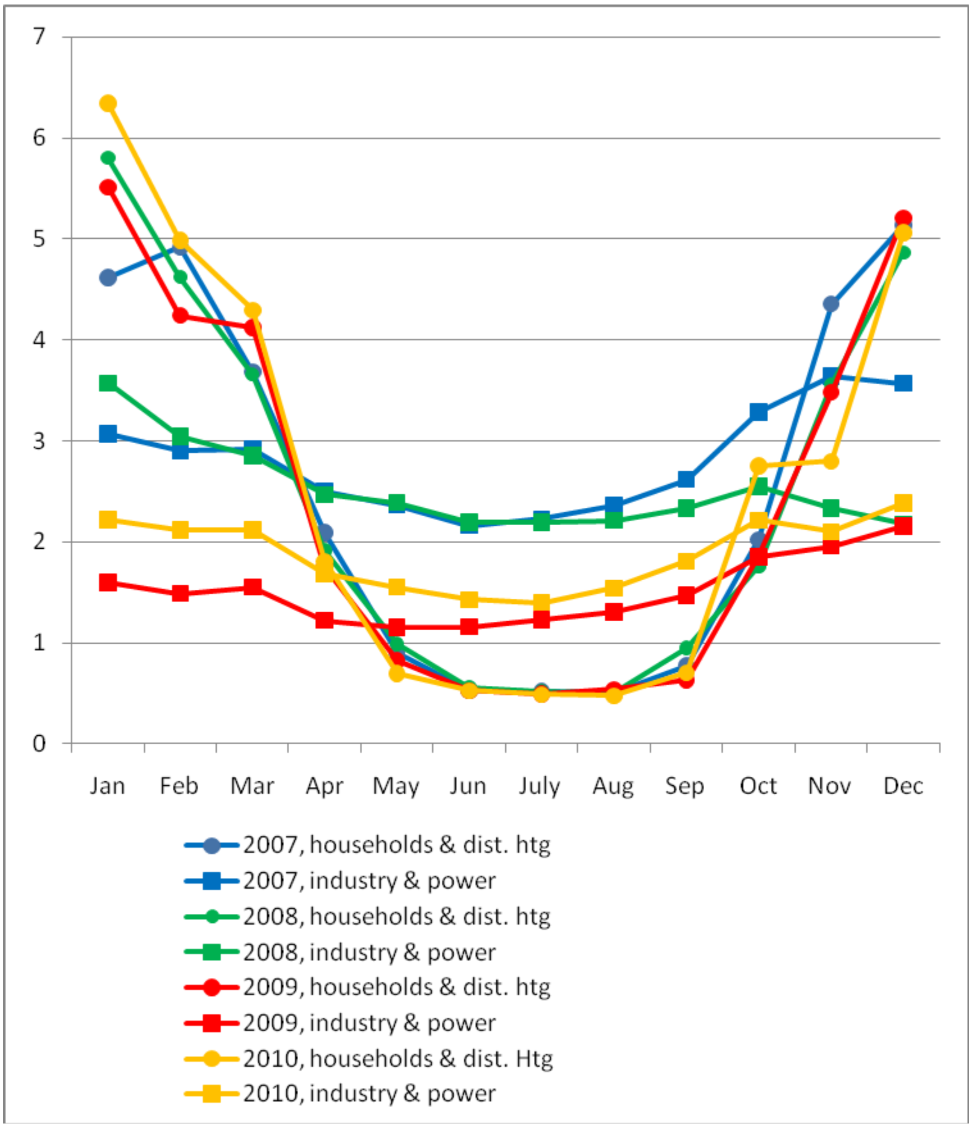


Source: energy ministry/ *Energobiznes*

The substantial gap between the level of demand in 2009 (red) and 2010 (orange) on one hand, and 2007 (blue) and 2008 (green) on the other, is evident. And while demand was at a record high in January 2010, by the summer it had fallen to 2009 levels.

Figure 4 shows Ukrainian demand for 2007-2010 from the industry, power, household and district heating sectors.

Figure 4: Ukrainian Monthly Gas Consumption 2007-2010: households & district heating compared to industry & power



Source: energy ministry/ *Energobiznes*

This figure – which displays information from Table 44 in Appendix 5 – shows that the substantial fall in demand in Ukraine is concentrated in industry and the power sector. Whereas demand from households and the district heating sector in 2009-10 was very similar to that in 2007-08, demand from industry and power was consistently lower, and by a large margin. In fact the collapse of demand in industry is noticeable from September 2008. It seems very likely that this sharp contrast is due to (i) the impact of the recession on Ukrainian industry, which was the most severe in any CIS country; (ii) the continued diversification away from gas to the greatest extent possible in the power sector, due to the price differential with coal; and (iii) the fact that the industry and power sector pay gas prices linked to imported gas prices, while prices for residential and district heating customers are steeply discounted.

1.e. Future demand trends: the impact of rising prices, market reform and energy efficiency policies

The main factors shaping future gas demand will include: economic growth and changes in population, discussed in the previous section; energy policies, including energy efficiency and environmental policies, prices and market reform – all of which are discussed in this Section; and sector-specific issues discussed in Sections 2-5 below.

Energy policies and the implications for gas demand[14]

In ***Russia***, the government's long-term commitment to liberalisation of gas, power and heat markets is one of the key political factors that will influence gas demand. This general approach, adopted in 2006-07, is moving the Russian gas market, by far the largest in the region, away from regulated tariffs and towards the use of market mechanisms. The government's determination to bring not only Russian domestic gas prices but also CIS import prices into line with those in Europe has had and will have profound implications for the region as a whole. (See "Prices", page 25, and "Market structure and reform", page 29, below.) In the coming years, efforts to improve the efficiency of gas, power and heat consumption – the most significant potential factor in reducing gas consumption – will be implemented in the first place by using these market mechanisms.

In the context of the commitment to liberalisation, there are tensions in Russian policy. The gas and power companies seek a faster route to price liberalisation, consumers and many politicians seek a slower one; in the gas market, the manner and order of liberalisation is the subject of dispute between Gazprom and non-Gazprom producers. Over the longer term, on the crucial question of electricity generation capacity, the principle enshrined in Russia's Energy Strategy, that dependence on gas should be reduced, is at odds with the belief by many in government that investment in gas-fired generation is the most rational approach economically. And it is not clear how many aspects of energy policy will be reconciled with the energy efficiency and climate change mitigation agenda now embraced by president Medvedev, and discussed below. These tensions will be referred to throughout the paper.

In ***Ukraine***, the largest net importer of gas in the CIS, all recent governments have emphasised the need to reduce dependence on gas imports from Russia; this is also a key theme of the Energy Strategy adopted in 2006. While the sharp rise in import prices since 2006 has given this issue added urgency, it has proved difficult to implement the necessary measures, such as improving energy efficiency (particularly in the district heating and residential sectors) and raising domestic gas production. Ukrainian governments' actions on these issues will be an important factor influencing future gas demand.

Belarus and ***Moldova***, the other net importers in the western CIS, face the same problem as Ukraine – excessive dependence on imported Russian gas – but are adopting different approaches to deal with it. Belarus has in recent years increased the proportion of gas in its

[14] The main source, in addition to those mentioned specifically, is the relevant chapters of Pirani (ed.), *Russian and CIS Gas Markets*.

fuel balance, partly due to declining domestic production of oil products. Gas consumption has increased, but much less rapidly than GDP thanks to strong energy efficiency policies. Moldova's policy, enshrined in the Energy Strategy of 2007, is to reduce dependence on gas imports by developing renewable energy sources and integrating into European networks.

The three Caucasian countries each have different emphases in their policies with respect to gas. The smallest, ***Armenia***, notwithstanding its hopes of increasing gas imports from Iran, suffers from import dependence on Russian gas in a way similar to Belarus and Moldova. In recent years demand growth from the power sector, the largest gas consumer, was restrained by improved efficiency, but substantial increases in consumption by industry and households buoyed demand. The shift by households from wood, kerosene and electricity to gas for cooking and heating was significant. A shift to widespread use of compressed natural gas in transport added further to demand. Government policy is focused on adapting to higher gas import prices.

Azerbaijan has experienced two fundamental changes. It has moved from being a net importer to being a net exporter. And in 2007, in the midst of an economic boom stimulated largely by new oil production projects coming on stream, it abandoned the model of regulated and subsidised gas and electricity tariffs that predominates across the CIS in one jump. It raised both tariffs by several orders of magnitude, and underpinned the price rises with a metering programme and efforts to improve collection rates. Electricity consumption fell by more than 10%; gas consumption fell, less dramatically. The national statistical agency, in a survey of household electricity and gas consumption conducted in 2009, reported further economies by households as a result of the installation of meters, more efficient light bulbs and other technology.[15] There is not yet sufficient data on the results of this shift of pricing policy, but the long-term consumption trends will be of importance not only in Azerbaijan but beyond.

Gas accounts for a smaller part of the energy balance of ***Georgia*** than of all other states in the CIS region except for the hydro producers Tajikistan and Kyrgyzstan. Nevertheless, it is a significant source of energy, especially for industry and households. Government policies are focused on diversification, in part because of the deterioration of relations with Russia, the main exporter of gas to Georgia.

Gas plays a distinctive role in ***Uzbekistan***, the third largest CIS consumer and one of the most gas-intensive economies in the region. There are two main reasons why Uzbekistan's consumption is especially high. First, government policy has prioritised gasification not only of urban areas, but also of rural settlements: the result is that in Uzbekistan, which is among the least urbanised CIS countries, 86.3% of the rural population is supplied with natural gas or LPG (compared to 45.5% in Russia), according to one set of data.[16] Second, gas is the

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[15] State Statistical Committee of Azerbaijan, *Results of survey on consumption of fuel and energy in the households in 2009*.

[16] A greater proportion of Uzbek residents (63%) live in the countryside than in all CIS countries except Kyrgyzstan (64%) and Tajikistan (75%). UNICEF, *The State of the World's Children 2008*, pp. 134-137. On gas supply, UNDP, *The Outlook for Development of Renewable Energy in Uzbekistan* (Tashkent, 2007).

main fuel for the power and heat sector, which is particularly inefficient compared to other countries in the region. In policy terms, Uzbekistan is focused, first, on reducing domestic consumption growth in order to free up gas for export, and second, on replacing some gas by coal in the power sector.

Kazakhstan, by contrast to Uzbekistan, has a far greater share of coal and a smaller share of gas in its domestic energy mix. The government envisages raising domestic gas consumption from 15.6 bcm in 2009 to 29.5 bcm in 2014. Transportation and gasification projects underway in the south of the country will raise residential consumption and replace some Uzbek imports with domestically-produced supplies. Over a longer time period, Kazakh policy aims to replace some oil- and coal-fired power generation with gas. The IEA has projected, over a time-scale up to 2035, that (i) gas will overtake coal as an energy source for the power and heat sector (implying rising gas demand), and also that Kazakhstan could achieve energy savings greater in scale than any other central Asian country (implying downward pressure on gas demand).[17]

The policy of ***Turkmenistan*** is to use domestic gas supply as an economic subsidy for industry, the public sector and the population. Gas is supplied at extremely low prices to industry and free to residents. This approach has been adopted in the context of gigantic gas resources – Turkmenistan is the world's fourth-largest holder of reserves after Russia, Iran and Qatar – and a small population of about 5 million. In 2009-2010 Turkmenistan's sales of gas to its traditional export market, Russia, were cut sharply, while exports to China began for the first time.[18] It may be that in future the considerable changes in the economics of the export trade, and the problems these are causing for the economy, may stimulate reconsideration of domestic gas consumption levels and pricing.

Energy efficiency and climate change policies

Given the predominant position of gas in the fuel balance of the CIS region, improvements in energy efficiency generally lead to reductions in gas consumption. The main causes of energy efficiency improvements are generally defined as: structural change in economies (e.g. the reduced role of heavy industry characteristic of the former Soviet Union over the past two decades); technological change and modernisation in energy-consuming sectors (housing, public buildings, industry, etc); tariff and price reform in markets for electricity and heat, as well as gas and other fuels, which stimulates changes in consumer behaviour; and other government policies directed at improving energy efficiency, and reducing carbon emissions, which may stimulate both technological change and changes in consumer behaviour, and obviously may influence tariff policies.

During the 1990s and 2000s, all former Soviet countries registered big reductions in the energy intensity of their economies. According to the large body of literature on the subject, this was made possible in the first place because of the extremely poor starting-point, i.e. the

[17] The government of Kazakhstan, *Zakon "o gaze i gazoshabzhenii": proekt* (2010); IEA, *World Energy Outlook 2010*, pp. 471-473.

[18] See Simon Pirani, *The Impact of the Economic Crisis on Russian and CIS Gas Markets*, pp. 26-29

extremely energy-intensive nature of the Soviet economy. Another key factor was the slump of the mid-1990s and the shift away from manufacturing industry, in particular heavy industry. Energy intensity of post-Soviet economies continued to fall during the 2000s. According to the consensus, structural change continued to play a role, although some researchers consider that, particularly in 2005-07, investment growth and the introduction of new technologies may have played some part.[19] Government policies on energy efficiency and climate change made little impact, however. The only success of government policy in this regard noted in surveys by international organisations was in Belarus, which made reducing its dependence on imported energy a policy priority, established energy efficiency institutions with a clear mandate, and financed more than $4 billion in energy-saving measures between 1996 and 2008 – measures which contributed to a 50% fall in energy intensity of the economy in that time period.[20] Ukraine also passed laws on energy efficiency and climate change – significantly, the law "on energy saving" of July 1994 and the law on alternative energy of 2003 – and set up a national commission on ecological investment, although these were slow to produce tangible effects.

In Russia, government policy shifted in 2008-09. Before then, international organisations had identified the lack of central government action as an obstruction to progress on energy efficiency and climate change issues. The UNDP said that, while the Russian parliament had passed a federal law "On energy saving" in April 1996, the issue of energy efficiency had "received less and less attention after the 1998 crisis"; government policy was "fragmentary"; the administrative reform of 2004 had "almost completely excluded" energy efficiency from the federal government's responsibilities; and it had been regional governments – 43 of which had passed local legislation, 53 of which had imposed construction standards and 75 of which had set up special funds or agencies to take action – rather than Moscow, that had acted as "pioneers in many aspects of energy efficiency".[21]

But in June 2008, the Russian government began to move to clarify energy efficiency policy with a decree by president Medvedev that called for measures to reduce energy intensity of the economy by 40% by 2020, compared to 2007. This was followed by the passing of a law "On Energy Saving and Improvement of Energy Efficiency" in 2009 and the adoption in late 2010 of a *State Programme on Energy Saving and Energy Efficiency Improvement to 2020*.[22] The law requires incremental regulation of incandescent lamp use, culminating in an outright ban in 2014; energy audits by state-owned and state-regulated companies, the first of which is

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[19] EBRD/Grantham Research Institute, *The Low Carbon Transition* (April 2011), p. 13; UNDP Russia, *National Human Development Report in the Russian Federation 2009: Energy Sector and Sustainable Development* (Moscow 2010), p. 90; World Bank, *Lights Out? The Outlook for Energy in Eastern Europe and the FSU* (Washington, 2010), p. 49.

[20] World Bank, *Lights Out?*, p. xxvi.

[21] UNDP Russia, *National Human Development Report 2009*, pp. 91-92.

[22] The Russian government, *Federal'nyi zakon RF No. 261-FZ ot 23.11.2009 g. "Ob energosberezhenii i o povyshenii energeticheskoi effektivnosti"*, web site of the ministry of economic development of the Russian federation; the Russian government, *Gosudarstvennaia programma RF "Energosberezhenie i povyshenie energeticheskoi effektivnost' na period do 2020 goda"* (27 December 2010, no. 2446-r). For commentary, see S. Charap and G. Safonov, "Climate change and the role of energy efficiency", in A. Aslund, S. Guriev and A. Kuchins (eds.), *Russia After the Global Economic Crisis*, pp. 125-150), (Peterson Institute for International Economics, Washington, 2010).

due at the end of 2012; installation of water, power and heat meters in housing; and energy labelling of household appliances. It also sets aside federal funds for public awareness and education campaigns and subsidies for energy-efficient technologies. Throughout 2010-11 president Medvedev referred repeatedly to energy-saving as an integral part of the modernisation of the economy. Having signed the Climate Doctrine prior to the Copenhagen conference in 2009, he linked energy-saving to climate change issues, over which Russian public opinion has become much more concerned in recent years.

The adoption of laws and issuing of decrees does not of course mean that change is being implemented. Nevertheless, some practical measures have been taken. First, the government has pressed ahead, albeit cautiously, with tariff reform not only in the gas market (see below, page 25) but also in electricity and heat. Second, a law "on heat supply" was passed in mid 2010 (see Section 2.e, page 68, below), in an effort to push ahead with change in one of the most energy-intensive sectors. Third, the government took action in 2009-10 to reduce natural gas flaring from oil production, one of the most damaging sources of carbon emissions (not considered in detail in this paper, which focuses on consumption).

In Ukraine, a National Agency for the Effective Use of Energy Resources was set up in 2006 to centralise energy-saving and energy efficiency initiatives at national level. Government has yet to achieve a significant breakthrough on district heating and municipal services reform, the single most important issue for energy efficiency (see Section 2.e, page 66, below); on the other hand, against a background of rapidly rising prices of imported gas, movement has begun towards the development of alternative fuels. In 2009 a "green feed-in tariff" was introduced for electrical power generated from wind, solar and hydro sources. While generation from these sources is at present insignificant, major companies have decided to invest: DTEK, Ukraine's largest power generator, has begun construction of a €300 million wind park, and a joint venture part-owned by Fuhrlander of Germany is working on a pilot project.[23]

Outside of Russia, Belarus and Ukraine, energy efficiency and climate change policies are likely to be of limited importance. In the Caucasus, energy efficiency concerns contributed to changes in pricing and consumption patterns in Azerbaijan mentioned above. In central Asia, Kazakhstan has recently identified energy saving as a key goal of energy policy,[24] although it is too soon to see any results. Other governments in the region have not identified it as a priority.

In terms of climate change mitigation policies, Russia and Ukraine are both Annex 1 countries under the Kyoto treaty and have in recent years begun to approve projects under the joint implementation scheme, which provides for investment in emissions reduction projects that generate tradable emissions reduction units (ERUs). The two countries between them

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[23] DTEK, *Annual report* 2009, p. 76; German Ainbinder, "Tol'ko desiat' protsentov", *Delovaia stolitsa*, 10 November 2010; "DTEK postroi vetrovuiu elektrostantsiu", *ESKO journal* October 2010; Oleksandr Kudrydyk, *Ukrainian Legislation on Green Tariff* (presentation), March 2011.

[24] The government of Kazakhstan, *Programma po razvitiiu neftegazovo sektora v Respublike Kazakhstan na 2010-2014 gg*. (Astana, October 2010); IEA, *World Energy Outlook 2010*, p. 484.

host more than half of the projects (by value in ERUs) registered by the UN Framework Convention on Climate Change (UNFCCC). Some associated gas recovery projects and gas pipeline upgrade projects are included; these reduce emissions of methane, which has a greater greenhouse effect than carbon dioxide, and therefore earn a greater return in terms of ERUs.[25] Few other countries in the region have adopted any active stance on climate change. For example the region lags far behind others in implementing clean development mechanism (CDM) projects under the Kyoto treaty: of the nine CIS region countries eligible to use CDM (all except for Russia, Ukraine and Belarus), only Uzbekistan (10 projects), Moldova (4) and Georgia (2) have done so.[26] Under the Copenhagen Accord of 2009, the only CIS countries to make commitments on emissions reductions were Russia, Ukraine, Belarus and Kazakhstan; Armenia and Georgia provided information to the UNFCCC on appropriate mitigation actions, but did not include quantitative targets.[27]

As for the results of energy saving and energy efficiency policies, both governments and international organisations have published extremely high estimates of what could be achieved. For Russia, a widely-quoted World Bank report stated that energy consumption could be cut by 45%, which would include an *annual* saving of 240 bcm of gas, 340 bn kwh of electricity, 89 million tonnes of coal and 43 million tonnes of crude oil and oil products.[28] The Russian government's *State Programme on Energy Saving and Energy Efficiency Improvement to 2020* envisages a total saving of 1,124 million tonnes of standard fuel[29] in 2011-2020, including 108 bcm of gas in 2011-2015 and 330 bcm of gas in 2011-2020. For Ukraine, the government's Energy Strategy predicts energy savings of 223 mtoe by 2030.[30] While such impressive numbers underline the tremendous potential of energy efficiency and energy saving, they should not be considered an accurate guide to future events, particularly in the timescales mentioned.

This paper, rather than discussing theoretical possible savings – which are undoubtedly very large, and desirable for human development and global warming mitigation – will focus on the changes already taking place, and changes that may soon take place. The main conclusion in this regard is that even small steps in the direction of energy efficiency and energy-saving will, together with price and market reform, influence gas consumption patterns over the next decade; significant changes in policy and institutional frameworks could also make a significant difference.

[25] UNFCCC joint implementation projects web site, <http://ji.unfccc.int/index.html>

[26] UNFCCC clean development mechanism web site, <http://ji.unfccc.int >

[27] IEA, *World Energy Outlook 2010*, p. 468.

[28] World Bank, *Energy Efficiency in Russia*, p. 35.

[29] Tonnes of standard fuel are a common measure of energy content used in former Soviet countries. See Appendix 1 for conversion factors.

[30] *Gosudarstvennaia programma RF "Energosberezhenie i povyshenie energeticheskoi effektivnost' na period do 2020 goda"* (27 December 2010, no. 2446-r), pp. 6-7; The Ukrainian government, *Energy Strategy of Ukraine for the Period Up to 2030*, pp. 82-91.

Prices

Changing gas prices are a significant factor in determining consumption patterns. They play a key role in shaping both producers' investment decisions (including investments in efficiency in production, transportation and distribution) and consumers' choices of fuel, as well as decisions on investment in efficient consumption. The long-term trend in the CIS region is towards higher prices, in the context of the move away from subsidies that originate in the Soviet period and towards market relationships.[31]

Since the mid 2000s, in line with market reforms, the Russian government has embraced the principle that prices (i) in the domestic market, and (ii) of gas sold to CIS importers (Ukraine, Belarus, Moldova, Georgia and Armenia), should rise to the European netback level, i.e. the equivalent of prices paid for Russian exports to customers in the EU, minus the extra transport costs. The government of Ukraine has also accepted the European netback principle, and other importers have accepted either this or some other method of liberalising prices, at least for industrial customers. In central Asia, governments have in price negotiations sought – and gone some way towards achieving – European netback prices for the gas they export to and through Russia; domestic prices, though, remain largely regulated and heavily discounted.

The most significant step towards liberalisation was taken by the Russian government in November 2006, when then president Putin announced that a timetable would be put in place to raise prices to European netback levels. In May 2007 the government decided that domestic prices would move up in stages, and that by early 2011 gas sold by Gazprom and its affiliates "on contracts (including long-term) to all consumers (except the population [i.e. the residential sector])" would be priced at European netback, i.e. according to the principle of "equal profitability of gas supply to domestic and foreign markets". The timetable for the transition was pushed back several times, and in mid 2009, government decided that the principle of "equal profitability" would be implemented in 2014. Further postponements are possible, even likely, although in December 2010 the government reiterated the pace of change up to 2014 and instructed ministries to work out a framework for liberalisation of supply and transit tariffs.[32] The aim of using the principle of European netback to price Russian and central Asian gas sold to the western CIS importers (Ukraine, Belarus and Moldova) has proved just as challenging to implement. In 2006-09, European gas prices, which are themselves linked to oil prices, rose extremely rapidly; this exacerbated the tension over import prices between Russia on one side and Ukraine and Belarus on the other, fanning the flames of the so-called "gas wars".[33]

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[31] The international financial institutions have put rising energy prices at the centre of their policy advice to all post-Soviet states. See, for example, World Bank, *Subsidies in the Energy Sector: An Overview* (Washington, July 2010).

[32] The government of Russia, Postanovlenie n. 333 "O sovershenstvovanii gosudarstvennogo regulirovaniia tsen na gaz", 28 May 2007; Gazprom, *Godovoi otchet 2009*, pp. 65-66; Postanovlenie no. 1205 "O sovershenstvovanii gosudarstvennogo regulirovaniia tsen na gaz", 31 December 2010.

[33] See Simon Pirani, Jonathan Stern and Katja Yafimava, *The Russo-Ukrainian Gas Dispute of January 2009: a comprehensive assessment* (OIES, 2009); Katja Yafimava, *The 2007 Russia-Belarus Gas Agreement* (OIES, 2007) and Jonathan Stern, *The Russian-Ukrainian Gas Crisis of January 2006* (OIES, 2006)

The progress and results of the European netback policy have been dealt with in other publications of our research programme; work is also in progress about the likely evolution away from oil linkage by European gas prices themselves, and the implication for the CIS region that, by the time the goal of European netback is reached, the dynamics of European prices themselves may have been transformed.[34] For this paper, the important developments are likely to be: (i) that prices for power sector and industrial consumers will continue to move upwards, probably reaching levels equivalent to those in Europe at some time in the second half of this decade (in Russia and Belarus), or sooner (in Ukraine, where they are already close to that level); (ii) that increasing prices for district heating companies and for residential customers is politically extremely sensitive, due to fears of popular opposition, and prices will remain below market levels in those sectors for longer; (iii) that price changes are already impacting consumption patterns and efficiency investments, most obviously in industry.

Table 10 summarises the price rises already implemented in Russia and the western CIS.

Table 10: Russian and Western CIS Gas Sales and Import Prices, 2003-2011

All prices in dollars/mcm	2003	2004	2005	2006	2007	2008	2009	2010	2011 (proj.)
Russia industry, wholesale	24.7	31.7	35.51	40.58	52.81	67.87	64.80	82.60	85.58
Russia households, wholesale	16.3	20.8	25.61	31.72	40.27	51.85	49.47	63.43	75.28
Ukraine import prices	**n/a**	**n/a**	**77**	**95**	**130**	**179.50**	**236.10**	**255.20**	**264#**
Ukraine industry (state-regulated, net of VAT)	45.83	58.78	69.11	107.3	142.6	192.5	251.50	258.90	287.03 #
Ukraine households (state-regulated, net of VAT)	n/a	30.5	30.5	67.16	57.4	52.35	56.54	70.25	83.98#
Belarus import prices	**34.37**	**46.68**	**55.08**	**55.08**	**118**	**125**	**150**	**187**	**223#**
Belarus wholesale (Beltransgaz)	41.36	54.82	59.54	58.87	n/a	n/a	n/a	n/a	n/a
Belarus retail/households (Beltopgaz)	50.89	67	72.3	75.16	141.7	171.3	205.50	278.50	n/a
Moldova import prices	**80**	**80**	**80**	**160**	**170**	**232**	**238**	**265**	**n/a**
European border price	**147.60**	**157.80**	**213.70**	**285.20**	**294.10**	**418.90**	**307.80**	**323.70**	**n/a**
# these are prices paid in the first quarter of 2011									

Notes/sources. Prices are indicative only. Currency conversions by author, using annual average exchange rates published by EBRD. Prices changed twice during the year in Ukraine in 2006, 2008 and 2010 and in Belarus in 2003 and 2010; values quoted are indicative annual averages, estimated by the author. Russian wholesale prices are published by the federal tariffs service; Ukraine, author's estimates using regulatory commission information; Belarus, and Moldova, from Katja Yafimava, *The transit dimension of EU Energy Security* (OUP, forthcoming 2011); European border price, Howard Rogers (OIES).

[34] See, in particular, Howard Rogers and Jonathan Stern, *The Transition to Hub-Based Gas Pricing in Continental Europe* (Oxford, OIES, March 2011).

Several points stand out. First, the very sharp increase in prices already implemented for Ukrainian industrial customers, and the wide differential between prices for industrial and residential customers in Ukraine. Second, the considerable discount on Belarussian import prices, on account of Belarus's membership of the Customs Union with Russia and sale of transport assets to Gazprom. Third, the steady upward trend of prices in Russia itself. And fourth, the fact that after the financial and economic crisis of 2008-09, domestic prices have continued to rise in dollar terms despite the considerable devaluation of the Russian and Ukrainian currencies. Also notable is that the crisis, while it has heightened concerns by governments in the region about the political difficulties of increasing prices in the residential and district heating sectors, has not led to any substantial change in the policy of moving prices upwards towards liberalised levels. Again the most important factor here is the pace of price rises in Russia. Government projections up to 2013 are shown in Table 11; at the time of writing (June 2011), these are under discussion in Russian government with a view to possible downward revision of tariff increases for industrial customers, to a level at or slightly above the level of inflation.[35]

Table 11: Actual and Projected Wholesale Price Increases in Russia, 2006-2013

		Actual					**Projected**		
		2006	2007	2008	2009	2010	2011	2012	2013
Wholesale regulated prices of gas, per mcm									
Russia industry	rubles	1104	1352	1690	1957	2478	2850	3277	3769
	dollars	40.58	52.81	67.87	64.80	82.60	85.58	113.00	129.95
	Ruble % incr. from year before		*22.5*	*25*	*15.8*	*26.6*	*15*	*15*	*15*
Russia households	rubles	863	1031	1291	1494	1903	2228	2656	3055
	dollars	31.72	40.27	51.85	49.47	63.43	75.28	91.59	105.33
	Ruble % incr. from year before		*19.4*	*25*	*15.8*	*27.3*	*17.1*	*19.2*	*15*
Exchange rate, annual average		27.2	25.6	24.9	31.7	30 est	29 est	29 est	29 est
European border price, dollars		285.2	294.1	418.9	307.8	323.7			

Sources: Federal Tariff Service web site (average prices up to 2010); ministry of economic development projections (up to 2013); author's calculations

The effects of rising prices in the power sector and in industry are discussed in the relevant sections below. It remains to comment on the difficulties of raising prices in the residential and district heating sectors. In Russia, as Table 11 shows, prices for residential customers have risen gradually but steadily. The regulated wholesale prices for gas destined for the residential sector rose in ruble terms by 15-27.5% each year between 2006 and 2010, and are projected by the economic development ministry to rise by 15-20% per year in the period up to 2013. The price-setting policy has maintained a discount of about one-fifth on wholesale prices for the industrial sector, and this is also projected to continue. Nevertheless, the government has allowed itself considerable flexibility to adjust the pace of tariff increases for

[35] Dmitrii Kaz'min, "Tarif 'Putinskii'", Vedomosti, 22 April 2011; Russian ministry of economic development and trade, *Iskhodnye usloviia dlia formirovaniia variantov razvitiia ekonomiki na period do 2013 goda (prilozhenie)*, April 2011.

residential consumers. The 2007 decision to move prices to European netback specifically excluded gas for residential customers from this principle, and Gazprom reiterated in 2011 that the price reform policy "does not apply to the population", and that prices in that sector would continue to be regulated with reference to the inflation rate only.[36]

The caution stems from concern about popular opposition to tariff increases. During the economic boom of 2002-08, protest movements of all kinds were at quite a low ebb – but the one national wave of street demonstrations, which led to an adjustment of government policy, in January 2005, concerned the reorganisation and partial withdrawal of welfare benefits. It is assumed that too-rapid increases in the prices of gas, heat, water and other municipal services – viewed by most families in a similar light as the welfare benefits, i.e. as well-deserved concessions from the government – might cause a similar reaction. A significant example of concerns about political risk arising from tariff reform is that of Kyrgyzstan, where attempts by the government to accelerate electricity tariff rises in early 2010 was a key cause of widespread civil disturbances.[37]

In Ukraine, a programme of accelerated price increases for residential gas customers has been decided upon by the government, as part of a series of revenue-raising measures agreed with the International Monetary Fund (IMF). The Fund mounted a major stand-by programme for Ukraine following the economic and financial crisis of 2008-09, and entered into negotiations with the government about reducing the consolidated budget deficit, which in 2009 was 8.8% of GDP, including Naftogaz Ukrainy's operational deficit, which was about 2.5% of GDP. Regulated gas tariffs for residential consumers were raised by 50% in August 2010, in accordance with the government's commitments to the IMF. A further 50% increase was scheduled for April 2011 but, subsequently, the Fund's representatives agreed that it would be implemented in stages: 10% in April, 20% in June and the remainder later in the year. As part of its policy aimed first at reducing Naftogaz's operational deficit to zero, and second at starting market reform of the gas sector, the government is committed to increases in gas prices paid by households and district heating companies that "will continue until domestic price levels reach import parity"; thereafter, gas prices will be "adjusted as needed to reflect market prices".[38] However the staggering of the tariff increases proposed for 2011 once again underlines the caution with which governments in the region approach the issue, because of their concerns about popular opposition. Further postponements and delays in implementing price reform policies are likely.

In Russia and Ukraine, in the district heating sector in particular, the effect of rising prices has been blunted by the return since the 2008-09 economic crisis of non-payment for gas, a problem that was rampant in the 1990s but that had disappeared almost entirely in the mid 2000s. District heating companies, whose own heat tariffs are usually regulated and do not

[36] Postanovlenie no. 333; *Gazprom v voprosakh i otvetakh* (2011 edition), p. 51.

[37] A recent survey of this issue in Russia is: Indra Overland and Hilde Kutschera, "Pricing Pain: Social Discontent and Political Willpower in Russia's Gas Sector", *Europe-Asia Studies* (2011) 63:2, pp. 311-331. On Kyrgyzstan, see IEA, *World Energy Outlook 2010*, p. 474.

[38] The government of Ukraine, *Memorandum of Economic and Financial Policies*, August 2010, and letter to Dominique Strauss-Kahn (managing director, IMF), 10 December 2010; Ukrainska Pravda, "MVF soglasovalsia na bolee postepennoe povyshenie tarifov", 31 March 2011.

always cover costs – and who know that it is politically and legally difficult to cut them off – allow large arrears to build up to their gas suppliers. In Russia, the director of Mezhregiongaz, Gazprom's domestic sales subsidiary, reported after the winter of 2009-10 that non-payment was at 8% across all sectors, but at 11.9% in the district heating sector, with aggregate bills of 13.7 billion rubles ($472 million). In Ukraine, the problem is more serious: Naftogaz Ukrainy reported in February 2011 that since the previous October, 5 billion hryvna ($620 million) of arrears had built up in the district heating sector, where the non-payment rate had reached 57%.[39]

Belarus faces similar pressures to Ukraine, as a result of rising import prices. While tariffs for residential consumers are among the highest in the CIS (see Table 10 above), the government has attempted to use various measures, such as discounts, delayed invoicing and scrapping the mark-up for the gas transport company Beltransgaz – a measure opposed by Gazprom, its part-owner – to protect industry from the effects.[40] The smaller importers (Moldova, Georgia and Armenia) all now pay prices linked to those in Europe, although Armenia secured lower prices by means of a deal that gave Gazprom a controlling stake in its gas transport company. Azerbaijan's prices were increased sharply in 2007, as mentioned above.

In central Asia, prices remain far below those in the rest of the CIS. In Kazakhstan, in contrast to Uzbekistan and Turkmenistan, the issue of raising prices is under discussion. In 2007, Kazakh domestic wholesale gas prices averaged $32-60/mcm (and were due to rise to $85/mcm in 2008). But the government's plan for oil and gas industry development, published in 2010, stated that the move towards liberalisation of prices in the Russian market made necessary "the preparation of gradual liberalisation of gas prices" in Kazakhstan; the intention is expressed to set prices "on the basis of price levels on the European market, minus transport costs, minus an additional 20-25%". In Uzbekistan, tariffs remain below cost recovery levels, and in Turkmenistan gas continues to be supplied to residents free of charge.[41]

Market structure and reform

In Russia, Ukraine, Moldova and Georgia, gas sector market reform is underway; limited reforms are proposed in Kazakhstan; in other CIS states market structure has not changed fundamentally. The reforms aim to replace the hybrid system of recent years with a market system, some elements of which will remain regulated. In Russia and Ukraine, as well as the reorganisation of national gas companies, the reform of the distribution sector – which is dominated by regional gas companies (oblgazy, i.e. *oblast'* (administrative district) gas companies) that are usually owned by the national energy companies – is envisaged.

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[39] Stenogramme of Gazprom press conference, "Postavok gaza na vnutrennii rynok", 21 June 2010; Naftogaz Ukrainy press release, "Dolga predpriiatii TKE", 15 February 2011

[40] Katja Yafimava, *The June 2010 Russian-Belarusian Gas Transit Dispute: a surprise that was to be expected* (Oxford, OIES, July 2010).

[41] The government of Kazakhstan, *Programma po razvitiiu neftegazovogo sektora v Respublike Kazakhstan na 2010-2014 gody* (Astana, 2010). Prices for 2007 from Pirani (ed.), *Russian and CIS Gas Markets*, relevant chapters.

In ***Russia***, the gas market is divided into regulated and unregulated sectors. In the regulated sector, the government regulates the wholesale prices of gas sold by Gazprom and its affiliates (which account for about 75% of the wholesale market by volume); tariff rates for transmission via high-pressure and low-pressure pipelines; and charges for supply and marketing services. The price charged to customers includes all of these elements. Limits are set by Gazprom on the volumes made available to industrial customers at regulated prices, but information about how this is decided is not made public. From 2007, rules were introduced allowing Gazprom and its affiliates to sell a proportion of gas at prices higher than the regulated prices up to a fixed price ceiling, to new customers and to those requiring extra volumes of gas in addition to those contracted before July 2007. Gazprom stated that in 2009 it sold 12.9 bcm under this arrangement. The government had also in 2006-08 initiated arrangements for both Gazprom and other producers to sell 10 bcm of gas on an exchange; the experiment was suspended in 2009 as a result of the sharp fall in demand for gas and the consequent fall in prices. The deregulated sector of the market, which is dominated by non-Gazprom producers selling to power and industrial sector customers, accounts for up to 25% of volumes, Gazprom has stated.[42]

Domestic sales of gas are shared between Mezhregiongaz, a 100% subsidiary of Gazprom, and traders linked to non-Gazprom producers who in recent years have raised their aggregate market share to more than 20%. In distribution, Gazprom's share appears to be around four-fifths or higher: the holding company Gazprom Gazoraspredelenie (until April 2011, Gazpromregiongaz), which is 99% owned by Mezhregiongaz, owns 214 regional gas companies that comprise the majority of Russia's distribution sector. In 2009, when 262.6 bcm was reported delivered through the Russian distribution networks, Gazprom-controlled distribution companies distributed 217.4 bcm of gas through 611,800 km of low-pressure pipelines that they managed; of these 201 bcm and 565,000 km respectively were under the Gazpromregiongaz umbrella.[43] A further 72 distribution companies are controlled by Rosgazifikatsiia, a subsidiary of the state holding company Rosneftegaz; at the time of writing, the transfer of these to Gazpromregiongaz is expected soon; Gazeks, a third group controlled by KES-Holding, reports supplying on average 27.5 bcm of gas annually.[44] Gazprom's share of supply appears to be similar to its share of sales and distribution; information on numbers of customers supplied is given in Appendix 11, Table 61.

The continued regulation of transport tariffs at a low level, which limits Gazprom's revenue from transport services, has been a matter of controversy. The government has pressed for a third party access regime to be introduced; Gazprom has delayed implementing this reform and pressed for higher transport tariffs in advance. Meanwhile, the need to investment in both high- and low-pressure pipelines remains urgent. Maintenance and replacement of high-

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[42] *Gazprom v voprosakh i otvetakh* (2011), pp. 47-52

[43] Gazprom Gazoraspredelenie web site; *Gazprom v tsifrakh 2005-2009 gg.: spravochnik* (Gazprom, 2010), p. 59.

[44] The transfer of Rosgazifikatsiia assets has been delayed because it is part of a larger and complex readjustment of state-controlled assets, including the raising of the state's directly-held stake in Gazprom above 50%. Olga Mordiushenko, "Prem'er otpisal GRO 'Gazpromu'", *Kommersant* 23 November 2010; "Gazovye raspredelitel'nye kompanii – ugrozy i vozmozhnosti", *Vedomosti* 15 December 2010. On Gazeks, "TNK-BP tianet gazovye seti", *Kommersant,* 1 December 2010.

pressure pipelines, which are owned directly by Gazprom, has been one of the largest items in its investment programme in recent years, but it continues to argue that this investment is limited by the low level of transport tariffs. There is a greater problem with low-pressure networks, which are owned by distribution companies (mostly Gazprom subsidiaries). In 2007, the Russian energy ministry estimated that of 318,100 kilometres of underground steel pipes, 19,000 km were more than 40 years old and another 34,000 km more than 30 years old; the problem was "especially acute" in urban areas, with pipes serving residential apartment blocks, that usually accounted for between two-thirds and three-quarters of the total.[45]

In ***Ukraine***, the gas market also has a dominant regulated sector, in which prices are set by the National Electricity Regulatory Commission, and a smaller unregulated sector used by industrial consumers. A law on the gas market, passed in July 2010, provides for reform modelled on European Union directives, with a new independent regulator, third-party access to the pipeline system and Naftogaz being reorganised with a separate transport division financed by transport tariffs. Adoption and implementation of the law were both part of the conditions for Ukrainian accession to the European Energy Community, which it joined in 2010. Implementation of the law is proceeding, and being monitored both by the European Union, which continues to negotiate with Ukraine about financial support for renovating its transit network, and by the IMF, with which Ukraine has a major loan programme.

The Ukrainian distribution sector comprises 42 regional gas companies. Gaz Ukrainy, the domestic sales division of Naftogaz Ukrainy, has stakes in most or all of them, but not necessarily control, following partial privatisation in the 1990s. Government policy on the regional gas companies has changed several times; the government of Yulia Timoshenko decided in 2009 that they were all to be transferred to a single holding company, a division of Naftogaz; in 2010, the government of Mykola Azarov abandoned this initiative. The state statistics agency records that at the end of 2008 there were 255,198 km of low-pressure pipelines in operation, and 109,513 km of piping within residential buildings. These networks deliver all the gas consumed by Ukrainian customers, with the exception of some large industrial enterprises that have direct connections to the trunk pipelines; in 2010, 52.6 bcm of the 57.6 bcm consumed in Ukraine was delivered via the networks.[46]

The degree of change in market structure in other CIS countries is varied. Moldova and Georgia are moving towards liberalisation: Moldova has joined the European Energy Community, with a view to harmonising its market legislation with that of EU countries, and aims to create a competitive market, while it continues to regulate retail gas tariffs; in Georgia, the state-owned gas company GOGC undertakes wholesale sales and manages transport, but distribution has been privatised and retail tariffs regulated. Belarus retains a system in which the market is shared between two monopoly sellers, state-owned Beltopgaz (which is responsible for domestic retail sales and gas distribution), and Beltransgaz (the gas

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[45] *General'naia skhema razvitiia gazovoi promyshlennosti na period do 2030 goda*, p. 6-5.

[46] Naftogaz Ukrainy web site; Derzhavnyi komitet statistiki Ukrainy, *Statistichnii biuleten' pro osnovny pokazniki roboti gazovogo gospodarstva Ukrainy za 2008 rik* (Kyiv 2009), p. 21; energy ministry statistics/ *Energobiznes*

transport company). In the Caucasus and central Asia, excepting Georgia, little change has been made to market frameworks in which prices are regulated and gas transportation, distribution and supply is in the hands of state-owned companies. Changes are proposed in Kazakhstan: a draft gas sector law provides for regulated competition in supply.

1.f. Natural gas consumption statistics

Research on natural gas consumption in the CIS region is hampered by the low quality of statistical data. Most, but not all, countries in the region report data on gas consumption to the IEA, but only a few countries publish consistent or detailed sets of data. The methodology used is inconsistent: the assumed chemical characteristics, temperature and pressure of gas are often not clear; categories of consumers are defined in different ways; in some countries sections of the market are omitted; and there are some large statistical anomalies. No temperature-corrected data has been compiled for any CIS country.

The only comprehensive set of statistics available for the region is that compiled by the IEA, using data reported by national ministries and statistical agencies. These include sectoral breakdowns where available and allow comparisons between countries. These statistics have therefore been used as the starting-point in this study. But there are shortcomings in the data reported to the IEA: for example, as noted above, in Russia there are significant differences – sometimes running to tens of bcm/year – between IEA data and data used by Gazprom. Other obvious problems are that the Kazakh data appear to reflect inconsistent reporting of reinjected and flared volumes; the Ukrainian data overstates volumes for heat plants; and reports to the IEA from Uzbekistan, the region’s third-largest consumer, and Turkmenistan, its second-largest producer, are insufficiently detailed to allow clear categorisation of consumers.

Conversion factors used are explained in Appendix 1. Appendix 6 lists the data consulted by the author, compares data published by national statistical agencies with those published by the IEA and discusses the significant differences.

In the Sections that follow, covering consumption by different end-use sectors, the data reported to the IEA is compared with other available data. The reader should bear in mind, however, (a) that the data have the inherent limitations just mentioned; and (b) that measures of efficiency of gas consumption are marked by inconsistencies far greater than those in the measures of volumes consumed.

2. Power and heat

The largest consumer of natural gas in the CIS region is the power and district heating sector. Gas is consumed by (i) gas-fired thermal electricity plants, most of which produce heat as a by-product; (ii) heat-power centres (*teploelektrotsentraly*), i.e. gas-fired combined heat and power plants (CHPs), built mostly in Soviet times in urban areas, sometimes at large industrial plants and sometimes supplemented by boilers at the same site, that supply electricity to the grid and heat to district heating systems and often to industry; (iii) centralised gas-fired boilers for district heating systems; and (iv) decentralised gas-fired boilers. This section will look at the power and district heating sector as a whole, and then the parts separately – because, while some power stations produce electricity and not heat, most produce both, and while most heat is produced by heat-only sources, more than one third of it is produced from electricity plants as a by-product, or by CHP plants.

The discussion will touch on a key cause of inefficient gas consumption, i.e. the way that Soviet urban infrastructure – of which CHP-supplied district heating systems were a key element – expanded rapidly in the 1960s and 1970s, on the assumption that cheap fuels would be available over the long term. This turned out not to be the case. Future consumption trends will be shaped in part by the way that that infrastructure is modernised and replaced.

This section will, first, present an overview of gas consumption for power and heat, and then the available statistics. Then it will cover, in turn, the Russian power sector and the impact of its reform; the power sector outside Russia; and the heat sector and prospects for its reform.

2.a Gas for power and heat: overview

The place of gas in the fuel balance in the power and heat sector is reflected in the IEA's data as follows. For the three largest CIS gas consumers – Russia, Ukraine and Uzbekistan – fuel consumption by power plants, CHP and boilers is reported separately. This information is presented in Table 12. The IEA's methodology counts as CHP not only the purpose-built CHP plants (*teploelektrotsentraly*), but also many larger power plants that produce heat as a by-product. Nevertheless, the breakdown into the three sub-sectors adds important detail.

Belarus and Moldova also report consumption by these three sub-sectors separately. However the other seven countries in the region only report to the IEA undifferentiated information about the fuel balance for the energy sector as a whole. (This is displayed in Table 42, in Appendix 4, in the rows for "heat and power sector".)

Table 13 shows the shares in electricity and heat produced of different energy sources, as percentages. It is derived from the rows showing "electricity produced" and "heat produced" in Table 12.

Table 12: Gas in the Fuel Balance in Russia, Ukraine and Uzbekistan, 2008

All values in 000s of tonnes of oil equivalent (rounded)		**Coal & peat**	**Crude oil**	**Oil products**	**Gas**	**Nuclear**	**Hydro**	**Geotherm, solar etc**	**Combust, renwable, waste etc**		**Total**
RUSSIA											
Electricity plants											
Energy consumed		0	0	661	2079	42501	14170	400	0		59811
Electricity produced		0	0	151	477	14025	14170	40	0		28863
CHP plants											
Energy consumed		61762	10	4974	151954	328	0	0	1614		220642
Electricity produced		16920	1	1232	42069	0	0	0	219		60442
Heat produced		17621	5	1707	42570	328	0	0	803		63034
Heat plants											
Energy consumed		13634	722	6220	58057	0	0	0	2204		80837
Heat produced		11930	629	5641	50551	0	0	7801	1940		78492
UKRAINE											
Electricity plants											
Energy consumed		18402	0	171	1297	23413	979	4	0		44266
Electricity produced		5714	0	55	415	7726	979	4	0		14894
CHP plants											
Energy consumed		584	0	11	5628	0	0	0	0		6223
Electricity produced		174	0	4	1480	0	0	0	0		1658
Heat produced		302	0	6	2826	0	0	0	0		3133
Heat plants											
Energy consumed		378	0	1	15217	0	0	0	0		15596
Heat produced		130	0	1	9557	0	0	0	0		9688
UZBEKISTAN											
Electricity plants											
Energy consumed		471	0	183	5213	0	977	0	0		6844
Electricity produced		114	0	61	1608	0	977	0	0		2759
CHP plants											
Energy consumed		406	0	234	5330	0	0	0	0		5970
Electricity produced		60	0	65	1365	0	0	0	0		1489
Heat produced		106	0	61	1027	0	0	0	0		1194
Heat plants											
Energy consumed		1	0	34	1630	0	0	0	0		1665
Heat produced		1	0	17	1143	0	0	0	0		1161

Source: IEA energy balances for 2008

Table 13: The Share of Fuels in Electricity and Heat Output, 2008

		Coal & peat	Crude oil	Oil products	Gas	Nuclear	Hydro	Geotherm solar etc	Comb-ust. renw., waste etc
Russia	Electricity produced	18.9%	0	1.5%	47.6%	15.7%	15.9%	0	0.2%
	Heat produced	20.9%	0.4%	5.2%	65.8%	0.2%	0	5.5%	1.9%
Ukraine	Electricity produced	35.6%	0	0.3%	11.4%	46.7%	5.9%	0	0
	Heat produced	3.4%	0	0	96.6%	0	0	0	0
Uzbekistan	Electricity produced	4.1%	0	3.0%	70.0%	0	23.0%	0	0
	Heat produced	4.5%	0	3.3%	92.1%	0	0	0	0

Source: IEA/Table 12; author's calculations. Rows may not add up due to rounding
Note. These are the shares of the energy content of electricity and heat output from the different fuels and energy sources, not shares of the fuel balance

The key points about the fuel balance for power and heat are:

In ***Russia***, gas is completely dominant in the production of both electricity and heat. Table 13 shows that, in 2008, gas produced 47.6% of all electrical power and 65.8% of heat produced – including 35.7% from gas-fired boilers. Coal is the second most important fuel: coal produced 18.9% of electrical power and 20.9% of heat energy, including 8.4% of heat produced by coal-fired boilers. Nuclear and hydro power stations accounted for 15.7% and 15.9% of the electricity produced.

The pattern of fuel consumption in Russia's thermal power stations is differentiated geographically. In the European part of Russia, including the Urals, almost 80% of thermal power station capacity runs on gas or diesel oil; in Siberia and the Far East, where there are large coal resources, 80% of thermal plants run on coal. An important determinant of future gas demand is the way in which outdated plants are replaced, and new ones built. Decisions about this depend not only on the relative future prices of gas and coal, but also on transport costs and infrastructure. This issue is discussed below in section 2.c.

An unexplained anomaly arises from the IEA statistics on Russian power generation. The energy consumed and electricity produced by gas-fired electricity plants (i.e. those with no heat output), 2,079 mtoe and 477 mtoe respectively, suggest unfeasibly poor efficiency (22.9%). This is discussed below in section 2.b, under the heading "Measures of efficiency", page 47.

Ukraine does not share Russia's dependence on gas for electricity generation. Most of its electricity plants are nuclear (accounting for 46.6% of electricity produced in 2008) or coal-fired (36.3%, including a small number of coal-fired CHP plants). Gas-fired CHP and gas-fired power plants jointly contribute only 11.4%. This is because eastern Ukraine has significant coal resources, while the western part of the country inherited nuclear power stations from the Soviet Union. But for producing heat, Ukraine's dependence on gas is far greater: in 2008 gas-fired CHP contributed 22% of heat produced, and gas-fired boilers a further 74.5%. Indeed district heating systems are a key factor in Ukraine's over-dependence on imported Russian gas, and in the medium to long term, reform of it will be a key means of reducing Ukraine's gas consumption.

Uzbekistan is heavily dependent on gas for both electricity generation and heat, and uses it more inefficiently by all measures than either Russia or Ukraine. Table 12 indicates that in 2008 gas-fired power plants contributed 37.8% of Uzbekistan's electricity, and gas-fired CHP a further 32.1%, a total of 70%. A further 23% came from hydro and 4.1% from coal (including both power stations and CHP by the IEA's definitions). Uzbekistan's reliance on gas for producing heat is just a little lower than Ukraine's: 43.6% came from gas-fired CHP and 48.5% from gas boilers, a total of 92.1%. Uzbekistan's great advantage over Ukraine is that it is burning its own gas, rather than buying it at steadily increasing prices. (The IEA statistics for Uzbekistan are less exact than for other countries, as the Agency has for the last several years extrapolated fuel consumption balances from other information.)

In ***Kazakhstan***, more than three-quarters of the energy for the power and heat sector is provided by coal; gas provides almost all of the rest, and its share is expected to grow. In ***Turkmenistan***, all power and heat is produced from gas. (The IEA data do not reflect the heat outputs; see Appendix 6, Table 50.) Gas is the main fuel for power and heat in ***Azerbaijan,*** with oil products also playing a role; ***Belarus*** is almost completely gas-dependent, and ***Moldova*** completely gas-dependent. In the other smaller countries in the region, gas's role is less significant. In ***Armenia***, gas is second in importance to nuclear energy for power and heat. ***Georgia, Kyrgyzstan*** **and** ***Tajikistan*** rely for power and heat mainly on hydro, with gas providing about one third, one quarter and one eighth respectively of the energy inputs.

In the decade up to 2008, gas consumption by the heat and power sector overall rose by 23% across the region, twice as fast as consumption by industry (see Table 7 in Section 1.d, page 12, above). This was the most significant element in the growth of consumption in that decade. Changes in consumption by the heat and power sector will probably be the most important factor in determining the level of consumption in the 2010s and 2020s.

Historical background

The history of the power and heat sector in Soviet times provides important context for its present and future. Although urbanisation, industrialisation and electrification were key themes in the Soviet Union from its inception in the early 1920s – when Lenin coined the slogan "communism = soviet power + electrification" – here we can start from the post-second world war period. Urbanisation, industrialisation and electrification picked up again in the 1950s. Coal was the main energy source at first, but after the development of the Shebelinka gas field in Ukraine in the late 1950s, natural gas accounted for a steadily increasing proportion of the fuel balance.

The rapid spread of CHP plants was an integral part of urbanisation. These very often supplied electricity and heat for large industrial works and served simultaneously as a heat source for neighbouring towns. Throughout the late Soviet period (i.e. the 1960s to the 1980s), the share of CHP-produced heat consumed by industry was usually much greater than that consumed by the residential sector. Nevertheless, the innovation of CHP – which replaced small boiler houses that were often obsolete and burned low-grade fuel – was of great social importance, being associated with other improvements in living standards. During the 1980s, there was a steady increase in natural gas consumption to produce power and heat, in power consumption (by more than one quarter) and in heat consumption (by about one-fifth). Replacement fuels were sought for oil products, as oil exports rose and domestic consumption was reduced. The coal and nuclear sectors failed to develop as effective substitutes, and gas became the dominant fuel. Moreover, the share of CHP rose, both in electricity production and in heat production. In heat production, centralised heat sources became predominant; by the end of the 1980s four-fifths of heat was generated from centralised sources, and of these 46% were CHP plants.[47]

By 1990 (i.e. at the end of the Soviet period), the power and heat sector had reached a historical peak in output, relying heavily on gas. The collapse of the Soviet Union was followed by a deep economic slump in all the post-Soviet countries. Estimates of the economic contraction vary widely: in 1991-95, the Russian economy shrank by 28% and the Ukrainian economy by 53%, according to one set of statistics.[48] It is well known that, in most of the former Soviet states, the decline in economic activity led to a steep fall in electricity consumption and power stations' load factors, and to a related fall in gas consumption. It is less commonly realised that while overall heat demand fell, demand from the residential and public sectors either continued to grow, largely because of continuing urbanisation, or did not fall as fast as demand from industry. Very low prices, and poor collection rates, also persisted in many parts of the residential and public sectors. The drastic changes in the ratio of industrial to residential consumption led to a further complication for the district heating systems and the CHPs that produced heat for them. As a Russian specialist noted: "[The] increase in the demand for heating and hot water supply [...] [did] not counterbalance the great decrease in industrial heat consumption. As a result, most [CHPs] are forced to operate under off-design, complicated conditions."[49] This, in turn, produced growing competition for CHP plants from decentralised heat sources.

During the 1990s and in the 2000s, centralised heating plants lost market share to decentralised heat sources, and, specifically, CHP lost share to heat-only boilers. In Russia (the largest and most important case), between 1990 and 2001, overall heat demand fell by 370 million Gcal/year, and CHPs' share of the reduced market fell too: their aggregate output fell by 470 million Gcal/year, while that of industrial and municipal boilers rose by 100 million Gcal/year, according to one group of researchers. The trend away from CHP continued during the economic recovery of the 2000s: between 1998 and 2007 CHPs' share of the heat market in Russia fell further, from 35% to 31%, according to the IEA.[50]

[47] IEA, *Energy Balances of Non-OECD Countries* (2010 edition), p. II.52; Thane Gustafson, *Crisis amid plenty: the politics of Soviet energy under Brezhnev and Gorbachev* (Oxford: Princeton University Press, 1989), p. 8; Y.A. Zeigarnik, "Some problems with the development of combined generation of electricity and heat in Russia", *Energy* 31 (2006), pp. 2387-2394.

[48] EBRD, Selected Economic Indicators.

[49] Zeigarnik, op. cit., p. 2388-2389

[50] Alliance to Save Energy, *Urban Heating in Russia: experience from the transition and future directions* (2006); IEA, CHP/DH Country Profile: Russia, p. 6

Every time district heating companies or other users switch from centralised, CHP-supplied heat to decentralised boiler-supplied heat, the CHP tends to become correspondingly less efficient. The process is further aggravated by cross-subsidisation from industry to residential users, i.e. the availability of cheap heat generated from industrial boilers. To the frustration of district heating managers and engineers, this "boilerisation" (*kotel'nizatsiia*) is unplanned. They express concern that demand for CHP-produced heat is being eroded, by a combination of badly-designed tariff systems and an absence of investment planning. Neither in Russia nor in Ukraine has a co-ordinated approach to modernising and improving heat production yet been developed. A recent survey of the Russian heat market pointed out that the loss of market share by CHP contradicts the international trend, and that in Moscow the fall in industrial production, illogical tariff-setting and excessive estimates of heat requirements has led to the closure of district heating plants contemporaneously with the construction of new heat sources with unneeded capacity. Likewise, managers in Kyivenergo, which manages Kyiv's electricity and heat production, state that the effectiveness of the city's two large CHP plants is undermined by the lack of coordination of electricity and heat demand, and poorly-designed tariffs.[51]

The obstacles to heat sector reform and how they may be overcome are discussed below in Section 2.e. One reason that progress has been slow is that, since heat is usually delivered in the residential sector together with other municipal services (hot and cold water, electricity, gas, sewage, building services), comprehensive change is only possible in the context of general municipal services reform, which is a major challenge requiring vast financial and political resources. Heat sector reform, once it takes effect, could substantially reduce gas consumption.

While modernisation of heat supply mainly lies ahead, the electricity sector, especially in Russia, has already begun to be transformed by reforms. During 2002-08 United Energy Systems – Russia's unified state-owned power company, one of the world's largest – was broken up and largely privatised. In its place there were established the Federal Grid Company and system operator (the Central Dispatching Authority); nuclear and hydro generating companies; six wholesale generating companies (OGKs) and 14 territorial generating companies (TGKs) for thermal generation; and local distribution companies. Regulatory functions were assigned to the Federal Tariffs Service, the Federal Antimonopoly Service and other regulators. A liberalised wholesale electricity market was gradually established, and was intended to be open to competition from January 2011. Work also began on opening retail electricity markets to competition, while retaining a central role for regulated guaranteed suppliers. Probably the major challenge for the electricity sector now is managing investment in new capacity. Most generation capacity, owned formerly by the quasi-monopoly UES, was privatised in 2007-08, with stringent investment conditions attached. The new owners of electricity production assets were required under the terms of privatisation sales to build a certain amount of new capacity at specific locations; to finance

[51] I.A. Bashmakov, "Povyshenie energoeffektivnosti v sistemakh teplosnabzheniia. Chast' I. Problemy rossiskikh sistem teplosnabzheniia", *Energosberezheniia* no. 2, 2010; Aleksandr Bogdanov, "Kotel'nizatsiia Rossii: beda natsional'nogo masshtaba", *Energorynok*, March 2006, nos. 3 and 6.

these investments the new owners concluded regulated contracts for the supply of capacity (*dogovory o predostavlenii moshchnosti*) remunerating the installed capacity of their power plants at regulated prices for a ten-year period. (These regulated contracts are distinct from the capacity trade in the competitive sector of the wholesale market.) A long-term competitive capacity market was set up to provide support for investment. Within a year of privatisation, the world financial and economic crisis intervened, sharply reducing industrial production and power consumption in Russia, and prompting a revision of the government's strategic plan for power sector investment; this is discussed in Section 2.c below.

Before and during the electricity sector reform, Russian government energy strategy provided for a reduction in the share of natural gas in the fuel balance – but the share continued to increase, from 65.9% in 2001 to 68.1% in 2006, while the share of coal fell from 26.7% to 25.3%.[52] Not for the first time in the history of Soviet and post-Soviet energy policy, plans to develop coal and nuclear failed to bear fruit, and dependence on gas increased. Future attempts to undertake diversification away from gas, along with investment in efficiency, will influence gas consumption trends. These issues are discussed below in section 2.c; the power sector outside Russia is covered in Section 2.d.

2.b. Statistical information on gas for power and heat

IEA statistics on natural gas consumption in the transformation sector, excerpted from Table 2 in Section 1.a above, the most comprehensive available, are presented in Table 14. This consumption is almost all in the power and heat sector, with negligible volumes consumed for other types of transformation (in Russia and Ukraine only). As is mentioned above, only five of the 12 countries in the region have reported to the IEA any breakdown between electricity plants, heat plants and CHP – although, fortunately for our purposes, this includes the three largest gas consumers.

[52] *General'naia skhema razmeshcheniia ob'ektov elektroenergetiki do 2020 goda* (approved by the Russian government 22 February 2008), p. 4

Table 14: Natural Gas Consumption in the Transformation Sector, 2008

bcm							
2008	**Russia**	**Ukraine**	**Belarus**	**Moldova**	**Armenia**	**Az'bjn**	**Georgia**
TRANSFORMATION	264.556	26.389	15.503	1.310	0.547	5.753	0.379
Electricity plants	2.574	1.546	4.869	0.789	n/a	n/a	n/a
CHP plants	188.166	6.653	7.279	0.387	n/a	n/a	n/a
Heat plants	71.893	18.147	3.354	0.134	n/a	n/a	n/a
Heat & power sector, unspecified					0.547	5.753	0.379
Other	1.923	0.042	0	0	0	0	0
2008	**Kazakh-stan**	**Turkm-enistan**	**Uzbeki-stan**	**Kyrgyz-stan**	**Tajiki-stan**		**Total**
TRANSFORMATION	2.560	7.163	14.950	0.410	0.275		339.797
Electricity plants	n/a	n/a	6.403	n/a	n/a		16.181
CHP plants	n/a	n/a	6.546	n/a	n/a		209.032
Heat plants	n/a	n/a	2.001	n/a	n/a		95.531
Heat & power sector, unspecified	2.560	7.163		0.410	0.275		17.088
Other	0	0	0	0	0		1.965

Source: IEA energy balances/ Table 1.A above

The quantities of gas consumed are striking: just short of 340 bcm, of which 225 bcm goes to electricity and CHP plants and 95 bcm to heat plants (i.e. boilers), and 17 bcm for which no breakdown is available. Of the 340 bcm for the power and heat sector, 265 bcm, i.e. more than three-quarters, goes to Russia, 26 bcm to Ukraine, 15 bcm each to Uzbekistan and Belarus, and 18 bcm to the other eight states.

Two significant additions can be made to the information provided by the IEA statistics. First, a more accurate picture can be painted, particularly for Russia, of the types of power stations and CHP plants to which gas is supplied. As has been mentioned, the IEA's very broad classification of CHP includes power stations that produce a small amount of heat as a byproduct, as well as the dedicated heat-power centres; a more accurate breakdown is published by the Agency for Forecasting Electrical Energy Balances (APBE or *Agentstvo po prognozirovaniiu balansov v elektroenergetike*).[53] Second, in both Russia and Ukraine government and industry bodies have published additional information on gas consumption in the heating sector.

Russia

The share of each type of plant in Russia's total thermal electricity generation capacity (i.e. coal- and diesel oil-fired as well as gas-fired), at the end of 2009, is shown in Table 15:

[53] The Agency was set up by the power holding company UES in 2005. When UES was broken up in 2008 it became a subsidiary of the Federal Grid Company UES. See http://www.e-apbe.ru/.

Table 15: Russian Power Generation Capacity by Type (end 2009)

	% of total		% of total	Notes
Thermal (condensing) power stations	39.0	1200 MW blocks	0.9	Most of these produce some heat as a byproduct
		800 MW blocks	8.6	
		500 MW blocks	2.4	
		300 MW blocks	15.9	
		200 MW blocks	11.2	
Condensing blocks refurbished for steam utilisation	4.1	300T blocks	2.9	Including plants fitted with topping or bottoming cycles
		200T blocks	0.4	
		150T blocks	0.8	
Other condensing stations	2.3	KES-90 blocks	2.3	Steam pressure = 90 kgs/cm2
Heat-power centres	46.6	TETs-240	3.8	Steam from the TETs-130pp plants is reheated in industrial processes
		TETs-130	31.5	
		TETs-130pp	2.6	
		TETs-90	8.7	
Gas turbine-based plants	4.4	CCGT/condensing	0.4	
		CCGT/TETs	2.4	
		Gas turbines	1.1	
		Gas turbines/cond	0.5	
Other	3.6	Diesel-fired blocks	0.3	
		Other	3.3	

Source: adapted from APBE, *Funktsionirovanie i razvitie elektroenergetiki RF v 2009 godu*, p. 39

Broadly speaking, 45% of generation capacity is at condensing plants, 47% at heat-power centres and 4.4% is new (i.e. post-Soviet) CCGT and simple-cycle gas turbines. During the power sector reform, the condensing plants were grouped into the wholesale generating companies (OGKs), and the heat-power centres into the territorial generating companies (TGKs), while nuclear and hydro capacity were separated out into two state-owned companies. The significant exceptions are (i) that three TGKs have hydro capacity (TGK-1, for which it is 45.5% of installed capacity, YuGK TGK-8, for which it is 8.9%, and TGK-9, for which it is 1.1%); (ii) that other regional power companies – i.e. Bashkirenergo (Bashkiriia), Dalnevostochnaia gen. ko. (in the Russian Far East), Tatenergo (Tatarstan), Irkutskenergo (Irkutsk, eastern Siberia), Novosibirskenergo (Novosibirsk, southern Siberia) and Norilsko-Taimyrskaia energo (Norilsk, northern Siberia) – own a range of different types of generation assets; and (iii) the state-owned holding company, Inter-RAO, owns some generating assets, including two of Russia's pioneering CCGT plants: Severo-Zapadnaia TETs in St Petersburg and Kaliningrad TETs-2.[54] Nevertheless, in broad terms, OGKs may be taken as a proxy for condensing power stations and TGKs for heat-power centres.

[54] APBE, *Funktsionirovanie i razvitie elektroenergetiki RF v 2009 godu*, pp. 41-42

Table 16 shows the fuel consumption and output of electricity and heat in 2008. It compares the totals of fuel consumption and output presented in the IEA's energy balances with fuel consumption and output by OGKs, TGKs and other generating companies, as reported to the APBE. The final row, Residual, is the difference between the total amounts reported to the IEA and the totals reported by companies to the APBE; it presumably reflects (i) activity by companies that do not report to the APBE but are included in national statistics, and (ii) differences in statistical and accounting methods. (A company-by-company breakdown of fuel consumption and output of electricity and heat, and estimates of fuel efficiency, may be found in Appendix 7, Tables 51-53.)

Table 16: Russian Thermal Power and CHP: IEA and APBE data for 2008 compared

000 tonnes of oil equivalent		**FUEL**					**OUTPUT**		
		Gas	**Coal & peat**	**Oil prods**	**Crude oil**		**Electr-icity**	**Heat**	**Total**
IEA balances									
Thermal electricity plants		2079	0	661	0		628	0	628
Thermal CHP		151954	61762	4974	10		60223	61903	122126
Total thermal elec plants and CHP		**154033**	**61762**	**5635**	**10**		**60851**	**61903**	**122754**
APBE information									
Wholesale generation cos (OGKs)		44071	19365	483	n/a		29372	1880	31252
Territorial gencos (TGKs)		67488	17217	1757	n/a		22874	34213	57088
Other regional gencos		16237	9042	539	n/a		12766	11668	24433
Inter RAO		1470	0	0	n/a		700	100	800
Other power companies		n/a	n/a	n/a	n/a		n/a	2709	n/a
Total reported to APBE		**129266**	**45624**	**2779**	**0**		**65712**	**50570**	**113573**
Residual		***24768***	***16138***	***2857***	***10***		***-4861***	***11333***	***9181***

Source: IEA energy balances 2008; APBE, *Funktsionirovanie i razvitie elektroenergetiki RF v 2008 godu*

Table 16 again reflects the difficulties faced by researchers in reconciling different sets of statistics, as the disparities reflected in the Residual row are considerable. However, the information is still sufficient to clarify the important issue of fuel consumption, and output of electricity and heat, by condensing plants (grouped in OGKs) and centralised heat-power plants (grouped in TGKs). The shares, judging solely by the information reported to the APBE, (and summarized in Table 17) are as follows: the OGKs, i.e. the condensing plants, which consume roughly one-third of the gas (54.6 bcm) and four-tenths of the coal supplied to this sector, produce almost half the electricity but just 4% of the heat. The TGKs, i.e. the heat-power centrals, consume more than half the gas (84.5 bcm) and nearly four-tenths of the coal, and produce a little more than one-third of the electricity and two-thirds of the heat.

The share of fuel consumption and output by the OGKs and TGKs, and the physical amounts involved, are summarised in Table 17.

Table 17: Fuel Consumption and Output by Russian OGKS and TGKS, 2009

		Fuel consumption			Output	
		Gas	Coal	Oil	Electricity	Heat
OGKs	% of total	34%	42%	17%	45%	4%
	physical	54.6 bcm	48 mt	0.5 mt	342 bn kwh	18.8 m Gcals
TGKs	% of total	52%	38%	63%	35%	68%
	physical	84.5 bcm	41 mt	1.9 mt	266 bn kwh	342 m Gcals
Other **(Inter RAO, regional energy co's, etc)**	% of total	14%	20%	20%	20%	28%
	physical	22.6 bcm	22 mt	0.6 mt	152 bn kwh	140 m Gcals

Source: Table 16 and Table 51, Appendix 7
Note: the percentages are of totals reported to the APBE, rounded

It remains to inquire further into gas consumption for heat production in Russia. Here there is a noticeable disparity between the statistics reported to, and published by, the IEA, and those published by the Russian government in its *Energy Strategy to 2030*.[55] The Russian government's statement of total heat output in 2008 is more than one-third higher than the IEA's (193.8 mtoe, compared to 141.5 mtoe). The two sets of statistics are presented in Table 18. The possible reasons for the disparity are (i) that the Russian government may include in its definition heat produced by autoproducers (in many cases, industrial plants) and used on site, or delivered free, whereas the IEA's definition does not; (ii) heat produced by autonomous decentralised sources, e.g. by groups of residents in rural areas, may be counted by the government, but is not counted under the IEA definition, which includes only heat that is sold; and (iii) there may be other differences in methodology.

[55] *Energeticheskaia Strategiia Rossiia na period do 2030 goda* (approved by the government 13 November 2009), Prilozhenie #4, "Prognoz poetapnogo izmeneniia svodnogo balansa tepla Rossii na period do 2030 goda". Actual output figures for 2005 and 2008 are presented, together with forecasts up to 2030.

Table 18: Heat Production in Russia: Government and IEA data compared

All values in 000 of tonnes of oil equivalent (rounded)		Energy input	Electricity output	Heat output
IEA statistics				
Total		**301479**	**60442**	**141526**
CHP plants		**220642**	**60442**	**63034**
	Gas	*151954*	*42069*	*42570*
	Coal & peat	*61762*	*16920*	*17621*
	Oil & products	*4984*	*1233*	*1712*
	Nuclear & renewables	*1942*	*219*	*1131*
Heat plants		**80837**	**0**	**78492**
	Gas	*58057*		*50551*
	Coal & peat	*13634*		*11930*
	Oil & products	*6942*		*6270*
	Nuclear & renewables	*2204*		*9741*
Statistics from the Russian Energy Strategy to 2030				
Total				**193800**
CHP plants & other centralised sources			**n/a**	**70400**
	CHP plants		*n/a*	*60100*
	Other centralised		*n/a*	*10300*
Heat plants			**0**	**121300**
	Centralised boilers			*67600*
	Decentralised boilers			*18700*
	Decentralised autonomous			*35000*
Heat losses total				***-33400***
Final heat consumption total				***160400***

Sources: IEA energy balances and Russian Energy Strategy to 2030. Values from energy strategy converted at rate of 1 million Gcals = 100,000 toe. Note that, in the Russian Energy Strategy, the total figure given is slightly more than the sum of the amounts given for the different energy sources; the figures published have been reproduced unchanged.

Whatever the reasons for the disparity, the government's figures, while unfortunately not indicating the fuel used by the heat sources listed, point up some key issues about heat production, including: (i) the widespread use of heat sources by industry, including many that also supply residential users; (ii) the large number of decentralised heat sources, most of them autonomous boilers for industrial or residential users; and (iii) the very high level of heat losses, which the government estimates at 33.4 mtoe (which e.g. in Russian boilers would take at least 40 bcm of gas to produce) annually. These points will be further addressed in Section 2.e below.

Ukraine

In Ukraine, it is possible to draw at least a general picture of fuel consumption in the power and heat sector from statistics compiled by the ministry of fuel and energy. As with Russia, there are substantial discrepancies between different sets of data. Table 19 shows the statistics published by the IEA, the energy ministry and the state statistics agency that measure total gas consumption in the power and heat sector, and the disparity between them.

Table 19: Ukraine Power & Heat, 2008: Sets of data compared

	bcm
IEA	
Electricity plants	1.546
CHP	6.653
Heat plants	18.147
Total	**26.347**
Energy ministry/ *Energobiznes*	
District heating	9.665
Power sector	6.745
Total	**16.410**
State statistics agency	
Production of electrical energy, gas and water	22.644

The total gas consumed by electricity plants and CHP plants, in the IEA's definition (about 8.2 bcm in 2008), is more than the amount defined by the energy ministry as power sector use (6.74 bcm in 2008), but the difference could easily be explained by differences in how heat-power centres (CHP) are counted. What can not be accounted for is the huge disparity between the IEA's measure of gas consumed by heating plants (more than 18 bcm in 2008) and the energy ministry's measure of gas consumed by the district heating sector (9.6 bcm in 2008). The likelihood of any major mistake here by the energy ministry is extremely small: its sectoral breakdown of gas consumption has been published regularly since 2003 and the 2008 figure is consistent with the rest of the time series. Moreover, great attention has been paid by Naftogaz Ukrainy, the energy ministry, the government and the IMF in recent years to gas consumption in the district heating sector, which is subsidised, and where companies regularly run up substantial debts for gas consumed. Even assuming the energy ministry's figure, i.e. the lower of the two, is correct, Ukraine's district heating sector is still an extremely inefficient consumer of gas. A possible explanation for the disparity is that the IEA's higher figure includes gas consumed not in heat plants but elsewhere.

Table 20 compares the energy ministry's data for fuel consumption in thermal power stations, heat-power centres, and boiler systems, with information reported by power companies.

Table 20: Ukraine: Power and district heating sector, 2008

Ownership	Power/heat producer	Elec prod'n, bn kwh	Heat prod'n, 000 Gcals		Fuel consumption		
					Gas, mmcm	Coal, 000 tonnes	Fuel oil, 000 tonnes
Thermal power stations and CHP		**82.35**	**24440**		**6745**	**34432**	
Thermal power stations (TES)		**72.4**	**1856**		**1545.6**	**33708**	**70.7**
Dneproenergo	Krivorozhskaya TES	6.334	88.2		41.4	2727.3	4.7
	Pridneprovskaya TES	4.067	616.1		148.6	1877.3	0.8
	Zaporozhskaya TES	5.661	124.2		107.8	2482.8	1.6
Donbassenergo	Starobeshevskaya TES	4.815	70.7		132.7	2185.8	9.6
	Slavyanskaya TES	2.381	94		23.4	1165.1	3.2
Zapadenergo	Burshtinskaya TES	8.922	99.4		124.1	4510.5	0.7
	Dobrotvortskaya TES	2.022	48.5		17.3	1066.6	0.5
	Ladyzhinskaya TES	3.934	135.5		166.7	1711.7	2.2
Tsentroenergo	Uglegorskaya TES	5.111	114.7		331.1	1866.6	0.9
	Tripolskaya TES	4.487	108.7		224	1977	2.4
	Zmievskaya TES	6.09	112.8		166.9	2657.8	1.8
Vostokenergo	Zuevskaya TES	5.459	21.9		17.5	2641.1	1.2
	Luganskaya TES	6.59	79.2		32.4	3005.8	2.1
	Kurakhovskaya TES	6.47	139.9		11.8	3812.8	38.6
Heat-power centres (TETs)		**9.95**	**22584**		**4329.9**	**723.9**	**31.9**
	Dneprodzerzhinskaya TETs	0.074	303.4		n/a		
	Nikolaevskaya TETs	0.091	329.7		n/a		
	Khersonskaya TETs	0.118	318.8		n/a		
	Odesskaya TETs	0.084	436		n/a		
	Kharkovskaya TETs-5	1.426	1386.3		*210*		
	Kharkovskaya TETs-2	0.56	13.4		*10*		
	Severodonetskaya TETs	0.227	406.5		n/a		
	Lisichanskaya TETs	0.032	607.4		n/a		
	Zuevskaya TETs	0.04	57.5		n/a		
Donetskoblenergo		n/a	4.1		n/a		
Lvovoblenergo		n/a	17		n/a		
Kyivenergo	(Kyivenergo total)	4.02	11689			0	0
	(Kyivenergo TETs total)				967	0	0
	(Kyivenergo boilers total)				888	0	0
Poltavaoblenergo	(Poltavaoblenergo total)	1.145	1763.9		n/a		
	Krivorozhskaya TTs	n/a	1697.4				
	Kremenchugskaya TETs	n/a	n/a		*900*		
	Kaluzhskaya TETs	0.268	332.8		n/a		
	SGS "+"	0.084	121.6		n/a		
	OOO "KrymTETs"	0.634	287		n/a		
	Mironovskaya TETs	0.4761	28.6		*0*		
	Sevastopolskaya TETs	n/a	n/a		*170*		
	Simferopolskaya TETs	n/a	n/a		*580*		
Residual (heat-power centres)		0.68	2784		*554.9*	723.9	31.9
Residual (all thermal power stations & CHP)					869.5		

Table 20 continued							
Ownership	**Power/heat producer**	**Elec prod'n, bn kwh**	**Heat prod'n, 000 Gcals**		**Fuel consumption**		
					Gas, mn cu metres	**Coal, 000 tonnes**	**Fuel oil, 000 tonnes**
District heating total					**9665**		
	Vinnitskie teplovye seti	0.026	329.7		*35*		
	Power/heat equipment				*4500*		
	Hot water boilers				*1500*		
	Residual				*3630*		
Other							
All hydro		**11.333**	**n/a**		**none**		
NAK Energoatom		**89.841**	**n/a**		**none**		
Wind, total		**0.004**	**n/a**		**none**		

Source: energy ministry/ Energobiznes/ Kyivenergo. All figures in italics are author's estimates

Although the information from companies is patchy, it is sufficient to show that: (a) the main fuel for Ukraine’s thermal power stations is coal, but they do use a small quantity of gas; (b) the nuclear power company, NAK Energoatom, produces more electricity than all the thermal stations together, and hydro also makes a significant contribution; (c) as in Russia, some power and a large volume of heat is produced by heat-power centres, including, for example, the two large gas-fired CHP plants in Kyiv; (d) even though the energy ministry classifies many of the largest heat and power companies (serving Kyiv, Kharkiv and some other large cities) as belonging to the power sector, its total gas consumption is still considerably smaller than that of the district heating sector. Apart from a distinction drawn between “power and heat equipment” (*energ. oborudovanie*) and hot water boilers, there is almost no breakdown of the large amount of gas consumed by the district heating sector (9.6 bcm in 2008, and up to 11 bcm in other recent years) – although a considerable amount of information on the monetary value of gas consumed is now available, published by Naftogaz in the course of its efforts to improve payments.

Measures of efficiency

There are statistics available on the electricity efficiency, and total efficiency (i.e. electricity plus heat) of power plants and CHP in Russia. Almost no information on power and heat sector efficiency is available from other countries in the region. Unfortunately, though, the organisations that publish the statistics on the Russian power and heat sector (Russian official agencies and the IEA) use differing methodologies; the available efficiency indicators differ from each other for reasons that are unclear; and in some cases the sets of statistics are internally contradictory. Sets of statistics published by Russian official agencies and by the IEA, and efficiency indicators based on them, are summarised in Table 21.

Table 21: Indicators Given for Electricity Efficiency, and Total Efficiency, of Russian Power Plants and CHP

Source	Indicator	Type of power station	Year	
1. Energy Strategy of the Russian Federation	Performance coefficient (electricity generation)	Gas-fired	2008	38%
		Coal-fired	2008	34%
2. General Scheme for Installation of Electricity Plant up to 2020	Performance coefficient (electricity generation)	All thermal	2008	36.70%
		Modern gas-fired	2008	approx 50%
		Modern coal-fired	2008	up to 41%
3. Agency for Forecasting Electrical Energy Balances / author's calculations	Efficiency of electricity generation	Aggregate for OGKs	2008	45.93%
			2009	47.40%
		Aggregate for TGKs	2008	26.42%
			2009	25.86%
	Total efficiency (electricity generation + heat output)	Aggregate for OGKs	2008	48.87%
			2009	50.73%
		Aggregate for TGKs	2008	65.93%
			2009	67.70%
4. IEA energy balances / author's calculations	Efficiency of electricity generation	Gas-fired electricity plants	2008	22.90%
		Gas-fired CHP	2008	27.68%
		Coal-fired CHP	2008	27.39%
	Total efficiency (electricity generation + heat output)	Gas-fired CHP	2008	55.70%
		Coal-fired CHP	2008	55.92%
5. IEA, Energy Efficiency Indicators for Public Electricity Production from Fossil Fuels	Efficiency of electricity production in public electricity and CHP plants, average	Gas-fired	2001-05	32.80%
		Coal-fired	2001-05	31.50%
		All fossil fuels	2001-05	32.50%

Indicators used

Indicator	Definition
Performance coefficient (electricity generation)	The energy made available for use, as a proportion of the quantity of energy received by the system (standard dictionary definition)
Efficiency of electricity generation	Energy output, as a proportion of the energy input, calculated by the author from APBE and IEA statistics
Total efficiency (electricity generation + heat output)	Energy output (electricity + heat), as a proportion of the energy input, calculated by the author from APBE and IEA statistics
Efficiency of electricity production in public electricity and CHP plants, average	Calculated by the IEA as E = (P + H x s)/I, where P = electricity production, H = useful heat output, s = correction factor between heat and electricity (defined as the reduction in electricity production per unit of heat extracted), and I = fuel input. In this analysis the IEA used a correction factor of 0.175.

The table is divided into five numbered bands, showing indicators from various sources. Bands nos. 1 and 2 show the efficiency of electricity production in thermal power stations in 2008, as stated by the Russian authorities: 36.7% overall; 34% for coal fired stations; and 38% for gas fired stations. (Efficiency is stated as a performance coefficient (*koeffitsient poleznogo deistviia*), which is calculated in the standard way that energy efficiency is calculated internationally, i.e. by dividing the total energy output by the total energy content of the fuel consumed.) The very high efficiency figures for modern gas-fired and coal-fired plants presumably refer only to those constructed most recently.

Band no. 3 shows the efficiency of power companies, calculated by the author on the basis of fuel consumption, electricity output and heat output reported to the energy ministry. (This reported data is presented in Appendix 7, in physical units in Table 51, and converted to terajoules in Table 52.) The OGKs, whose assets consist mainly of thermal power stations, have electricity efficiency indicators considerably higher than the Russian average: in fact the figure of 47.4% average efficiency for the OGKs is implausibly high, given the level of power station technology in Russia. The average for the TGKs, whose assets consist mainly of heat-power centres, is considerably lower and the TGKs' total efficiency (i.e. (heat + power output) divided by energy content of fuel) is considerably higher.

Band no. 4 shows the electricity efficiency, and total efficiency, of gas-fired electricity plants, gas-fired CHP and coal-fired CHP (according to the IEA's method of classification), derived by the author from the IEA statistics presented in Table 12 above. These numbers seem incompatible with those from the Russian authorities: for reasons that are unclear they suggest efficiency of electricity generation that is low for CHP (by the IEA's wide definition) and even lower for gas-fired electricity plants without heat output.

Finally, band no. 5 shows efficiency indicators presented in the IEA publication *Energy Efficiency Indicators for Public Electricity Production from Fossil Fuels*, and used in other IEA research. A correction factor has been applied to the indicators to account for the reduction in electricity output caused by heat extraction. These indicators are lower than those published by the Russian authorities, perhaps due to this correction factor, but do not seem to correlate with those in band no. 4 derived from IEA statistics.

It should be stressed that, notwithstanding these inconsistencies in sector-wide statistics, a great deal of attention is paid to efficiency by Russian power and heat producers. The APBE collects, and publishes, a great deal of information on it, and some companies publish efficiency indicators in their annual reports. Usually these indicators are given in the form of (i) specific fuel consumption per unit output of electricity (usually expressed in grammes of standard fuel per kwh of electricity), and (ii) specific fuel consumption per unit output of heat (usually expressed in kilogrammes of standard fuel per Gcal of heat). However, conversion factors are not always clear, and it is also unclear how companies decide the proportions of fuel counted as producing electricity and heat respectively. Therefore no attempt has been made here to compare these indicators to those covering the power and heat sector as a whole. In Appendix 7, Table 53 summarises some of the company-by-company information published in this form by the APBE, and Table 54 presents an example of plant-by-plant information on fuel consumption published in companies' annual reports.

To sum up, the sector-wide numbers published by the Russian authorities do not seem irreconcilable with the information gathered by the energy ministry from companies, but more research would be needed to come up with any meaningful insights into the relative efficiency of different companies and different type of plants and, significantly, how this compares with power generation in other countries. The efficiency indicators implied by the IEA's energy balances seem incompatible with other available information, and its research on energy efficiency in electricity production uses a corrective ratio that makes it difficult to compare with information from other sources. Finally, it remains unclear to this author how the data reflect the relationship of the efficiency of electricity production and total efficiency (i.e. heat plus power) of heat-power centres and other CHPs. For the CIS region, this is of cardinal importance, since it affects decisions about how to renew the vast stock of Soviet-era CHPs and how to manage the trade-off between electricity efficiency and heat production.

2.c The Russian power sector: reform and its impact

The future level of gas demand for electricity production will depend mainly on (i) the level of electricity demand, (ii) changes in gas's share of the fuel balance, and (iii) the level of fuel efficiency. These second and third factors will in turn depend on decisions made about the rate at which generating capacity is replaced, and the way that investments in new capacity are made. The sheer size of the Russian power sector, and the continuing transition to market mechanisms, have made it especially difficult for government and other parties to make forecasts on which to base investment decisions. In the case of heat-power centres, the lack of a strategic approach to heat supply is a further complication.

Electricity demand and forecasts

The level of electricity demand in Russia in recent years is shown in Table 22, with changes in GDP and population shown for comparison.

Table 22: Electricity Demand in Russia

	2000	2005	2006	2007	2008	2009
Electricity demand, bn kwh	863.7	940.7	980.0	1002.5	1022.7	977.1
Electricity demand, year on year change (%)		1.8	4.2	2.3	2.0	-4.5
GDP in bn rubles (2000 prices)	7305.6	9832.2	10586.9	11443.6	12082.9	11122.4
GDP, year on year change (%)		6.4	7.7	8.1	5.6	-7.9
Population, mn, avg for the year	146.6	143.15	142.5	142.1	142.0	141.9
Electricity consumption per head, kwh/person	5892	6571	6877	7055	7205	6886

Source: APBE, *Funktsionirovanie i razvitie elektroenergetiki RF v 2009 godu*, p. 131

The growth in electricity demand has been uneven, and slower than economic growth, the APBE noted. Electricity demand growth slowed from 2006, and the reduction of 4.5% in 2009, due to the international economic crisis, reversed about half of the demand growth of 2004-08. The agency considers that the volatility of electricity demand is mainly due to the very large share of electricity consumed by industry (between 50% and 60% of total demand in recent years), and in particular by a small number of energy-intensive industries, such as metallurgy and the chemical sector, which between them account for more than 18% of total electricity demand. Consequently electricity demand depends to a large extent on the level of industrial output and of energy efficiency in industry.[56]

The *Energy Strategy of Russia Up to 2030*, which includes forecasts of electricity demand, has been debated publicly together with a more detailed document on electricity capacity, the *General Scheme for Installation of Electricity Plant Up to 2020*, drawn up by energy ministry officials.[57] No sooner had this latter document been approved than the international financial and economic crisis erupted, prompting a substantial revision downwards of electricity demand projections, and, as will be discussed below, a reconsideration of the strategic approach to development of new generation capacity. As a result, the government approved a corrected version of the *General Scheme* in June 2010. The projections were further developed by energy ministry officials in the *Scenario Conditions for the Development of Electrical Energy*, published in late 2010.[58] Published information on the projections of electricity demand, and of fuel demand for electricity production, are shown in Table 23.

[56] APBE, *Funktsionirovanie i razvitie elektroenergetiki RF v 2009 godu*, pp. 126-129

[57] *Energeticheskaia strategiia Rossii na period do 2030 goda*, adopted by government decree no. 1715-r of 13 November 2009; *General'naia skhema razmeshcheniia ob"ektov elektroenergetiki do 2020 goda*, approved by government decree no. 215-r of 22 February 2008

[58] "Pravitel'stvo RF odobrilo korrektirovku General'noi skheme", energy ministry press release, 3 June 2010; Ministry of energy/ APBE, *Stsenarnye usloviia razvitiia elektroenergetiki na period do 2030 goda*, 2010.

Table 23: Russian Official Projections of Electricity Demand and Power Sector Duel Demand up to 2030

			Actual		Forecast				
			2006	2008	2010	2015	2020	2025	2030
Electricity demand, billions of kwh									
General scheme for installation of electricity plant	Maximum scenario		980		1260	1600	2000		
	Basic scenario		980		1197	1426	1710		
General scheme for installation, corrected version	Maximum scenario		980		1026	1151	1388	1619	1860
	Basic scenario		980		1018	1127	1288	1419	1553
Scenario conditions for the development of electrical energy, basic scenario	Total			969*		1139	1364	1494	1627
	Thermal power stations			633*		738	919	980	1018
	Nuclear			164*		211	250	303	370
	Hydro			170*		188	192	206	213
	Renewables			2*		2	2	5	25
Power sector fuel demand									
General scheme for installation of electricity plant	Basic scenario	Gas, musf	201		232.4	238.9	241.5		
		Gas, bcm	*174.2*		*201.4*	*207.0*	*209.3*		
		Fuel oil, musf	10.6		13	7.1	6.7		
		Fuel oil, m t	*7.3*		*9.0*	*4.9*	*4.6*		
		Coal, musf	74.8		101.8	142.2	168.9		
		Coal, m t	*97.4*		*132.6*	*185.2*	*219.9*		
General scheme for installation, corrected version	Maximum scenario	*Gas, bcm*		*181*		*190*	*223*	*232*	*234*
		Fuel oil, m t		*4.5*		*3*	*3.2*	*2.6*	*2.4*
		Coal, m t		*146*		*157*	*210*	*234*	*261*
	Basic scenario	*Gas, bcm*		*181*		*186*	*212*	*216*	*214*
		Fuel oil, m t		*4.5*		*2.9*	*2.9*	*2.4*	*2.3*
		Coal, m t		*146*		*151*	*193*	*199*	*203*
* Actual demand in the Scenario conditions is for 2009, not 2008									

Sources: *General'naia skhema razmeshcheniia ob"ektov elektroenergetiki do 2020 goda*, prilozhenie no. 1 and prilozhenie no. 10; *Stsenarnye usloviia razvitiia elektroenergetiki na period do 2030 goda*, p. 88; presentations by Sergei Shmatko, energy minister, June 2010 and I.S. Kozhukhovskii, APBE, 23 November 2010
Note: in the initial version of the *General Scheme*, amounts of fuel were stated in millions of units of standard fuel (musf). The author has estimated the physical volumes, using standard conversion factors (see Appendix 1). In the corrected version, presentations made by the energy ministry stated the amounts of fuel as physical volumes.

The corrected version of the basic scenario for total electricity demand now projects 1127 billion kwh in 2015 and 1288 billion kwh in 2020, as against 1426 billion kwh in 2015 and 1710 billion kwh in 2020 in the original version. These are drastic revisions, downwards by one fifth and one quarter respectively. Projections of fuel demand were revised accordingly, with gas demand for the power sector, under the basic scenario, at 186 bcm in 2015 and 212 bcm in 2020, as against the 207 bcm in 2015 and 209 bcm in 2020 envisaged previously. The implications for gas production are considerable: while projections for gas demand in 2020 in the two versions of the scheme are very close, the projected demand in 2015 was reduced by 21 bcm. Clearly this, together with revisions of projected demand in other Russian markets and in Europe, is impacting discussions about the timing of major new projects such as the development of Yamal gas fields and changes in arrangements for pipeline access to oil companies for natural and associated gas. A substantial increase in total thermal power generation, and gas demand – as well as a noticeable increase in generation from renewables – is projected only after 2020.

Policy discussions on investment in power generation

The revision of the government's projections for the installation of new generation capacity is just as substantial as its changed view of electricity demand. The corrected version of the *General Scheme* envisages that the total thermal capacity required will be 169 GW in 2015, and 190-199 GW in 2020, compared to the earlier projections of 202-230 GW in 2015 and 222-262 GW in 2020. Again, a substantial increase in thermal generation capacity is envisaged only after 2020. The two sets of projections are shown in Table 24.

Table 24: Russian Official Projections of Power Station Capacity for the Centralised Grid

			Actual		Forecast				
Gigawatts			**2006**	**2008**	**2010**	**2015**	**2020**	**2025**	**2030**
General scheme for installation of electricity plant	Maximum scenario	Hydro	44.9		49.2	57.9	76.5		
		Nuclear	23.5		26.9	38.1	59		
		Thermal	142.4		167.7	230.2	262.2		
	Basic scenario	Hydro	44.9		49.2	57.1	71.7		
		Nuclear	23.5		26.9	38.1	53.2		
		Thermal	142.4		167.7	202.3	222.5		
General scheme for installation, corrected version	Maximum scenario	Hydro		45.9		51.4	53.6	59.4	62.6
		Nuclear		23.5		30.9	38.7	50.3	57.4
		Thermal		145		169	199	221	244
	Basic scenario	Hydro		45.9		51.4	53.6	57.0	58.6
		Nuclear		23.5		30.9	36.4	44.5	50.5
		Thermal		145		169	190	198	208

Sources: *General'aia skhema razmeshcheniia ob"ektov elektroenergetiki do 2020 goda*, prilozhenie no. 7; presentation on the scheme by I.S. Kozhukhovskii, APBE, 23 November 2010

The revision of the generation capacity projections in the *General Scheme* is the latest step in a public discussion on new capacity requirements that began in the mid 2000s, prior to the privatisation of generating companies in 2006-07. Under the *Energy Strategy to 2020*, which preceded the current *Energy Strategy to 2030*, the government set out a five-year capacity commissioning programme (2008-12). It aimed to construct 44.2 GW of new capacity, with specific targets for each year. At privatisation, buyers agreed to investment conditions that included the construction of this new capacity. At the same time, the *General Scheme* was drafted, projecting the construction of 186.1 GW of new capacity (including new build and the replacement of decommissioned units).

With the revision of the *General Scheme* in 2010, the projected new capacity to be constructed in the decade to 2020 was revised down to 78 GW.[59] Furthermore, the strategic approach to the construction of new capacity was shifted, with significant implications for the fuel balance and the place of gas in it. Whereas the *Energy Strategy Up To 2030* referred to the need for the "accelerated development of nuclear, coal and renewable energy (including hydro), with a view to reducing the [electricity] sector's dependence on natural gas", and the "wider introduction of new ecologically clean and highly-effective technologies for burning coal",[60] the correction of the *General Scheme* implied that some aspects of policy would be shaped primarily by the constraints on financial resources. The principles on which the correction of the *General Scheme* is based were listed by the director of the APBE[61] as including:

> "A shift from prioritising the maximum possible development of nuclear and hydro stations to economic criteria for the optimisation of capacity" (which implies a preference for investing in cheaper gas-fired capacity, or a recognition that the other types of plants are not feasible);
>
> "Maintaining the modestly more rapid pace of development of coal-fired generation relative to gas-fired generation" (i.e. not accelerating investment in coal-fired capacity further);
>
> "Enforced' modernisation"; and
>
> "A shift away from the separate production of electrical energy, heat and cooling with preference given to cogeneration and trigeneration".

Furthermore, consideration is being given to upgrading, and prolonging the life of, nuclear power stations and some coal-fired power stations,[62] which would reduce the extent of investment required in new capacity.

This suggests that, in the period up to 2020, gas demand will be constrained, because total projected electricity demand will be lower. In the period after 2020, gas demand could increase because it will compete well with other fuels.

Efficiency of thermal power stations and heat-power centres

Raising the efficiency of power stations and heat-power centres is naturally a key aim of Russian energy policy. The *General Scheme* projects improving national average electricity

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[59] "Pravitel'stvo RF odobrilo korrektirovku General'noi skheme", energy ministry press release, 3 June 2010

[60] *Energeticheskaia strategiia Rossii na period do 2030 goda,* p. 60. For details on projections for the development of generation capacity prior to the economic crisis, see also A.A. Makarov et al, "Prospects of the Development of Electricity Generation Capacities in Russia", *Thermal Engineering* 55:2 (2008), pp. 98-111.

[61] Presentation on the correction of the *General Scheme*, I.S. Kozhukhovskii (general director, APBE), 23 November 2010

[62] *Stsenarnye usloviia*, p. 52 and pp. 54-57

efficiency (i.e. performance coefficient) from 36.7% to 43.4% by 2020.[63] The *Energy Strategy to 2030* designated the priorities in new capacity construction as: (i) installing new 300-350 MW gas turbines, and incorporating them into 500-1000 MW CCGT plants working at 60% efficiency; (ii) installing generic, prefabricated 100-170 MW CHP units, working at 53-55% efficiency, at heat-power centres; (iii) installing 600-800 MW high-efficiency "clean" coal-fired units, working at 43-46% efficiency; (iv) installing 200-600 MW CCGT units fuelled with gasified coal, working at 50-52% efficiency. These basic aims, with an emphasis on the introduction of CCGT both at electricity stations producing heat as a by-product and at heat-power centres, have been retained during more recent public discussions.[64]

CCGT capacity has been commissioned by some of Russia's largest power companies, but it is too recent, and on too small a scale compared to the power sector as a whole, for the exact extent of efficiency improvements to be measurable. The first Russian CCGT plant was commissioned in December 2006 at the Severo-Zapadnaia TETs (heat-power centre) in St Petersburg, owned by the state holding company Inter-RAO. Other CCGT capacity includes two CCGT blocks at Kaliningrad TETs-2, also owned by Inter-RAO; and blocks at the TETs-27 and TETs-21 in Moscow, owned by TGK-3 Mosenergo, a Gazprom subsidiary. A CCGT unit is under construction at the Shaturskaia power station outside Moscow, which is owned by OGK-4, an E.On subsidiary.[65]

The significant part played by the heat-power centres in the Russian power sector poses additional challenges with respect to the renewal of generation capacity. Most of the CHP at the heat-power centres is of three types: (i) back-pressure turbines, with steam pressure of 7-15 kgs/cm^2, designed mainly to supply heat to industrial plants; (ii) turbines from which steam is bled off at different pressures for both industrial and residential users; and (iii) condensing units with steam produced at lower pressures only (0.5-2.5 kgs/cm^2) to supply residential heating networks. In the case of type (i), the heat produced from the back-pressure can all be used, but the electricity capacity depends on the level of heat load, and in the absence of the latter (in summer time for heat-power centres supplying heat to residents, for example), they can not use the electricity-producing capacity. So these are used only where heat demand is more or less constant, i.e. mostly to supply heat to industry. Type (ii), in which the heat from the condensing steam is lost, are also only used when there is heat demand. Type (iii) can work like type (i) when there is high heat demand, and can regulate the heat and electricity output more or less independently of each other, and so these are used more widely. Furthermore, it is often the case that turbines can not meet peak heat demand and are supplemented at heat-power centres by hot-water boilers.

Whereas a framework is being worked out for investment in upgrading large thermal power stations selling into the wholesale electricity market (see below), no such foundation has yet

[63] *General'naia Skhema*, p. 18.

[64] Presentation by energy minister Sergei Shmatko, "O korrektirovke general'noi skhemy razmeshcheniia ob'ektov elektroenergetiki do 2020 goda", June 2010; presentation on the correction of the *General Scheme*, I.S. Kozhukhovskii (general director, APBE), 23 November 2010

[65] Information from company annual reports

been laid for the replacement and/or modernisation of the heat-power centres. The lack of a strategy for the heat sector, including the lack of a framework for long-term supply contracts, is cited by companies as an obstacle. While some of the largest TGKs have begun to invest in new generation capacity at heat-power centres – including the examples in Moscow and St Petersburg mentioned above – the availability of funds for investment is extremely uneven. At local level, heat-power centres are in some cases installing gas turbines or diesel engines of 0.6-6 MW capacity to supplement existing equipment. According to Y.A. Zeigarnik, another retrofitting option is to top district boilers houses and industrial boiler houses with appropriate gas turbines. The problem is very often finding space at the heat-power centre to install these.[66] Over the longer term, some observers believe that micro-CHP will be a significant element in the development of the Russian power and heat sector.

Investment criteria

Of course when it comes to actual investment decisions, efficiency gains that arise from installing new plant will be considered alongside financial issues. Two of these that figure prominently in current discussions are (i) the development by the government of a framework for the owners of wholesale generation companies (OGKs) to invest in new capacity, comprising agreements to deliver capacity alongside a long-term capacity market; and (ii) the relative prices of fuels.

Following power sector privatisation, the government has used two instruments to ensure investment in capacity: (i) agreements for the delivery of capacity, under which owners of OGKs and TGKs made commitments to invest, and payments for capacity were agreed for ten years in advance; and (ii) the establishment of a competitive long-term capacity market, under which the system operator determines the capacity requirement and accepts bids from companies to build it. The wholesale electricity market is deregulated, but retail tariffs are regulated. As a result of the financial crisis of 2008-09 and the resulting sharp fall in electricity demand, many OGKs failed to meet their investment commitments. On the other hand, the government revised the timetable for the increase and eventual liberalisation of retail electricity tariffs, prompting complaints that this undermined the basis of revenue forecasts and raised investment risks. This has resulted in a series of disputes (that are unresolved at the time of writing) between the government and the owners of OGKs – about the terms on which investment will be made in capacity, and the pace at which regulated retail electricity tariffs are raised.[67] The character and timing of investments will in part depend on the outcome of these discussions

The second consideration that will play a key role in investment decisions is the price of fuels. On the one hand, rising gas prices will help to trigger investment in CCGT; Tatiana Mitrova has argued that once gas prices exceed $100/mcm, “investment in gas saving

[66] TGK-3 Mosenergo annual report; Y.A. Zeigarnik, “Some problems with the development of combined generation of electricity and heat in Russia”, *Energy* 31 (2006), pp. 2387-2394.

[67] Alemar Investment Group, *Elektroenergetika: investitsii v moshchnost’*, 10 March 2010; Denis Fedorov, “KASKO novoi moshchnosti”, *Vedomosti*, 29 November 2010; “Pravitel’stvo gotovit novuiu versiiu rynka moshchnosti”, *Vedomosti*, 1 March 2011; “Energetika bez pravil”, *Vedomosti*, 9 March 2011.

becomes economically justified", because replacement of old turbines will become more efficient than investing in maintenance and upgrades. It is likely that prices for Russian industrial and power sector consumers of gas will pass this threshold in 2011-12. On the other hand, rising gas prices will make new gas-fired generation capacity less competitive with other fuels[68] – although the repeated experience of the past several decades has been that diversification towards coal, the main competitor, has often been discussed but never realised.

Conclusions on the Russian power sector

The Russian power sector (including the heat-power centres) consumed 181-190 bcm of natural gas in 2008, i.e. significantly more than total Russian exports to Europe and almost as much as the aggregate total consumption of the CIS outside Russia. Therefore even small changes in consumption forecasts have a considerable impact.

In the period to 2015, the revised forecast in the corrected *General Scheme for Installation of Electricity Plant Up to 2020* envisages, under the basic scenario, gas-for-power demand rising from 181 bcm in 2008 to 186 bcm, instead of 207 bcm (as implied in the original version of the scheme).[69] In other words, annual gas-for-power demand is expected to rise by 5 bcm, not 26 bcm as previously envisaged.

In the period to 2020, the *General Scheme* still assumes a significant increase in gas-for-power demand, from 181 bcm in 2008 up to 212 bcm. This forecast assumes that, by this time, new power station capacity will have started to be commissioned. However, the reduced projection for 2015 implies that further postponements of investment decisions are likely.

In the period beyond 2020, the adjustment in emphasis in the *General Scheme* – away from prioritising nuclear and hydro, and for a modest increase in coal's share at the expense of gas – may strengthen gas demand. If the approach in the corrected *General Scheme* continues to guide government policy, and companies' investment decisions, then the aim of substantially reducing dependence on gas may not be realised. Here the experience of the past decade – during which the government expressed its intention to reduce dependence on gas, but was unable to do so – may be indicative.

Over this longer time scale, i.e. beyond 2020, the revised version of the General Scheme assumes, under the basic scenario, that gas-for-power demand levels off, reaching 216 bcm in 2025 and 214 bcm in 2030. Presumably, part of the energy ministry's reasoning here is that fuel savings, as a result of more efficient electricity generation, may start to take effect. The *Energy Strategy to 2030* envisages raising average gas-fired power station efficiency by 5-10% by 2030. While government targets rarely turn out to be an accurate guide to actual events, the potential impact of any efficiency improvement should be borne in mind. A 5%

[68] Mitrova, "Natural Gas in Transition", in Pirani (ed.), *Russian and CIS Gas Markets*, pp. 42-44.

[69] The 2008 consumption figure used, 181 bcm, differs from the IEA's figure, 190 bcm, due to different definitions of the power and heat sector.

increase in the electricity efficiency of gas-fired plants (assuming a corresponding heat generation efficiency improvement in CHPs) could amount to a saving of up to 10 bcm/year.

2.d. The power sector outside Russia

Significant issues in the power sector outside Russia that will impact gas demand are as follows.

In ***Ukraine***, in round numbers, electricity is generated 47% from nuclear power stations, 6% from hydro, 36% from coal, and 11% from gas (see Table 13 above). There are 14 large thermal power stations, all of which use coal as the primary fuel, supplemented by small volumes of gas – about 1.5 bcm in 2008, according to the energy ministry. About three times that volume of gas is consumed by heat-power centres in most of Ukraine's large cities, including Kyivenergo's two large CHP plants, the main source of power and heat for the capital. (See Table 20 above.) After reaching a peak in 2006-07 (8.6 bcm and 8.4 bcm respectively), gas consumption in the power sector (as measured by the energy ministry) fell to 7.5 bcm in 2008, 5 bcm in 2009 and 7.2 bcm in 2010. Power companies report that electricity production from gas has been cut to the minimum technically possible as, after the increase in import prices, it is uncompetitive with other fuels. Ukraine is a net electricity exporter and there are no short- or medium-term plans to raise the share of gas in electricity generation. In the longer term, e.g. after 2015, as energy companies undertake modernisation, efficiency savings could reduce gas consumption by the power sector further.

In ***Uzbekistan***, development of electricity generation to meet the rising demand driven by population growth and economic growth, implies the upgrading or replacement of low-efficiency gas-fired electricity plants and CHP. The IEA states that since 1991, only two new power generation projects have been completed, both designed to expand capacity rather than replace old, inefficient plants. However, a modernisation programme has now begun. The government aims to replace 570 MW of low-efficiency generation capacity and install three CCGT power plants, totalling 1600 MW. In 2009, construction of two projects, in Tashkent and Navoi, began, and the go-ahead was given for a third, in Talimarjan. Uzbekistan also suffers from unmet gas and electricity demand (i.e. there are areas of the country where demand is intermittently supplied or not supplied). While the main population centres and gas production areas are in the south of the country, most electricity generation capacity is in the north; transmission capacity is limited, resulting in regular shortages of electricity. Growth of gas demand for domestic electricity generation will be a key call on Uzbek gas supply in the coming years.[70]

In ***Kazakhstan***, plans to raise the share of gas in electricity generation will put upward pressure on demand in the coming years. Despite excess electricity production in northern and central Kazakhstan, the western and southern parts of the country rely on imports from Russia and Uzbekistan respectively. The Kazakh government intends to build new gas-fired power plants in western Kazakhstan, in the first place, and also to replace existing coal- and

[70] IEA, *World Economic Outlook 2010*, p. 490.

oil-fired generation capacity with gas-fired stations. The extent to which gas demand will rise depends on the pace of investment in new capacity, and the extent to which efficiency improvements that result from it offset the effect of rising demand for electricity.[71]

In ***Azerbaijan***, a large-scale modernisation programme of electricity generation capacity has already begun. The country's first CCGT unit was commissioned in 2002, a second one in 2009, and a third is due to be completed in 2011-12. Gas has almost completely backed out fuel oil in power generation, and improvements in generation and transmission have dramatically improved electricity supply. Electricity generation is on the way to becoming the most efficient of any CIS country, and will provide useful indicators of how efficiency savings and the replacement of other fuels by gas, influence the level of gas consumption.[72]

2.e. District heating: the challenge of reform

It is appropriate to introduce the discussion of gas demand for the heat sector with a reminder of its great scale. Table 25 presents the quantities of heat produced from gas-fired CHP and gas-fired heat plants, compared to all such plants (with most of the others fuelled by coal), in the former Soviet Union,[73] and for the big three gas consumers.

The reader will recall that the data for CHP plants accords with the IEA's wide definition, which includes large condensing power stations that produce heat as a by-product. Nevertheless, working with round numbers for the former Soviet Union as a whole, the table shows that, if half the gas supplied to CHP plants is counted as gas-for-heat – since the CHPs' aggregate heat output is almost equal to (in fact slightly higher than) the electricity output in energy terms – then it follows that in 2008, roughly 114 bcm of gas was used to produce heat from CHPs, in addition to the 97 bcm burned in heat plants. It should also be borne in mind that, in Russia, due to differences in methodology, the government counts heat output at about one-third above the IEA's figure, as shown in Table 25 below.

[71] Shamil Yenikeyeff, "Kazakhstan's Gas Sector" in Pirani (ed.), *Russian and CIS Gas Markets*, p. 340; IEA, *World Economic Outlook 2010*, p. 486.

[72] Bowden, "Azerbaijan", in Pirani (ed.), *Russian and CIS Gas Markets*, pp. 213-215; IEA, *World Energy Outlook 2010*, p. 483.

[73] Here I have used data from the IEA energy balances for the former Soviet Union as a whole (including the three Baltic states that are otherwise omitted from this paper), because it contains the IEA's estimates of the breakdown of heat produced from CHP and heat plants, which is not available for all countries separately. The three Baltic states in aggregate accounted for 1.6% of fuels consumed in CHP and 1.2% of fuels consumed in heat plants in the FSU.

Table 25: Gas for Heat in the Former Soviet Union, 2008 (from IEA balances)

			Gas-fired plants, 000 toe	Gas, bcm		Total, all fuels, 000 toe	Gas as % of total
FORMER SOVIET UNION							
CHP plants	*Energy consumed*		*184140*	*227.96*		*278290*	*66.2*
	Electricity produced		50556			75930	
	Heat produced		51504			82370	
Heat plants	*Energy consumed*		*78590*	*97.29*		*103180*	*76.1*
	Heat produced		64435			93560	
RUSSIA							
CHP plants	*Energy consumed*		*151954*	*188.11*		*220642*	*68.8*
	Electricity produced		42069			60442	
	Heat produced		42570			63034	
Heat plants	*Energy consumed*		*58057*	*71.87*		*80837*	*71.8*
	Heat produced		50551			78492	
UKRAINE							
CHP plants	*Energy consumed*		*5628*	*6.71*		*6223*	*90.4*
	Electricity produced		1480			1658	
	Heat produced		2826			3133	
Heat plants	*Energy consumed*		*15217*	*18.14*		*15596*	*97.6*
	Heat produced		9557			9688	
UZBEKISTAN							
CHP plants	*Energy consumed*		*5330*	*6.54*		*5970*	*89.3*
	Electricity produced		1365			1489	
	Heat produced		1027			1194	
Heat plants	*Energy consumed*		*1630*	*2.00*		*1665*	*97.9*
	Heat produced		1143			1161	

Sources: Table 12 above, IEA energy balances. Physical gas volumes converted from IEA statistics by the author

Across the CIS region, in the district heating sector (which accounts for most heat provision) in particular and municipal services as a whole, market reforms have proceeded slowly. Providers of heat often collect only enough revenue, or less than enough revenue, to pay for fuel – mainly gas – and running costs. The mobilisation of investment is patchy. Little progress has been made in dealing with the substantial heat losses in production, distribution and consumption. Heat losses are attributable to a large extent to aging equipment and pipe networks, and this is in turn part of a larger problem, i.e. the ever-more-pressing need to modernise all the infrastructure put in place during the urbanisation of the Soviet Union from the 1950s onwards, including housing stock, and to reform municipal services (i.e. the provision of heat; gas for homes; hot water heated in gas-fired boilers; and electricity, often produced from gas; along with cold water, sewage and building repairs). Here heat demand

and associated losses will be discussed; then heat production and distribution; and then the progress of relevant reforms in Russia and Ukraine, the CIS's two largest consumers of gas-for-heat.

Heat consumption and heat losses

Across the CIS region, heat is supplied via (urban) district heating networks and from decentralised sources, including boilers and autonomous sources (such as heat pumps, electrical heaters, or in rural areas coal or wood). In Russia, the government and industry specialists estimate that just under three-quarters of heat is supplied via the district heating networks and a little more than one-quarter from decentralised sources.[74]

The three largest consumers of heat are industry, public buildings and the residential sector, but their shares of heat demand have changed significantly in the two post-Soviet decades.

Demand from industry fell steeply during the 1990s: the problems this caused for heat-power centres geared to providing heat for industrial plants were described in the overview above, pages 37-39. Accurate statistics are hard to come by, but it is estimated that in Russia heat consumption by industry fell by 55% between 1993 and 2007 (from 4,117 petajoules to 1,867 petajoules).[75]

Residential demand for heat from district heating systems seems to have stayed level or increased during the 1990s. In the 2000s the demand for centrally-provided heat fell, as households found it more economic to seek decentralised sources of heat. In Russia, the housing stock expanded by 8% in 2000-07, and the share of it connected to centralised district heating systems rose from 73% to 81%, but total household demand for centrally-provided heat fell, as households moved away from centrally-provided heat to decentralised sources; the same trend can be observed in Ukraine.[76]

Demand from public buildings is very high (in Russia, estimated by local specialists at about 20% of the total, slightly higher than the 18.5% suggested by IEA statistics), and characterised by an especially high degree of losses.

The predominance of industry, households and public buildings (which comprise most of the IEA's "commercial and public services" category) in heat demand is illustrated in table 26.

Some heat from decentralised and autonomous sources is not included in the IEA's energy balances, which only include heat that is sold. Therefore it is unsurprising that the residential sector's share is estimated by industry sources in the region to be higher than the table shows. In Appendix 8, Table 55 shows estimates of heat output and consumption in Russia in 2000-02. Although these are several years old, they are interesting because they give estimates for

[74] Table 18 above; I.A. Bashmakov, "Povyshenie energoeffektivnosti v sistemakh teplosnabzheniia. Chast' I. Problemy rossiskikh sistem teplosnabzheniia", *Energosberezheniia* no. 2, 2010

[75] Bashmakov, "Povyshenie energoeffektivnosti", op cit

[76] Bashmakov, "Povyshenie energoeffektivnosti", op cit; IEA, CHP/DH Country Profile: Russia.

(i) the proportions of heat produced by industrial boilers, municipal boilers and CHP plants, and (ii) heat losses by sector, showing the scale of this problem in public buildings, above all.

Table 26: Heat Consumption in the Former Soviet Union, 2008

	million toe
Total	**91.92**
Industry	44.29
Residential	16.91
Commercial and public services	16.95
Transport	8.67
Other	5.1

Source: IEA energy balances

Heat losses in consumption are extremely high in all sectors. A World Bank survey of energy efficiency in Russia said that the "greatest potential" for energy savings, mostly in the form of heat, lies in residential, commercial and public buildings. The bank estimates energy end use in buildings (including space heating (58% of final energy use), water heating (25%) and electricity – all mostly produced from gas) at 144.5 mtoe/year. It estimates that 68.6 mtoe of this could be saved with current technology, and that 85% of those savings are economically viable. The scale of the problem is reflected in other research. I.A. Bashmakov puts heat losses from public and residential buildings at 460 million Gcal, and in industry at 160 million Gcal, i.e., in round numbers, losses of 620 million Gcal out of final consumption of around 1,600 million Gcals in recent years. He concluded that a reduction in demand of at least 130 million Gcals could be achieved "simply by getting rid of the disbalance between supply and demand of heat for buildings, by automating the heat supply process".[77] In Ukraine, the ministry of housing and communal services estimates heat losses in consumption at 30%, and estimates that they could be reduced to 10% by technologically feasible improvements.[78]

In the residential sector, much of the problem lies with Soviet-era housing stock, and in particular the ubiquitous multi-apartment urban housing blocks, in which the heating supply equipment does not allow for individual households to adjust the level of heat. A group of Russian researchers found that, as a result, individual households pay not only for lost heat but also for unwanted but delivered heat. Their representation of the heat required, delivered and paid for in a typical Moscow apartment block is shown in Figure 5.[79]

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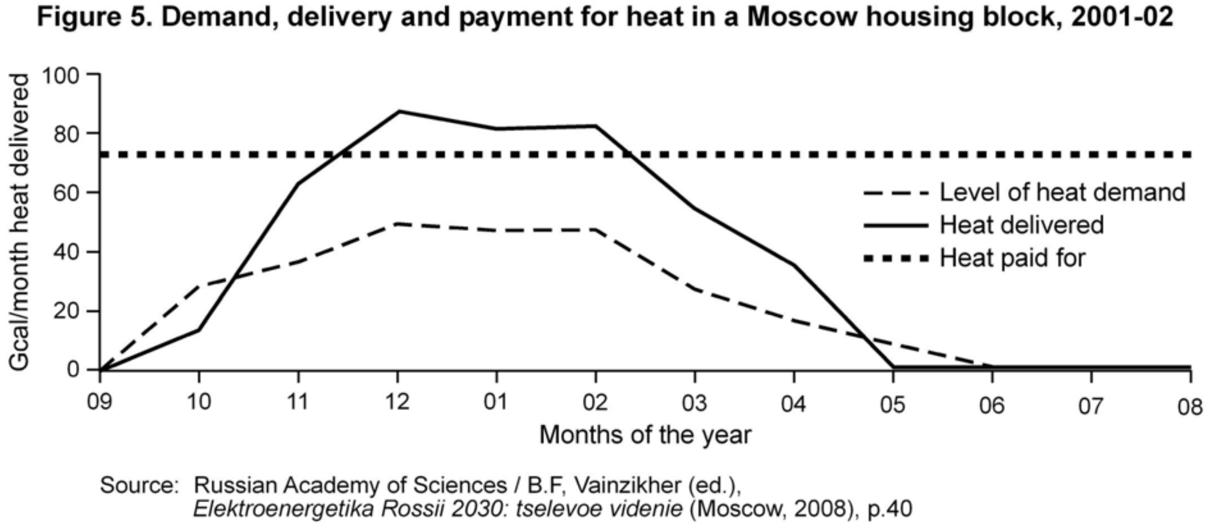
77 World Bank, *Energy Efficiency in Russia: Untapped Reserves* (Washington, 2007), pp. 39-46; Bashmakov, "Povyshenie energoeffektivnosti", op cit.

78 IEA, *Ukraine Energy Policy Review* (2006), p. 310

79 B.F. Vainzikher (ed.), *Elektroenergetika Rossii 2030: tselevoe videnie* (Moscow, Alpina Business Books, 2008), p. 40.

Figure 5: Demand, Delivery and Payment for Heat in a Moscow Housing Block, 2001-02



Engineers working on an energy-saving programme for the Ukrainian government said in an interview that the problem of inflexible supply systems, which usually pipe heat to apartments in series rather than in parallel, is as serious a problem as the lack of meters. They estimate that 20% of households in Ukraine that use centralised municipal services now have meters, but only 1% have the ability physically to reduce their heat supply independently of their neighbours. In Uzbekistan, research by the UNDP found that in Tashkent, heat released to consumers is regulated by varying the temperature of the hot water being released. The problem is that the water at the heat source must be maintained at a prescribed level even when ambient temperatures are high enough that the apartment buildings do not need heating; this results in overheating and discomfort to residents, which in turn leads to people making unauthorised interventions in the regulation of the heating system, which in turn disrupts the flow of water to neighbouring buildings.[80]

Cutting heat losses by consumers is probably the lowest of all the “low hanging fruit” in energy saving terms in the CIS region, and it is therefore tempting to total up enormous numbers showing the theoretically possible energy savings. The principal reasons these have not been implemented are institutional: infrastructure renewal and municipal services reform will presumably require the sort of political prioritisation and execution that was applied to power sector reform, and will, like power sector reform, take many years. For the period up to 2015, these savings are likely to be modest. Once reforms are implemented and start to take effect, they could be substantial.

Heat production and distribution

Most heat in the CIS region is produced (i) by heat-power centres, equipped with CHP and often with supplementary boilers, described in section 2.a above; (ii) by district boiler houses built in the Soviet period; and (iii) by decentralised and autonomous boilers and other heat sources. The ownership of these resources is varied. In Russia, the TGKs own many (but not

[80] UNDP, *The Outlook for Development of Renewable Energy in Uzbekistan* (Tashkent, 2007).

all) heat-power centres and some district boiler houses; some heat-power centres and most boiler houses are owned by local heat supply companies that began the post-Soviet period as municipal property but have in many cases been privatised. Some of the power companies that own TGKs, and some other companies of which KES-Holding is the most prominent, have begun to acquire and manage district heating assets.

Table 27 presents a picture of Russia's district heating assets gathered by an industry specialist. Table 28 shows information on the Ukrainian heat sector (boilers only, excluding CHP) gathered by the state statistical agency.

Table 27: Inventory of Heat Sector in Russia

	2000	**2006**
Number of installations		
Isolated heating systems	about 50,000	
Heating enterprises	21,368	17,183
Customers of heating enterprises	about 44 million	
Sources of heat supply		
CHPs for general use	242	244
CHPs used by industrial enterprises	245	253
Boiler houses, total	67,913	65,985
Boiler houses, less than 3 Gcal/hr	47,206	48,075
Boiler houses, 3-20 Gcal/hr	16,721	14,358
Individual heat generators	more than 12 million	
Boilers, installed in boiler houses	192,216	179,023
Central heating points	0	22,806
Capacity of boiler houses, Gcal/hr	664,862	619,984
	2000	**2006**
Length of heating networks, km		
Total	183,545	176,514
Diameter up to 200 mm	141,673	131,717
200-400 mm	28,959	28,001
400-600 mm	10,558	10,156
more than 600 mm	5,396	6,640
Tariffs		
Average tariff for heat, rubles/Gcal	195	470
Aggregate sales of heat, billion rubles	322	770

Source: I.A. Bashmakov, "Povyshenie energoeffektivnosti v sistemakh teplosnabzheniia. Chast' I. Problemy rossiskikh sistem teplosnabzheniia", *Energosberezheniia* no. 2, 2010

Table 28: Ukrainian Heat Boilers

		Total installed capacity, gcal/yr	Number of boiler plants	Heat output, 2007, gcal
Total stock of boilers		**138347.9**	**29965**	**112130.1**
	up to 3 gcal/yr	21472.9	24668	11203
	3-20 gcal/yr	31450.1	4265	18241
	20-100 gcal/yr	30948.7	813	19836
	100+ gcal/yr	54476.2	219	48530.7
--{{{}}}--				
Total number of boilers				**69801**
	more than 20 years old			16546
Heat distribution pipes, km				**35754.3**
	outworn & dangerous, km			5185.4

Source: State statistics committee of Ukraine, *Statistichnii biuleten' pro osnovny pokazniki roboti opaliuval'nikh kotelen' i teplovikh merezh Ukrainy*
Note: These statistics cover heat boilers only, not heat produced by CHPs. The totals for installed capacity and heat output, greater than the sum of the four parts, is copied from the original.

The efficiency of district heating networks depends on the efficiency of CHP and boilers, and on the condition of heat pipes. Data on efficiency are in a similar condition to those on efficiency in the power sector, discussed above. Nevertheless, the points made about the efficiency of CHPs in Russia above (page 55 are relevant, and the following may be said of the efficiency of boilers and pipes. In Russia, the average efficiency of boilers was estimated in a recent survey by I.A. Bashmakov at 78% in 2006, down from 80% in 2000; the World Bank quoted official reports giving the average efficiency of boilers at industrial plants at 68.6%, district heating boilers at 80.3% and small boilers at 81.6%; estimates of heat losses in transport and distribution range between 20% and 31%.[81] In Russia, the problem of outworn heat pipes is recognised at the highest political level: president Dmitry Medvedev has drawn attention to the fact that 80% of heat pipes are older than their projected lifespan, more than 65% are designated as worn and torn, and 30% are damaged.[82] In Ukraine, heat losses in production and transport/distribution are estimated by the ministry of housing and communal services at 22% and 25% respectively; the ministry says that technologically feasible efficiency improvements would reduce these numbers to 14.5% and 13%.[83]

[81] I.A. Bashmakov, “Povyshenie energoeffektivnosti v sistemakh teplosnabzheniia. Chast’ I. Problemy rossiskikh sistem teplosnabzheniia”, *Energosberezheniia* no. 2, 2010; World Bank, *Energy Efficiency in Russia*, p. 57.; Alliance to Save Energy, *Urban Heating in Russia*.

[82] Figures used by president Medvedev quoted by Igor Mayzel, director of the Russian Association of Manufacturers and Users of Plastic Pipes, at the Energy Commission of the state Duma, meeting in October 2009. Josephine Bollinger-Kanne, “Russia’s Heat Supply Sector Under Pressure”, *Euro Heat & Power* (English edition) 2009, IV, pp. 20-21.

[83] IEA, *Ukraine Energy Policy Review* (2006), p. 310

Heat sector reform

Heat sector reform, and the possible energy efficiency savings that could result, will be a key factor in determining gas demand. The three most significant challenges appear to be (i) that heat sector reform can only be carried through comprehensively as part of the broader reform of municipal services and urban infrastructure, and strategies are only beginning to evolve for this in the largest CIS countries; (ii) strategies are still evolving for reforming heat tariffs, along with other municipal services tariffs, in the context of social pressure on governments; and (iii) any reform strategy will need to strike the correct balance between centralisation and decentralisation of heating systems, which at present are being decentralised willy-nilly, aggravating some inefficiencies.

The first point, that the heat sector has to be reformed in the context of broader municipal services reform, arises partly from the physical characteristics of the infrastructure. The post-war Soviet urban housing developments that still house most families in the CIS were often built with standard infrastructure supplying heat, hot water, electricity, gas and sewage services. Now, not only do the heat pipes require large-scale renewal or replacement, but so does the rest of the supply infrastructure, and the buildings themselves. The rate at which capital repairs (i.e. refurbishment of infrastructure and replacement of gas, water and sewage pipes inside buildings) are conducted has sunk. In Russia, the statistical agency records that the amount of housing (measured in square metres of floor space) for which capital repairs were conducted in 2000 was 6.8% of the level in 1980. By 2006, at the height of the boom, this ratio had only risen to 9.5%; only with the launch of the national programme to improve housing did things improve, with the level of repairs rising to 22.2% of the 1980 level in 2008 and 31.1% in 2009.[84]

Reform of municipal services also means reform of the organisational structure. In Russia, Ukraine and most other CIS countries, municipal services, along with housing management and administration, are provided by housing and municipal sector enterprises, many of which retain their old Soviet acronym, ZhEK.[85] These organisations were at the start of the post-Soviet period owned by the municipal authorities; in Russia, particularly, considerable numbers of them have now been privatised. The challenge presented by municipal services reform was presented in an information booklet published by the Ukrainian ministry of housing and communal services in a diagram, reproduced in Figure 6.

[84] Rosstat web site (www.gks.ru), table "Osnovnye pokazateli zhilishchnykh uslovii naselenii"

[85] ZhEK stands for *zhilishno-ekspluatatsionnaia kontora*, which may be translated roughly as housing deployment bureau.

Figure 6: Provision of Municipal Services to Households in Ukraine

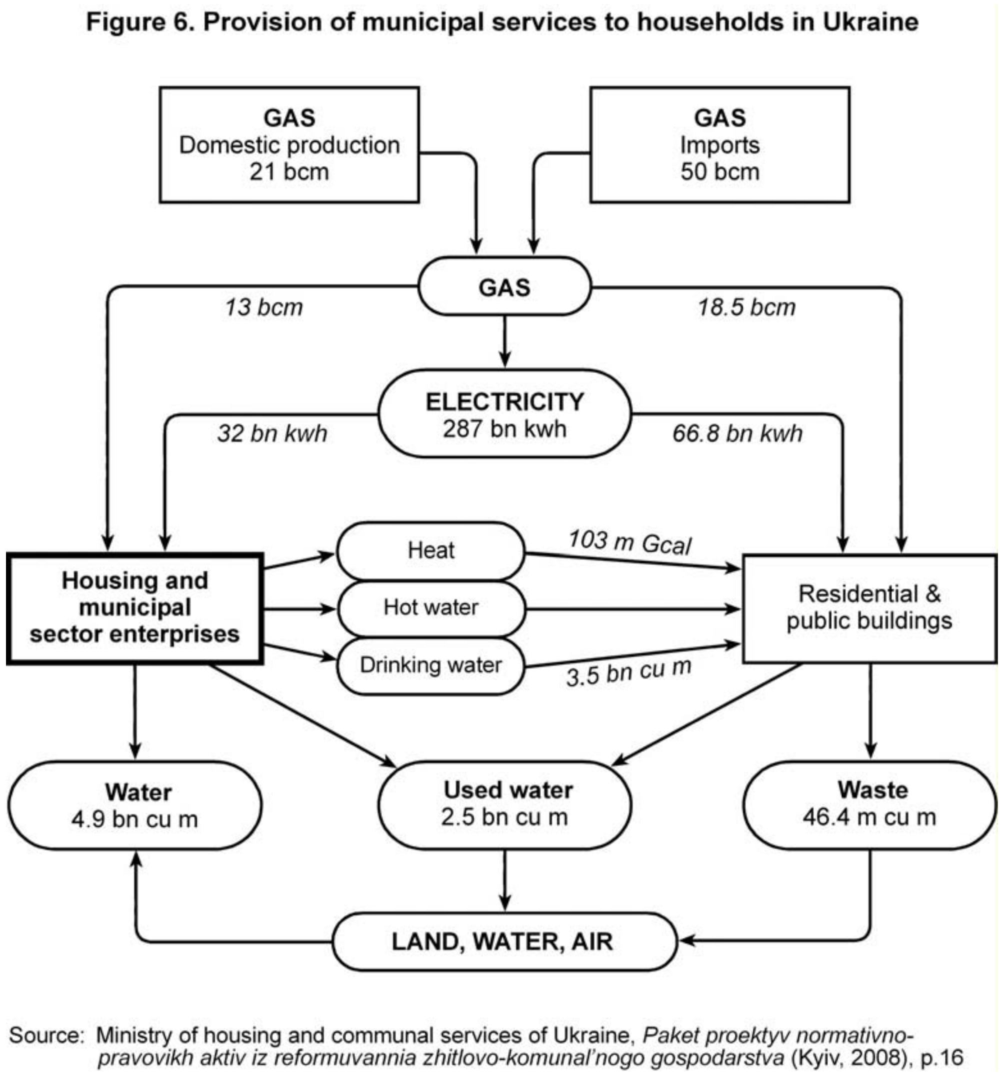


Figure 6 shows the key role played by the housing and municipal services organisations. Until the objectives of the reform of their status, and their ownership and relationship to commercial actors is clearly defined, and frameworks for investment established, the catastrophic decline in the rate of capital repairs is unlikely to be reversed.

The second aspect of reform to which attention is drawn is the establishment of viable systems of tariffs for heat, which are set along with tariffs for other municipal services. In both Russia and Ukraine, tariffs were generally not cost reflective in the 1990s, and reforms began in the early 2000s. In Russia, the district heating trade association reported that the average heat tariff rose from €4.50/Gcal in 2000 to €10.80/Gcal in 2006; an industry researcher estimated that it rose from 195 rubles/Gcal in 2000 to 470 rubles/Gcal in 2006. From the early 2000s the government urged the regions, which set tariffs locally, to end cross-subsidisation and raise tariffs to cost recovery levels; and heat subsidies were largely abolished in 2004-06.[86] However, tariffs rose much faster than inflation and massive disparities opened up between tariff levels in different regions: maximum levels exceeded minimum levels by 30 times for electricity, 40 times for water supply and sanitation, six times for district heating and eight times for hot water supply. One study of municipal services economics showed that disparities in levels of investment were even more extreme; the maximum levels of investment per capita were "hundreds or even thousands of times" greater than the minimum levels. The author argued that the law on local self-government, under which the tariff reforms were being undertaken, was not being implemented effectively because of underlying disparities between regions and the lack of managerial and regulatory capacity, among other reasons.[87] In Ukraine, tariffs are set by local government, and although a cost-plus methodology is used, revenue is only 75-85% of cost recovery on average and less than 50% in Kyiv. In 2009, approved heat tariffs were reported at $37.08/Gcal for residential consumers and $88.56/Gcal for industrial consumers.[88]

The third problem, of striking a correct balance between centralised and decentralised heating, has arisen against a background, on the one hand, of deep-going urban and social change, and, on the other, of a lack of progress made on the first (organisational) and second (tariff structure) problems. The changes in post-Soviet cities have led to changes in heat consumption patterns. First, the closure of industries has led to a shift away from CHP-produced heat towards boiler-produced heat, some of it decentralised, as described in the overview above. Second, de-industrialisation, against a background of changes in the composition of families and households, has led (i) to the construction of new housing stock, often low-rise in contrast to Soviet high-rise blocks, that is supplied by decentralised heating sources and (ii) to households in apartment blocks disconnecting from district heating systems and installing decentralised heating sources. In Russia, the district heating trade association has estimated that the share of centralised heating fell from 35% in 2000 to 31% in 2006; it is estimated that, between 2000 and 2008, the proportion of small boiler houses (i.e. producing 3 Gcal/year or less) has risen from 70% to 73% of the total; and the proportion of heat energy produced from individual sources has risen from 18% to 20%. The Alliance to Save Energy observed that, with real investment far below the level required, centralised systems have lost their market niches; whole cities and whole districts of Moscow are now supplied by decentralised systems; and even where there are centralised systems, they are losing parts of the market to small local or individual boilers.[89]

The progress of heat sector reform may be summarised as follows. In Russia, the law "on heat supply", passed in July 2010, set out a framework for the development of the heat market; it followed the law "on energy efficiency and energy saving" (see Section 1.e above, page 19). The heat supply law envisages a transition, by 2012, away from "cost plus" tariff

[86] Euro Heat & Power, *District Heating and Cooling*, p. 326; Bashmakov "Povyshenie energoeffektivnosti (Chast'1), op. cit.

[87] Roman Martusevich, *Regional disparities in the utility sector services in Russia: does the reform of local self-governance help reduce them?* (PSI Research Unit, June 2008), pp. 2, 6 and 10

[88] Author's information from the ministry of housing and communal services and Kyivenergo; Hi-chun Park, "Towards Cost-Reflective Energy Pricing in Ukraine", *IAEE Energy Forum*, 1st quarter 2011, pp. 15-18.

[89] Euro Heat & Power, op. cit; Bashmakov, "Povyshenie energoeffektivnosti v sistemakh teplosnabzheniia. Chast' II", op cit; Alliance to Save Energy, *Urban Heating in Russia*, op cit.

setting, and towards a system of long-term contracts and/or RAB (regulated asset base) regulation to underpin investment, and provides for an independent federal tariff regulator. A number of energy companies have begun to accumulate heat-producing assets on a large scale; KES-Holding, which has the largest portfolio, claims to be the largest privately-owned producer of heat in the world. (Information on the largest owners of heat generation capacity in Russia is presented in Appendix 8, Table 56.) The presence in the sector of large corporations that also own electricity generation assets, and who have worked with government on preparation and implementation of legislation, is a spur to reform. The president of KES-Holding, Mikhail Slobodin, has stated that the move towards long-term contracts between heat suppliers and major commercial customers, the shift towards longer tariff regulation periods and double-rate tariffs (i.e. separate payments for power and energy), and the exemption of some large customers from regulation, are all likely positive outcomes of the current stage of reform. As well as the many unresolved issues in the heat sector reform itself, there are constraints that will be placed on it by the speed at which the municipal sector reform, including the reorganisation and privatisation of municipal services providers, proceeds.[90]

Ukraine has more barriers to overcome on the way to heat sector reform. A National Heating Strategy, outlining some key reform principles, and a State Targeted Economic Programme for Communal Heating Modernisation 2010-2014 were adopted in November 2009. A high level task force was then appointed to develop the strategy: its tasks included setting up an independent regulator, improving revenue collection rates by municipal services providers and implementing model upgrades to heating systems. A further law, “on the national commission for communal services market regulation of Ukraine”, was passed in early 2010. Following the presidential election of February 2010, and the subsequent change of government, the personnel in charge of the programme changed. Since then, on one hand, it is unclear what progress has been made on municipal services reforms. On the other, the IMF, under its large lending programme to Ukraine begun in October 2008, has prioritised municipal services tariff reform. In early 2011 the government said it was implementing the establishment of an independent regulator. Tariff reform thus has further to go in Ukraine than in Russia. Another noticeable difference between the Russian and Ukrainian heat sectors is that the latter lacks a group of large power companies that are investing in the sector; the only large power company that has publicly pushed for heat sector reform is DTEK, the power company that owns Kyivenergo.[91]

Conclusions on the heat sector

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[90] The Russian government, *Federal’nyi zakon o teplosnabzhenii no. 190-F3*, 27 June 2010; the Russian government, *Federal’nyi zakon RF No. 261-FZ ot 23.11.2009 g. “Ob energosberezhenii i o povyshenii energeticheskoi effektivnosti”*, web site of the ministry of economic development of the Russian federation; Mikhail Slobodin, “Russian Heat Supply Sector Must Radically Increase Its Efficiency”, *Euro Heat & Power* (English edition) 2009 IV, p. 22-24; VTB Capital, “TGK: stavka na reformu teplovogo rynka”, *Vedomosti*, 12 November 2010; Evgeniia Pis’mennaia, “Memorandum ZhKKh”, *Vedomosti*, 28 December 2010; Ekaterina Derbilova, “Chem vyshe podnimaemsia”, *Vedomosti*, 13 January 2011.

[91] Resolution of the Cabinet of Ministers #1216, 4 November 2009; USAID press release, *Ukraine’s National Heating Strategy Moves Forward*, November 2009; author interviews.

Two conclusions about the heat sector arise from the points made above. (1) The potential energy savings – in production, distribution and consumption – are substantial, and could make a substantial impact on gas demand. In round numbers, annual gas demand for heat in the CIS region exceeds 200 bcm; a 10% demand reduction would free up 20 bcm of gas annually, and far greater savings are technically and economically feasible. (2) Substantial savings will only result from a series of substantial reforms, all of which will take time. First, the potential heat efficiency improvements of public and residential buildings will only be realised in the context of major renewals of the late Soviet building stock. Second, the potential energy savings in heat distribution will only be realised in the context of municipal services reform (which includes the reform of gas distribution to the residential sector, electricity supply and hot water distribution, all of which also have implications for the total energy balance). Third, energy savings in heat production require the reform of the district heating sector and the formation of new investment frameworks. This will involve the refurbishment or replacement of much of the Soviet-era district heating plants.

In the period up to 2015 it seems unlikely that energy saving in the heat sector will make a substantial difference to gas demand. But once infrastructure renewal and reforms are implemented, and the effects begin to feed through, the impact on gas demand could be substantial.

3. Industry

Industry in the CIS region consumes significant amounts of gas (i) as feedstocks for the chemical industry and (ii) as fuel to provide process heat. (This is in addition to the role gas plays in generating electricity and space heat for industry.) Table 29, excerpted from IEA energy balances, presents a picture of the place of gas in energy supply to industry.

Table 29: Energy Supply to Industry in the CIS Region, 2008

000 tonnes of oil equivalent										
		Coal & peat	**Oil prod-ucts**	**Gas**	**Re-new-ables**	**Electri-city**	**Heat**	**Total**		**Gas as % of total**
Russia	Industry	10117	13039	30128	269	30967	40571	125111		24.1%
	Chem. feedstocks		*15630*	*23749*				*39379*		*60.3%*
Ukraine	Industry	8844	1492	9471	54	5774	5128	30763		30.8%
	Chem. feedstocks	*6*	*257*	*4784*				*5047*		*94.8%*
Belarus	Industry	54	548	1783	199	1249	1989	5821		30.6%
	Chem. feedstocks		*1*	*1151*				*1152*		*99.9%*
Moldova	Industry	37	27	200	0	66	703	403		49.6%
Azerbaijan	Industry	0	168	581	0	256	363	1368		42.5%
Armenia	Industry	0	0	840	0	101	19	960		87.5%
Georgia	Industry	20	36	179	0	61	19	315		56.8%
Kazakhstan	Industry	8090	2950	780	0	2842	4043	18704		4.2%
Turkmenistan	Industry	0	0	0	0	271	0	271		0
Uzbekistan	Industry	144	216	6614	0	1342	0	8317		79.5%
	*Chem. feedstocks**		*338*	*1767*				*2189*		*80.7%*
Kyrgyzstan	Industry	417	0	0	0	215	0	632		0
Tajikistan	Industry	0	0	0	0	556	0	556		0

* Uzbekistan reports these volumes of fuel as "non-energy use for industry", but not specifically as chemical feedstocks. The author has assumed that is how they are used.

Source: IEA energy balances

Issues to be borne in mind include (i) that the amounts of gas recorded for industrial consumption in Russia are significantly lower than shown in statistics used by Gazprom, as discussed in Section 1.a above; (ii) chemical feedstocks are recorded on a separate line, in accordance with IEA practice; (iii) Uzbekistan does not record in the energy balances any gas used for chemical feedstocks, but there are volumes of gas recorded as "industry, non-energy use" that are surely used in this way;[92] and (iv) Turkmenistan uses gas in industry, probably about 4-5 bcm/year, but does not report any information on that.[93]

[92] For estimates of the level of gas consumption in the chemical sector in Uzbekistan, see Zhukov, "Uzbekistan", in Pirani (ed.), *Russian and CIS Gas Markets*, op. cit., pp. 355-394, especially p. 367.

[93] On Turkmenistan, see Appendix 6, Table 50, and "Turkmenistan", in Pirani (ed.), *Russian and CIS Gas Markets*, op. cit., pp. 271-315, especially p. 284.

Nevertheless the table highlights important points about energy supply to industry. Among the primary fuels supplied to industry, in ***Russia, Belarus*** and ***Moldova***, gas accounts for a greater share than do coal and oil products together – even though, in Russia, the volume of oil products consumed is significant. In ***Ukraine***, coal accounts for nearly as great a share as gas, except when it comes to chemical feedstocks; the amount of gas consumed is increased by about half again when these are included. In central Asia, gas plays an overwhelming role in the fuel supply to industry in ***Uzbekistan***, where its position is almost monopolistic. That is likely to be the case in ***Turkmenistan***, too. In ***Kazakhstan***, by contrast, gas plays a negligible role in industry, which is mainly fuelled by coal. Industry in the Caucasian countries also relies heavily on gas, ***Armenia*** significantly more so than the others.

Gas consumption by industry across the region rose by 12% in the decade to 2008, i.e. at about half the rate that it rose in the power and heat sector (see Table 7 in Section 1.d above). Preliminary indications from 2009-10 are that gas consumption in industry fell much more heavily than in the power sector during the recession. Changes in consumption by industry will probably be second in importance to those in the power and heat sector in determining consumption in the 2010s and 2020s.

Table 30 shows gas consumption in industry. It is excerpted from the IEA's energy statistics for 2008, displayed in Table 2 above. The first part of Table 30 covers Russia and Ukraine, giving natural gas consumption in bcm, and then the consumption of natural gas, coke oven gas and blast furnace gas in terajoules. This underlines the importance of coke oven gas and blast furnace gas, that are by-products of industrial processes, particularly steelmaking; in Russia and Ukraine they account respectively for 20.2% and 27.5% of gas consumed in industry (by energy content). The second part of the table shows gas consumption for seven other states in the region (excluding Turkmenistan, Tajikistan and Kyrgyzstan, which do not provide data to the IEA on consumption by industry), and totals for the nine states.

Table 30: Gas Consumption in Industry in the CIS Region, 2008

	Natural gas		**All types of gas**					
	Russia	**Ukraine**	**Russia**			**Ukraine**		
	Natural gas, bcm	Natural gas, bcm	Natural gas, t/j	Coke oven gas, t/j	Blast furnace gas, t/j	Natural gas, t/j	Coke oven gas, t/j	Blast furnace gas, t/j
INDUSTRY	**66.716**	**17.024**	**1401950**	**124215**	**230683**	**440656**	**49950**	**117524**
As % of industrial gas consumption			**79.8%**	**7.1%**	**13.1%**	**72.5%**	**8.2%**	**19.3%**
Iron & steel	16.243	5.374	610365	121159	217340	209680	49037	117404
Non-metallic min'ls (incl. cement)	13.462	2.808	505858	1703	0	109580	7	0
Chemical & petrochemical	2.130	0.672	80048	0	13343	26238	543	0
Chemical feedstocks	29.408	5.705	1105104	0	0	223621	0	271
Other industry	5.473	2.465	205679	1353	0	95158	363	0

Table 30 continued

	Belarus	Mol-dova	Arme-nia	Azer-baijan	Georgia	Kazakh-stan	Uzbeki-stan		Total natural gas
Natural gas, bcm									
INDUSTRY	**3.535**	**0.241**	**1.037**	**0.701**	**0.218**	**0.930**	**8.123**		**98.525**
Iron & steel	0.127	0	n/a	0.006	0.039	n/a	0		21.789
Non-metallic min'ls (incl. cement)	1.231	0		0.139	0.033		0		17.673
Chemical & petrochemical	0.489	0		0.223	0.062		0		3.577
Chemical feedstocks	1.387	0		n/a	0		2.170		38.670
Other industry	0.301	0.241		0.333	0.083		5.953		14.849

Source: IEA energy statistics

Note. Turkmenistan, Tajikistan and Kyrgyzstan do not provide to the IEA any disaggregated information on how much gas is consumed in industry

The column recording the totals shows that, across the region, industrial consumption of natural gas is dominated by three sectors that together account for more than four-fifths of the total: the *chemical and petrochemical* industries (43%, including the feedstocks and a small amount of gas used as fuel); *iron and steel making* (22%, not including the considerable volumes of industrially-produced gases); and *non-metallic minerals*, the IEA category that includes cement making (18%). These will now be dealt with in turn.

Chemical and petrochemical industry

There are two main types of chemical production in which natural gas is used as feedstock, i.e. as raw material rather than fuel: gas processing plants, and chemical fertiliser production.

Gas processing plants are essentially part of the gas production process, and so are not part of this paper's subject matter – but they border on it. These plants, usually sited near to oil and gas producing fields, separate the components of gaseous phase hydrocarbon production ("wet" gas). The principal product stream is "dry gas" or "grid-specification natural gas", which can be introduced into the national transportation and transmission system; this is composed of around 98% methane, 1% of other hydrocarbons, principally ethane, with the balance being nitrogen and carbon dioxide. The other hydrocarbon product streams are ethane, propane, butane and higher alkanes. Collectively these are termed natural gas liquids (NGLs); propane and butane are commonly also referred to as liquid petroleum gas (LPG). Prior to the separation of these product streams the raw gas is processed to remove water, excess nitrogen, sulphur compounds and trace mercury compounds.

Since the liquids are removed before the gas goes into the transmission system and becomes part of the gas balance, they are of marginal concern. However the part of the gas removed as NGLs is counted by the IEA, and apparently by Russian statistical agencies, as having been consumed as chemical feedstocks, i.e. a non-energy use, and so it should be kept in mind. The NGLs are intermediary products, often used in the same plants in the production of petrochemicals. Due to the gradual shift of Russian gas production to fields with a higher proportion of “wet” gas containing substantial quantities of NGLs, mentioned above in Section 1.b, this significant use of by-products from gas will increase in the coming years.

A large proportion of Russian gas processing capacity is owned by integrated petrochemicals companies. The largest, Sibur, in 2009 processed 16.8 bcm of associated petroleum gas, supplied mainly by non-Gazprom producers (the three largest were TNK-BP, Rosneft and Gazpromneft). Its main business is the manufacture of synthetic rubbers and plastics from hydrocarbon liquids, including those originating as by-products from “wet” gas; the “dry” gas resulting from processing is either sold on the market or used as raw material by Sibur Mineral Fertilisers, a subsidiary. Sibur has recently changed ownership, with a controlling shareholding being sold by Gazprombank to companies linked to owners of Novatek. Another petrochemicals company with significant gas processing capacity, Salavatnefteorgsintez of the Bashkir republic, is now majority controlled by Gazprom. Its main business is the production and marketing of oil products, but from the dry gas available it also manufactures ammonia and mineral fertilisers.[94] That part of these companies’ dry gas used in fertiliser production also counts as gas consumed for non-energy purposes.

Unlike the gas processing plants, the *chemical fertiliser plants* consume “dry” natural gas as raw material; purchase of it is their most significant production cost. Russia consumes about 15 bcm/year of gas in fertiliser production, and Ukraine 7.5-8.5 bcm/year.[95] Gas is the principal raw material for the production of ammonia, which is then either marketed as fertiliser or used for the production of urea or ammonium nitrate. Gas comprises 80% or more of the production cost of ammonia, and the efficiency of its use is therefore crucial. In Russia the fertiliser producers’ federation stated that an average of 1.152 mcm of gas is used per tonne of ammonia production; in Ukraine an estimated 1.05-1.3 mcm is used; in western Europe an estimated 0.7 mcm is used on average. Russia has produced 12-13 million tonnes of ammonia per year in recent years and Ukraine produced 4.7-5.3 million tonnes per year in 2001-06. Russia has six major fertiliser producers that own two or more plants each, while Ukraine has six plants in total; these are listed in Appendix 9, in Table 57.

The chemical fertiliser sector provides an example of change brought about by rising gas prices. The sharp increase in gas prices in Ukraine, from 2006, put the chemical fertiliser plants there at a disadvantage to their Russian competitors. Even before the financial crisis, they responded with some efficiency upgrades: at Rivneazot, the reconstruction of two production units in 2007 reportedly reduced the gas consumed per tonne of ammonia production from 1.24 mcm to less than 1. Financing such upgrades was easier in 2006-07 since fertiliser prices, which are linked to the demand for agricultural products, were in general rising. In 2008-09, they fell as a result of the world economic crisis, while Ukrainian gas import prices, and therefore industrial consumers’ prices, rose sharply. Some of the Ukrainian fertiliser producers were forced to close down production capacity rather than operate at a loss. Industry analysts estimated that production of both ammonia and ammonia-

[94] Sibur company presentation; Sibur Mineral Fertilisers annual report; Salavatnefteorgsintez annual reports.

[95] Russian Association of Fertiliser Producers, presentation, “O situatsii na rossiiskom rynke mineral’nykh udobrenii”, February 2010; Derzhavnyi komitet statistiki Ukrainy, *Palivno-energetichny resursy Ukrainy: statistichniy zbirnyk* (Kyiv, 2004, 2006 and 2009).

based fertilisers fell by more than half in 2009 (there is insufficient information from the companies themselves, only one of which, Stirol, is publicly traded). In response to fears for the future of the sector, from 2008 until April 2010, the energy regulator imposed discounts on gas sold to chemical and metallurgical companies, and an extra discount for producers of mineral fertilisers. Between January 2009 and April 2010, total gas prices including VAT and transportation costs for Ukrainian industrial customers were $327.40/mcm, and for mineral fertiliser producers $260.71/mcm; from April 2010 the discount was removed. But these measures failed to prevent losses and production cutbacks, which resulted in a wave of consolidation. One owner of chemical fertiliser plants – Group DF headed by Dmitry Firtash, which also has gas sector assets – bought out others. Group DF, which already controlled Rivneazot, in late 2010 and early 2011 acquired controlling interests in Severodonetskii Azot, Stirol and Cherkasskii Azot, taking a dominant position in the sector.[96]

The Russian fertiliser producers were less severely affected by the crisis than their Ukrainian counterparts. In 2010, world prices for ammonia-based fertilisers began to rise again, in line with increased demand, and higher prices, for agricultural commodities. The increased costs caused by rising gas prices for industrial consumers in Russia were offset by higher revenues, and they continued to enjoy competitive advantage over their Ukrainian and eastern European competitors. The largest Russian producer of ammonia-based fertiliser, Evrokhim, estimates that it buys gas at its plants at $108/mcm, compared to $307/mcm for Ukrainian producers and $340/mcm for eastern European producers. It projects that the application of the principle of "European netback" in the Russian market will bring gas prices at its plants to $150/mcm, and that even then it will retain its advantage. (Evrokhim's estimates of costs and urea prices can be found in Appendix 9, Table 58.) Furthermore, Evrokhim management states that in order to reduce the impact of rising gas prices on its business, it plans a programme of energy efficiency improvements, removal of bottlenecks and product diversification (in particular from prilled urea to granular urea) to "reduce the share of natural gas cost in the product price". Management also reports that it is considering measures to diversify its gas supply, in particular by buying gas from non-Gazprom producers.[97]

It appears that the future level of gas consumption by chemical fertiliser producers will be determined (a) by the demand for fertilisers and for the agricultural commodities with which they are linked, which at present seems to be on a long-term upward trend; (b) by the rate at which Russian gas prices continue to rise, and the efforts by Russian fertiliser producers to minimise the impact, including by efficiency improvements; (c) by the extent to which the setback suffered by Ukrainian producers during the crisis, and the loss of competitive advantage caused by the differential in gas prices, causes permanent loss of market share and reduction of capacity.

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[96] National Electricity Regulatory Commission of Ukraine web site and author's estimates (for prices); Viktor Tarnavskii, "Potrebitel'skie nastroeniia", *Energobiznes*, 2 June 2010; Group DF press release, *Dmitry Firtash Grows His Group's Chemical Companies*, 2 March 2011; "Azotnoe more", *Kommersant-Ukraina*, 3 March 2011.

[97] Evrokhim presentation, "Introducing EuroChem", 30 November 2010

The expansion of the chemical industry is also expected to be a factor influencing consumption levels in Uzbekistan in the coming years. Uzbekistan's chemical industry consumed 2.17 bcm of gas in 2008, according to the IEA; other estimates put its annual consumption at 2.5-3 bcm. The industry produces a wide range of industrial chemicals and mineral fertilisers, as well as LPG that is consumed domestically and exported to Iran and Afghanistan. Considerable expansion is underway, the most significant project being a gas-to-liquids plant at Karchi with a projected output of 35,000 barrels per day, being built jointly by Uzbekneftegaz, Petronas and Sasol, using Sasol technology. The IEA estimates it will be operational by 2020, and will consume up to 3.5 bcm/year of gas.[98]

Iron and steelmaking

The 21.8 bcm of natural gas recorded by the IEA as being consumed in 2008 by the iron and steel sector is accounted for almost entirely by Russia (16.2 bcm) and Ukraine (5.4 bcm). It is supplemented by considerable volumes of coke oven gas and blast furnace gas. National ministries and companies use higher figures for gas consumption by the iron and steel sector, possibly because they are including (i) these artificially-produced gases, and (ii) gas used for heat and in some cases power production at metals plants.

The metals sector differs from both chemicals and cement, because although some of its processes are very energy-intensive, as a whole it is far less gas-intensive than those sectors. The metals sector consumes large quantities of electricity and coal, as well as gas, and is consequently less directly exposed to increasing gas prices. For the large steel companies that dominate the Russian industry, energy accounts for 5-10% of costs, of which 2-4% is gas, judging from the accounts of those that are publicly quoted. In Appendix 9, the energy items in the costs of those companies, and of the leading Ukrainian iron ore producer Ferrexpo, are shown in Table 59. To the extent that the metals sector has been exposed to rising gas prices – in Ukraine earlier and more severely than in Russia – companies have started to implement efficiency improvements, and, although these were interrupted by the economic and financial crisis, they appear to be yielding results.

The Ukrainian steel industry was until the mid-2000s extremely energy-inefficient by international standards, and once prices began to rise, companies focused on three methods of reducing gas consumption:

(i) Replacement of gas with coal in pig iron production, with the introduction of coal and coke injection technology. (This upgrade was completed at Donetskstal prior to the crisis; in 2010 two units were commissioned at Alchevsk steel works; and at the time of writing installation work is in progress at Zaporozhstal, the Mariupol (Il'ich) steelworks and Arcelor Mittal Krivoi Rog. Among Russian producers, Evraz steel is also introducing this technology at its two largest plants, and expects to commission it by 2013.)

(ii) Replacement of open hearth furnaces with oxygen converter furnaces, and reducing output from open hearth furnaces where possible (e.g. at Azovstal).

[98] IEA, *World Energy Outlook 2010*, p. 490.

(iii) More effective use of blast furnace gas and coke oven gas (e.g. at Alchevsk and Krivoi Rog).

Other upgrades that are desirable from the point of view of overall efficiency, such as the installation of continuous casting machines in steel rolling, also reduce fuel consumption.

In 2009, the Ukrainian energy information group *Energobiznes* published estimates that the steelmaking sector, which had consumed 9.5-9.7 bcm/year of gas prior to the crisis, would reduce its consumption to 7.5-8.5 bcm/year by 2012 (assuming a return to pre-crisis levels of steel production, in line with industry expectations). It projected that further reductions to 5-5.5 bcm/year were entirely possible by the end of the decade.[99]

The Russian steel plants are on average more technically advanced than the Ukrainian ones, and in particular the proportion of open hearth furnaces in operation is lower. Nevertheless, during the Russian economic boom of the 2000s, easily-attainable energy savings were begun in the course of modernisation and expansion. Continuous casting capacity was installed, and CCGT and other equipment installed for using artificial gases. Both government and companies consider that significant further energy efficiency improvements are possible. Significantly, the *Strategy for the Development of the Russian Metallurgical Industry Up To 2020*, adopted by the government in March 2009, projects three scenarios of development for the industry, all of which would result in increases in production of varying degrees – and under all of which, gas demand from metals producers would fall to between 91% and 99% of its 2007 level.[100]

Cement industry

The third largest industrial consumer of gas after chemicals and the metallurgical sector is the cement industry, which accounts for most of the IEA "non-metallic minerals" category. The IEA energy balances show total consumption by that category in the CIS region in 2008 as 17.6 bcm, including 13.5 bcm consumed in Russia and 2.8 bcm in Ukraine. The real figure is probably higher, as it will include volumes used in central Asian countries but not reported to the IEA. Cement making in the CIS region is particularly energy intensive: fuel accounts for up to 40% of costs, and most producers use gas. In Russia, 85% of plants use the old and relatively energy intensive "wet" process; government and industry see upgrading these as a strategic priority. Russian cement production rose steadily from 33 million tonnes in 2000 to 60 million tonnes in 2007, due to a country-wide boom in building made possible by the oil-driven economic recovery. Production fell rapidly during the recession to 53 million tonnes in 2008 and 44 million tonnes in 2009; it was estimated at 49 million tonnes in 2010.

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[99] Viktor Tarnavskii, "Potrebitel'skie nastroeniia", *Energobiznes*, 2 June 2010; Ivan Kharchuk, *New Gas Prices: Second Wind for Industry* (Alfa Bank report, 3 January 2006).

[100] Ministry of Industry and Trade of Russia, *Strategiia razvitiia metallurgicheskoi promyshlennosti Rossii na period do 2020 goda*, p. 82; Wood Mackenzie, *Finding Equilibrium* (Edinburgh, 2009), p. 9.

The future of cement making, and gas consumption by cement makers, will depend on (a) the pace at which the construction industry recovers, (b) the extent to which companies are able to improve the efficiency of their plants, and (c) the relationship between gas and coal prices. The recovery of the construction industry is a political priority, since, quite apart from the property boom in Russia's larger cities that had bubble-like characteristics, there is a fundamental need to renew the housing stock. Housing is one of Russia's four designated "national projects" and the government remains committed to spending part of Russia's oil revenues on it. However from a gas demand point of view, it is quite possible that increases in cement output will to some degree be offset by energy efficiency improvements. The government's *Strategy for the Development of the Building Materials Industry in the Period to 2020*, adopted in 2010, gives an indication of political intentions. It projects an increase in cement production, which was 60 million tonnes in 2007 and 44 million tonnes in 2009, to 97.7 million tonnes in 2020. It also projects a reduction in the energy intensity of cement manufacture from 202 units of standard fuel per tonne of clinker, to 120 units (a saving of 40.5% of the energy used per unit of production), which would bring Russia in line with the European average. If both of these projections were realised, the net result would be a small reduction in gas consumption by the cement industry, in the range of 2-4%. In Ukraine, parliamentarians have made similar estimates of the potential reduction in the energy intensity of cement production: they say that fuel use per tonne could be reduced from 102-108 kilogrammes of oil equivalent to 60-69, by installing the now-standard dry process equipment.[101]

It may be objected that the projected energy efficiency improvements are over-ambitious. (For comparison, between 1970 and 1999 the US cement industry saved 27.4% of the energy used per unit of production.[102]) On the other hand it may be that the Russian projection for cement production, which assumes an entirely favourable economic environment, is also too high. The most likely outcome seems to be that gas consumption by cement makers will regain its pre-crisis level and then increase, but not nearly as rapidly as cement production.

Conclusions on industrial consumption

From what has been said above, the following preliminary conclusions can be drawn:

- For the rest of this decade, the main factor that would increase gas demand will be increased industrial output, which in turn depends on demand for manufactured goods. In many industrial sectors in the CIS region, a large part of that demand is for exports. In the three largest gas consuming sectors, given at least steady economic recovery, that demand should increase. But whether the resulting increase in gas demand will outweigh the factors that will depress gas demand is far less certain.

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[101] Ministry of regional development of Russia, *Strategiia razvitiia promyshlennosti stroitel'nykh materialov na period do 2020 goda*, April 2010, pp. 76 and 78; Olga Miagchenko, *Ministerstvo utdverdil strategiiu*, Ards group web site (www.ards-c.ru), March 2010; Oleh Dudkin, *Analysis of policy reforms for attraction of investments into development of energy efficiency and renewable energy sources in Ukraine* (presentation, Geneva, 7-9 October 2009).

[102] Ernst Worrell and Christina Galitsky, *Energy Efficiency Improvement and Cost Saving Opportunities for Cement Making*, March 2008, p. iii.

- The most significant factor that will depress gas demand in industry is efficiency improvements. In Ukraine, these began in the mid 2000s, and it seems probable that these have led to a reduction of the gas intensity of industry. In Russia, there has also been a certain amount of renewal of the capital stock of industry. The difficulty of gathering sufficient statistical information, and the disruptive effect of the economic crisis, means that the extent of falling gas intensity of industry can not yet be measured with any certainty.

- In Ukraine, rising gas prices have stimulated efficiency improvements. Prices are rising at a more gradual pace in Russia, Belarus and other CIS countries, but there is every reason to think that they will act as stimulants for efficiency improvements in those countries too.

- The scope for economically feasible efficiency improvements in this decade is sufficient that, in the metallurgical and cement industries, the Russian ministries that oversee their development do not expect any increase in gas demand, even assuming that these sectors increase output more or less rapidly. While government projections rarely work out as expected, and the expectation of efficiency improvements in the cement industry are particularly optimistic, this is indicative of the available potential.

- Given the combination of rising gas prices and efficiency improvements, the question needs to be asked: why should there be substantial increases in gas demand from industry? The ERTA consultancy, which has monitored gas demand in Russia for many years, recently pointed out that a projection by Gazprom of an absolute increase in Russian domestic demand of 80 bcm/year between 2009 and 2020 rested on an assumption that non-energy-intensive industrial sectors would raise their consumption by 70% in that time frame. ERTA questions this assumption.[103]

- The central Asian states have not set out strategies for raising gas prices, and the factors that will depress gas demand from industry will not work so noticeably there as in Russia and the western CIS.

[103] ERTA presentation, *Natural gas consumption 2010-2030: how much is actually needed?*, 2010.

4. Household consumption

Of the total energy supplied to the residential sector in the CIS region, the IEA records that natural gas occupies first place, followed closely by heat, and with electricity third. IEA statistics, excerpted from its energy balances for 2008, are shown in Table 31.

Table 31: Energy Supplied to the Residential Sector in the CIS Region, 2008

000 tonnes of oil equivalent										
	Coal & peat	**Oil prod-ucts**	***Gas***	**Renew-ables**	**Electri-city**	**Heat**		**Total**		*Gas, bcm*
Russia	3014	7588	*39900*	1223	10074	52148		113946		*49.41*
Ukraine	1407	667	*13822*	422	2674	4403		23394		*16.48*
Belarus	206	1378	*1198*	548	544	2097		5970		*1.44*
Moldova	0	285	*228*	0	118	126		757		*0.27*
Azerbaijan	0	118	*2581*	0	640	33		3372		*3.11*
Armenia	0	0	*0*	0	154	16		171		*0*
Georgia	6	81	*193*	343	246	10		879		*0.23*
Kazakhstan	0	193	*0*	0	639	2009		2841		*0*
Turkmenistan	0	0	*0*	0	158	0		158		*0*
Uzbekistan	14	17	*14971*	0	635	0		15638		*18.39*
Kyrgyzstan	0	0	*0*	0	197	0		197		*0*
Tajikistan	0	0	*0*	0	267	0		267		*0*
TOTAL	**4647**	**10327**	***72893***	**2536**	**16346**	**60842**		**167590**		***89.33***

Source: IEA energy balances

The statistics in Table 31 are limited by the patchiness of information reported to the IEA and by the omission from its methodology of autoproduced heat. Nevertheless some key points stand out: above all the ubiquity of gas consumption. The amount of gas consumed (by energy content) is more than 15 times the amount of coal and more than seven times the amount of oil products. The conversions in the final column show that the IEA recorded residential sector gas consumption in the CIS region of 89.3 bcm in 2008. Residential sector consumption in central Asia, except for Uzbekistan, was not reported to the IEA, so to this figure must be added probably 1.5-2 bcm in Turkmenistan, 1.0 bcm in Kazakhstan and small amounts in Kyrgyzstan and Tajikistan.

Gas consumption by households across the CIS region fell noticeably in the decade to 2008 (see Table 7 above, page 12). Total consumption was 92.4 bcm in 1998 and 89.3 bcm in 2008, i.e. 3.3% lower. Consumption rose and fell several times during the decade, but the trend was downwards: the annual average for the three years 1998-2000 was 94.5 bcm, and for the three years 2006-08, 88.2 bcm, i.e. 6.7% lower. The fall in population in Russia and the western CIS, and changes in household composition patterns, are among the likely reasons for this. The prospect that residential consumption could continue to decline will be a significant element in estimating the level of consumption in the 2010s and 2020s.

Gas delivered to the residential sector is used for cooking, space heating and water heating and, although gas connections are much higher than in many parts of the world, there is room for expansion and that is being considered in many CIS countries. In Russia, according to the state statistics agency, there are 59.55 million homes, of which 69% are supplied either with pipeline gas or with deliveries of liquefied petroleum gas (LPG).[104] According to the *General Scheme for the Development of the Gas Sector*, in 2007 30.5 million households were connected to the pipeline network, and a further 9.8 million supplied by LPG. Gazprom stated that, of these, 26.1 million households were supplied by Gazprom subsidiaries. By 2009, the number of households supplied by Gazprom subsidiaries had risen to 26.7 million. The total is likely to rise further in the coming years as a result of the policy of gasifying new regions, discussed below. In Ukraine, there were 13.1 million households connected to the pipeline network at the end of 2008, of which 10.3 million were in urban areas and 2.8 million in the countryside.[105]

It seems likely that some of the gas recorded as being consumed by households may be volumes lost from low-pressure pipelines. Industry publications and participants across the region emphasise the outworn state of much infrastructure, and future research should take this into account.

4.a. Gas supply to households

In Russia, Ukraine and much of the rest of the CIS, gas for household consumption is delivered by regional gas companies (i) to municipal services companies, who supply it to residents of multi-apartment housing blocks along with other services (heat, electricity, hot and cold water, etc), as mentioned above in Section 2.e, page 59, on the heat sector, (ii) directly to private households, and (iii) to other bodies, e.g. consumer associations, condominiums, etc. Residential gas supply to the multi-apartment blocks shares many characteristics with heat supply: modern and efficient as it was during Soviet urbanisation in the 1950s-70s, it is now inflexible and in need of upgrading or replacement. Much remains to be done to make efficiency savings. On one hand metering has only begun to be introduced, and on the other, in most apartment blocks, the gas supplier is unable to reduce or cut off the supply to an individual flat. In Ukraine, in mid 2009, meters had been installed in 7.7 million of the 13.1 million households connected to the network, compared to 4.1 million of 11.3 million households connected to the network in 2004. Naftogaz Ukrainy stated that this had resulted in a reduction of the delivery of gas in excess of norms (i.e. in excess of the volumes the company estimates are required by households) from 0.8 bcm in 2004 to 0.3 bcm in 2009.[106] In Russia, industry sources estimate that meters are now installed in between one-quarter and one-third of homes.

[104] Rosstat web site (www.gks.ru), tables "Chislo zhilykh kvartir po sub'ektam RF v 2009 g." and "Blagoustroistvo zhilishchnogo fonda".

[105] See also Appendix 11, Table 61. *Gazprom v voprosakh i otvetakh* (2007 edition), p. 42; *Gazprom v tsifrakh 2005-2009 gg.: spravochnik*, p. 59; Derzhavnyi komitet statistiki Ukrainy, *Statistichnii biuleten' pro osnovny pokazniki roboti gazovogo gospodarstva Ukrainy za 2008 rik* (Kyiv 2009), p. 5.

[106] Svetlana Mizina, "Stoprotsentnii uchet gaza – eto real'no", *Neft' i Gaz* (Kyiv), June 2009, p. 18.

Gas delivered to residents is priced below that delivered to industry and district heating, as discussed in Section 1.e above. In Russia and Ukraine, and some other CIS countries, the regulated prices are set in bands that depend (i) on whether or not the household has had a meter installed, and (ii) on the volume of gas used by the households. For those without meters, the volumes are determined by the size of the residence, measured in square metres of floor space. To illustrate the range of regulated prices, the current price list for Ukrainian residential customers is displayed in Appendix 11, Table 60.

The difficulties faced by the Russian and Ukrainian governments in raising gas prices for individual households have been noted in Section 1.e. Firstly, there is considerable social resistance to tariff increases, and this has caused the governments to tread carefully. Secondly, in the absence of legislation allowing or requiring suppliers to cut off non-paying customers, price increases have led to increased non-payment in both Russia and Ukraine. Although non-payment is much less of a problem among residents than among district heating companies, it places a limit on accelerated price increases.

Consequences of fixed dual pricing

Some important questions about residential consumption in Ukraine, which may be relevant to other CIS states too, have been raised by the Institute for Economic Research and Policy Consulting, a prominent Ukrainian centre for economic and fiscal research. The Institute compared two sets of data collected by the state statistical agency: (i) on the size of Ukrainian residences, and (ii) on the level of gas consumption by households. It found that a significant proportion of households were consuming implausibly large volumes of gas: according to the statistical agency's data, 8% of urban households and 21% of rural households were consuming more than 3 mcm/year, and the levels of consumption by the most profligate users were 20 mcm for urban households and 33 mcm for rural households. This compares to estimates made by the IEA that 100 square metres of living space – i.e. the aggregate floor space of two or three typical apartments in the CIS – require about 2.5 mcm, given current levels of efficiency and infrastructure. The Institute concluded that, while average recorded household consumption, of 1.0 mcm/year for urban households and 1.9 mcm/year for rural households, was reasonable, individual records of household consumption of 3-33 mcm/year were implausible.

One likely explanation for this anomaly is that some gas recorded as residential consumption is diverted to commercial and industrial users. The Institute pointed out that the differential between household and industrial prices "creates arbitrage opportunities for gas producers and traders", making corrupt activities more likely despite legal barriers.[107] The author's interviews with Ukrainian market participants also lend credibility to such an explanation. This is an important issue from the standpoint of sector reform and market development. Most governments in the region intend to continue direct or indirect subsidies to lower-

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[107] Institute for Economic Research and Policy Consulting/ German Advisory Group on Economic Reform, *Household gas prices in Ukraine: how to combine economic and social requirements* (Kyiv, December 2006), pp. 4-6

income residential customers. Where subsidies are continued via dual pricing systems, the distortions created by these arbitrage opportunities are likely to continue.

Future trends

In the residential sector, the market reforms in progress, mentioned in Section 1.e above, involve (i) increases in prices, and (ii) the renewal of supply infrastructure within apartment blocks, and the installation of meters and of equipment that allows individual customers to be cut off. This latter type of change is most likely to be made at the same time as refurbishment of housing, that is required on a large scale in any case, and is therefore dependent on the overall schedule of municipal service reform.

Tariff levels are likely to rise only slowly, due to the social and political factors mentioned. The installation of meters, which involves significant capital outlay, is in practice likely to be undertaken only under conditions where both prices and collection rates are higher. For this reason, among others, metering schemes and the renewal of supply infrastructure within residential housing will probably take many years to complete.

The considerable efficiency gains possible in the residential sector will take time to realise, as with district heating – but could be substantial when completed.

4.b. Gasification

Gasification, i.e. the construction of new transmission and distribution networks to make pipeline gas available in new geographical areas, has been and continues to be a significant means of expanding gas demand in the CIS region. Gasification was a key element of Soviet-era urbanisation and modernisation strategy, and remains important in the social welfare agenda of many of the post-Soviet states.

In Russia, the government encouraged heavy investment in gasification – along with housing, education and other items of social spending – during the boom of 2002-08. Consequently, between 2005 and 2009 Gazprom invested 90 billion rubles in the gasification of new regions. In that period, the proportion of households to which pipeline gas is supplied rose from 61% to 67.5% in urban areas and from 36% to 45.5% in rural areas, i.e. from 54.2% to 63.2% overall. More than 14,000 km of new pipeline was laid and 885 new connections between residential areas completed. In line with government policy of maintaining infrastructure and social spending through the economic crisis, Gazprom projected its spending on gasification in 2010-11 at 50 billion rubles. The gasification programme addresses the disproportionate availability of gas across Russian regions: in 2007, in the Central, Southern and Volga federal districts, up to 90% of the population had access to gas supply, including 69-74% with access to pipeline gas, while in other regions it was significantly lower. In particular, there are almost no pipeline gas networks in eastern Siberia and the Russian Far East.[108]

Gazprom's gasification programme, undertaken primarily to implement government municipal and social welfare policies, was in 2010 modified with a view to "more effective use of resources" and better coordination with local authorities. This followed a series of disputes with local government in areas where the completion of supply infrastructure lagged behind the construction of gas pipelines, meaning that pipelines were built but gas could not be delivered through them.[109] Under the revised programme, Russian regions were divided into three groups, (i) with networks already developed and connected to the unified gas supply system (UGSS), (ii) where there are local networks independent from the UGSS and gas or gas condensate fields, and (iii) where there are no links to the UGSS and no gas production. In parts of (ii), and all of (iii), liquefied and compressed gas, and LPG, will be used and pipeline infrastructure will not be built. With this more discriminating approach, greater weight will be given to the relative costs of supplying pipeline gas and liquefied gas.[110]

A key element of gasification in Russia is the provision of pipeline gas from the Sakhalin fields, and future east Siberian production, to the local population. A development programme for gas production, transmission and supply in eastern Siberia and the Far East was approved by government in September 2007. This prioritises the expansion eastwards of the gas pipeline system, as gas exports to the Pacific region develop, and envisages a gas market operating "on the basis of competitive pricing among various fuels without direct administrative price regulation by the state". The extra consumption envisaged is significant: annual aggregate gas consumption in eastern Siberia and the Far East would rise from 13.2 bcm in 2009 to 21 bcm in 2015 and 31 bcm in 2020,[111] according to the draft *General Scheme for the Development of the Gas Industry* – although these estimates, made prior to the economic crisis, may be revised.

In 2011, Gazprom stated that it had completed agreements on gasification with nine of the 14 adminstrative regions in the Far East and East Siberia. The first strategic gasification project is the Sakhalin-Khabarovsk-Vladivostok pipeline; Gazprom states that it expects to start delivering about 1.2 bcm/year of gas to the city of Vladivostok and Russkii island, out of 1.6 bcm/year that will be available to it for domestic sales from the Sakhalin II project. In the longer term the company plans to deliver gas to the Khabarovsk and Primorskii regions, and the Jewish Autonomous Region, via this pipeline. Mezhregiongaz, Gazprom's domestic sales division, reports that it has orders for 12 bcm/year from these regions, but that prior to signing contracts the gas needs to be sourced. Some of it will come from Sakhalin III

[108] *Gazprom v voprosakh i otvetakh* (2011 edition), p. 52; "Gazprom napravit 25 mlrd rub. na gazifikatsiiu", *Vedomosti*, 24 December 2010; *General'naia skhema razvitiia gazovoi otrasli*, p. 6-1.

[109] The director of Mezhregiongaz, Kirill Seleznev, complained publicly about the failure of seven regions to complete work on time. See protocol of Gazprom press conference, "Postavki gaza na vnutrennii rynok", 21 June 2010.

[110] Gazprom press release, "Gazprom management committee approves updated concept for gasification", 1 December 2009.

[111] *General'naia skhema razvitiia gazovoi otrasli na period do 2030 goda: proekt* (Moscow, 2008), p. 2/4

(Kirinskoe field), which is expected to produce 0.5 bcm in 2012 rising to 4-5 bcm/year subsequently; larger volumes from the Sakhalin I project would only be available in 2017 at the earliest. In the second half of the decade Gazprom also hopes to supply gas to the Irkutsk region, from the Kovykta project, and the Sakha region, from new gas production there.[112]

Gasification has played an important part in the energy policy of other CIS countries. The most significant investment seems to be in Uzbekistan, as mentioned above in Section 1.e, where gasification not only of urban but also of rural areas has resulted in very high levels of gas availability to rural homes (with estimates ranging from 77% to 83%), as well as LPG supply to 720,000 households. Armenia, Belarus and Moldova also completed major gasification programmes in the decade up to 2007. In the coming years, Kazakhstan intends to expand gasification. Initially, according to the government's programme for oil and gas sector development, funds are to be invested in the southern part of the country. A pipeline under construction between Beineu and Shymkent will serve a dual purpose: to feed the central Asia-China pipeline for export, and to make Kazakh rather than Uzbek gas available in the heavily populated south-east of Kazakhstan. Gasification is also under consideration for western and north-western regions near Kazakhstan's own oil and gas fields, whereas pipeline gas to the central, eastern and northern parts of Kazakhstan is unlikely ever to be economically feasible.[113]

It is not possible to quantify the increase in demand that has resulted or will result from gasification. No information, even in the form of estimates or projections, has been published on this, to the author's knowledge. The gains are possibly more significant in social welfare terms – i.e. the provision of gas to those formerly unable to receive it – than in terms of the volumes involved. Nevertheless, it is a factor that increases demand that must be taken into account.

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[112] *Gazprom v voprosakh i otvetakh* (2011), pp. 13-14; Gazprom web page on gasification (http://www.gazprom.ru/production/projects/east-program/); stenogramme of press conference "Gazprom na Vostoke Rossii, vykhod na rynki stran ATR", 21 June 2011.

[113] The government of Kazakhstan, *Zakon "o gaze i gazoshabzhenii": proekt* (2010); Yenikeyeff, "Kazakhstan's Gas Sector", in Pirani (ed.), *Russian and CIS Gas Markets*, op. cit.

5. Consumption during production, transport and distribution

Substantial quantities of gas are consumed (i) in oil and gas production, usually to provide power for upstream operations, and (ii) in transport, along both high-pressure pipelines and low-pressure distribution networks. The relevant rows from the IEA's energy statistics are shown in Table 32.

Table 32: The Energy Industry's Own Use of Gas, 2008

bcm	Russia	Ukraine	Belarus	Moldova	Armenia	Azer-baijan	Georgia
Energy ind. own use	16.48	1.41	0	0.36	0	0.51	0.10
Distribution losses	6.54	1.05	0.15	0.08	0	0.74	0.10
Pipeline transport	43.67	3.53	0.54	0.01	n/a	0	0
Own use total	66.69	5.98	0.69	0.44	0	1.24	0.20
DOMESTIC SUPPLY	*453.43*	*66.77*	*21.31*	*2.38*	*2.22*	*10.95*	*1.32*
Own use as % of domestic supply	*14.7%*	*9.0%*	*3.3%*	*18.6%*	0	*11.3%*	*15.0%*
2008, bcm	Kazakhstan	Turkmen-istan	Uzbek-istan	Kyrgyz-stan	Tajik-istan		**Total**
Energy ind. own use	5.62	1.68	2.18	0	0		**28.33**
Distribution losses	0.98	0	2.05	0	0		**11.68**
Pipeline transport	0	0	1.71	0	0		**49.45**
Own use total	6.60	1.68	5.93	0	0		**89.46**
DOMESTIC SUPPLY	*32.83*	*16.93*	*53.51*	*0.74*	*0.54*		***662.96***
Own use as % of domestic supply	*20.1%*	*9.9%*	*11.1%*	*0*	*0*		***13.5%***

Source: IEA energy statistics; excerpted from Table 2 in Section 1.a

There are some anomalies in the table. Kazakhstan records a very large amount of gas used by the energy industry; it may be that some of the large volumes reinjected in Kazakh oil and gas fields are included here, although under IEA methodology they should be excluded. (IEA and government statistics are compared in Appendix 6, Table 48.) There are several countries that report no gas consumed for pipeline transport to the IEA; for Turkmenistan and Kazakhstan, most obviously, this is incorrect. It is also noteworthy that since 2005, Gazprom has published figures for its technical use of gas: for 2008, this is (i) higher than the IEA's figure for pipeline transport, and slightly lower than the IEA's sum of pipeline transport and distribution losses, and (ii) lower than in the preceding years, but higher than in 2009, as shown in Table 33:

Table 33: Gazprom Technical Use of Gas

bcm	2005	2006	2007	2008	2009
Total internal gas consumption	444.4	458.9	467.1	462.5	432.2
Gas for technical purposes for pipelines and storage	51.7	52	49.5	49.6	36.3

Source: *Gazprom v tsifrakh* (2010 edition), p. 42

Table 32 is useful as it shows the large proportion of gas consumed by the energy industry: the total for the region, 89.5 bcm (13.5%) in 2008, is, if anything, understated. Of this 89.5 bcm of gas, 28.3 bcm was used in upstream operations, mostly in Russia. (Considerable volumes of gas flared, or reinjected in oil and gas fields, are excluded from these statistics, and are excluded from consideration in this study.) The other 61.1 bcm of gas consumed by the energy sector in 2008, i.e. more than two-thirds of it, was consumed by the gas transportation system, either as fuel for compressor stations or as losses. This system, mainly built in the late Soviet period, stretches from central Asia (mainly Uzbekistan and Turkmenistan, across Kazakhstan to Russia), across Russia, to all the western CIS states, much of which are served by the same high-pressure pipelines used to deliver gas to Europe, and also to the Caucasus. The remainder of this section focuses on this gas.

In recent years, increasing public attention has been focused on the opportunities (i) for making compressor stations more efficient, and (ii) for reducing leakage from the pipelines. While both are important in terms of energy efficiency, the issue of leakage is also paramount from the standpoint of reducing greenhouse gas emissions, since the greenhouse effect of methane is more than 20 times greater than that of carbon dioxide.[114] The political interest in the issue was summed up by Sergei Shmatko, Russian energy minister, in October 2010, when he stated that the pipeline system uses about 60 bcm of gas annually, and argued that "if we use modern pipes and more effective equipment – in particular, domestically manufactured gas compressor units of 40%+ efficiency – we could reduce annual consumption [by the pipeline system] by 15-20 bcm."[115] The available information suggests that such numbers are high, but by no means unrealisable. Some key points about the potential for raising the energy efficiency of the pipeline system are as follows:

- In *Russia*, Gazprom, the operator of the United Gas Supply System (UGSS) that covers the European part of the country, stated that in 2009 the system comprised 160,400 km of pipelines; of these 27.4% were more than 33 years old and a further 17.1% between 21 and 33 years old. The energy ministry described the main technical problems as (i) corrosion defects; (ii) the dominance of pipes built in the 1980s with polyethylene external protective coating with an effective lifetime of ten years, that still requires replacement; (iii) the urgent need to restore old pipelines to projected standards, and in particular crossings of rivers, roads and railways. In 2009 the Russian pipeline system was operating 215 compressor stations with 3,675 units, the total capacity of which was 42,000 MW. The energy ministry drew attention to the urgency of replacing 31.8% of compressors that had passed their design life, some by many years; to the need to replace outworn electrical generation equipment (68% of generators at compressor stations, 74% of distributors and 85% of sub-stations have

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[114] Methane is more than 20 times more effective in trapping heat in the atmosphere than carbon dioxide (CO_2) over a 100-year period. <http://www.epa.gov/methane/>; Intergovernmental Panel on Climate Change, *Fourth Assessment Report*, Working Group 1, p. 212.

[115] Ministry of energy of Russia, *Doklad ministra energetiki RF S.I. Shmatko "O proekte general'noi skhemy razvitiia gazovoi otrasli na period do 2030"*, 12 October 2010.

passed their design life); and to the unnecessarily high energy intensity of many multi-unit stations with an assortment of different compressors.[116]

The IEA, using data collected by three teams of researchers – from Gazprom and Ruhrgas, Gazprom and TransCanada, and the Wuppertal Institute – published estimates of greenhouse gas emissions from Russia's pipeline system in 2004.[117] These are summarised in Table 34:

Table 34: Gas Used and Greenhouse Gas Emissions from the Russian Pipeline System, 2004

	Gas used, bcm	Emissions, millions of tonnes CO_2 equivalent
Gas consumed by compressor stations	40.8	
CO_2 emissions at compressor stations		81.6
CH_4 emissions at compressor stations	4.8	72.2
CH_4 emissions on transmission pipelines	1.4	20.6

Source: IEA, *Optimising Russian Natural Gas, p. 100*

- In Ukraine, the pipeline system comprises 39,800 km of pipelines, including 14,000 km of large-diameter (1,020-1,400mm) lines, and 74 compressor stations with a total of 112 compressor units. [118] Investment in upgrades has run at a lower level than in Russia during the post-Soviet period due to the economically unfavourable position of Ukraine as a gas importer and the financial position of Naftogaz Ukrainy. As import prices started to rise substantially from 2005, it has been reported that Ukrtransgaz, Naftogaz Ukrainy's transport subsidiary, sought ways to reduce gas consumption, in the first place by substituting other fuels for gas at compressor stations and where possible modifying them for cogeneration.

Statistics from the energy ministry suggest that in 2006-2010, when the total amounts delivered through the Ukrainian network fell – because both transit volumes and volumes consumed in Ukraine were falling – the consumption of technical gas by Ukraine's transport companies fell at a faster rate. This implies that some energy efficiency measures have produced results. The evidence is not conclusive (because the total amounts delivered are not differentiated between volumes that travel long distances and those that travel short distances), but it provides some grounds for optimism. Table 35 compares the technical gas used by transport companies with the total volumes transported; the lower half shows technical gas used by production companies.

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[116] *Gazprom v tsifrakh 2005-2009 gg.: spravochnik*, p. 41; *General'naia skhema razvitiia gazovoi otrasli*, pp. 3-27 to 3-28.

[117] IEA, *Optimising Russian Natural Gas: Reform and Climate Policy* (Paris, 2006), pp. 96-101.

[118] Naftogaz Ukrainy web site.

Table 35: Gas Used for Technical Purposes in Ukraine, 2006-2010

		2006	2007	2008	2009	2010
Technical gas for transport companies		7.281	6.263	6.302	4.691	4.322
Tech. gas for transport, % of 2006 level		***100.0%***	***86.0%***	***86.6%***	***64.4%***	***59.4%***
	Ukrtransgaz	6.021	5.186	5.234	3.69	3.347
	Gas distribution companies	1.260	1.077	1.068	1.001	0.975
Total transit gas + gas for Ukraine, bcm		220.886	203.365	202.172	158.998	170.08
Total volume, % of 2006 level		***100.0%***	***92.1%***	***91.5%***	***72.0%***	***77.0%***
Total tech. gas, production companies		0.786	0.745	0.721	1.032	0.717
	Ukrgazdobycha	0.371	0.339	0.324	0.632	0.362
	Ukrnafta	0.38	0.372	0.361	0.358	0.314
	Chernomorneftegaz	0.024	0.022	0.023	0.022	0.019
	Other	0.011	0.012	0.013	0.02	0.022

Source: ministry of energy statistics/ *Energobiznes*

The top part of the table shows that the rate of consumption of technical gas fell faster (i.e. by 2010 to 59.4% of its 2006 level) than the volume of gas transported fell (i.e. by 2010 to 77% of its 2006 level).

Table 36 shows the potential efficiency savings projected by Naftogaz in 2007.

Table 36: Potential Energy Savings at Naftogaz Ukrainy

	Tonnes of coal equivalent	bcm
Modernisation of compressor stations	1.16	0.812
Use of cogeneration at compressor stations	3.5	2.45
Introducing turboexpanders on distribution lines	0.35	0.245
Commissioning of power stations in upstream operations	0.2	0.14
Introduction of standards throughout Naftogaz	0.4	0.28
Total	5	3.5

Source: Naftogaz Ukrainy web site (2007), conversions to bcm by author. Note that, in the original, the total is lower than the sum of the items; the author has left this uncorrected.

While constant, and so far inconclusive, discussions about major investment in upgrades to the Ukrainian system dominate the news agenda, it may be interesting to research further whether the considerable reduction in technical gas volumes already achieved is the result only of reduced volumes of gas transported, or also of efficiency savings. Account needs to be taken, also, of the further reduction in transit volumes that are likely in the next 3-4 years, due to transit diversification to the new Nord Stream pipeline, which may also reduce the volume of fuel gas required for the Ukrainian system.

-- In *Central Asia*, a project on the technologies and methodologies for reducing gas losses, undertaken by the EU Cooperation Programme for Central Asia in 2009, conducted technical studies of leakage at compressor stations and from pipelines that showed that there is potential for efficiency improvements on at least the same scale as those in Russia and Ukraine. Some relevant results of this survey are summarised in Appendix 12.

It is widely acknowledged that investment in modernising the pipeline systems is desirable in order to raise efficiency, cut waste and reduce greenhouse gas emissions. Russian minister Shmatko's statement that 15-20 bcm/year could be saved in Russia alone is optimistic but by no means outlandish. The pace at which such modernisation is undertaken will depend on the pace of investment. In Russia, Gazprom already invests hundreds of millions of dollars per year in upgrading the transport system; in Ukraine, by contrast, failure to agree on a medium- or long-term development strategy for the pipeline system, combined with the poor financial state of Naftogaz Ukrainy, has resulted in a lack of investment. There is some reason to believe, though, that even under these circumstances Naftogaz may have achieved some efficiency savings in the transport system. It seems probable, therefore, that even with some expansion of the pipeline systems due to gasification, efficiency savings across the old systems will reduce total consumption for technical purposes.

6. Issues for future research

For the author – and it is hoped, for readers too – this paper has opened up as many questions about gas consumption in the CIS region as it has answered. Among the possible starting-points for further research are:

- The effect of temperature on demand in the CIS region and the possibility of calculating accurate temperature-corrected data;

- The dynamics of gas consumption in thermal power stations, CHP plants and boilers, in order to gain a better understanding of factors that currently influence the efficiency of power and heat production; and

- The gas intensity of industrial production.

As for factors that will influence demand in the future, it might be beneficial to study further:

Possible and probable changes in power generating capacity (the effect on gas demand of the replacement, modernisation and development of capacity, including changes in levels of efficiency, changes in the fuel mix, with a focus on actual investment decisions rather than government plans or targets);

- Possible and probable changes to district heating systems and the provision of municipal services;

- The effect of gasification on consumption by volume;

- The effect on demand of rising prices, which should soon become clearer in those countries in which they are advancing furthest (Ukraine, Azerbaijan, Belarus, etc), residential-sector metering, and other market reforms;

- The actual effect of energy saving and energy efficiency measures already realised, and a better understanding of the factors that will determine their extent in future; and

- The macroeconomic factors that influence gas demand, including the structural changes in economies in the region, and the political and social factors that surround the use of cheap fuel as a subsidy. Some comparison with other regions internationally might be of value.

Apart from these research issues, there are some questions that researchers might legitimately raise with the various industry bodies and statistical agencies about how the quality of statistical information might be improved. There could be fairly obvious benefits to all from, e.g.

- Standardisation of conversion factors between energy content and volume of gas;

- Standardisation of the measures of the efficiency of gas, power and heat consumption;

- Standardisation of the classification of different types of power plants (thermal power plants, CHP etc), and of the method of measuring energy efficiency in plants that produce both electricity and heat.

7. Factors impacting demand outlook, and conclusions

Conclusions from the foregoing discussion, with particular reference to factors that will shape natural gas demand outlook in the CIS region up to 2020, may be summarised as follows.

The main consumption trends in the period covered were:

- In the ten years up to 2008, gas consumption in the region, as measured by the IEA, rose by 19.50% or an average of 1.80% annually, from 554.78 bcm (1998) to 662.96 bcm (2008). Consumption in Russia rose at a slightly slower rate than in the CIS as a whole, by 17.78% or an average of 1.65% annually. These increases took place under conditions of steady – and in 2004-07, in Russia and some other CIS countries, quite rapid – economic growth, combined with declining population in Russia and Ukraine, and rising population in other CIS states. (Note that statistics published by Gazprom since 2005 on total Russian consumption put it 9-14 bcm higher than the statistics published by the IEA, but the two sets of figures reflect year-to-year changes in a broadly consistent manner. This issue is explained in Appendix 6.)

- The economic crisis of 2008-09 caused a very substantial fall in gas consumption in Russia and Ukraine (by 6.5% and 21.5% respectively). The 2008 level was essentially regained in 2010 in Russia (although the rebound was caused in part by the weather, which was very cold at the beginning and end of the year and very hot in the summer), but not regained in Ukraine (where consumption was 67.3 bcm in 2008, 52.8 bcm in 2009 and 57.6 bcm in 2010). The effect of the crisis on consumption in other CIS states, particularly in central Asia, was probably much less marked.

- Prices of gas for industrial customers have been rising since 2006, substantially in Ukraine but also noticeably in Russia, Belarus, Moldova and Azerbaijan. Prices in central Asian countries have moved more slowly (e.g. Kazakhstan and Kyrgyzstan), or negligibly (e.g. Uzbekistan and Turkmenistan). Although it is difficult to disentangle the effects of price rises and economic crisis from each other, it appears that in Ukraine the price rises have accelerated the trend towards more efficient consumption. Aggregate consumption for industry, the power sector and pipeline transport in Ukraine was 41.0 bcm in 2006 and 41.2 bcm in 2007, and then fell to 37.7 bcm in 2008 and 24.9 bcm in 2009, before recovering to 29.4 bcm in 2010.[119] Import prices, with which prices for these customers are broadly correlated, rose from $95/mcm in 2006 to $232.54/mcm in 2009, and an average of $257/mcm in 2010 even taking into account the 30% Russian government discount. The fact that consumption by these three sectors fell by 9.3% in 2008 (when the effect of the economic crisis was only registered at the end of the year), and that it recovered so little in 2010 despite the end (just!) of the economic recession in Ukraine, suggests that higher prices have helped to reduce consumption.

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[119] Author's calculations from energy ministry/ *Energobiznes* statistics

The main factors that will determine consumption in the period to 2020 are as follows:

- *The progress of the economic recovery* and accompanying increases in energy use. The consensus among economists is that the CIS economies will continue to grow, but not as rapidly as they did in the 2000s. Of course such projections are subject to changes in external conditions, of which movements in the prices of oil and other commodities are perhaps the most likely to impact the CIS economies.

- *The continuing slow decline in population in Russia and Ukraine, with continuing steady growth in most other CIS states*. While energy use per head of population is expected to continue to rise – in large part due to rising living standards – this will be at least partly offset by the decline in population where it is taking place.

- *The continued progress away from regulated gas prices towards some form of market pricing defined either in relation to European prices or by gas supply and demand*. The most important issue here is the pace of increases in regulated wholesale gas prices in Russia: in ruble terms these rose by an estimated 26.7% in 2010. They are scheduled to rise by 15% per year in 2011-13, although this was being reconsidered by the government at the time of writing (June 2011), and the government now appears to favour increases at or slightly above the rate of inflation.[120] Nevertheless, the CIS's largest economy is slowly following Ukraine and Moldova along the path to higher gas prices and relatively liberalised markets, opening up considerable possibilities for improvements in the efficiency of consumption, especially in industry. Prices are also moving upwards in the Caucasus countries, especially Azerbaijan, but in central Asia will not do so soon or at great pace.

- *Energy policies, including energy efficiency and energy saving policies that will reduce natural gas demand*. In Russia, the economic recession of 2008-09 sharply reduced the economy's energy efficiency, because the reduction in industrial output was not matched by the reduction in fuel consumption. The economic development ministry estimates that the energy intensity of the economy rose by 3.1% in 2009, that it will fall to its 2008 level in 2011-12, and continue to fall thereafter. It estimates that implementation of the government's programme of energy efficiency and energy saving measures can achieve a 7.4% reduction in the economy's energy intensity by 2015, and that this will lead directly to a reduction in gas consumption of 4-10 bcm per year.[121] In Ukraine and some of the Caucasus countries, energy efficiency and energy-saving policies have been more actively considered in recent years and this may yield results. In central Asia, where energy-saving policies have only begun to be discussed, it is possible that the prospect of increasing gas exports to China may stimulate consideration of them. Uzbekistan and Turkmenistan, the most gas-intensive economies in the CIS, could presumably quite easily free up extra volumes for export

[120] Ministry of Economic Development of the Russian Federation, *Prognoz sotsial'no-ekonomicheskogo razvitiia RF* (Moscow, September 2010), p. 67

[121] Ministry of Economic Development of the Russian Federation, *Prognoz sotsial'no-ekonomicheskogo razvitiia RF* (Moscow, September 2010), pp. 45-46

by implementing basic energy-saving measures to reduce consumption in the residential and industrial sectors.

- *Gasification policies*, which expand the domestic market geographically, especially in Russia (eastern Siberia and the Russian Far East) and possibly in Kazakhstan and other CIS countries. In Russia, the draft *General Scheme for the Development of the Gas Industry* envisages annual aggregate gas consumption in eastern Siberia and the Far East rising from 13.2 bcm in 2009 to 21 bcm in 2015 and 31 bcm in 2020,[122] although these estimates, made prior to the economic crisis, may be revised. It should be borne in mind that the gasification plans envisage almost all parts of eastern Siberia and the Far East being supplied from new production, in tandem with the development of exports to Pacific markets, and are therefore not making a call on gas supplied to European Russia and/or for export to the western CIS or Europe.

Sectoral factors that will play a part in determining consumption trends are:

- Most significantly, plans for development of the ***electricity sector***, and in particular investment in new generation capacity, will impact gas consumption. The importance of Russia is even greater in this sector than in others. Gas is merely a supplementary fuel in the electricity sectors of the second and third largest CIS economies, Ukraine (nuclear and coal) and Kazakhstan (coal), but is the main fuel in Russia, Uzbekistan and several smaller CIS countries. In the period to 2015 in Russia, the sharply reduced projections for electricity demand, and for new generation capacity, imply only a minimal increase in gas consumption (2.7%, i.e. from 181 bcm to 186 bcm, according to the projections discussed in section 2.e above). Thereafter, given continued economic recovery and continued increase in power demand, the adjustment in emphasis in investment plans could favour new gas-fired capacity. But the overall impact will only become clear when investment decisions are taken, and these are being postponed where possible. Moreover, while government policy favours diversifying away from gas, previous experience has shown that hesitation to invest in new coal and nuclear capacity leads to gas being called upon as a fall-back option, and this pattern could well be repeated. Demand growth from Russian thermal power stations and CHP – which account for more than one quarter of total consumption in the CIS region – will be a key factor in determining demand overall.

- Reform of the ***heat sector***, while more difficult due to its integration with other municipal services and the related institutional challenges, is unlikely to lead to any substantial reductions in gas consumption in the period up to 2015. But once reforms are implemented, quite considerable energy savings could be made in consumption, distribution and production of heat, particularly as old district heating networks are replaced. This could lead to quite substantial reductions in gas consumption.

[122] *General'naia skhema razvitiia gazovoi otrasli na period do 2030 goda: proekt* (Moscow, 2008), p. 2/4

- In the ***industrial sector***, rising prices and liberalisation, and energy efficiency and energy saving policies, are apparently already having an effect – e.g. in Ukraine, where in addition to the effect of price increases mentioned above, substantial investment in energy efficiency was made in 2006-07 in the metallurgical sector, a large gas consumer. This investment was cut short by the economic crisis, but assuming that economic recovery continues it may be expected to be revived before 2015. The same is true of the Russian industrial sector. The level of industrial consumption will be determined partly by the relative speed with which these efficiency savings, and increases in demand stimulated by the economic recovery, take place.

- In the ***residential sector***, in most countries in the region rising prices will take effect much more gradually. In both Russia and Ukraine, regulated prices for residential customers have begun to increase but remain far below industrial prices and below cost-recovery levels. Government policies in this respect are unlikely to change and, even when they do, the lack of meters and other infrastructure means that there are unlikely to be significant reductions in consumption before 2015. The downward impact on natural gas demand caused by rising prices and renewal of infrastructure will be counteracted by the upward impact of gasification policies, and also, possibly, by the growth in the use of autonomous boilers and heat sources as better-off households choose to produce their own heat instead of buying it from district heating companies.

- With respect to ***gas industry own use***, the possible efficiency savings from upgrades to gas transport systems have been highlighted at political level in both Russia and Ukraine. Although minimal savings may be expected in the period up to 2015, in the period after that there is a prospect that third-party access regimes, liberalisation and a clearer framework for investment in upgrading and modernising transport systems will be introduced. This could result in significant savings.

Conclusions with respect to the supply-demand balance may be drawn as follows:

- In the decade up to 2008, natural gas demand grew on average by 1.80%/year in the CIS as a whole and 1.65%/year in Russia. On balance it seems that, in the period up to 2020, factors that would increase demand (mainly, economic recovery and gasification policies) are likely to be counteracted more strongly than in the decade to 2008 by factors that will decrease demand (mainly, rising prices and liberalisation, and energy efficiency and energy saving policies). On balance, therefore, the question should be asked: is there any convincing reason why demand should grow more rapidly than it did in the decade to 2008? This author's answer, based on the research in the paper, would be negative. Barring the unexpected, it seems more likely that demand will recover its 2008 level between 2010 and 2012, and then grow either at the pace of 1999-2008, or at a slower pace, or remain flat. That would imply consumption in 2010 of up to 455 bcm in Russia and 663 bcm for the whole CIS region, and consumption in 2020 of 455-535 bcm in Russia and 663-793 bcm for the whole CIS region.[123]

- There is only limited policy interest in reducing demand by means of energy saving and efficiency. This issue has become a consistent strand of Russian policy discussions only recently and outside Russia has played a significant role in energy policy considerations only in Belarus and Ukraine. Tangible results of energy efficiency policies are evident only on a small scale, e.g. in Belarus and some Russian regions. This suggests that the region's great potential for energy saving will be realised only slowly, and that the consequent demand reduction could be considerable, but only in the long term. In contrast to many other regions of the world, there is little political conviction in the CIS region that it is possible for energy demand to fall even as GDP increases, and little belief that reducing greenhouse gas emissions is a priority issue.

- When it comes to gas demand forecasts, in Russia, energy minister Shmatko recently cited official projections that gas demand would grow from 432 bcm in 2009 to 549-599 bcm in 2030, i.e. at an average of 1.15-1.57% /year; the range projected for 2030 is 50 bcm higher than in the draft *General Scheme for the Development of the Gas Industry*, which was compiled before the impact of the economic crisis was known.[124] Long-range forecasts are necessarily speculative, and this one must rely on uniformly optimistic assumptions about economic development and pessimistic assumptions about energy saving policy implementation. On the other hand, the economic development ministry's short term projections are of 1%/year gas demand growth in 2011-13 under its conservative scenario (GDP growth of 3-3.3%), with more rapid growth (no exact figure given) under its moderately optimistic scenario (GDP growth of 3.9-4.5%). The research in this paper suggests that demand growth in Russia is more likely to move slowly, i.e. that the economic development ministry's more modest projections have a stronger rationale.

- With respect to the CIS outside Russia, in 1999-2008 demand growth was slightly faster than in Russia, and it is reasonable to expect this pattern to continue, although the impact of one key factor – Ukraine's recovery from the crisis and the impact on its industrial sector – is particularly hard to assess.

- The prospect of demand in the CIS growing slowly or even remaining flat has profound implications for the supply-demand balance. Russian gas production strategy has since the early 2000s assumed constant growth of both exports to Europe and domestic sales. Demand from both markets fell sharply as a result of the recession; European sales have not yet regained their 2008 level; neither have non-Russian CIS sales; Russian sales have regained their 2008 level, possibly in part

[123] This assumes a return to the 2008 level of consumption in 2010. IEA statistics for 2010 are not yet available.

[124] Stenogramme of the meeting chaired by prime minister Putin on the General Scheme for the Development of the Gas Industry, 11 October 2010; *General'naia skhema razvitiia gazovoi otrasli na period do 2030 goda: proekt* (Moscow, 2008), p. 2/5.

because of the unusually cold winter of 2009-10, followed by the hot summer of 2010. If Russian and CIS demand does indeed grow more slowly than previously expected, this has important implications for the timing of investments in new Russian gas production and for the changing contributions of Gazprom and non-Gazprom producers to production.

Finally, it is worth underlining some points about the wide gap between the CIS region's great potential for energy efficiency and energy saving measures, and the progress made on these issues – that is, why the potential is so elusive, as suggested in the paper's title. First, as was argued in Section 1.e above (page 19), assertions about the potential themselves deserve to be interrogated. Comparing the high energy consumption per person, or per unit of GDP, in the CIS with countries that have substantially different geography, weather and political and economic structure can provide a very general indication of the scale of waste, but that is not the same thing as a measurement of energy saving potential. The scale of that potential depends partly on a range of assumptions about how the economy, and the way people live, will change. This paper has made no attempts at such forecasts, but has tried to show why progress so far has been limited. Much has been included about the physical state of the energy infrastructure, urban infrastructure and industrial capital stock, all of which use energy inefficiently. Many of the problems with infrastructure – the generally heavy dependence on gas by power generators, industry and the population, the large-scale waste of heat in public and residential buildings and the inefficient use of gas in district heating systems – go back to the manner of urbanisation and industrialisation in the late Soviet period. (One factor that may willy-nilly force change is the outworn state of much of this infrastructure: as time goes on, it will be cheaper to replace it than to repair it.) The central role in post-Soviet economies of energy-intensive industries can also be traced back to that time, when the development of these industries was viewed as a means of progress for a developing country with surplus energy resources, as the USSR was.

But why so little change, twenty years on from the collapse of the USSR? Partly, because the transition from Soviet economic relationships to market relationships has been slower than was generally expected. This is directly reflected in the gas sector – in the persistence of below-cost tariffs and badly-designed tariff systems for electricity, heat and gas. The extreme case, Turkmenistan's provision of free gas to residents, underlines the importance of the trend. As this paper has emphasised, pricing policies are now changing, and this will eventually stimulate significant changes in energy use. A second reason given for the lack of progress, in the discussion of power and heat sector reform in section 2.c and 2.e in particular, is the lack of interest by institutions in energy saving. Thirdly, the role of government policy has been noted. Institutional change is not guaranteed by governments' adoption of energy-saving policies, but is not likely to happen without it. And since governments have only recently begun to pay serious attention to energy saving issues, together with climate change issues, it is too soon to discern appreciable results in gas consumption statistics. Governments – even those that pay little attention to energy saving *per se* – may push it harder to the extent that (i) they come to regard it as a fiscal benefit, and (ii) it might supplement the modernisation policies to which most governments in the region aspire. Hopefully, we will witness a feedback effect, i.e. as the obvious advantages of energy saving and energy efficiency become more generally recognised, they will be practised more widely. Such developments could change gas consumption trends far beyond the modest improvements that this paper has suggested are likely.

Appendix 1. Conversion factors

Natural gas may be measured by volume or by energy content. In the former Soviet countries, *volumes* are usually measured in thousands, millions or billions of cubic metres (mcm, millions of cu m, or bcm). The most common measures of *energy content* used internationally are kilojoules, megajoules or terajoules (kj, mj or tj), or tonnes of oil equivalent (toe); in the former Soviet countries units of standard fuel (usf) are also used.

The energy content of natural gas varies from one cubic metre to another, depending mainly on the chemical composition (e.g. presence of sulphur or non-methane gases) and temperature. There are two international standard sets of conditions for the measurement of gas by volume: (i) *normal conditions* (at a temperature of 0 degrees Celsius and pressure of 760 mm Hg (millimetres of mercury)); and (ii) *standard conditions* (at a temperature of 15 degrees Celsius and pressure of 760 mm Hg. Furthermore, when gas is measured by energy content, it may be stated at gross calorific values (gcv) or net calorific values (ncv). The net calorific value is usually assumed to be 10% lower than the gross calorific value, as it excludes the latent heat of vaporisation of the water vapour produced during combustion of gas. The ncv = gcv x 0.9.

The IEA, whose statistics are used as the starting-point in this study, assumes the gross calorific value of Russian gas to be 37,578 kj/cubic metre. This implies a net calorific value of 33,820.2 kj/cubic metre. Russian government bodies and statistical agencies assume an almost identical energy content. The State Statistics Committee of the Russian Federation measures a cubic metre of natural gas as 1.154 units of standard fuel, and assumes the energy content of a unit of standard fuel to be 0.0293076 terajoules. This implies that the energy content of a cubic metre of Russian gas is 33,820.9 kj, i.e. identical for all practical purposes to the net calorific value estimated by the IEA.[125]

The IEA uses different conversion factors for natural gas consumed in different countries, as shown in Table 37:

[125] IEA, *Energy Statistics Manual* (OECD/IEA, Paris, 2005), pp. 57-67 and 182-183; Gosudarstvennyi komitet RF po statistike, *Postanovlenie: ob utverzhdenii "metodologicheskikh polozhenii po raschetu toplivno-energeticheskogo balansa RF v sootvetstvii s mezhdunarodnoi praktike"*, 23 June 1999, no. 46.; email to the author from IEA Energy Data Department, 4 January 2011.

Table 37: Conversion Factors Applied to Domestically Consumed Natural Gas

kj/cu metre, gross calorific value		
	National statistical agency	IEA statistics
Russia	37578	37578
Ukraine		39020
Belarus		38622
Moldova		38676
Armenia		37700
Azerbaijan	38938	38566
Georgia		38215
Kazakhstan	39020	39030
Turkmenistan		37700
Uzbekistan		37889
Kyrgyzstan		39020
Tajikistan		38000

Sources: Russia, derived from government decree on energy statistics; Kazakhstan, derived from publications of state statistical agency; Azerbaijan, derived from state statistical committee data; IEA, *Natural Gas Information 2010*, p. xxix

The IEA uses measurements of energy content in its published statistics. In most of the tables in this study, the author has converted these to measurements of volume (bcm), using the conversion factors in Table 37. In some of the tables comparing natural gas with other forms of energy, the author has followed the IEA's practice in using net calorific values, in order to compare with other forms of energy.

Some statistical agencies in the CIS countries, when converting measurements of physical volume of natural gas (e.g. bcm) to measurements of energy content (e.g. units of standard fuel), refer to net calorific values, rather than gross calorific values. This issue needs to be borne in mind when working with different sets of statistics.

The standard international conversion factors for measures of energy content used in this study are:

Table 38: Standard Conversion Factors for Energy

To	***Tj***	***Gcal***	***Mtoe***	***GWh***
From:	**Multiply by:**			
TJ	1	238.8	2.388×10^{-5}	0.2778
Gcal	4.1868×10^{-3}	1	10^{-7}	1.163×10^{-3}
Mtoe	4.1868×10^{4}	10^{7}	1	11630
GWh	3.6	860	8.6×10^{-5}	1

Source: IEA

This paper uses the standard conversion between international units and units of standard fuel used in former Soviet countries, that is used by the Russian statistical agency and other state organisations:

1 TJ = 1 tonne of standard fuel x 0.0293076

The conversion factors used by the Russian statistical agency and other state organisations for the energy content of fuels include the following:[126]

One tonne of standard fuel =

1,154 cu m of natural gas
570 cu m of coke oven gas
430 cu m of blast-furnace gas
768 kilogrammes of coal (with variations depending on grade)
467 kilogrammes of brown coal
1.45 tonnes of fuel oil

Appendix 2. 2008 consumption, full table

Table 39 shows natural gas consumption in 2008, country-by-country and with sectoral breakdown information. The physical volumes have been derived by the author from IEA statistics, which count energy content. Table 2 in Section 1.a presents the same information in abbreviated form.

[126] A full table of conversion factors used in Russia may be found in Gosudarstvennyi komitet RF po statistike, *Postanovlenie: ob utverzhdenii "metodologicheskikh polozhenii po raschetu toplivno-energeticheskogo balansa RF v sootvetstvii s mezhdunarodnoi praktike"*, 23 June 1999, no. 46.

Table 39: Natural Gas Consumption in 2008

2008, bcm		**TOTAL**		**Russia**	**Ukraine**	**Belarus**	**Moldova**
DOMESTIC SUPPLY		662.961		**453.435**	**66.771**	**21.311**	**2.385**
Transfers		-1.938					
Statistical differences		0.040		-0.003	0.042	0	0
TRANSFORMATION		**339.797**		**264.556**	**26.389**	**15.503**	**1.310**
Electricity plants		16.181		2.574	1.546	4.869	0.789
CHP plants		209.032		188.166	6.653	7.279	0.387
Heat plants		95.531		71.893	18.147	3.354	0.134
Heat & power, unspecified		17.088					
Liquefaction		0.028		0	0.028	0	0
Other		1.938		1.923	0.015	0	0
ENERGY IND. OWN USE		**28.334**		**16.480**	**1.409**	**0**	**0.360**
Fuel mining & extraction		16.311		14.586	1.237	0	0
Elec., CHP & heat plants		1.169		0.503	0.036	0	0.360
Petroleum refineries		0.131		0	0.131	0	0
Other		2.818		1.391	0.005	0	0
DISTRIBUTION LOSSES		**11.680**		**6.538**	**1.048**	**0.154**	**0.075**
FINAL CONSUMPTION		**281.251**		**165.858**	**37.968**	**5.654**	**0.639**
Industry		**61.999**		**37.308**	**11.293**	**2.148**	**0.241**
Iron and steel		21.789		16.243	5.374	0.127	0
Chem. & petrochem.		3.577		2.130	0.672	0.489	0
Non-ferrous metals		0.891		0	0.887	0.004	0
Non-metallic minerals		17.673		13.462	2.808	1.231	0
Transport equipment		0.599		0.503	0.096	0	0
Machinery		1.678		1.183	0.331	0.164	0
Mining & quarrying		2.029		1.538	0.491	0	0
Food and tobacco		1.464		0.947	0.366	0.071	0.081
Paper, pulp and print		0.241		0.178	0.037	0.022	0.004
Wood & wood products		0.231		0.178	0.053	0	0.001
Construction		0.826		0.710	0.065	0.003	0.048
Textile and leather		0.044		0.030	0.009	0.004	0.002
Industry, non-specified		10.957		0.207	0.106	0.033	0.105
Transport		**50.008**		**43.846**	**3.620**	**0.561**	**0.016**
Road		0.516		0.178	0.067	0.021	0.008
Pipeline transport		49.466		43.669	3.528	0.540	0.008
Non-specified		0.026		0	0.026	0	0
Other		**130.377**		**55.296**	**17.324**	**1.555**	**0.383**
Residential		89.343		49.408	16.483	1.443	0.274
Commerc. & pub. services		9.441		4.852	0.650	0.044	0.101
Agriculture/forestry		1.645		1.035	0.190	0.068	0.007
Non-specified		29.947		0	0	0	0.001
Non-energy use		**38.869**		**29.408**	**5.731**	**1.390**	**0**
in industry		38.696		29.408	5.731	1.387	0
of which, feedstocks		36.500		*29.408*	*5.705*	*1.387*	*0*
Other non-energy		0.003		0	0	0.003	0

TABLE 39 CONTINUED. NATURAL GAS CONSUMPTION IN 2008									
2008, bcm	**Armenia**	**Azer-baijan**	**Georgia**		**Kazakh-stan**	**Turkmen-istan**	**Uzbek-istan**	**Kyrgyz-stan**	**Tajik-istan**
DOMESTIC SUPPLY	**2.222**	**10.954**	**1.317**		**32.832**	**16.933**	**53.514**	**0.745**	**0.543**
Transfers	0	0	0		-1.938	0	0	0	0
TRANSFORMATION	**0.547**	**5.753**	**0.379**		**2.560**	**7.163**	**14.950**	**0.410**	**0.275**
Electricity plants	n/a	n/a	n/a		n/a	n/a	6.403	n/a	n/a
CHP plants	n/a	n/a	n/a		n/a	n/a	6.546	n/a	n/a
Heat plants	n/a	n/a	n/a		n/a	n/a	2.001	n/a	n/a
Heat & power, unspecified	0.547	5.753	0.379		2.560	7.163		0.410	0.275
ENERGY IND. OWN USE	**0**	**0.506**	**0.099**		**5.618**	**1.683**	**2.180**	**0**	**0**
Fuel mining & extraction	n/a	n/a	n/a		n/a	n/a	0.488	n/a	0
Elec., CHP & heat plants	n/a	n/a	n/a		n/a	n/a	0.269	n/a	0
Petroleum refineries	n/a	n/a	n/a		n/a	n/a	0	n/a	0
Other	n/a	n/a	n/a		n/a	n/a	1.422	n/a	0
LOSSES	**0**	**0.736**	**0.099**		**0.985**	**0**	**2.045**	**0**	**0**
FINAL CONSUMPTION	**1.675**	**3.959**	**0.741**		**21.730**	**8.087**	**34.339**	**0.335**	**0.268**
Industry	**1.037**	**0.701**	**0.218**		**0.930**	**0**	**8.123**	**0**	**0**
Iron and steel	0	0.006	0.039		0	0	0	0	0
Chemical & petrochemical	0	0.223	0.062		0	0	0	0	0
Non-ferrous metals	n/a	n/a	n/a		0	0	0	0	0
Non-metallic minerals	0	0.139	0.033		0	0	0	0	0
Other industry	n/a	n/a	n/a		n/a	n/a	0	n/a	n/a
Industry, non-specified	1.037	0.333	0.083		0.930	n/a	8.123	0	0
Transport	**0.123**	**0.001**	**0.034**		**0**	**0**	**1.785**	**0.008**	**0.014**
Road	0.123	0	0.020		0	0	0.079	0.008	0.014
Pipeline transport	n/a	0.001	0.014		0	0	1.706	0	0
Non-specified	0	0	0		0	0	0	0	0
Other	**0.516**	**3.177**	**0.400**		**20.800**	**8.087**	**22.261**	**0.327**	**0.254**
Residential	0	3.114	0.234		0	0	18.387	0	0
Commercial & pub services	0	0.051	0.066		0	0	3.678	0	0
Agriculture/forestry	0.063	0.006	0.079		0	0	0.197	0	0
Non-specified	0.453	0.005	0.021		20.800	8.087	0.000	0.327	0.254
Non-energy use	**0**	**0.081**	**0.089**		**0**	**0**	**2.170**	**0**	**0**
in industry	n/a	n/a	n/a		n/a	0	2.170	0	0

Source: IEA energy statistics, 2008

Appendix 3. The supply mix of natural gas and other types of gas

Table 40 shows the consumption in Russia and Ukraine of natural gas, coke oven gas, blast furnace gas and gas works gas, measured by energy content. For natural gas, a conversion to volumes has been provided.

Table 40: Natural Gas and Other Types of Gas in the Supply Mix in Russia and Ukraine, 2008

	Russia					**Ukraine**					
	Natural gas, t/j	*Nat gas, bcm*	Coke oven gas, t/j	Blast furn. gas, t/j	Total domestic supply, t/j	Natural gas, t/j	*Nat gas, bcm*	Gas works gas, t/j	Coke oven gas, t/j	Blast furn. gas, t/j	Total, t/j
DOMESTIC SUPPLY	**17039180**	***453.4***	**226573**	**398062**	**17664268**	**2605405**	***66.8***	**3398**	**160904**	**147954**	**2917728**
as % of total domestic supply	**96.5%**		**1.3%**	**2.3%**	**100%**	**89.30%**		**0.12%**	**5.50%**	**5.10%**	**100%**
Statistical differences	-112	*0.0*	180	0		1658	*0.0*	-69	0	271	
TRANSFORMATION, incl.	**9941485**	***264.6***	**64930**	**137794**		**1029706**	***26.4***	**2280**	**38440**	**30430**	
Electricity plants	96726	*2.6*	0	0		60331	*1.5*	0	22595	28511	
CHP plants	7070902	*188.2*	61648	117841		259604	*6.7*	2278	0	666	
Heat plants	2701595	*71.9*	3282	19953		708113	*18.1*	0	15125	1253	
Other transformation	72262	*1.9*	0	0		1658	*0.0*	2	720	0	
ENERGY IND. OWN USE	**619286**	***16.5***	**37608**	**29585**		**54969**	***1.4***	**1004**	**72514**	**0**	
PIPELINE TRANSPORT	**1640980**	***43.7***	**0**	**0**		**137651**	***3.5***	**0**	**0**	**0**	
DISTRIBUTION LOSSES	**245685**	***6.5***	**0**	**0**		**40878**	***1.0***	**0**	**0**	**0**	
INDUSTRY, incl.	**1401950**	***37.3***	**124215**	**230683**		**440656**	***11.3***	**45**	**49950**	**117524**	
Iron and steel	610365	*16.2*	121159	217340		209680	*5.4*	0	49037	117404	
Chemical & petrochemical	80048	*2.1*	0	13343		26238	*0.7*	0	543	0	
Chemical ind. feedstocks	1105104	*29.4*	0	0		223621	*5.7*	0	0	271	
Non-met. min'ls, incl. cement	505858	*13.5*	1703	0		109580	*2.8*	0	7	0	
Other industry	205679	*5.5*	1353	0		95158	*2.4*	45	363	0	
RESIDENTIAL	**1856664**	***49.4***	**0**	**0**		**643160**	***16.5***	**0**	**0**	**0**	
COMMERCIAL & PUB. SERVICES	**182 331**	***4.9***	**0**	**0**		**25354**	***0.6***	**0**	**0**	**0**	
OTHER/NON-SPECIFIED	**45583**	**1.2**	**0**	**0**		**11068**	***0.3***	**0**	**0**	**0**	

Source: IEA energy statistics

Table 41 shows the consumption in Kazakhstan of natural gas, associated petroleum gas (which has been counted separately by the statistical agency), blast furnace gas and coke oven gas.

Table 41: Gas Consumption in Kazakhstan, 2009 (abbreviated)

	Natural gas, t/j	*Natural gas, bcm*	Associated petroleum gas, t/j	*Associated petroleum gas, bcm*		Blast furnace gas, t/j	Coke oven gas, t/j		Total, t/j
Extractive & mining (incl. reinjected gas)	11394	*0.292*	632561	*13.875*					
Processing industries	33479	*0.858*	5106	*0.112*		20864	17238		
Prod'n and distrib'n of electricity, water & gas	146130	*3.745*	33782	*0.741*					
Transport, construction, agriculture & other	59895	*1.535*	1094	*0.024*					
Public sector, incl. health, education	6009	*0.154*	593	*0.013*					
Total excluding mining	245514	*6.292*	40575	*0.89*		20864	17238		324191
	76%		13%			6%	5%		100%

Source: abbreviated from "Potreblenie toplivno-energeticheskikh resursov po vidam ekonomicheskoi deiatel'nosti v 2009 godu", in Statistical Agency of the Kazakh republic, Toplivno-energeticheski balans respubliki Kazakhstan.
Note. Conversion factors used by the statistical agency for 1 cubic metre of gas are: Natural gas 39020 kj; associated petroleum gas 45590 kj; blast furnace gas 4000 kj; and coke oven gas 17590 kj.

Appendix 4. Energy balances

Table 42 presents energy balances for the 12 countries covered by the study, summarised from the IEA's energy balances. The IEA's methodology is used. Under "transformation", the table shows energy consumed in order to produce another form of energy as a negative value. So gas or coal consumed in power stations are represented by a negative value; the electricity and heat produced is a positive value. The row "heat and power sector" is the sum of the three rows "electricity plants", "CHP plants" and "heat plants" in the IEA balances. Oil consumed to produce oil products is also a negative value, although no separate row has been included for oil refineries as these are largely irrelevant to this study.

Total final consumption is total primary energy supply, plus or minus changes in the transformation sector. Industry and residential consumption are from this study's point of view the most significant sub-divisions of total final consumption; transport and other categories are not shown here separately.

Table 42: Summary of Energy Balances of CIS Countries, 2008

Millions of tonnes of oil equivalent, 2008, net calorific basis		Coal	Crude oil	Oil prod-ucts	Gas	Nucl-ear	Hydro	Renew-ables	Elect-ricity	Heat		Total
Russia	Production	167	489	0	535	42.8	14.2	0.4	0	0		1254
	Import	18.8	2.5	1.0	6.4	0	0	0	0.3	0		28.9
	Export	-64.3	-244	-97.3	-158	0	0	0	-1.8	0		-566
	TOTAL PRIMARY ENERGY SUPPLY	**117**	**243**	**-102**	**366**	**42.8**	**14.2**	**6.6**	**-1.5**	**0**		**687**
	TRANSFORMATION, incl.	**-100**	**-243**	**-4.8**	**-232**	**-42.8**	**-14.2**	**-4.3**	**63.9**	**114**		**-251**
	heat and power sector	-75.4	-0.7	-11.8	-212	-42.8	-14.2	-4.2	89.3	142		-130
	TOTAL FINAL CONSUMPTION, incl.	**16.6**	**0.1**	**107**	**134**	**0**	**0**	**2.3**	**62.4**	**114**		**436**
	industry	10.1	0	13.0	30.1	0	0	0.3	31.0	40.6		**125**
	residential	3.0	0	7.6	39.9	0	0	1.2	10.0	52.1		114
Ukraine	Production	33.7	4.3	0	18.0	23.4	1.0	0.9	0.0	0		81.3
	Import	8.6	7.0	7.2	44.1	0	0	0	0.2	0		67.1
	Export	-3.1	0	-3.9	0	0	0	0	-0.8	0		-7.8
	TOTAL PRIMARY ENERGY SUPPLY	**40.8**	**11.5**	**3.2**	**56.0**	**23.4**	**1.0**	**0.9**	**-0.6**	**0**		**136**
	TRANSFORMATION, incl.	**-29.1**	**-11.4**	**10.3**	**-24.2**	**-23.4**	**-1.0**	**-0.4**	**12.2**	**9.5**		**-57.5**
	heat and power sector	-19.4	0	-0.2	-22.1	-23.4	-1.0	0	16.6	12.8		-36.7
	TOTAL FINAL CONSUMPTION, incl.	**11.7**	**0**	**13.5**	**31.8**	**0**	**0**	**0.5**	**11.6**	**9.5**		**78.7**
	industry	8.8	0	1.5	9.5	0	0	0.1	5.8	5.1		30.8
	residential	1.4	0	0.7	13.8	0	0	0.4	2.7	4.4		23.4
Belarus	Production	0.6	1.7	0	0.2	0	0	1.5	0.0	0		4.0
	Import	0.1	21.6	1.9	17.5	0	0	0	0.6	0		41.7
	Export	-0.1	-1.5	-15.0	0	0	0	0	-0.4	0		-17.0
	TOTAL PRIMARY ENERGY SUPPLY	**0.5**	**21.4**	**-13.2**	**17.7**	**0**	**0**	**1.5**	**0.2**	**0**		**28.1**
	TRANSFORMATION, incl.	**-0.2**	**-21.4**	**19.8**	**-13.0**	**0**	**0**	**-0.5**	**2.4**	**5.2**		**7.8**
	heat and power sector	-0.1	0	-0.6	-12.9	0	0	-0.5	3.0	6.2		4.9
	TOTAL FINAL CONSUMPTION, incl.	**0.3**	**0**	**6.6**	**4.7**	**0**	**0**	**1.0**	**2.5**	**5.2**		**20.3**
	industry	0.1	0	0.5	1.8	0	0	0.2	1.2	2.0		5.8
	residential	0.2	0	1.4	1.2	0	0	0.7	0.5	2.1		6.0
Moldova	Production	0	0	0	0	0	0	0	0	0		0.1
	Import	0.1	0	0.7	1.9	0	0	0	0.2	0		3.1
	Export	0	0	0	0	0	0	0	0	0		0
	TOTAL PRIMARY ENERGY SUPPLY	**0.1**	**0**	**0.7**	**1.9**	**0**	**0**	**0**	**0.2**	**0**		**3.1**
	TRANSFORMATION, incl.	**0**	**0**	**0**	**-1.4**	**0**	**0**	**0**	**0.1**	**0.3**		**-1.1**
	heat and power sector	0	0	0	-1.1	0	0	0	0.3	0.3		5.1
	TOTAL FINAL CONSUMPTION, incl.	**0.1**	**0**	**0.7**	**0.5**	**0**	**0**	**0**	**0.3**	**0.2**		**2.0**
	industry	0	0	0	0.2	0	0	0	0.1	0.1		0.4
	residential	0	0	0.3	0.2	0	0	0	0.1	0.1		0.8

Table 42, continued

Millions of tonnes of oil equivalent, 2008, net calorific basis		Coal	Crude oil	Oil prod-ucts	Gas	Nucl-ear	Hydro	Renew-ables	Elect-ricity	Heat		Total
Azerbai-jan	Production	0	44.7	0	13.7	0	0	0.2	0	0		58.6
	Import	0	0	0.1	0	0	0	0	0	0		0.1
	Export	0	-37.0	-3.1	-4.4	0	0	0	-0.1	0		-44.6
	TOTAL PRIMARY ENERGY SUPPLY	**0**	**7.7**	**-3.5**	**9.1**	**0**	**0**	**0.2**	**-0.1**	**0**		**13.4**
	TRANSFORMATION, incl.	**0**	**-7.7**	**6.3**	**-5.8**	**0**	**0**	**-0.2**	**1.4**	**0.4**		**-5.6**
	heat and power sector	0	0	-0.4	-4.8	0	0	-0.2	2.1	0.5		-2.8
	TOTAL FINAL CONSUMP'N, incl.	**0**	**0**	**2.8**	**3.3**	**0**	**0**	**0**	**1.3**	**0.4**		7.8
	industry	0	0	0.2	0.6	0	0	0	0.3	0.4		1.3
	residential	0	0	0.1	2.6	0	0	0	0.6	0		3.4
Georgia	Production	0	0	0	0	0	0.6	0.4	0	0		1.1
	Import	0	0	0.1	1.1	0	0	0	0	0		2.0
	Export	0	0	0	0	0	0	0	0	0		-0.1
	TOTAL PRIMARY ENERGY SUPPLY	**0**	**0**	**0.1**	**1.1**	**0**	**0.6**	**0.4**	**0**	**0**		3.0
	TRANSFORMATION, incl.	**0**	**0**	**0**	**-0.5**	**0**	**-0.6**	**0**	**0.5**	**0**		0.5
	heat and power sector	0	0	0	-0.3	0	-0.6	0	0.7	0		-0.2
	TOTAL FINAL CONSUMP'N, incl.	**0**	**0**	**0.1**	**0.6**	**0**	**0**	**0.4**	**0.5**	**0**		2.4
	industry	0	0	0	0.2	0	0	0	0.1	0		0.3
	residential	0	0	0	0.2	0	0	0.3	0.2	0		0.9
Armenia	Production	0	0	0	0	0.6	0	0	0	0		0.8
	Import	0	0	0.5	1.8	0	0	0	0	0		2.3
	Export	0	0	0	0	0	0	0	0	0		-0.1
	TOTAL PRIMARY ENERGY SUPPLY	**0**	**0**	**0.4**	**1.8**	**0.6**	**0**	**0**	**0**	**0**		3.0
	TRANSFORMATION, incl.	**0**	**0**	**0**	**-0.4**	**-0.6**	**0**	**0**	**0.4**	**0**		-0.8
	heat and power sector	0	0	0	-0.4	-0.6	0	0	0.4	0		-0.7
	TOTAL FINAL CONSUMP'N, incl.	**0**	**0**	**0.4**	**1.4**	**0**	**0**	**0**	**0.4**	**0**		2.2
	industry	0	0	0	0.8	0	0	0	0.1	0		1.0
	residential	0	0	0	0	0	0	0	0.1	0		0.2
Kazakh-stan	Production	48.8	71.0	0	27.6	0	0.6	0.2	0	0		148
	Import	0.6	3.2	2.5	5.2	0	0	0	0.2	0		11.7
	Export	-19.2	-60.4	-4.0	-5.2	0	0	0	-0.2	0		-89.1
	TOTAL PRIMARY ENERGY SUPPLY	**30.2**	**13.8**	**-1.5**	**27.5**	**0**	**0.6**	**0**	**0**	**0**		**70.9**
	TRANSFORMATION, incl.	**-21.5**	**-13.8**	**11.6**	**-9.3**	**0**	**-0.6**	**0**	**4.7**	**8.3**		**-20.8**
	heat and power sector	-19.5	0	-0.8	-2.1	0	-0.6	0	6.9	9.5		-6.8
	TOTAL FINAL CONSUMP'N, incl.	**8.7**	**0**	**10.1**	**18.2**	**0**	**0**	**0.2**	**4.7**	**8.3**		**50.2**
	industry	8.1	0	2.9	0.8	0	0	0	2.8	4.0		18.7
	residential	0	0	0.2	0	0	0	0	0.6	2.0		2.8

Table 42, continued

Millions of tonnes of oil equivalent, 2008, net calorific basis		Coal	Crude oil	Oil prod-ucts	Gas	Nu cl-ear	Hydro	Re-new-ables	Elect-ricity	Heat		Total
Turkmen -istan	Production	0	11.2	0	57.4	0	0	0	0	0		68.6
	Import	0	0	0.1	0	0	0	0	0	0		0.1
	Export	0	-2.4	-3.7	-43.7	0	0	0	-0.1	0		-49.9
	TOTAL PRIMARY ENERGY SUPPLY	**0**	**8.8**	**-3.6**	**13.7**	**0**	**0**	**0**	**-0.1**	**0**		**18.8**
	TRANSFORMATION, incl.	**0**	**-8.8**	**-0.2**	**-7.2**	**0**	**0**	**0**	**0.9**	**0.2**		**-7.6**
	heat and power sector	0	0	0	-5.8	0	0	0	1.3	0.2		-4.3
	TOTAL FINAL CONSUMPTION, incl.	**0**	**0**	**3.8**	**6.5**	**0**	**0**	**0**	**0.8**	**0.2**		**11.2**
	industry	0	0	0	0	0	0	0	0.3	0		0.3
	residential	0	0	0	0	0	0	0	0.2	0		0.2
Uzbek-istan	Production	1.2	5.0	0	54.9	0	0	0	0	0		62.0
	Import	0.1	0	0	0.9	0	0	0	-1	0		1.9
	Export	0	0	-0.3	-12.2	0	0	0	-1	0		-13.5
	TOTAL PRIMARY ENERGY SUPPLY	**1.2**	**5**	**-0.3**	**43.6**	**0**	**0**	**0**	**0**	**0**		**50.5**
	TRANSFORMATION, incl.	**-0.9**	**-4.9**	**3.6**	**-15.6**	**0**	**0**	**0**	**3.5**	**2.4**		**-12.9**
	heat and power sector	-0.9	0	-0.5	-12.2	0	0	0	4.2	2.4		-7.9
	TOTAL FINAL CONSUMPTION, incl.	**0.3**	**0.1**	**3.4**	**28.0**	**0**	**0**	**0**	**3.5**	**2.4**		**37.6**
	industry	0.1	0	0.2	6.6	0	0	0	1.3	0		8.3
	residential	0	0	0	15.0	0	0	0	0.6	0		15.6
Kyrgyz-stan	Production	0.2	0.1	0	0	0	0.9	0	0	0		1.2
	Import	0.4	0.1	1.4	0.6	0	0	0	0	0		2.5
	Export	0	0	-0.3	0	0	0	0	0	0		-0.4
	TOTAL PRIMARY ENERGY SUPPLY	**0.5**	**0.1**	**0.7**	**0.6**	**0**	**0.9**	**0**	**0**	**0**		**2.9**
	TRANSFORMATION, incl.	**-0.1**	**-0.1**	**0.1**	**-0.3**	**0**	**-0.9**	**0**	**0.7**	**0.2**		**-0.5**
	heat and power sector	-0.1	0	0	-0.3	0	-0.9	0	1.0	0.2		-0.2
	TOTAL FINAL CONSUMPTION, incl.	**0.4**	**0**	**0.8**	**0.3**	**0**	**0**	**0**	**0.6**	**0.2**		**2.4**
	industry	0.4	0	0	0	0	0	0	0.2	0		0.6
	residential	0	0	0	0	0	0	0	0.2	0		0.2
Tajikistan	Production	0.1	0	0	0	0	1.4	0	0	0		1.5
	Import	0	0	0.5	0.4	0	0	0	0.4	0		1.4
	Export	0	0	0	0	0	0	0	-0.4	0		-0.4
	TOTAL PRIMARY ENERGY SUPPLY	**0.1**	**0**	**0.5**	**0.4**	**0**	**1.4**	**0**	**0.1**	**0**		**2.5**
	TRANSFORMATION, incl.	**0**	**0**	**0**	**-0.2**	**0**	**-1.4**	**0**	**1.1**	**0.1**		**-0.4**
	heat and power sector	0	0	0	-0.2	0	-1.4	0	1.4	0.1		-0.1
	TOTAL FINAL CONSUMPTION, incl.	**0.1**	**0**	**0.5**	**0.2**	**0**	**0**	**0**	**1.2**	**0.1**		**2.1**
	industry	0	0	0	0	0	0	0	0.6	0		0.6
	residential	0	0	0	0	0	0	0	0.3	0		0.3

Appendix 5. Russian and Ukrainian demand since the economic crisis

Table 43 shows monthly natural gas demand in Russia. The 2010 volumes have been published by the energy ministry on its web site; the 2009 volumes have been extrapolated from that information by the author. Table 44 gives a breakdown of monthly natural gas consumption in Ukraine in 2007-2010.

Table 43: Russia: Natural gas consumption, 2009-2010 (monthly, bcm)

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
2009	50.841	45.634	43.954	35.243	25.578	22.129	23.202	23.797	26.573	37.235	43.538	52.771
2010	57.555	54.711	47.744	35.812	26.883	26.381	26.899	27.310	31.108	44.407	42.662	52.557

Table 44: Ukraine: Natural gas consumption by sector, 2007-2010 (monthly, bcm)

2007	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Households & pub. sector	2.888	2.897	2.111	1.431	0.632	0.334	0.34	0.335	0.548	1.379	2.672	3.117
District heating	1.727	1.841	1.424	0.579	0.217	0.149	0.132	0.125	0.181	0.558	1.549	1.835
Other in low price bands	0.001	0.179	0.148	0.081	0.053	0.044	0.045	0.046	0.049	0.088	0.134	0.184
Industry: power sector	0.949	0.93	0.778	0.473	0.342	0.342	0.326	0.439	0.526	0.793	1.301	1.327
Industry: metals	0.884	0.843	0.881	0.802	0.779	0.738	0.759	0.785	0.796	0.816	0.859	0.916
Industry: other	1.234	1.134	1.261	1.228	1.242	1.08	1.142	1.139	1.297	1.676	1.483	1.326
Technical	0.565	0.687	0.526	0.443	0.544	0.546	0.496	0.476	0.501	0.564	0.76	0.862
Other	0.016	0.015	0.017	0.015	0.014	0.016	0.016	0.016	0.015	0.015	0.017	0.017
Total	8.264	8.526	7.146	5.052	3.823	3.249	3.256	3.361	3.913	5.889	8.775	9.584
2008	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Households & pub. sector	3.633	2.793	2.192	1.299	0.699	0.358	0.344	0.33	0.736	1.298	2.26	3.018
District heating	2.069	1.667	1.326	0.535	0.237	0.154	0.125	0.127	0.165	0.371	1.2	1.689
Other in low price bands	0.1	0.164	0.139	0.083	0.055	0.049	0.048	0.05	0.052	0.09	0.1	0.161
Industry: power sector	0.825	0.992	0.785	0.501	0.357	0.309	0.294	0.34	0.539	0.572	0.408	0.823
Industry: metals	0.927	0.867	0.764	0.731	0.751	0.705	0.718	0.68	0.591	0.486	0.406	0.479
Industry: other	1.821	1.185	1.305	1.237	1.282	1.181	1.179	1.192	1.206	1.493	1.519	0.876
Technical	0.711	0.813	0.752	0.626	0.609	0.562	0.425	0.45	0.515	0.5	0.424	0.536
Other	0.007	0.016	0.016	0.016	0.015	0.018	0.016	0.016	0.015	0.016	0.007	0.016
Total	10.09	8.497	7.279	5.028	4.005	3.336	3.149	3.185	3.819	4.826	6.324	7.598

Table 44 continued. (monthly, bcm)												
2009	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Households & pub. sector	3.385	2.57	2.485	1.155	0.562	0.34	0.326	0.355	0.413	1.289	2.054	3.153
District heating	1.917	1.507	1.5	0.515	0.204	0.137	0.12	0.138	0.168	0.492	1.289	1.9
Other in low price bands	0.212	0.166	0.139	0.083	0.055	0.049	0.045	0.045	0.051	0.079	0.137	0.158
Industry: power sector	0.693	0.553	0.566	0.278	0.141	0.138	0.152	0.175	0.214	0.409	0.703	0.972
Industry: metals	0.422	0.414	0.412	0.331	0.355	0.367	0.454	0.466	0.456	0.483	0.503	0.575
Industry: other	0.482	0.52	0.575	0.612	0.659	0.652	0.622	0.664	0.803	0.962	0.753	0.61
Technical	0.532	0.416	0.399	0.301	0.346	0.346	0.439	0.419	0.418	0.514	0.675	0.707
Other	0.017	0.015	0.017	0.015	0.015	0.015	0.015	0.016	0.015	0.015	0.015	0.015
Total	7.66	6.161	6.093	3.29	2.337	2.044	2.173	2.278	2.538	4.243	6.129	8.09
2010	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Households & pub. sector	3.885	3.026	2.568	1.242	0.464	0.344	0.337	0.323	0.498	1.746	1.61	3.103
District heating	2.308	1.847	1.629	0.511	0.198	0.152	0.124	0.124	0.174	0.933	1.09	1.828
Other in low price bands	0.149	0.113	0.1	0.055	0.034	0.032	0.029	0.03	0.034	0.075	0.098	0.129
Industry: power sector	1.16	1.051	0.883	0.425	0.255	0.258	0.226	0.263	0.286	0.624	0.722	1.034
Industry: metals	0.626	0.564	0.595	0.511	0.498	0.437	0.474	0.486	0.508	0.565	0.557	0.619
Industry: other	0.432	0.501	0.641	0.749	0.798	0.733	0.699	0.793	1.014	1.026	0.823	0.731
Technical	0.591	0.527	0.446	0.325	0.313	0.277	0.257	0.237	0.295	0.487	0.49	0.644
Other	2.25	0.018	0.018	0.018	0.016	0.015	0.016	0.016	0.016	0.017	0.018	0.02
Total	11.4	7.647	6.88	3.836	2.576	2.248	2.162	2.272	2.825	5.473	5.408	8.108

Source: energy ministry/ *Energobiznes*

Appendix 6. Statistics

The availability of published statistics on gas consumption is as follows. The author would be grateful to learn of any sources not mentioned.

Russia. The energy ministry in 2010 started publishing total annual and monthly consumption statistics, but no sectoral or regional breakdowns are published. This is the largest gap in the information in the region. Gazprom has since 2005 published information on its gas balance, and a broad breakdown of its sales volumes by sector, but similar information is not available from other companies. IEA and Gazprom data are compared in Tables 46 and 47 below.

Ukraine publishes more statistical information than any other CIS country. Detailed gas balances are published by the energy ministry, including breakdowns by sector; T44 in

Appendix 5 summarises some such information. Energy balances published since 1998 by the state statistical agency give detailed sector-by-sector breakdowns of gas consumed.

For ***Kazakhstan***, the state statistical agency publishes energy balances that include a natural gas balance, but are of limited use (for example, consumption via the distribution network and exports are counted as one category). From 2008 the agency also started to publish detailed consumption information with sectoral and regional breakdowns.

The ***Moldovan*** state statistics agency has published quite detailed gas balances, including sectoral breakdowns, although these do not include consumption in the Pridnestrovye region, the sovereign status of which is unresolved, but which is administered autonomously. The statistical agency of ***Azerbaijan*** publishes energy balances on its web site that include gas consumption, with a sectoral breakdown. Partial but inconsistent information has become publicly available about consumption in ***Georgia, Armenia*** and ***Tajikistan***. For ***Belarus***, Beltransgaz publishes annual consumption statistics (but with no sectoral breakdown) on its web site. No statistics, apart from the limited information reported to the IEA, are published for ***Uzbekistan, Turkmenistan*** or ***Kyrgyzstan***. (The one exception is that a sectoral breakdown for Turkmen consumption in 2005 was published by the UNDP, see Table 50 below.)

Published gas consumption statistics consulted by the author, in addition to the IEA's energy statistics, are listed in Table 45.

Table 45: Published Gas Consumption Statistics for Countries in the CIS Region

Country	Source	Information included	Period covered
Russia	Ministry of energy web site (minenergo.gov.ru)	Total consumption	2010
	Gazprom	Total consumption	2004-2010
Ukraine	Ministry of fuel and energy/ *Energobiznes*	Total consumption, and sectoral and regional breakdown. (Details of volumes transported and stored also available.)	2004-2010
	State statistics agency of Ukraine publication, *Pavlivno-energetichny resursy*	Energy balances, including gas	1998-2008
	State statistics agency of Ukraine publication, *Pavlivno-energetichny resursy*	Fuel, including natural gas and other gases, consumed, with detailed sectoral and regional breakdown	1998-2008
Belarus	Beltransgaz web site (www.btg.by)	Total consumption	2000-2009
Moldova	National Agency for Energy Regulation (ANRE), *Activity Report 2008* and press releases	Volumes imported, sectoral and regional breakdown	Some info, 2004-2010; full info, 2006-2008
Azerbaijan	State Statistical Committee of the Republic of Azerbaijan (www.azstat.org)	Energy balances, balances for gas and all other fuels, household consumption surveys	2007-2009
	"	Balances of fuel and energy	2000-2006
Armenia	Yeghiazaryan, "Natural Gas Markets in Armenia", p. 241 (using NSS and Armrosgazprom information)	Total consumption and sectoral breakdown	2000-2006
Georgia	Ministry of energy web site (www.minenergy.gov.ge)	Gas distribution by company	2005-2007
Kazakhstan	Kazakh Republic Statistics Agency (www.stat.kz) almanac, *Toplivno-energeticheskii balans respubliki Kazakhstan*	Total consumption, sectoral breakdown, regional breakdown	2008-2009
	"	Summary energy balances, including gas	2004-2009
Turkmenistan	None		
Uzbekistan	None		
Kyrgyzstan	None		
Tajikistan	Tajik statistics agency (www.stat.tj)	Total consumption, as a proportion of 1991 consumption	1991-

The following tables compare statistics published in Russia, Kazakhstan, Azerbaijan and Turkmenistan with those published by the IEA. Significant differences between these and the IEA statistics are discussed. A significant difference between IEA statistics and those published by the Ukrainian authorities, on consumption by district heating plants, is discussed above in Section 2.b, page 45, including Table 19.

Russia

Table 46 compares consumption statistics produced by Gazprom, apparently based on measurements taken at the point of sale, with statistics compiled by the IEA.

Table 46: Russian Natural Gas Consumption: Gazprom and IEA data compared, 2001-2004

Gazprom statistics					**IEA**				
bcm	**2001**	**2002**	**2003**	**2004**	**bcm**	**2001**	**2002**	**2003**	**2004**
TOTAL	**360.67**	**364.93**	**375.51**	**383.95**	**DOMESTIC SUPPLY**	**402.72**	**403.15**	**424.13**	**429.15**
Statistical diff'nces	0.00	0.00	0.00	0.01	Transfers & stat diff'nces	0.03	0.00	0.00	0.00
TRANSFORMATION (ASSUMED)	**187.95**	**189.19**	**193.83**	**197.56**	**TRANSFORMATION**	**240.39**	**242.46**	**251.61**	**255.32**
Electrical power production	140.59	141.83	143.82	149.20	Electricity plants	0.71	0.90	0.98	1.36
					CHP plants	160.05	163.16	168.18	170.61
Municipal services	30.77	30.74	32.09	30.16	Heat plants	74.16	74.49	76.46	76.17
Gazprom	16.58	16.62	17.92	18.21	Other transformation	5.47	3.91	5.98	7.19
ENERGY IND'Y USE (ASSUMED)	**10.71**	**11.28**	**12.07**	**13.93**	**ENERGY IND. OWN USE**	**10.97**	**11.30**	**13.69**	**13.15**
Oil industry	10.71	11.28	12.07	13.93					
INDUSTRY (ASSUMED)	**71.48**	**73.01**	**75.65**	**78.27**	**INDUSTRY**	**53.85**	**51.01**	**53.54**	**53.99**
Metallurgy	28.59	28.55	28.81	29.42	Iron & steel	14.84	14.87	15.56	15.97
Cement industry	5.02	5.37	5.75	6.35	Non-met. min'ls (incl. cement)	6.59	6.96	7.67	8.55
Petrochemical	6.13	6.56	7.99	8.51	Chemical & petrochemical	3.16	3.04	2.99	2.36
Agri-chemical	17.78	18.84	19.32	20.43	Chemical feedstocks	21.11	17.87	19.50	19.73
Agri-industrial complex	10.13	10.30	10.28	9.98	Other industry	8.13	8.26	7.82	7.39
Auto and agri machinery	3.84	3.39	3.50	3.58					
RESIDENTIAL	**41.68**	**42.93**	**44.83**	**44.81**	**RESIDENTIAL**	**53.30**	**52.22**	**56.32**	**52.89**
COMM'L & PUBLIC SERVICES	**0**	**0**	**0**	**0**	**COMM'L & PUBLIC SERVICES**	**2.94**	**2.88**	**3.10**	**3.37**
OTHER	**48.86**	**48.52**	**49.12**	**49.28**	**OTHER/ NON-SPECIFIED**	**1.60**	**2.17**	**1.69**	**1.80**
					DISTRIBUTION LOSSES	**6.21**	**6.10**	**5.61**	**6.30**
					PIPELINE TRANSPORT	**33.50**	**35.01**	**38.56**	**42.34**

Sources: Gazprom, IEA energy statistics

The significant differences are: (i) The IEA statistics include gas used for pipeline transport and distribution losses, the Gazprom statistics do not (and if these volumes are subtracted from the IEA totals, the latter are not substantially different from the Gazprom totals). (ii) I have assumed that gas categorised by Gazprom as “municipal services” is used as fuel in boilers in the district heating sector, and that gas categorised as “Gazprom” goes to the transformation sector, but even so, considerably less is counted as transformation sector consumption by Gazprom than by the IEA. (iii) Gazprom’s statistics show higher consumption by industry than do the IEA’s. This may be, partly, because gas used to produce heat consumed by industrial plants themselves or elsewhere, but not sold, is counted by Gazprom, but not counted by the IEA. However, this factor would not by itself explain this particularly large discrepancy. (iv) Gazprom’s statistics show lower consumption by residents than do the IEA’s.

Table 47 compares total Russian natural gas consumption statistics published by Gazprom and by the IEA for the years 2004-09.

Table 47: Total Russian Natural Gas Consumption: Gazprom and IEA data compared, 2004-2009

Total Russian domestic gas consumption, bcm	2004	2005	2006	2007	2008	2009
Gazprom published information	n/a	444.4	458.9	467.1	462.5	432.2
IEA energy statistics	429.152	432.876	444.065	453.173	453.435	n/a

Note. IEA energy statistics are presented as energy content measured in terajoules; physical volumes calculated by the author using the IEA's standard conversion factors

The IEA total demand figures are consistently 9-14 bcm lower than Gazprom’s, but the year-to-year changes shown by both sets of figures are similar. This suggests that, while different methods of calculation are used, the numbers are similarly reflective of consumption trends.

Kazakhstan

Table 48 compares statistics on Kazakh gas production, import, export, reinjection and flaring, and consumption, from various sources.

Some confusion surrounds gas consumption statistics in Kazakhstan, due mainly to inconsistent treatment of volumes of associated gas reinjected and flared. The energy ministry has consistently reported that more than half of the gas produced is reinjected or flared, and this is in line with information made available from the producing companies. However in the energy balances compiled by the Kazakh statistical agency, it appears that some of the gas reinjected or flared is included in the gas balance and reinjection and flaring counted as consumption by the extractive industry. This unsatisfactory method of counting is also reflected in the IEA statistics, where total domestic supply is counted at 11-33 bcm/year in 2002-08, more than twice its real level, including unfeasibly large volumes, 7-21 bcm/year in 2002-08, listed as “other consumption”.

Table 48: Kazakhstan Gas Balance: Data compared, 2005-2009

	Min. of energy				2005			2008			2009
	2005	2006	2007		IEA	Min. of energy		IEA	Kazakh stats		Aidar-bekov
Production	26.2	27	29.6		24.97	n/a		32.87			36.0
Reinjected and flared	14.6	14.7	16.2		3.55#	7.5		5.62#	14.167##		16.3
Imports					11.22	n/a		6.2			3.0
Exports					15.42	7.5		6.24			10.1
Total domestic supply (sales gas)					17.22*	12.0		27.213*	7.182*		12.6*
Domestic consumption					3.945*	7.0		3.49*	7.182*		8.6
Technical use and losses					0.11	5.0		0.93	0		3.0
Domestic consumption, "other"					13.16	0		20.8	0		0
Gas pumped into storage					0	0		0	0		1.0
* derived, # IEA "energy industry own use", ## listed as consumption by extractive industries											

Sources: energy ministry information from Shamil Yenikeyeff, "Kazakhstan's Gas Sector", in Pirani (ed.), *Russian and CIS Gas Markets*, p. 323; IEA energy statistics; Kazakh statistical agency energy balances; S. Aidarbekov, "Problemy i perspectivy razvitiia rynka", *Ekonomika i statistika*, no. 3 2010

Table 48 demonstrates the problem. The first three columns show the level of reinjection and flaring reported by the energy ministry, implying available domestically-produced gas of 11-14 bcm/year, as opposed to the 17-28 bcm/year implied by the IEA statistics. The next two columns compare IEA statistics to energy ministry statistics. I have assumed that gas categorised as "energy industry own use" by the IEA is used during the production process, and assumed a figure for total domestic supply that excludes that gas. This total domestic gas supply, according to the IEA's figures, was 17.2 bcm in 2005, whereas another set of figures from the energy ministry suggests it was 12 bcm, including 5 bcm of technical use and losses, and in reality it was probably lower than that. The IEA counts as part of the gas supplied domestically not only those volumes that I have included in the "domestic consumption" row (i.e. the sum of all volumes listed by the IEA as consumed domestically, except "energy industry own use" and "other"), but also the unfeasibly large "other" category. One possible explanation for this anomaly is that gas that is reinjected or flared has ended up in the "other" category. For 2008 I have compared IEA statistics to those from the Kazakh statistical agency, which in that year began to compile consumption statistics. If one assumes that volumes categorised by the agency as "extractive industry use", and amounting to more than 14 bcm, are reinjected or flared, then there remains 7.18 bcm of gas consumed elsewhere, which more or less accords with other government and industry information. The final column in the table, derived from a recent article in a journal published by the statistical agency, gives an outline of the gas balance in 2009.

Azerbaijan

Table 49 compares IEA data for gas consumption in Azerbaijan with those published by the state statistical committee. There are many differences, the most substantial of which is that the IEA states industrial consumption at a higher level than the statistics committee.

Table 49: Azerbaijan Natural Gas Consumption: State statistical committee and IEA data compared

IEA				Azeri state statistics committee		
Natural gas, bcm	**2007**	**2008**		**Natural gas, bcm**	**2007**	**2008**
DOMESTIC SUPPLY	**9.3023**	**10.9536**		**GROSS DOMESTIC CONSUMPTION**	**9.1937**	**10.8494**
Statistical differences	n/a	n/a		Statistical differences	0.0193	0.0314
TRANSFORMATION	**5.0548**	**5.7533**		**TRANSFORMATION SECTOR**	**5.2511**	**5.9446**
Electricity plants*	5.0548	5.7533		Thermoelectric power stations: social needs	4.5183	5.0403
				Thermoelectric power stations: enterprises' needs	0.6317	0.7536
Heat plants	n/a	n/a		Central heating stations	0.0711	0.0877
Other	0	0		Gas processing plants	0.03	0.063
ENERGY IND. OWN USE	**0.5587**	**0.5055**		**ENERGY SECTOR CONSUMPTION**	**0.4146**	**0.4471**
Fuel mining & extraction	n/a	n/a		Oil and gas producing enterprises	0.3531	0.3871
Elec., CHP & heat plants	n/a	n/a		Gas and petroleum processing plants	0.0615	0.06
Other	n/a	n/a				
LOSSES	**0.5636**	**0.7360**		**DISTRIBUTION AND OTHER LOSSES**	**0.5566**	**0.7288**
FINAL CONSUMPTION	**3.1253**	**3.9588**		**AVAILABLE FOR FINAL CONSUMPTION**	**2.9714**	**3.7289**
INDUSTRY	**0.5698**	**0.7007**		**INDUSTRY**	**0.3672**	**0.4916**
Iron and steel	0.0163	0.0061		Iron and steel	0.0174	0.006
Chemical & petrochemical	0.4176	0.2230		Chemicals (incl prod'n of rubber & plastics)	0.053	0.08
Non-ferrous metals	n/a	n/a		Non-ferrous metallurgy	0.034	0.051
Non-metallic minerals	0	0.1391		Prod'n of other nonmetal minerals	0.1682	0.1784
Transport equipment	n/a	n/a		Prod'n of machinery, transp't & equipment	0.0264	0.047
Machinery	n/a	n/a				
Mining & quarrying	n/a	n/a		Mining & quarrying	0.0014	0.0004
Food and tobacco	n/a	n/a		Production of foodstuffs	0.035	0.086
Paper, pulp and print	n/a	n/a		Pulp & paper, publishing	0.0001	0.0001
Wood and wood products	n/a	n/a		Woodworking and woodwork prod'n	0.0001	0.0001
Construction	n/a	n/a				
Textile and leather	n/a	n/a		Weaving, textiles, leather, footwear	0.0016	0.0026
Non-specified	0.1358	0.3325		Other spheres of industry	0.03	0.04
TRANSPORT	**0.0149**	**0.0008**		**TRANSPORT**	**0**	**0**
Road	0	0				
Other/non-specified	0.0149	0.0008				
OTHER	**2.5406**	**3.1766**		**OTHER**	**2.5304**	**3.1424**
Residential	2.5112	3.1138		Households	2.4821	3.0837
Commercial & pub services	0.0104	0.0515		Trade, hotels and restaurants	0.0013	0.0017
Agriculture	0.0164	0.0061		Agriculture, forestry and fishing	0.016	0.012
Non-specified (incl fishing)	0.0026	0.0053		Other (non-specified)	0.031	0.045
NON-ENERGY USE	**0**	**0.0808**		**NON-ENERGY PURPOSES**	**0.0544**	**0.0635**
in industry	0	n/a		Chemicals	0.0544	0.0607
of which, feedstocks	0	n/a		Other	0	0.0028
* single figure including power plants and CHP						

Sources: IEA energy statistics, Azeri state statistical committee energy balances, table 2.18

Turkmenistan

Table 50 compares statistics published by the UNDP for 2005 with data published by the IEA.

Table 50: Turkmen Gas Consumption Statistics: IEA and UNDP data compared

UNDP statistics, 2005			IEA statistics, 2005 and 2008		
	Gas, peta-joules	Gas, bcm		Gas, bcm	
				2005	2008
Total	639.4	16.624	Total	15.131	16.933
Joint production of heat and electricity	288.3	7.496	Electricity plants	6.106	7.163
n/a	n/a	n/a	Energy industry own use	1.504	1.683
Industry	177.4	4.612	Final consumption (unspecified)	7.522	8.087
Commercial & public sector	22.2	0.577			
Residential	77.6	2.018			
Other	73.9	1.921			

Notes: the author has assumed that the UNDP information is presented in petajoules, as the units are not specified. See UNDP, *Strategiia razvitiia sistemy tsentralizovannogo teplosnabzheniia (proekt)* (UNDP, Ashgabat, 2006). Conversions by the author

Appendix 7. The Russian power sector: fuel consumption, electricity and heat output and efficiency

Table 51 shows the consumption of gas, coal and fuel oil, the production of electricity and heat, in the Russian power sector (thermal generation only), sub-divided by company.

Table 51: Thermal Power and Heat Production in Russia, 2008-09

	Gas consumption, bcm		**Coal consumption, m tonnes**		**Fuel oil consumption, m tonnes**	
	2008	2009	2008	2009	2008	2009
OGK total	**54.63**	**49.17**	**48.00**	**40.6**	**0.50**	**0.30**
OGK-1	13.07	10.76	2.11	2.08	0.07	0.03
OGK-2	10.69	10.42	7.71	6.64	0.08	0.04
OGK-3	5.67	5.16	7.52	6.08	0.16	0.12
OGK-4	12.27	11.97	6.87	5.81	0.01	0
Enel OGK-5	6.7	6.14	12.48	11.63	0.09	0.06
OGK-6	6.23	4.72	11.3	8.35	0.1	0.05
TGK total	**84.51**	**78.69**	**41.06**	**38.9**	**1.91**	**2.13**
TGK-1	5.82	5.61	0.42	0.42	0.34	0.37
TGK-2	3.27	2.99	1.22	1.00	1.00	1.07
TGK-3 Mosenergo	21.96	21.16	0.45	0.46	0.06	0.13
TGK-4 Kvadra	7.2	6.17	0.13	0.05	0.02	0.02
TGK-5	4.32	3.34	0.33	1.37	0.01	0.01
TGK-6	5.24	4.8	0.28	0.39	0.015	0.016
TGK-7 Volzhskaya	12.86	11.94	0.07	0.15	0.03	0.05
YuGK TGK-8	6.07	5.62	0	0	0.06	0.07
TGK-9	8.49	7.92	3.01	3.02	0.08	0.1
Fortum (former TGK-10)	2.07	2.02	4.93	4.33	0.02	0.01
TGK-11	0.5	0.49	13.56	12.75	0.08	0.06
TGK-12 Kuzbassenergo	0	0	12.49	10.52	0.05	0.05
TGK-13 Eniseiskaya TGK*	0	0	6.57	5.62	0.02	0.02
TGK-14	0	0	3.44	3.89	0.02	0.02
Regional generators, total*						
Bashkirenergo	8.55	8.6	0.25	0.4	0.38	0.5
Dalnevostochnaya gen. ko.	1.4	1.4	13.0	16.3	0.15	0.2
Tatenergo	8.9	7.9	0.016	0.3	0.19	0.1
Irkutskenergo	0	0	13.6	11.0	0.015	0.01
Novosibirskenergo	0.26	0.5	7.66	6.5	0	0
Norilsko-Taimyrsk. energo	2.53	2.7	0	0	0	0
Inter-RAO	1.83	2.2	0	0	0	0
Other power companies	n/a	n/a	n/a	n/a	n/a	n/a

Table 51, continued									
		Total fuel consumption, m tsf			Electricity prodn, m kwh			Heat prodn, m gcals	
		2008	2009		2008	2009		2008	2009
OGK total		**91.37**	**81.34**		**341.66**	**314.18**		**18.8**	**18.7**
OGK-1		16.51	13.85		39.14	31.64		1.1	1
OGK-2		16.82	15.91		49.83	47.17		2.5	2.4
OGK-3		11.27	9.78		33.91	29.52		1.6	1.5
OGK-4		18.05	17.09		56.68	53.95		2.3	2.4
Enel OGK-5		14.8	14.17		42.98	41.34		6.8	6.8
OGK-6		13.92	10.56		38.86	28.95		4.4	4.4
TGK total		**123.72**	**117.49**		**266.08**	**247.34**		**342.2**	**344.6**
TGK-1		7.36	7.18		26.93	26.76		26.3	26.9
TGK-2		5.9	5.55		10.53	9.39		19.2	19.1
TGK-3 Mosenergo		25.53	24.78		64.27	61.75		62.4	65.4
TGK-4 Kvadra		8.03	7.16		12.88	10.67		27.6	26.7
TGK-5		5.28	5.18		11.29	10.63		15.7	16
TGK-6		6.39	6.01		13.08	11.96		16.9	16.8
TGK-7 Volzhskaya		14.97	14.03		27.89	25.41		47.4	46
YuGK TGK-8		7.13	6.65		14.66	13.14		15.5	15.1
TGK-9		11.45	11.03		16.34	15.27		40.4	40.2
Fortum (former TGK-10)		7.97	7.73		18.39	17.79		18.5	19
TGK-11		5.2	4.86		9.40	8.38		15.8	16.5
TGK-12 Kuzbassenergo		10.02	9.66		23.63	22.22		15.1	15
TGK-13 Eniseiskaya TGK*		6.59	5.64		14.28	11.35		15.3	15.7
TGK-14		1.91	2.02		2.50	2.63		6.1	6.4
Regional generators, total*		**46.48**	**44.48**		**148.49**	**138.16**		**116.7**	**113.5**
Bashkirenergo		10.4	10.6		22.32	19.83		25.3	23.9
Dalnevostochnaya gen. ko.		9.6	9.6		20.72	19.17		21.7	22.3
Tatenergo		10.5	9.6		23.97	21.38		29.1	26.8
Irkutskenergo		8.18	6.48		60.21	56.80		26	25.4
Novosibirskenergo		4.9	5.1		11.84	11.57		14.6	15.1
Norilsko-Taimyrsk. Energo		2.9	3.1		9.44	9.41		n/a	n/a
Inter-RAO		2.1	2.5		8.14	9.75		1.04	1.03
Other power companies		n/a	n/a		n/a	n/a		27.1	27.3
* Information for the regional generating companies in 2008, and TGK-13 in both years, was in units of standard fuel; the physical amounts are the author's estimates, using standard conversion factors									

Sources: APBE, *Funktsionirovanie i razvitie elektroenergetiki RF v 2009 godu*, pp. 53-54, 56-57, 184 and 193; Inter RAO annual report, 2009

Table 52 shows the same information as Table 51, converted into terajoules by the author.

Table 52: Thermal Power and Heat Production in Russia (Values in Terajoules), 2008-09

All values in terajoules		Gas consumption			Coal consumption			Fuel oil consumption	
		2008	2009		2008	2009		2008	2009
OGK total		**1845500**	**1667896**		**810941**	**704555**		**20222**	**11137**
OGK-1		440493	364000		40738	41031		2638	1172
OGK-2		362535	354036		127488	110490		3224	1465
OGK-3		190206	173794		134522	108731		5862	4103
OGK-4		416754	407962		110490	92612		586	117
Enel OGK-5		226255	209549		203395	203102		3810	2345
OGK-6		209256	158847		194602	148590		4103	1758
TGK total		**2826132**	**2649407**		**720967**	**705434**		**73562**	**82061**
TGK-1		194602	188155		8206	8499		12895	13775
TGK-2		109904	101404		22274	18464		38100	41031
TGK-3 Mosenergo		736500	711589		9378	9965		2052	4982
TGK-4 Kvadra		232409	208377		2052	879		586	586
TGK-5		144193	111955		7327	34876		293	293
TGK-6		175553	161192		5862	8792		5862	6155
TGK-7 Volzhskaya		435804	405617		1465	3517		1172	2052
YuGK TGK-8		206326	191965		0	0		2345	2931
TGK-9		283404	266992		48944	52168		3517	4103
Fortum (former TGK-10)		224203	221565		9378	4689		59	586
TGK-11		70924	68873		80889	73269		879	586
TGK-12 Kuzbassenergo		12309	12309		278129	268458		2931	2638
TGK-13 Eniseiskaya TGK*		0	0		191086	163536		2052	2052
TGK-14		0	0		55391	58615		586	586
Regional generators, total		**679936**	**718036**		**378654**	**550104**		**22567**	**32825**
Bashkirenergo		287214	287214		4396	2931		14654	17585
Dalnevostochnaya gen. ko.		0	49823		0	225669		0	5862
Tatenergo		298938	272561		293	293		7327	8792
Irkutskenergo		0	0		239150	189327		586	586
Novosibirskenergo		8792	17585		134815	131884		0	0
Norilsko-Taimyrsk. energo		84992	90854		0	0		0	0
Inter-RAO		61546	73269		0	0		0	0

Table 52, continued						
All values in terajoules	Total fuel consumption		Electricity production		Heat production	
	2008	2009	2008	2009	2008	2009
OGK total	**2677835**	**2383880**	**1229992**	**1131032**	**78712**	**78293**
OGK-1	483868	405910	140912	113886	4605	4187
OGK-2	492954	466284	179376	169797	10467	10048
OGK-3	330297	286628	122082	106289	6699	6280
OGK-4	529002	500867	204034	194211	9630	10048
Enel OGK-5	433752	415289	154717	148816	28470	28470
OGK-6	407962	309488	139887	104231	18422	18422
TGK total	**3625936**	**3443350**	**957877**	**890430**	**1432723**	**1442771**
TGK-1	215704	210429	96933	96340	110113	112625
TGK-2	172915	162657	37908	33793	80387	79968
TGK-3 Mosenergo	748223	726242	231386	222290	261256	273817
TGK-4 Kvadra	235340	209842	46362	38425	115556	111788
TGK-5	154744	151813	40635	38275	65733	66989
TGK-6	187276	176139	47098	43069	70757	70338
TGK-7 Volzhskaya	438735	411186	100404	91474	198454	192593
YuGK TGK-8	208963	194896	52777	47293	64895	63221
TGK-9	335572	323263	58826	54967	169147	168309
Fortum (former TGK-10)	233582	226548	66219	64027	77456	79549
TGK-11	152400	142435	33833	30186	66151	69082
TGK-12 Kuzbassenergo	293662	283111	85086	79993	63221	62802
TGK-13 Eniseiskaya TGK*	193137	165295	51409	40844	64058	65733
TGK-14	55978	59201	9002	9456	25539	26796
Regional generators, total	**1362217**	**73269**	**534576**	**497930**	**488600**	**475202**
Bashkirenergo	304799	310661	80356	71403	105926	100065
Dalnevostochnaya gen. ko.	281353	281353	74581	68996	90854	93366
Tatenergo	307730	281353	86283	76975	121836	112206
Irkutskenergo	239736	189913	216756	204472	108857	106345
Novosibirskenergo	143607	149469	42621	41659	61127	63221
Norilsko-Taimyrsk. energo	84992	90854	33979	33885	0	0
Inter-RAO	61546	73269	29310	35103	4187	4187

Source: APBE, *Funktsionirovanie i razvitie elektroenergetiki RF v 2009 godu*. Converted by author from units of standard fuel to terajoules (1 tj = 1 tonne of standard fuel x 0.0293076)

Table 53 summarises the reported efficiency of Russian thermal power companies. Table 54 presents examples, from the published reports of Enel OGK-5 and TGK-7 Volzhskaia, of the type of information available from some companies on fuel consumption and efficiency. The figures for TGK-7, which owns and manages a large number of gas-fired heat-power centres, again emphasise the trade-off between electricity efficiency and total efficiency.

Table 53: Reported Efficiency of Thermal Power and Heat Production by OGKS and TGKS in Russia, 2009

	Specific fuel consump'n per unit of electricity, g/kwh		Specific fuel consumption per unit of heat, kg/Gcal		
			Total	Thermal power stations and CHP	Boilers
OGK average	**339.8**		**152.9**	**152.9**	**237.7**
OGK-1	340.8		171.6	171.5	214.3
OGK-2	347.2		152.1	152.1	
OGK-3	341.9		177.4	177.3	263.0
OGK-4	322.2		156.3	156.3	215.4
Enel OGK-5	334.8		144.6	144.5	
OGK-6	365.4		151.6	151.6	
TGK average	**325.4**		**144.6**	**142.6**	**164.9**
TGK-1	300.8		141.4	139.8	170.0
TGK-2	341.9		146.6	144.8	168.6
TGK-3 Mosenergo	283.8		131.9	131.9	
TGK-4 Kvadra	336.7		152.3	148.4	164.0
TGK-5	313.5		140.0	140.0	
TGK-6	331.0		149.4	148.7	160.2
TGK-7 Volzhskaya	335.1		142.4	139.3	168.4
YuGK TGK-8	354.9		147.0	145.1	156.8
TGK-9	374.0		152.2	150.9	159.5
Fortum (former TGK-10)	313.7		145.4	142.7	157.9
TGK-11	344.1		145.4	142.7	157.9
TGK-12 Kuzbassenergo	372.9		156.8	156.6	168.5
TGK-13 Eniseiskaya TGK*	346.2		151.5	148.4	170.7
TGK-14	413.8		176.9	172.4	191.1

Source: APBE, *Funktsionirovanie i razvitie elektroenergetiki RF v 2009 godu*, p. 71

Table 54: Power and Heat Output and Fuel Consumption at ENEL OGK-5 and TGK-7 Volzhskaya, 2009

		OUTPUT			FUEL		
		Electr-icity, GWh	Heat, 000 Gcal		Gas, m cu m	Fuel oil, 000 tonnes	Coal, 000 tonnes
Enel OGK-5, 2009		**41338**	**6767**		**6143**	**60.6**	**11629.6**
Konakovskaya GRES		7469	250		2032.8	5.2	0
Nevinnovmysskaya GRES		5515	1706		1706.9	12.5	0
Reftinskaya GRES		21147	434		0	38.9	11629.6
Sredneuralskaya GRES		7208	4376		2403.3	4	0
TGK-7 Volzhskaya, 2009		**20271**	**36540**		**9601.144**	**42.19708**	**160.74**
Samara region total		**12645**	**23471**				
Samarskaya GRES		191	901		154.419	0	0
Samarskaya TETs		2292	3877		1023.527	2.664	0
Bezymanskaya TETs		817	1944		468.432	0.168	0
VAZ (car factory) TETs		4772	6554		1908.813	5.423	0
Tol'yatinskaya TETs		2037	4861		996.828	0.000	160.74
Novokubyshevskaia TETs-1		561	1076		313.128	1.569	0
Novokubyshevskaia TETs-2		1164	445		492.374	3.212	0
Syzranskaya TETs		811	1346		373.839	4.737	0
Samara, central boiler hses		0	2467		347.574	0	0
Saratov region total		**4867**	**8676**				
SarGRES		240	1027		181.716	0	0
SarTETs-1		47	304		55.841	0.044	0
SartTETs-2		824	1617		446.300	2.168	0
SarTETs-3		577	845		254.879	0.489	0
SarTETs-4		1373	1866		588.553	0.664	0
SarTETs-5		1806	1905		618.380	12.985	0
Saratov boilers		0	1112		178.943	0	0
Ulyanovskii region total		**2758**	**4393**				
UlTETs-1		1610	2431		670.295	7.650	0
UlTETs-2		1148	1629		480.598	0.423	0
UlTETs-3		0	333		46.707	0.000	0

Table 54 continued											
	OUTPUT, TJ				FUEL, TJ					EFFICIENCY	
	Electr-icity, tj	Heat, tj	Output total, tj		Gas, tj	Coal, tj	Diesel oil, tj	Fuel total, tj		Electr-icity effic.	Total effic.
Enel OGK-5, 2009	**148817**	**28332**	**177149**		**209549**	**203102**	**2345**	**415289**		**35.8%**	**42.6%**
Konakovskaya GRES	26888	1047	**27935**		68751	0	209	68960		39.0%	40.5%
Nevinnovmysskaya GRES	19854	7143	**26997**		57729	0	502	58231		34.1%	46.6%
Reftinskaya GRES	76129	1817	**77946**		0	261762	1562	263324		28.9%	29.6%
Sredneuralskaya GRES	25949	18321	**44270**		81282	0	161	81443		31.9%	54.3%
TGK-7 Volzhskaya, 2009	**72976**	**152986**	**225961**		**324720**	**3618**	**1694**	**330032**		**22.1%**	**68.5%**
Samara region total	**45522**	**98268**	**143790**								
Samarskaya GRES	688	3772	4460		5223	0	0	5223		13.2%	85.4%
Samarskaya TETs	8251	16232	24483		34617	0	107	34724		23.8%	70.5%
Bezymanskaya TETs	2941	8139	11080		15843	0	7	15850		18.6%	69.9%
VAZ (car factory) TETs	17179	27440	44619		64558	0	218	64776		26.5%	68.9%
Tol'yatinskaya TETs	7333	20352	27685		33714	3618	0	37332		19.6%	74.2%
Novokubyshevskaia TETs-1	2020	4505	6525		10590	0	63	10653		19.0%	61.2%
Novokubyshevskaia TETs-2	4190	1863	6054		16653	0	129	16782		25.0%	36.1%
Syzranskaya TETs	2920	5635	8555		12644	0	190	12834		22.7%	66.7%
Samara, central boiler hses		10329	10329		11755	0	0	11755			87.9%
Saratov region total	**17521**	**36325**	**53846**								
SarGRES	864	4300	5164		6146	0	0	6146		14.1%	84.0%
SarTETs-1	169	1273	1442		1889	0	2	1890		9.0%	76.3%
SartTETs-2	2966	6770	9736		15094	0	87	15181		19.5%	64.1%
SarTETs-3	2077	3538	5615		8620	0	20	8640		24.0%	65.0%
SarTETs-4	4943	7813	12755		19905	0	27	19932		24.8%	64.0%
SarTETs-5	6502	7976	14477		20914	0	521	21436		30.3%	67.5%
Saratov boilers	0	4656	4656		6052	0	0	6052			76.9%
Ulyanovskii region total	**9929**	**18393**	**28321**								
UlTETs-1	5796	10178	15974		22670	0	307	22977		25.2%	69.5%
UlTETs-2	4133	6820	10953		16254	0	17	16271		25.4%	67.3%
UlTETs-3	0	1394	1394		1580	0	0	1580			88.3%

Sources: company annual and quarterly reports, APBE statistics, author's calculations.

Appendix 8. Russia's heat market

Table 55 shows estimates of Russia's annual average heat balance by the Alliance to Save Energy. Table 56 lists the largest companies active in the Russian heat market.

Table 55: Estimates of Russia's Annual Average Heat Balance in 2000-02, by the Alliance to Save Energy

Million gcal	Total	Public utility companies	Industrial & municipal boilers	Industrial boilers
Generation	**2299.6**	**1515.7**	**613.2**	**170.7**
including CHP		*680*		
... RAO UES		*494*		
... Industrial CHP		*176*		
... Other		*165.7*		
Own use	73.9	52.7	21.2	0
Sold to network	2225.7	1463	592	170.7
Heat losses	**441.7**	**284.7**	**157**	
Industry	91	74	17	
Agriculture	12.3	8.8	3.6	
Residential buildings	147.4	61.4	86	
Public buildings	153.7	105.3	48.4	
Other	37.2	35.1	2.1	
Final heat consumption	**1783.9**	**1178.3**	**435**	**170.7**
Industry	695.4	599	96.4	
Agriculture	70	49.7	20.2	
Residential buildings	514.6	143.4	200.6	170.7
Public buildings	358.6	245.8	112.8	
Other	145.4	140.5	4.9	

Source: 2000-02, Alliance to Save Energy, *Urban Heating in Russia*, Table 1

Table 56: Heat Generating Capacity: The six largest companies in Russia, 2010

	Installed capacity, 000 Gcal/hr
KES (Integrated Energy Systems)	67.7
Gazprom	54.0
Evrosibenergo	17.5
MOEK (Moscow unified energy co)	16.6
SUEK (Siberian coal energy co)	15.8
Bashkirenergo	15.6

Source: KES presentation, *Novaia Energetika Rossii*

Appendix 9. The chemical industry

Table 57 lists the main chemical fertiliser plants in Russia and Ukraine. Table 58 shows Evrokhim's estimates of production costs and prilled urea prices for export to Europe.

Table 57: Chemical Fertiliser Plants in Russia and Ukraine

Company	Plant	2008		2009	
		Ammo-nia output, tonnes	Volume of gas used, bcm	Ammo-nia output, tonnes	Volume of gas used, bcm
RUSSIA TOTAL		**12683**	**15.0**	**12957**	**15.0**
Evrokhim		2570		2790	4.12
	Nomoskovskii azot			*1670*	
	Nevinomysskii azot			*1160*	
FosAgro				3105	
	Cherepovetskii Azot				
	Agro-Cherepovets				
Uralkhim				1811	
	Azot (Berezniki)				
Akron		1494	2.07	1682	2.25
	Akron				
	Dorogobuzh				
Sibur Fertilisers		1360		1400	
	Azot (Kemerovo)				
	Angarskii azotnotukovyi zavod				
	Minudobreniia				
Gazprom subsidiaries					
	Salavatnefteorgsintez			*399.1*	
	Mendeleevskazot				
Minudobreniia Rossosh				647	
Tol'iattiazot					
KuibyshevAzot					
Shchekinoazot					
UKRAINE TOTAL			**7.802**		**4.5**
Group DF and associated companies					
	Rivneazot				
	Stirol	2050		957	
	Severodonetskii azot				
	Cherkassky Azot				
Odessa priportovyi zavod					
Dniproazot					

Sources. Ros. Assosiatsiia Proizvoditelei udobreniia; Derzhkomstat. Ammonia output: Evrokhim and Akron reports, author's estimates

Table 58: Fertiliser Production Cost Estimates by Evrokhim

Prilled urea delivered to Europe, cost						
		Current prices				With $150/ mcm gas in Russia
		Nevinno-mysskiy Azot	Europ-ean plants	Ukraine plants		Nevinno-mysskiy Azot
Gas price, $/mcm, delivered to plant		108	312	307		150
Cost per tonne of output, $	Gas cost	74	196	210		103
	Other costs	63	65	65		63
	Transportation costs	67	10	54		67
	Import duty (EU)	26	0	26		26
	Total	**230**	**271**	**355**		**259**

Source: Evrokhim, Annual report and accounts 2010

Appendix 10. The steel industry

Table 59 presents the available information on energy costs for large Russian and Ukrainian steel producers.

Table 59: Energy Items in Steelmakers' costs

Company		***Year***	**Natural gas**	**Electric power**	**Other energy**
NLMK, consolidated costs	Total for the group	*2008*	3.0%	6.0%	1.0%
	Steel segment	*2008*	3.5%	4.2%	1.1%
	Long products	*2008*	0.9%	5.8%	1.2%
	Mining segment	*2008*	1.3%	31.8%	6.8%
Severstal Russian Steel, cost of sales structure		*2008*	2.6%	2.9%	1.6%
		2009	3.5%	3.5%	1.9%
Ferrexpo, cost of sales*		*2008*	7.8%	21.2%	9.6%
		2009	8.4%	23.8%	7.0%
* Ferrexpo information was presented in absolute numbers; percentages calculated by the author. The item "fuel" has been placed in the column "other energy".					

Source: company annual reports

Appendix 11. Tariffs, distribution and supply

Table 60 lists regulated retail gas tariffs in Ukraine. Table 61 presents available information about the numbers of Russian retail customers supplied by Gazprom affiliates.

Table 60: Regulated retail Gas Prices in Ukraine

Prices set by the National Energy Regulatory Commission from 30 March 2011, hryvna/mcm				
			Incl. VAT	Ex-VAT
Retail gas prices, including transport and supply costs, and distribution companies' investment surcharge, for households, religious organisations and some youth organisations				
	using up to 2500 cu m per year	with a meter	725.40	604.50
		without a meter	798.00	665.00
	using up to 6000 cu m per year	with a meter	1098.00	915.00
		without a meter	1207.80	1006.50
	using up to 12,000 cu m per year	with a meter	2248.20	1873.50
		without a meter	2473.20	2061.00
	using more than 12,000 cu m per year	with a meter	2685.60	2238.00
		without a meter	2954.10	2461.75
Retail gas prices, including transport and supply costs, and distribution companies' investment surcharge, for district heating companies			1309.20	1091.00
Retail gas prices, excluding transport and supply costs, and distribution companies' investment surcharge, for industrial customers and public sector organisations			3063.84	2553.20

Source: Gaz Ukrainy web site
Note: current exchange rate (June 2011): 7.98 hryvna = $1

Table 61: Numbers of Gas Customers in Russia, 2007

TABLE 61. NUMBERS OF GAS CUSTOMERS IN RUSSIA, 2007		
	Russia total	Supplied by Gazprom
Flats and private houses	40.7 million*	26.1 million
Municipal sector enterprises	190,000	173,400
Boilers	44,300	35,700
Industrial enterprises	18,900	15,900
* Of these, 10.2 million were supplied with LPG.		

Source: *Gazprom v voprosakh i otvetakh* (2007 edition), p. 42; *General'naia skhema razvitiia gazovoi otrasli do 2030 g.*, p. 6-1.

Appendix 12. The potential for reducing gas losses from pipelines and compressor stations

Central Asia

A project on “Technologies and Methodologies for Reducing Gas Losses in Gas Transit”, funded by the European Union within its Cooperation Programme for central Asia, studied the extent of gas losses from pipelines and compressor stations in the region. The project executor, WYG International, worked with gas transport companies in Kazakhstan, Turkmenistan, Uzbekistan and Kyrgyzstan.

Tests were conducted on stretches of pipeline and at compressor stations in the four participating countries.

Examples of the results of tests on stretches of pipeline are summarised in Table 62. The length of the stretch of pipeline tested, pipeline diameter, number of leaks and volume of gas leaking per year are shown. The table also shows the project’s estimates of the values of the annual leakage from each stretch of pipeline (assuming a gas price of $150/mcm), and average values of the cost of leakage in dollars per km of pipeline per year.

Table 62: Examples of Gas Leakage in Central Asia

Country	km of pipe	diameter, mm	no. of leaks	mcm/year leakage	value/year @ $150/mcm	value $/km/year
A	230	700/1020	7	3173	$475,950	$2070
B	114	700	17	1428	$214,200	$1880
C	130	1220	3	4227	$634,050	$4880
D	230	700/1020	4	538	$80,700	$350
Total	**704**		**31**	**9366**	**$1,404,900**	**Average $1995.60**

Source: EU Cooperation Programme for Central Asia, Technologies and Methodologies for Reducing Gas Losses project reports

Similar tests were carried out at compressor stations. Results from one compressor station, which measured “leak speed” in dollars per year, assuming a $150/mcm gas price, highlighted $52,500/yr from a gas flue with oil lock (350 mcm/yr); $142,500/yr from offtake for power gas, from 24 leaks (950 mcm/yr); $650,000/yr from installation valves, from 13 leaks (4333 mcm/yr); $180,000/yr from blowoff valves, from 10 leaks (1200 mcm/yr) and $56,250/yr from the gas flue of a starting device, from 24 leaks (375 mcm/yr).

The project conducted risk assessments and cost-benefit analysis, and highlighted the most cost-effective types of repairs, including replacement of blow-off valves, fuel valves, oil seals, starter valves and unit valves. The tests conducted showed that just 20% of leaks on the pipeline system lead to loss of 80% of total volume of gas, suggesting that targeted repairs are very cost-effective.

An example of three sets of leaks given by WYG International showed that the total leakage was 4.2 mmcm of gas per year, worth $636,735/year. The cost of the three repairs ($13,900 each) was $41,690 and the cost of the vented gas $350,100. This means that within less than a year the investment will have paid for itself. This is net of the possibility of earning credits under Kyoto schemes for reducing emissions.

Ukraine

A previous project, conducted by Heath, an engineering contractor, for the EU in Ukraine, with the distribution company Cherkasytransgaz, found 169 leaks, with a total leakage of 2,209,000 cu m/year, at Zadniprovskaia compressor station, and 112 leaks with a total leakage of 749,000 cu m/year at the Kremenchugskaia compressor station. The project analysis showed that 70% of the total leakage at each site comes from 20% of the leaking components, i.e. that targeted repairs can be very effective. Repairs were conducted under the project that reduced the total leakage at the two compressor stations by 1,954,000 cu/m per year.

Bibliography

Statistical and price data

Azerbaijan, State Statistical Committee of, *Results of survey on consumption of fuel and energy in the households in 2009*.

[Belarus], Beltransgaz consumption statistics (www.btg.by)

BP, *Statistical Review of World Energy*, June 2011.

EBRD, Selected Economic Indicators (www.ebrd.com/pages/research/economics/data/macro.shtml#macro)

Gazprom, *Annual Reports* 2004-2010

Gosudarstvennyi komitet RF po statistike, *Postanovlenie: ob utverzhdenii "metodologicheskikh polozhenii po raschetu toplivno-energeticheskogo balansa RF v sootvetstvii s mezhdunarodnoi praktike"*, 23 June 1999, no. 46.

[Georgia] Ministry of energy gas distribution report (www.minenergy.gov.ge)
International Energy Agency, *Energy Balances of Non-OECD Countries* (OECD/IEA, Paris, 2010)

International Energy Agency, *Energy Statistics Manual* (OECD/IEA, Paris, 2005)

International Energy Agency, *Energy Statistics of Non-OECD Countries* (OECD/IEA, Paris, 2010)

International Energy Agency, *Natural Gas Information* (OECD/IEA, Paris, 2010)

Kazakhstan, Statistical Agency of the Republic of, *Toplivno-energeticheskii balans Respubliki Kazakhstana* (Astana, 2010)

[Moldova] National Agency for Energy Regulation (ANRE), *Activity Report 2008*

[Russia], Ministry of energy, "Statisticheskaia informatsiia" (www.minenergo.gov.ru)

[Russia], State statistics committee, tables "Chislo zhilykh kvartir po sub'ektam RF v 2009 g." and "Blagoustroistvo zhilishchnogo fonda", "Osnovnye pokazateli zhilishchnykh uslovii naselenii" (www.gks.ru)

[Tajikistan] statistics agency fuel consumption information (www.stat.tj)

[Ukraine], Derzhavnyi komitet statistiki Ukrainy, *Palivno-energetichny resursy Ukrainy: statistichniy zbirnyk* (Kyiv, 2004, 2006 and 2009)

[Ukraine], Derzhavnyi komitet statistiki Ukrainy, *Statistichnii biuleten' pro osnovny pokazniki roboti gazovogo gospodarstva Ukrainy za 2008 rik* (Kyiv 2009)

[Ukraine], Derzhavnyi komitet statistiki Ukrainy,*Statistichnii biuleten' pro osnovny pokazniki roboti opaliuval'nikh kotelen' i teplovikh merezh Ukrainy* (Kyiv, 2009)

[Ukraine, ministry of energy], statistical information published by *Energobiznes*

Statistical information published on the internet by Russian wholesale and territorial electricity generating companies has also been consulted.

Newspapers and periodicals

Delovaia stolitsa (Kyiv)
Energobiznes (Kyiv)
ESKO journal (Kyiv)
Euro Heat & Power (Brussels)
Interfax Russian Oil and Gas Report (Moscow)
Kommersant (Moscow)
Kommersant-Ukraina (Kyiv)
Neft' i Gaz (Kyiv)
Vedomosti (Moscow)

Web sites

Ards group (www.ards-c.ru)
Assosiatsiia po prognozirovaniu balansov v elektroenergetike (www.e-apbe.ru)
Environmental Protection Agency, USA (www.epa.gov)
Gazprom (www.gazprom.ru)
Gazprom Gazoraspredelenie (www.gazpromrg.ru)
Naftogaz Ukrainy (www.naftogaz.com)
National Electricity Regulatory Commission of Ukraine (www.nerc.gov.ua)
Ukrainska Pravda (www.pravda.com.ua)
UNFCCC joint implementation projects web site, (http://ji.unfccc.int/index.html)
UNFCCC clean development mechanism web site, (http://ji.unfccc.int)

Laws, draft laws, state programmes and decrees

Kazakhstan, the government of, *Programma po razvitiiu neftegazovo sektora v Respublike Kazakhstan na 2010-2014 gg*. (Astana, October 2010)

Kazakhstan, the government of, *Zakon "o gaze i gazoshabzhenii": proekt* (Astana, 2010)

Ministry of Economic Development of the Russian Federation, *Prognoz sotsial'no-ekonomicheskogo razvitiia RF* (Moscow, September 2010)

Ministry of Energy of the Russian Federation, *Doklad ministra energetiki RF S.I. Shmatko "O proekte general'noi skhemy razvitiia gazovoi otrasli na period do 2030"* (Moscow, 12 October 2010)

Ministry of Energy of the Russian Federation, *General'naia skhema razvitiia gazovoi otrasli na period do 2030 goda: proekt* (Moscow, 2008)

Ministry of Industry and Trade of the Russian Federation, *Strategiia razvitiia metallurgicheskoi promyshlennosti Rossii na period do 2020 goda* (Moscow, 2009?)

Ministry of regional development of the Russian Federation, *Strategiia razvitiia promyshlennosti stroitel'nykh materialov na period do 2020 goda*, April 2010

Russian Federation, the government of, *Energeticheskaia strategiia Rossii na period do 2030 goda*, adopted by decree no. 1715-r of 13 November 2009

Russian Federation, the government of, *Federal'nyi zakon RF No. 261-FZ ot 23.11.2009 g. "Ob energosberezhenii i o povyshenii energeticheskoi effektivnosti"*

Russian Federation, the government of, *Federal'nyi zakon o teplosnabzhenii* no. 190-F3, 27 June 2010

Russian Federation, the government of, *General'naia skhema razmeshcheniia ob"ektov elektroenergetiki do 2020 goda*, approved by government decree no. 215-r of 22 February 2008

Russian Federation, the government of, *Gosudarstvennaia programma RF "Energosberezhenie i povyshenie energeticheskoi effektivnost' na period do 2020 goda"* (27 December 2010, no. 2446-r)

Russian Federation, the government of, Postanovlenie n. 333 "O sovershenstvovanii gosudarstvennogo regulirovaniia tsen na gaz", 28 May 2007

Russian Federation, the government of, Postanovlenie no. 1205 "O sovershenstvovanii gosudarstvennogo regulirovaniia tsen na gaz", 31 December 2010

Ukraine, the government of, *Energy Strategy of Ukraine for the Period Up to 2030* (Kyiv, 2006)

Ukraine, Cabinet of Ministers of, Resolution #1216, 4 November 2009

Books, articles, reports and presentations

Aidarbekov, S., "Problemy i perspectivy razvitiia rynka", *Ekonomika i statistika* (Astana) no. 3, 2010

Alemar Investment Group, *Elektroenergetika: investitsii v moshchnost'*, 10 March 2010
Alliance to Save Energy, *Urban Heating in Russia: experience from the transition and future directions* (Moscow, 2006)

APBE, *Funktsionirovanie i razvitie elektroenergetiki RF v 2009 godu* (Moscow, 2010)

Bashmakov, I.A., "Povyshenie energoeffektivnosti v sistemakh teplosnabzheniia. Chast' I. Problemy rossiskikh sistem teplosnabzheniia", *Energosberezheniia* no. 2, 2010

Bogdanov, Aleksandr "Kotel'nizatsiia Rossii: beda natsional'nogo masshtaba", *Energorynok*, March 2006, nos. 3 and

Bowden, Julian, “Azerbaijan: from gas importer to exporter”, in Pirani (ed.), *Russian and CIS Gas Markets*,

Charap, S., and G. Safonov, “Climate change and the role of energy efficiency”, in A. Aslund, S. Guriev and A. Kuchins (eds.), *Russia After the Global Economic Crisis*, pp. 125-150), (Peterson Institute for International Economics, Washington, 2010)

DTEK, *Annual report* (Kyiv, 2009)

Dudkin, Oleh*Analysis of policy reforms for attraction of investments into development of energy efficiency and renewable energy sources in Ukraine* (presentation, Geneva, 7-9 October 2009)

ERTA presentation, *Natural gas consumption 2010-2030: how much is actually needed?* (Moscow, 2010)

EBRD/Grantham Research Institute, *The Low Carbon Transition* (London, April 2011)
Euro Heat & Power, *District Heating and Cooling: Country by Country Survey* (Brussels, 2009)

Evrokhim presentation, “Introducing EuroChem”, 30 November 2010

Gazprom, *Godovoi otchet 2009*

Gazprom v voprosakh i otvetakh (Gazprom: Moscow, 2007)

Gazprom v voprosakh i otvetakh (Gazprom: Moscow, 2011)

Gazprom v tsifrakh 2005-2009 gg.: spravochnik (Gazprom: Moscow, 2010)

Gazprom presentation, *Gaining Momentum: Gazprom Investor Day* (February 2010)

Gazprom press conference stenogramme, “Postavki gaza na vnutrennii rynok”, 21 June 2010

Gazprom press conference stenogramme, “Gazprom na Vostoke Rossii, vykhod na rynki stran ATR”, 21 June 2011

Gustafson, Thane, *Crisis amid plenty : the politics of Soviet energy under Brezhnev and Gorbachev* (Oxford : Princeton University Press, 1989)

Henderson, James, *Non-Gazprom Gas Producers in Russia* (London, Oxford University Press, 2011)

Honore, Anouk, *European Natural Gas Demand, Supply and Pricing* (London, Oxford University Press, 2010)

Institute for Economic Research and Policy Consulting/ German Advisory Group on Economic Reform, *Household gas prices in Ukraine: how to combine economic and social requirements* (Kyiv, December 2006)

Intergovernmental Panel on Climate Change, *Fourth Assessment Report*, Working Group

International Energy Agency, *Ukraine Energy Policy Review* (OECD/IEA, Paris, 2006)

International Energy Agency, *Optimising Russian Natural Gas: Reform and Climate Policy* (OECD/0IEA, Paris, 2006)

International Energy Agency, *Energy Efficiency Indicators for Public Electricity Production from Fossil Fuels* (OECD/IEA, Paris, 2008)

International Energy Agency, *World Energy Outlook 2010* (OECD/IEA, Paris, 2010)

International Energy Agency, *Special Report: Are We Entering a Golden Age of Gas?* (OECD/IEA, Paris, June 2011)

International Energy Agency, *CHP/DH Country Profile: Russia* (OECD/IEA, Paris, 2009)

Kharchuk, Ivan, *New Gas Prices: Second Wind for Industry* (Alfa Bank report, 3 January 2006)

Kozhukhovskii, I.S., Presentation on the correction of the *General Scheme* (Moscow, APBE, 23 November 2010)

Kudrydyk, Oleksandr, *Ukrainian Legislation on Green Tariff* (presentation), March 2011.
Makarov, A.A., et al, "Prospects of the Development of Electricity Generation Capacities in Russia", *Thermal Engineering* 55:2 (2008), pp. 98-111

Martusevich, Roman, *Regional disparities in the utility sector services in Russia: does the reform of local self-governance help reduce them?* (London, PSI Research Unit, June 2008).
Ministry of economic development and trade of the Russian Federation, *Iskhodnye usloviia dlia formirovaniia variantov razvitiia ekonomiki na period do 2013 goda (prilozhenie)*, April 2011

Ministry of energy of the Russian Federation/APBE, *Stsenarnye usloviia razvitiia elektroenergetiki na period do 2030 goda* (Moscow, 2010)

Mitrova, Tatiana, "Natural Gas in Transition", in Pirani (ed.), *Russian and CIS Gas Markets*, pp. 13-53

Overland, Indra, and Hilde Kutschera, "Pricing Pain: Social Discontent and Political Willpower in Russia's Gas Sector", *Europe-Asia Studies* (2011) 63:2, pp. 311-331

Park, Hi-chun, "Towards Cost-Reflective Energy Pricing in Ukraine", *IAEE Energy Forum*, 1st quarter 2011, pp. 15-18

Pirani, Simon (ed.), *Russian and CIS Gas Markets and Their Impact on Europe* (London, Oxford University Press, 2009)

Pirani, Simon, *The Impact of the Economic Crisis on Russian and CIS Gas Markets* (Oxford: OIES, December 2009)

Pirani, Simon, Jonathan Stern and Katja Yafimava, *The Russo-Ukrainian Gas Dispute of January 2009: a comprehensive assessment* (OIES, 2009)

Rogers, Howard, and Jonathan Stern, *The Transition to Hub-Based Gas Pricing in Continental Europe* (Oxford, OIES, March 2011)

Russian Association of Fertiliser Producers, presentation, “O situatsii na rossiiskom rynke mineral’nykh udobrenii”

Russian Federation, the government of, Stenogramme of the meeting chaired by prime minister Putin on the General Scheme for the Development of the Gas Industry, 11 October 2010

Salavatnefteorgsintez annual reports 2007, 2008 and 2009

Shmatko, Sergei, “O korrektirovke general’noi skhemy razmeshcheniia ob’ektov elektroenergetiki do 2020 goda” (Moscow, Ministry of energy, June 2010)

Sibur company presentation

Sibur Mineral Fertilisers annual report 2009

Stern, Jonathan, *The Future of Russian Gas and Gazprom* (London, Oxford University Press, 2005)

Stern, Jonathan, *The Russian-Ukrainian Gas Crisis of January 2006* (OIES, 2006)

Stern, Jonathan, *Future Gas Production in Russia: is concern about lack of investment justified?* (OIES, Oxford, 2009)

Tokmazishvili, Micheil, “Georgia’s Gas Sector”, in Pirani (ed.), *Russian and CIS Gas Markets*

“Turkmenistan”, in Pirani (ed.), *Russian and CIS Gas Markets*

Ukraine, the government of, *Memorandum of Economic and Financial Policies*, August 2010, and letter to Dominique Strauss-Kahn (managing director, IMF), 10 December 2010

UNDP, *The Outlook for Development of Renewable Energy in Uzbekistan* (Tashkent, 2007)

UNDP Russia, *National Human Development Report in the Russian Federation 2009: Energy Sector and Sustainable Development* (Moscow 2010)

UNICEF, *The State of the World’s Children 2008* (UNICEF: Geneva, 2008)

USAID press release, *Ukraine’s National Heating Strategy Moves Forward*, November 2009

Vainzikher, B.F. (ed.), *Elektroenergetika Rossii 2030: tselevoe videnie* (Moscow, Alpina Business Books, 2008)

Wood Mackenzie, *Finding Equilibrium* (Edinburgh, 2009)

World Bank, *Energy Efficiency in Russia: Untapped Reserves* (Washington, 2008)

World Bank, *Lights Out? The Outlook for Energy in Eastern Europe and the FSU* (Washington, 2010)

World Bank, *Subsidies in the Energy Sector: An Overview* (Washington, July 2010)

Worrell, Ernst, and Christina Galitsky, *Energy Efficiency Improvement and Cost Saving Opportunities for Cement Making* (Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, California: March 2008)

Yafimava, Katja, *The 2007 Russia-Belarus Gas Agreement* (Oxford, OIES, 2007)

Yafimava, Katja, *The June 2010 Russian-Belarusian Gas Transit Dispute: a surprise that was to be expected* (Oxford, OIES, July 2010)

Yenikeyeff, Shamil, "Kazakhstan's Gas Sector", in Pirani (ed.), *Russian and CIS Gas Markets*, op. cit

Zeigarnik, Y.A., "Some problems with the development of combined generation of electricity and heat in Russia", *Energy* 31 (2006), pp. 2387-2394

Zhukov, Stanislav, "Uzbekistan", in Pirani (ed.), *Russian and CIS Gas Markets*