THE ENERGY RESEARCH INSTITUTE
OF THE RUSSIAN ACADEMY OF SCIENCES

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OF THE RUSSIAN FEDERATION

GLOBAL AND RUSSIAN ENERGY OUTLOOK TO 2040

АНАЛИТИЧЕСКИЙ ЦЕНТР
ПРИ ПРАВИТЕЛЬСТВЕ
РОССИЙСКОЙ ФЕДЕРАЦИИ

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INTRODUCTION

INTRODUCTION

• In the year since the publication of the last forecast we have seen particular changes in the global economy which, together with developments in the fields of energy, and politics, could, in the long term, profoundly influence the development of global energy markets.

• Slightly improved figures for the global economy, together with an increased UN forecast for population figures and higher energy intensity, have resulted in a forecast of increased global energy consumption.

• The political process, which in the long term will create the conditions for Iran's large-scale emergence on global oil and gas markets, has begun; together with the continued growth in shale oil production, this make for ever-increasing expectations of a supply surplus and a fall in oil prices. Last year we examined the Shale Breakthrough Scenario in detail, and the realistic growth of shale oil and gas production is covered in the Baseline Scenario, but we regard greater growth as unlikely. In this forecast we examine the New Producers Scenario in detail, assess the prospects for the emergence of new players in the oil and gas markets (above all Iran), and consider the consequences of surplus supply for the markets. Analysis of the fundamental factors showed that even in the most optimistic scenario concerning increased production, oil prices will fall by no more than $9 per barrel, while at the same time cheaper suppliers will win a share of the market at the expense of the USA and Russia. The emergence of new gas suppliers could reduce prices on the European and Asian markets by $50–60 per thousand cubic metres and also replace significant volumes of Russian (70 bcm) and potential American exports (45 bcm).

• Tensions between the EU and Russia will unavoidably influence their interaction in the energy sphere. We do not regard the introduction of large-scale sanctions as a realistic scenario, but changes in the EU's energy policies will lead, nonetheless, to significant shifts in the European energy balance, and therefore to changes in the directions of hydrocarbon supplies.

• Analysis of the key drivers in the development of global energy has brought to light yet another new factor that could seriously change the conjuncture of global markets. There are good grounds for predicting that 'peak coal' will be reached in China and India in the next ten years, in which case the two largest and most dynamically developing Asian economies will need significant volumes of additional energy supplies, above all natural gas and coal. In addition to this, it will be difficult for China to continue to function as the 'Workshop of the World' given such limitations, and a great deal of industrial production will move to the other developing countries of Asia and Africa, as well as to the USA and Russia, stimulating their growth and additional energy exports. In the Other Asia Scenario we assess the influence of these conditions on the directions and volumes of international trade in energy.

• All these processes will unavoidably have an impact on Russia. On the one hand, additional risks will arise and, on the whole, the likelihood of negative scenarios arising has noticeably increased. On the other hand, new opportunities will appear, such as, for example the Other Asia Scenario.

• We see our task as being one of conducting regular analysis of the changes in external conditions and of the Russian energy sector's reaction to them. This is particularly important in the preparation of the new version of the Russian Federation's Energy Strategy to 2035, in which all the authors of this forecast are involved.

Section 1
Baseline Scenario

SECTION 1. BASELINE SCENARIO

The Baseline Scenario's assumptions on GDP and population have changed significantly, and the forecast methodology has been refined, resulting in adjustments to last year's forecast.

In this section we revise the 2013 Global and Russian Energy Outlook[1] (Outlook 2013) taking into account changes that have taken place. In the preparation of Outlook 2014 the methodology employed for the previous version[2] has been refined; in particular the sections dealing with oil and coal are expanded and given in more detail, with countries' forecast energy consumption examined using the emergent trend of reduced GDP energy intensity for different countries, with changes in the distribution of income among the population being taken into account.

Assumptions in the Baseline Scenario

The main assumptions in Outlook 2014 (Table 1.1) are very similar to last year's.

Table 1.1 – Basic assumptions in the Baseline Scenario

Topic	Assumptions
Technologies	Only those technologies that are already in use at the present time, or those that have been approved, have been considered. The gradually increasing competitiveness of new technologies and the continuation of the existing trend for reduction of GDP energy intensity are assumed.
Energy Policy	The continuation of existing priorities in countries' energy policies and the gradual introduction of plans and programmes that had already been announced at the end of 2013 are assumed. Additional assumptions have been introduced concerning measures adopted by energy-importing countries to increase energy security.
Demographics	The worlds' population is growing at an average annual rate of 0.9% and will increase by almost 2 billion to over 9 billion by 2040.
GDP	Global GDP will grow at an average annual rate of 3.5%; by 2040 it will have increased by 2.8 times compared to the level in 2010.

Source: ERI RAS

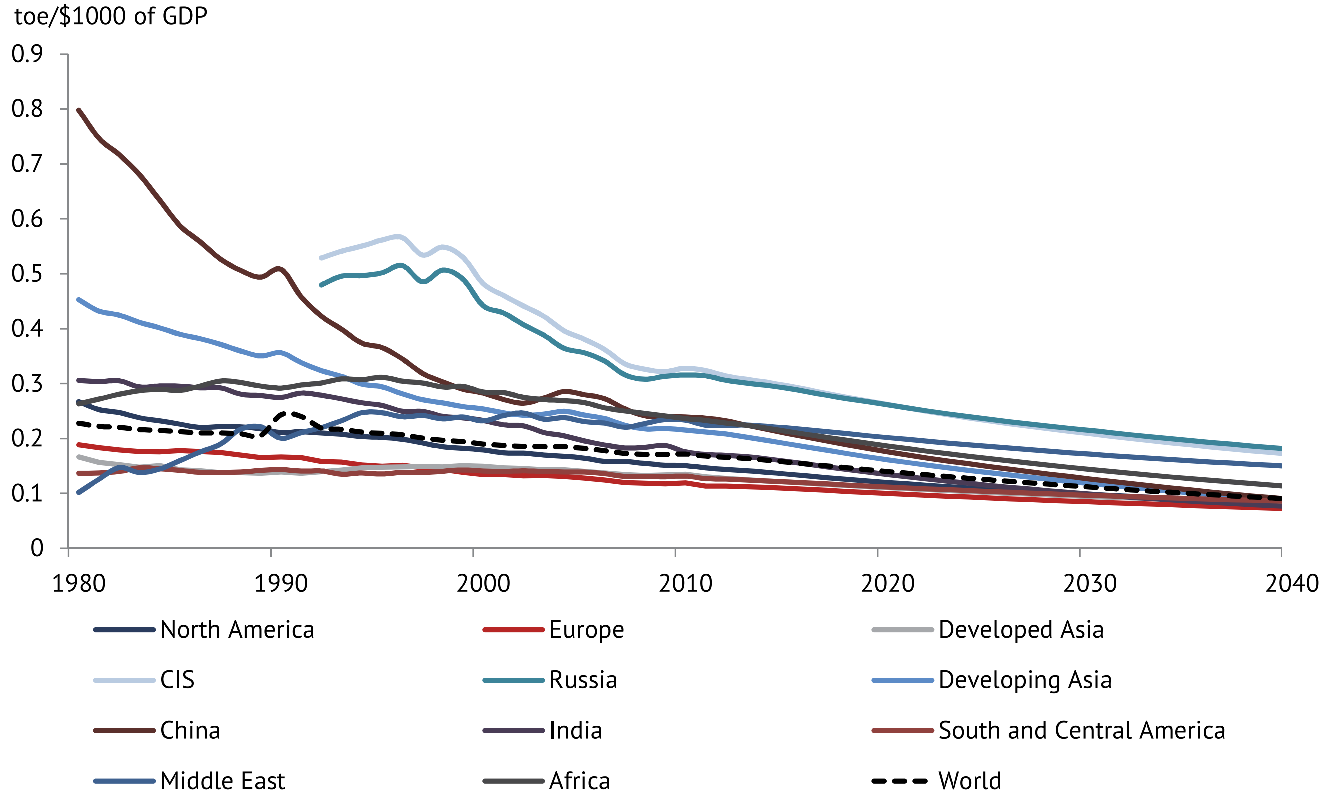
The established natural course of scientific and technical progress provides for the introduction of new technologies as they gradually become less expensive, and also maintains the established downward trend in the GDP energy intensity of both countries and regions, with a tendency for them to converge by the end of the forecast period (Figure 1.1). The absence of any significant technological revolutions or breakthroughs has been assumed. The global economy's energy intensity for the period 1972 through 2012 decreased by 32 per cent, and a further reduction of 44 per cent is predicted for the period 2014–40. Moreover, in Outlook 2014 energy intensity is predicted by country and not by groups of countries, as was the case in previous research, which has allowed us to establish its significance more accurately. In particular, when compared with the previous forecast, GDP energy intensity has increased in South and Central America (+20 per cent by 2040), in the developing Asian countries, apart from China and India, (+16 per

1 Global and Russian Energy Outlook up to 2040, under the direction of A. A. Makarov and L. M. Grigoriev, ERI RAS, Moscow, 2013.

2 Global and Russian Energy Outlook up to 2040, under the direction of A. A. Makarov and L. M. Grigoriev, ERI RAS, Moscow, 2013. p. 96.

cent), and in Africa (+11 per cent). It has declined slightly in North America (−2.2 per cent), the developed Asian countries (−2.4 per cent, although only as a result of Japan, where it is −17 per cent), and also China (−5.9 per cent) and India (−5.1 per cent). On the whole, global GDP energy intensity in Outlook 2013 and Outlook 2014 are practically the same, coming to 0.09 toe/$1,000 in 2040.

Figure 1.1 – Dynamic of GDP energy intensity by region (1980–2040)



Source: ERI RAS

Last year's assumptions concerning the energy policy priorities of the major players, and the measures already taken to realize them, have been retained in the Baseline Scenario. Only the more active measures for diversifying the energy mix and increasing energy security for importing countries have been added, particularly in Europe.

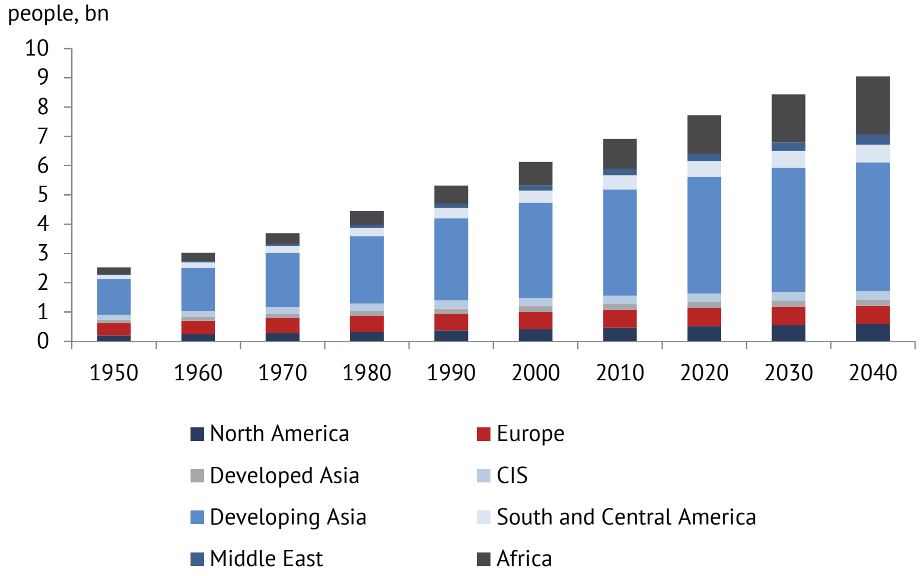
Demography

By 2040 the world's population will grow by almost 2 billion, with an increase of almost 1 billion in Africa.

Assumptions regarding the dynamics of the world's population have been refined in Outlook 2014, in accordance with the UN's[3] latest estimates. At 1 June 2013 the world's population was 7.16 billion; this will, according to the Baseline Scenario, increase in the next 26 years by more than a quarter to more than 9 billion (Figure 1.2).

3 'World Population Prospects 2012 Revision',. United Nations, Population Division of the Department of economic and social affairs, June 2013.

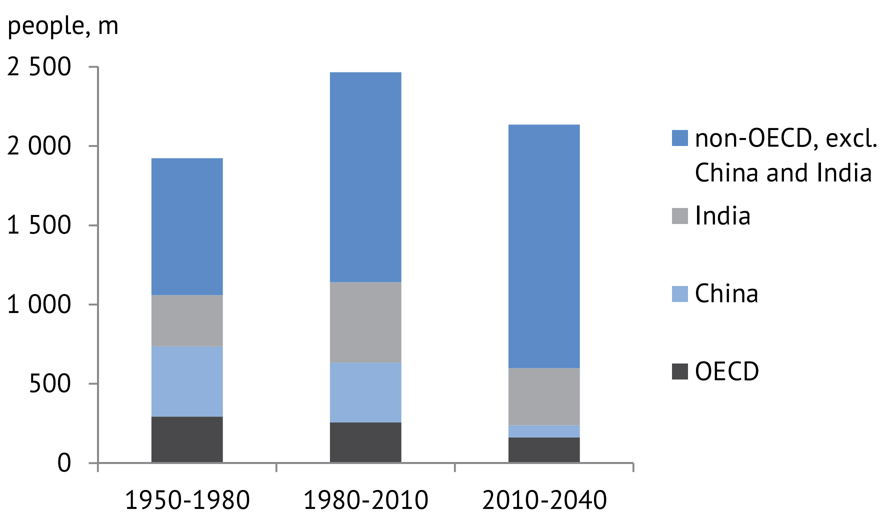
Figure 1.2 – World population by region 1950–2040



Sources: ERI RAS, UN 2013

During this period there will be a demographic transition from high to low birth and death rates in all regions of the world. This has already occurred in developed countries, resulting in a noticeable slowdown in population growth (Figure 1.3), which largely explains the expected slowdown in growth of energy consumption. Nevertheless, in order to provide energy to nearly 2 billion more people than today, the world's energy system will need to go through a series of major transformations.

Figure 1.3 – World population growth (1950–2040)

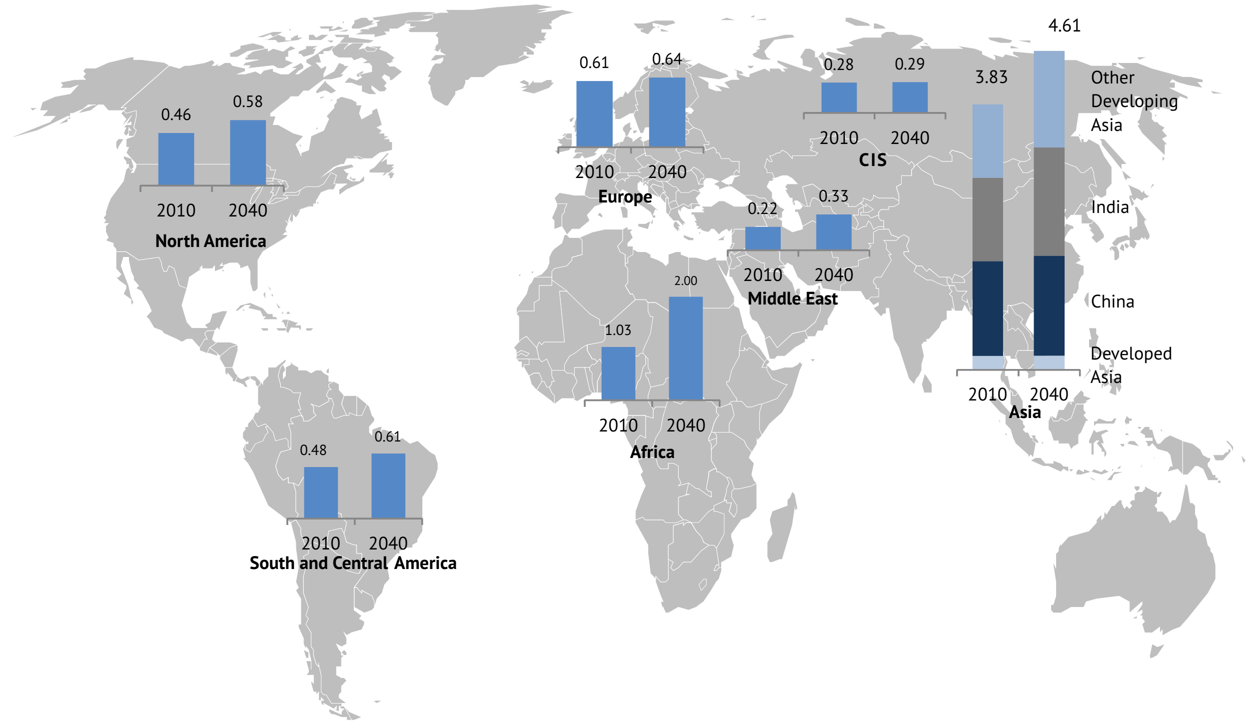


Source: UN 2013

By 2030 the most populous country in the world will be India, with over half a billion people. However, nearly half (in excess of 900 million) of the world's absolute increase in population over the period 2010 to 2040 will be in Africa, which will become the most important regional driver of energy demand. Apart from Africa, the highest population growth is expected in the Middle East (over 50 per cent) and the developing countries of Asia[4] (over 20 per cent) (Figure 1.4).

4 Except China, where the population will hardly change due to the 'one family one child' policy.

Figure 1.4 – World population in 2010 and 2040, billions



Sources: ERI RAS, UN 2013

In the developed countries and China, populations will remain practically the same.

In OECD countries and, especially importantly, in China (due to the ongoing policy of restricting childbirth) population growth will virtually come to a standstill (among OECD countries a noticeable increase, 25 per cent, is only expected in North America).

Table 1.2 – World population dynamics by region

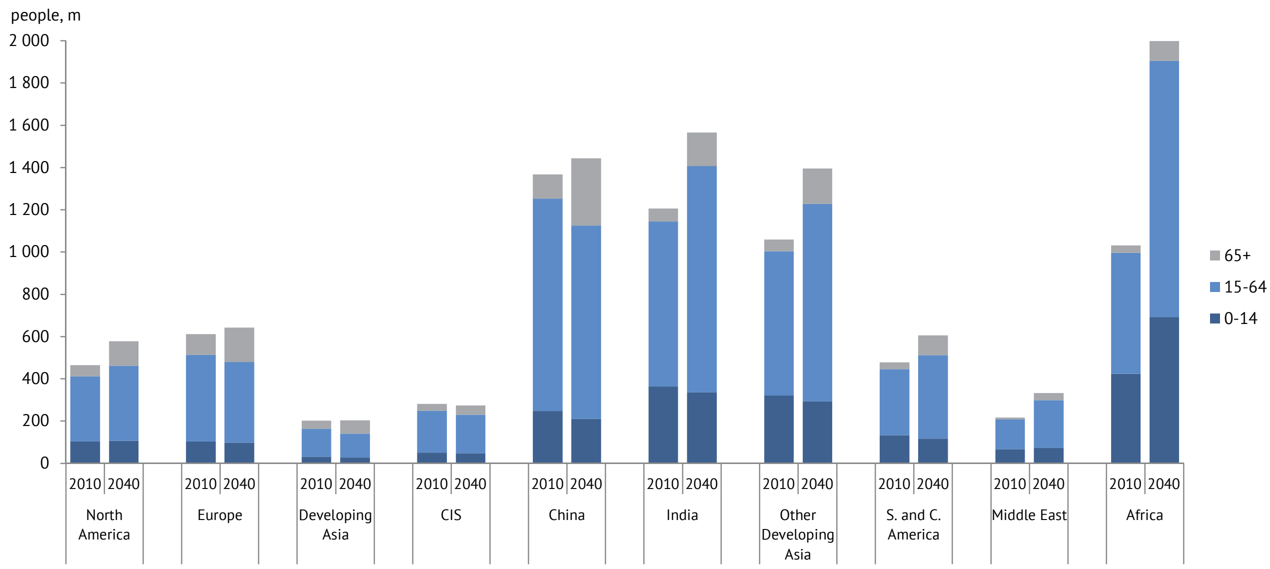
	Population, millions[5]		Average annual population growth, %	Level of urbanization, %		Employable population, %	
	2010	2040	2010–40	2010	2040	2010	2040
North America	**464**	**578**	**0.7**	**81**	**87**	**66**	**62**
USA	312	383	0.7	82	88	67	60
Europe	**611**	**643**	**0.2**	**73**	**81**	**67**	**59**
EU-28	506	516	0.1	74	81	67	58
Developed Asia	**203**	**203**	**0.0**	**88**	**94**	**66**	**56**
Japan	127	115	–0.4	91	97	64	53
CIS	**280**	**286**	**0.1**	**64**	**70**	**70**	**67**
Russia[5]	143	139	–0.1	74	80	72	66
Developing Asia	**3632**	**4404**	**0.6**	**40**	**57**	**68**	**66**
China	1367	1444	0.2	50	74	74	63
India	1206	1566	0.9	31	46	65	68
South and Central America	**478**	**605**	**0.8**	**79**	**85**	**65**	**65**
Brazil	195	229	0.5	84	90	68	66
Middle East	**216**	**332**	**1.4**	**68**	**74**	**65**	**68**
Africa	**1031**	**1999**	**2.2**	**39**	**53**	**55**	**61**
World	**6915**	**9051**	**0.9**	**52**	**64**	**66**	**64**

Sources: UN 2013, Rosstat

5 Population figures for Russia have been taken from the Forecast for Social and Economic Development in the Russian Federation to 2030, March 25, 2013. http://www.economy.gov.ru/wps/wcm/connect/economylib4/mer/activity/sections/macro/prognoz/doc20130325_06

The most important demographic factor affecting economic growth rates and energy consumption levels is the proportion of the population that is aged 15 to 64 and employable. The regions losing the most workers are the developed Asian countries (–16 per cent), Europe (–7 per cent), the EC (–11 per cent), and the CIS (–3.5 per cent) (Figure 1.5). The highest growth rates for the employable population of countries/regions by 2040 are expected to be in Africa (112 per cent), India (37 per cent), the Middle East (60 per cent), and South and Central America (26 per cent). North America, with a quite significant increase in its employable population (15 per cent), will simultaneously face a substantial increase in its elderly population. It is expected that the situation in China will stabilize, although there will be a reduction in its employable population after 2020. Together with a steady increase in the proportion of over 65s, this will have important consequences for the development of the country's economy. Russia where, by 2040, the more active part of the population will have declined by 11 per cent while the proportion of the elderly will have increased by 40 per cent compared to 2010, will face similar problems.

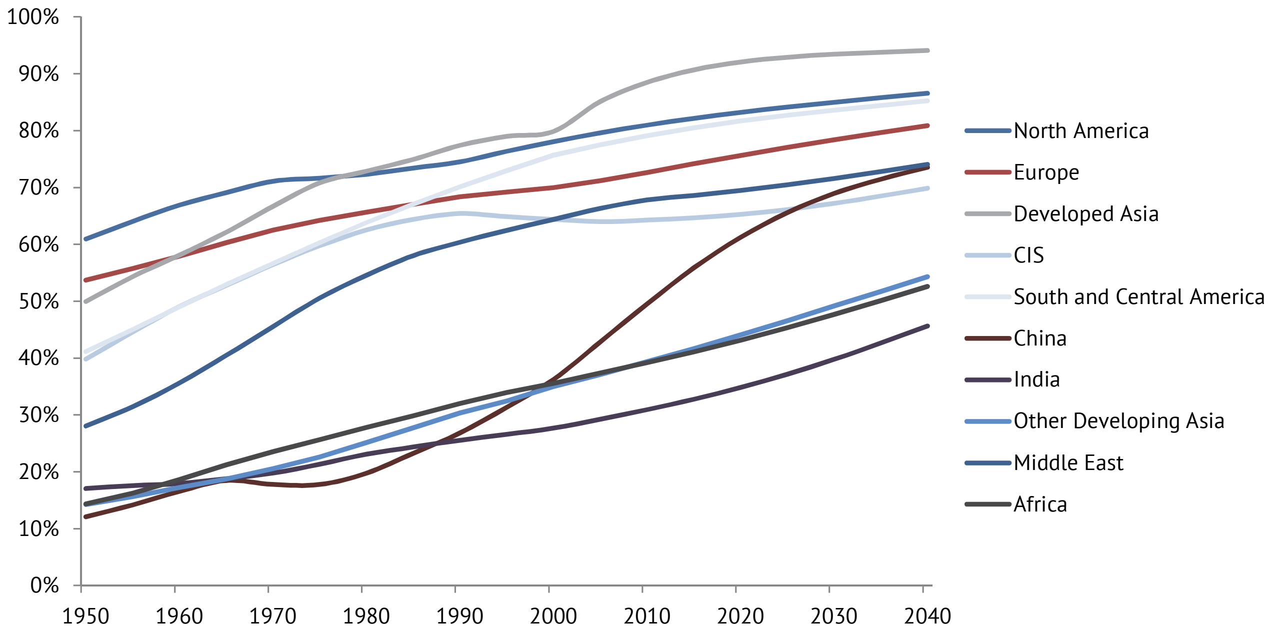
Figure 1.5 – Proportion of employable population aged 15–64 to total population by region



Sources: ERI RAS, UN 2013

With practically all population growth happening in urban areas, urbanization will play a large role in the changing character of energy consumption. On average, residents in urban areas use more energy while, unlike those in rural areas, having access to more efficient centralized forms of energy production. By 2040 the average global proportion of town-dwellers will exceed 60 per cent (compared to 52 per cent in 2010, see Figure 1.6). The highest rates of growth in urban population by 2040 will be in the developing Asian countries (+17 per cent), among whom the leaders are China (+24 per cent) and India (+15 per cent). The developed countries have practically exhausted their potential for urbanization, and for these countries the urbanization factor will lose its significance in relation to growth in energy consumption.

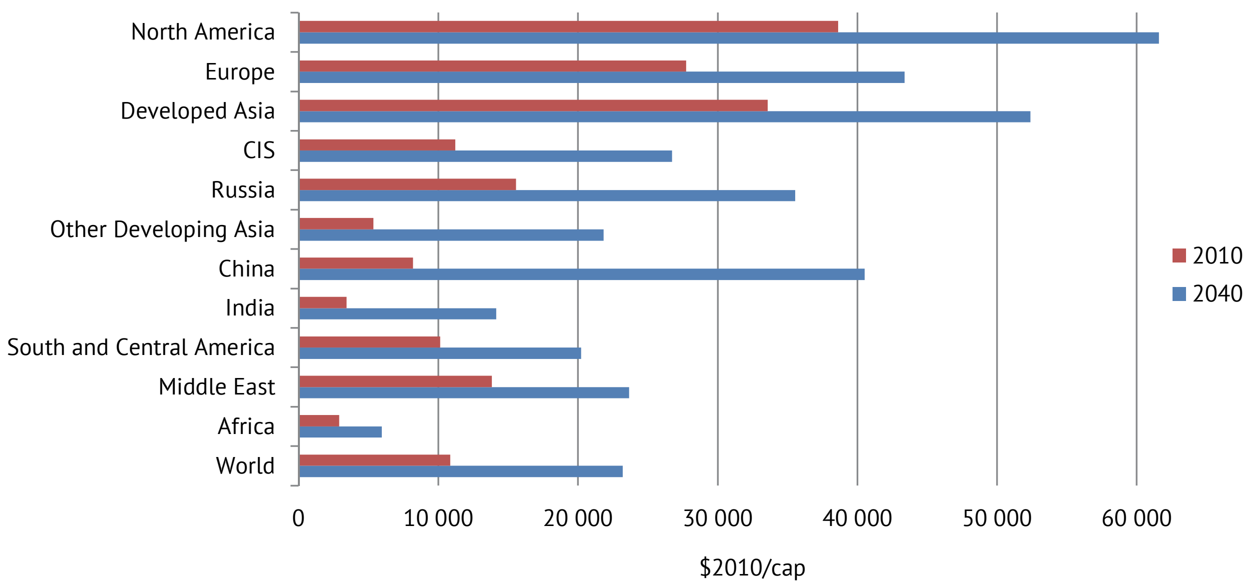
Figure 1.6 – Proportion of urban population by region (1950–2040)



Sources: ERI RAS, UN 2013

Energy consumption is also closely linked to personal income, with demand for energy-intensive products (cars, air conditioning etc.) inevitably increasing as incomes rise. On average, global per capita GDP will grow by 2.6 per cent a year from $10,900 in 2010 to $23,200 in 2040, though regional differences are very important (Figure 1.7), as is the distribution of income.

Figure 1.7 – Per capita GDP (PPP) by region (2010 and 2040)



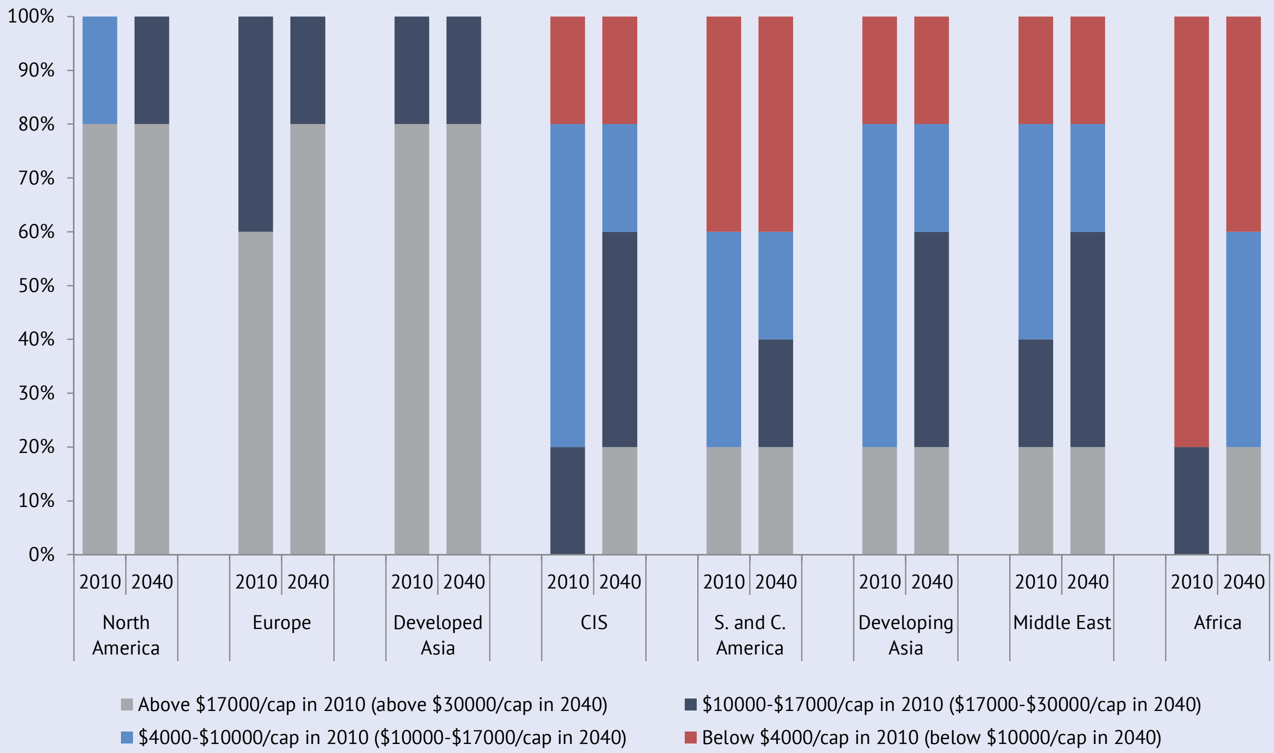
Sources: ERI RAS, ACRF, UN

Income distribution

In order to refine the forecast for energy consumption in Outlook 2014, domestic social structure based on statistics for 560 quintiles[6] in 112 countries in 2010 was taken into account, in addition to technological factors and increasing per capita GDP. The econometric equalization of these countries' energy intensity was linked to per capita GDP figures and the number of 'wealthy' (over $17,000 per capita) and 'poor' (less than $4,000) quintiles in the country. We also used a new approach[7]: having recalculated income per quintile (for the 112 countries) in GDP figures by PPP (purchasing power parity), we were able to link the growth in energy consumption of the more affluent sections of society with the overall energy intensity in 2010 and the forecast for 2040. The latter was built on the assumption of rigidity in the social structure (based on research[8] that showed minimal changes in most countries between 1992 and 2010).

Figure 1.8 shows in which groups (identified by per capita GDP) the regional population quintiles will fall in 2040, based on the economic growth figures adopted in this forecast. Worldwide, in the period from 2010 to 2040, poverty (up to $4,000 per person) has declined to a significant extent; the category of up to $10,000 has therefore been used as the lowest for well-being in the developing world (both red for both years). For developed countries the category of over $17,000 has mainly been replaced by the category of over $30,000 (both red for both years). Analysis has shown that social factors are statistically significant and that they influence the predominant direction of growth in energy consumption.

Figure 1.8 – Per capita GDP (PPP) by quintile by region



Source: ACRF

6 A quintile is one fifth of the population. Quintile coefficients are used to measure income inequality. The entire population is divided into 5 groups of 20% according to income levels.

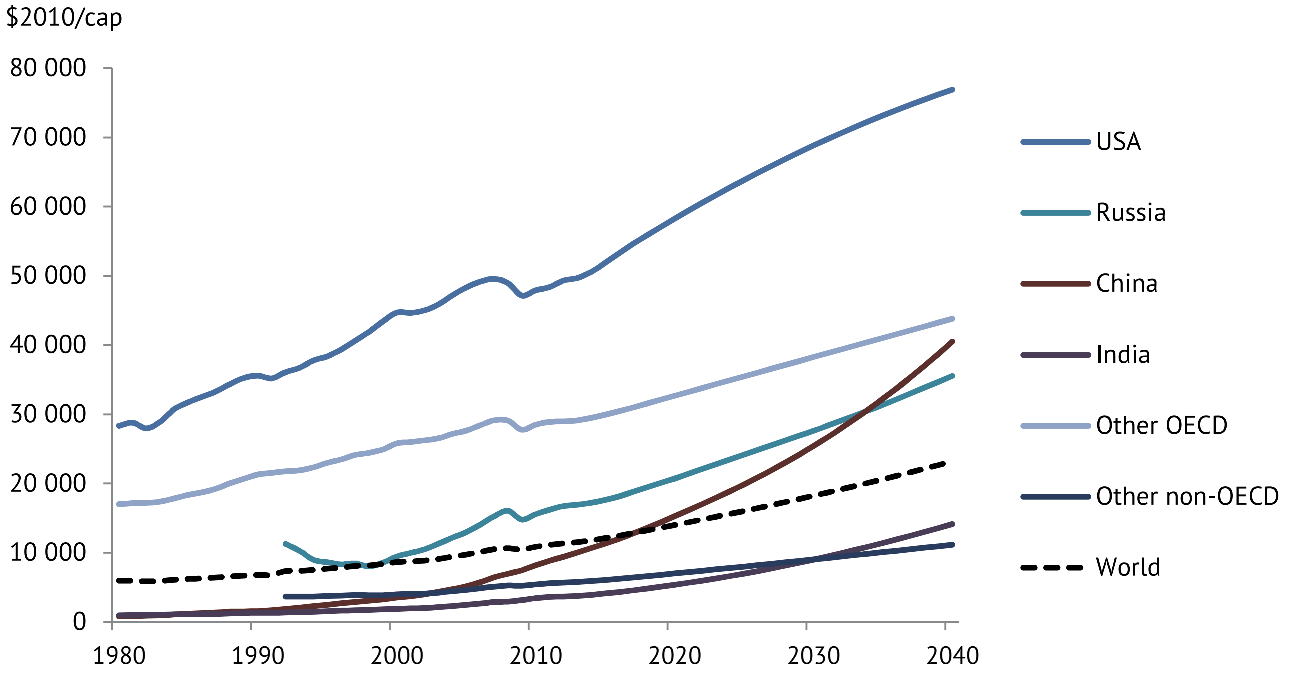
7 L. M. Grigoriev, A. A. Salmina – The Structure of Social Inequality in the Modern World:. Sociological Journal. 2013. № 3. P. 5-21.

8 L.Grigoriev, V.Kulpina, Economic Transformation and Social Inequality in Eurasian Countries.12 EBESC conference, Singapore, Jan. 2014.

Global economy

In Outlook 2014 we have revised the estimated rates of economic growth. We based the figure for the period to 2018 as a whole on the latest IMF forecast[9], which proved to be more optimistic than last year's: a GDP growth rate of 3.5 per cent is projected for 2014, with a gradual acceleration to 4.1 per cent by 2018. There is an upwardly revised forecast for the USA while for a number of countries – India, Brazil, Russia, and the EU – the forecast has been reduced. For the subsequent period (2018 to 2040) the forecast for global economic growth was calculated using the methodology described in Outlook 2013[10], which was based on the forecast population size and expected changes in per capita GDP (in contrast to other indicators, this method shows low volatility and good predictability – see Figure 1.9).

Figure 1.9 – Dynamic of per capita GDP (PPP) by region, Baseline Scenario (1980–2040)



Sources: ERI RAS, ACRF

For the world as a whole this has been another positive year, although growth has been too slow to begin to resolve the social and economic problems (especially budgetary and fiscal) that have accumulated during the past six years. In this regard, any growth in the early years of a period has a significant impact on long-term forecasts. Finally, in the assessment of long-term growth and the analysis of energy markets in the future, the probable economic recessions not only in developed, but also in developing countries, caused by the so-called 'trap of the average level of development', were taken into account.

The global economy has not yet recovered from the effects of the crisis which started in 2008 – the recovery is still not of a sustainable nature.

9 World Economic Outlook, IMF, October 2013. This Outlook was slightly corrected taking intoot account regional data available.

10 The methodology for forecasting GDP is described in detail in Global and Russian Energy Outlook up to 2040, under the direction of A. A. Makarov and L. M. Grigoriev, Moscow 2013, pp. 10–14.

Moreover, in the period to 2040, no basis for the maintenance, let alone acceleration, of the global GDP growth rate can be seen – especially when compared with the unique period in human history of sustainable growth between 1990 and 2010 (Figure 1.10). Not only is increased military and political instability standing in the way, but also such fundamental factors as: reduced intensity of basic production, slowing population growth, increased water supply problems, rising prices of basic natural resources, and the passing of the active phase of economic growth and industrialization in the developing countries of Asia (primarily in China). Even successes in scientific and technical progress and labour productivity are unable to fully offset these negative factors. Overall, it is predicted that in the period to 2040, global GDP will grow on average by 3.5 per cent, which should result in more than a doubling in size of the global economy, which will create serious challenges for its energy supply.

In Outlook 2014, new factors reducing the growth rate in certain large countries, particularly in the BRICS and various other developed countries, have been taken into account. We have considered the relatively new trend towards lower rates of growth in world trade, in comparison with growth of production, as well as the delay in resumption of sustainable growth in the Eurozone countries and, to some degree, in the CIS. The EU cannot as yet overcome the effects of severe crisis, the excess burden of social spending, and the sovereign debt crisis in some countries.

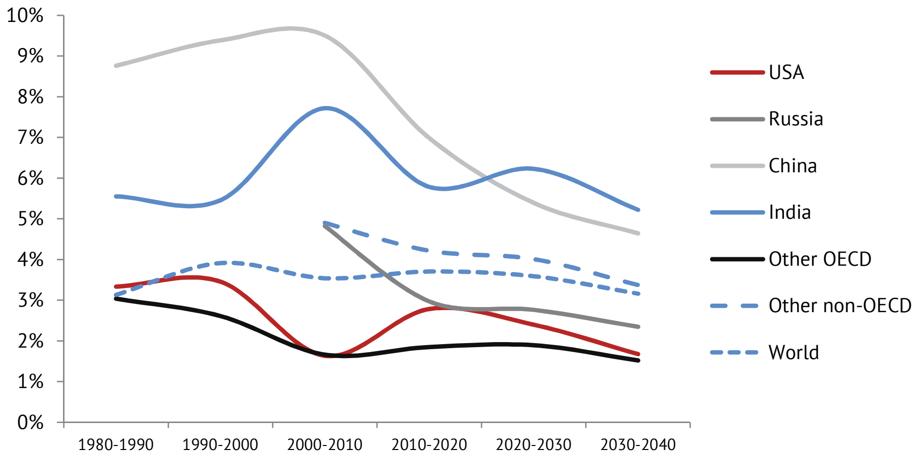
Against this backdrop, the USA's position looks somewhat more favourable, although it also is experiencing serious budgetary problems. It is assumed that the USA will also retain some advantage in growth in the future, in comparison with other developed countries (Japan and the EU); this is of fundamental importance for energy consumption.

The developing countries, even without China, will retain a great advantage in growth, gradually overcoming the difficulties of industrialization and entering the post-industrial phase. China, which has previously stood out from the rest of the world so distinctly, will find itself on a trajectory comparable to the other non-OECD countries that are still considered to be developing (Figure 1.11).

India will have some difficulties in establishing infrastructure for development, particularly in the energy sector. In Brazil, the slowing down of growth is due to the exhaustion of the consumer boom which was based on credit granted to the new middle class – the country now being faced with high exchange rates, import growth, and inadequate growth in investment.

The very restrained dynamic of Russia's GDP in Forecast 2014's Baseline Scenario is close to the Risk Analysis Scenario in the Russian Federation's Energy Strategy to 2035, with some adjustments (for more detail see Section 3).

Figure 1.10 – Average annual GDP growth rates for regions and the world's largest countries, Baseline Scenario



Sources: ERI RAS, ACRF

Table 1.3 illustrates forecast GDP dynamics.

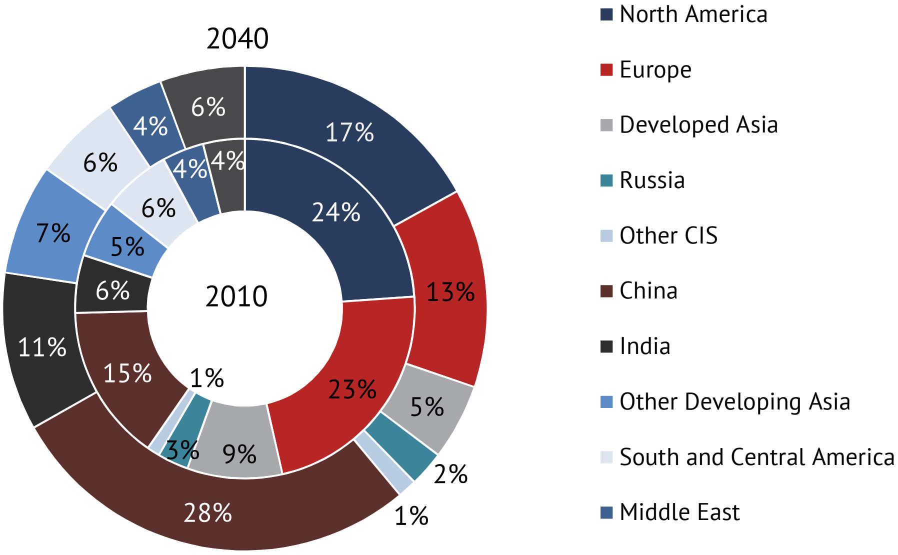
Table 1.3 – GDP dynamic for regions and the world's largest countries, Baseline Scenario

	GDP (PPP) trillion dollars. 2010							GDP growth rate, %		
	2010	2015	2020	2025	2030	2035	2040	2010–20	2010–30	2010–40
North America	**17.9**	**20.2**	**23.6**	**26.9**	**30.0**	**32.9**	**35.6**	**2.8**	**2.6**	**2.3**
USA	15.0	16.9	19.7	22.4	25.0	27.3	29.5	2.8	2.6	2.3
Europe	**16.9**	**17.9**	**19.8**	**21.8**	**23.8**	**25.8**	**27.9**	**1.6**	**1.7**	**1.7**
EU-28	15.2	15.9	17.4	18.9	20.5	22.0	23.6	1.3	1.5	1.5
Developed Asia	**6.8**	**7.5**	**8.2**	**9.0**	**9.6**	**10.2**	**10.7**	**1.9**	**1.8**	**1.5**
Japan	4.4	4.6	4.9	5.1	5.3	5.5	5.6	1.1	1.0	0.9
CIS	**3.1**	**3.6**	**4.3**	**5.1**	**5.9**	**6.7**	**7.6**	**3.3**	**3.2**	**3.0**
Russia	2.2	2.5	3.0	3.5	3.9	4.4	4.9	3.0	2.9	2.7
Developing Asia	**19.5**	**26.5**	**36.1**	**47.6**	**61.3**	**77.5**	**96.1**	**6.4**	**5.9**	**5.5**
China	11.2	15.9	22.0	28.9	37.2	47.0	58.5	7.0	6.2	5.7
India	4.1	5.3	7.3	9.9	13.3	17.4	22.1	5.8	6.0	5.7
South and Central America	**4.8**	**5.7**	**6.9**	**8.1**	**9.4**	**10.8**	**12.2**	**3.5**	**3.4**	**3.1**
Brazil	2.2	2.4	2.9	3.4	3.9	4.5	5.0	2.9	3.0	2.9
Middle East	**3.0**	**3.5**	**4.2**	**5.1**	**5.9**	**6.9**	**7.9**	**3.6**	**3.5**	**3.3**
Africa	**3.0**	**3.7**	**4.8**	**6.1**	**7.7**	**9.6**	**11.9**	**4.8**	**4.8**	**4.7**
World	**75.1**	**88.7**	**108.0**	**129.7**	**153.7**	**180.5**	**209.9**	**3.7**	**3.6**	**3.5**
OECD	41.5	45.4	51.5	57.5	63.4	68.9	74.1	2.2	2.1	2.0
Non-OECD	33.6	43.3	56.5	72.1	90.4	111.6	135.7	5.3	5.1	4.8
OPEC	3.7	4.5	5.5	6.8	8.2	9.7	11.5	4.1	4.0	3.8
BRICS	20.2	26.8	35.8	46.5	59.3	74.5	92.0	5.9	5.5	5.2

Sources: ERI RAS, ACRF

It is expected that there will be major structural shifts in the global economy. For example, by 2017 non-OECD countries should overtake OECD countries in total GDP. By as early as 2017 China will have the world's largest economy (and by 2040 will provide about a quarter of global GDP), while the USA and the rest of the OECD countries will have a reduced share in the world economy (Figure 1.11 and Table 1.4). The main growth will be concentrated in the developing countries of Asia, with India showing the highest growth rate (reaching 11 per cent of world GDP by 2040). This area represents a large part of the world's population and it will continue to grow while problems of poverty and social inequality will endure, as will the complexities of the transition to new (and expensive) efficient technologies.

Figure 1.11 – Structure of global GDP (PPP), Baseline Scenario



Sources: ERI RAS, ACRF

Table 1.4 – Changes in countries' shares of global GDP, Baseline Scenario

Ranking by GDP (PPP), 2010			Rating by GDP (PPP), 2040		
		Share of global GDP in 2010			Share of global GDP in 2040
1	EU-28	20%	1	China	28%
1	USA	20%	2	USA	14%
2	China	15%	2	EU-28	11%
3	Japan	6%	3	India	11%
4	India	6%	4	Japan	3%
5	Germany	4%	5	Brazil	2%
6	Russia	3%	6	Russia	2%
7	Great Britain	3%	7	Germany	2%
8	Brazil	3%	8	Great Britain	2%
9	France	3%	9	Mexico	2%
10	Italy	2%	10	France	2%

Sources: ERI RAS, ACRF

It should be noted that although the outlook for the global economy is quite restrained, it nonetheless does not radically differ from the macroeconomic forecasts of other organizations (Table 1.5).

Table 1.5 – Comparison of the latest long-term average GDP growth forecasts

	Source	Start of forecast period	End of forecast period		
			2030	2035	2040
Weight by PPP	ERI RAS-ACRF Outlook 2014	2013	3.7	3.6	3.5
	OECD (2013)	2012	3.7	3.6	3.4
	Oxford Economics (2013)	2012	3.9	3.9	-
	EIA (2013)	2010	3.8	3.7	3.6
	IEA (2013)	2011	-	3.6	-
	ERI RAS-ACRF (2013)	2010	-	3.4	3.4
	ERI RAS-REA, baseline(2012)	2010	-	3.6	-
	ERI RAS-REA, pessimistic (2012)	2010	-	3.2	-
Weight by current rate of exchange	World Bank, rapid(2013)	2012	3.1	-	-
	World Bank, inertial (2013)	2012	2.6	-	-
	Oxford Economics (2013)	2012	3.1	3.1	-
	USDA (2013)	2012	3.2	-	-
	EIA (2013)	2012	3.1	3.1	3

Source: ERI RAS, ACRF

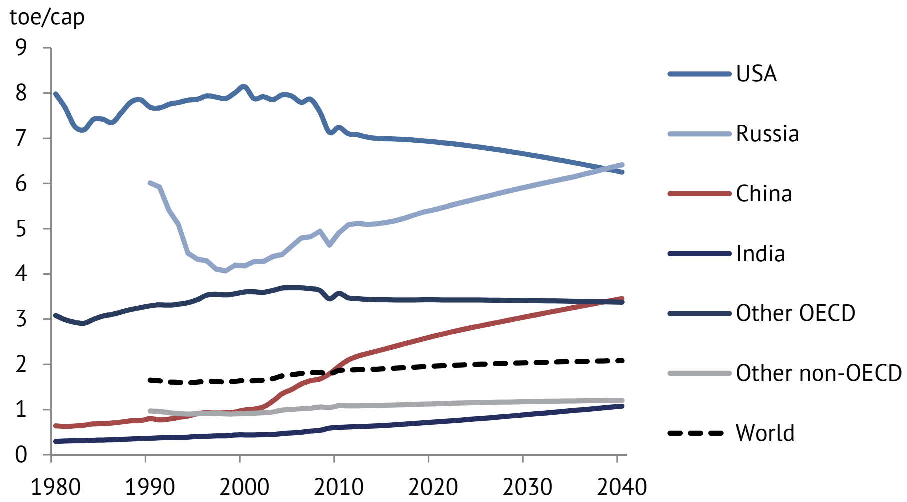
Primary Energy Consumption

As in Outlook 2013, the methodology for forecasting energy consumption is based on the coordination of the dynamics of consumption in countries. This is arrived at by:

• a demographic method (in terms of population size and per capita energy consumption). This has a varied dynamic in OECD countries, where there will be a reduction in per capita energy consumption, while China and other developing countries, on the contrary, will show an increase (Table 1.12), and

• an economic method (in per capita GDP and GDP energy intensity)[11].

Figure 1.12 – Per capita energy consumption, global and by groups of countries



Source: ERI RAS

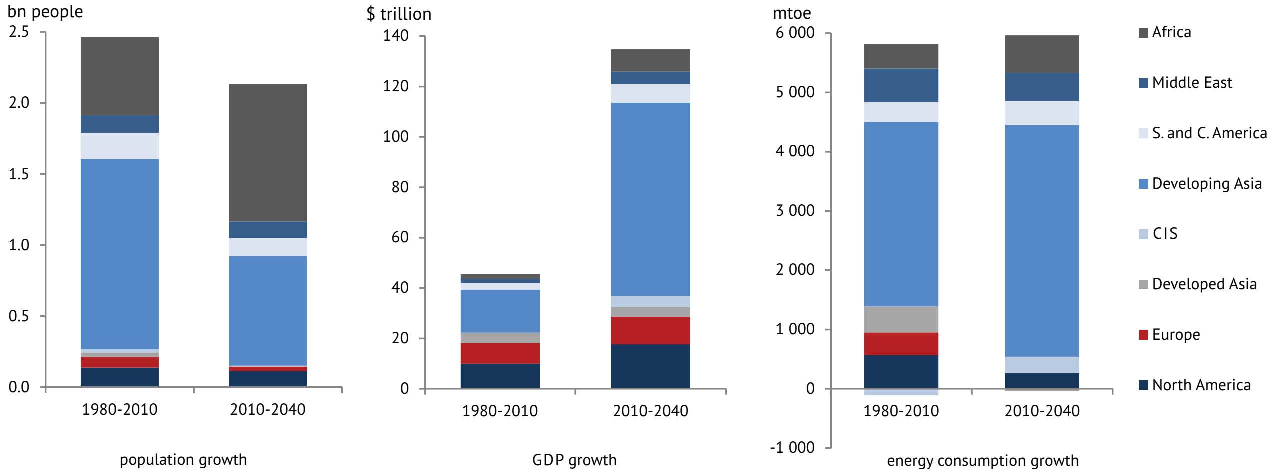
In the light of higher reported GDP and retrospective primary energy consumption figures, Outlook 2014 has revised and raised the figures for global primary energy consumption and is predicting annual growth rate of 1.3%.

The forecast of global demand for primary energy obtained in this way shows an increase in 2010–40 of 46 per cent (or an average of 1.3 per cent per year). Compared to the previous forecast, Outlook 2014 predicts higher volumes of energy consumption. This is primarily explained by trends already in existence, with reported figures for 2011 being much higher than expected, particularly in China. Moreover, Outlook 2014's macroeconomic forecast is also higher (to a significant degree in the period to 2018, if we accept the GDP dynamic of the IMF's new, more optimistic forecast).

Global distribution of energy consumption is changing noticeably (Figure 1.13, Table 1.6). With population growth in the developing countries, there is an ever more dynamic shift in economic growth and energy consumption in those countries. But by 2040 the developed countries, on account of their active energy conservation, will have only increased their consumption by 4.6 per cent, and moreover all of this growth will occur in the period to 2030 – growth in energy demand in the OECD will practically come to a standstill after 2030. Several regions – the developed countries in Asia and Europe – will reduce their absolute volumes of energy consumption by 2040.

11 The methodology for predicting primary energy consumption is described in detail in Global and Russian Energy Outlook up to 2040, under the direction of A. A. Makarov and L. M. Grigoriev, ERI RAS, Moscow, 2013, pp. 10-11.

Figure 1.13 – Growth of population, GDP (PPP) and energy consumption by region, Baseline Scenario



Source: ERI RAS

Table 1.6 – Primary energy demand by region, Baseline Scenario

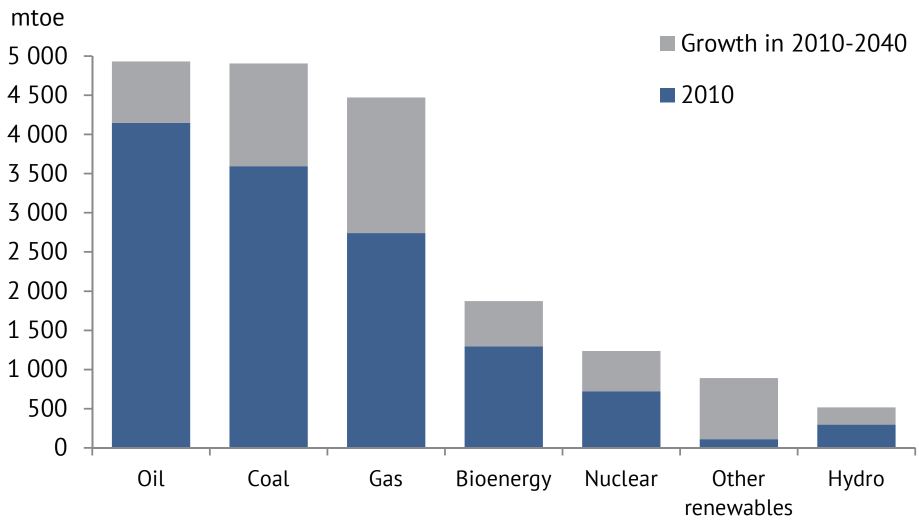
	Consumption of primary energy resources, mtoe							Energy consumption growth rate, %		
	2010	2015	2020	2025	2030	2035	2040	2010–20	2010–30	2010–40
North America	**2699**	**2738**	**2832**	**2901**	**2947**	**2966**	**2964**	**0.5**	**0.4**	**0.3**
USA	2261	2273	2340	2385	2409	2411	2395	0.3	0.3	0.2
Europe	**2020**	**1956**	**1983**	**2003**	**2014**	**2018**	**2016**	**–0.2**	**0.0**	**0.0**
EU-28	1814	1731	1741	1743	1737	1725	1708	–0.4	–0.2	–0.2
Developed Asia	**918**	**900**	**910**	**913**	**908**	**897**	**880**	**–0.1**	**–0.1**	**–0.1**
Japan	509	462	445	426	405	384	362	–1.3	–1.1	–1.1
CIS	**1047**	**1094**	**1150**	**1201**	**1239**	**1271**	**1308**	**0.9**	**0.8**	**0.7**
Russia	718	752	789	822	845	866	892	0.9	0.8	0.7
Developing Asia	**4187**	**5021**	**5744**	**6402**	**7008**	**7577**	**8094**	**3.2**	**2.6**	**2.2**
China	2676	3309	3775	4157	4473	4751	4985	3.5	2.6	2.1
India	727	835	977	1137	1313	1497	1681	3.0	3.0	2.8
South and Central America	**637**	**695**	**767**	**840**	**912**	**981**	**1047**	**1.9**	**1.8**	**1.7**
Brazil	269	295	330	366	403	439	476	2.1	2.0	1.9
Middle East	**698**	**766**	**856**	**941**	**1020**	**1097**	**1172**	**2.1**	**1.9**	**1.7**
Africa	**704**	**789**	**887**	**993**	**1103**	**1217**	**1334**	**2.3**	**2.3**	**2.2**
World	**12911**	**13970**	**15130**	**16194**	**17150**	**18024**	**18815**	**1.6**	**1.4**	**1.3**
OECD	5581	5542	5679	5776	5833	5852	5837	0.2	0.2	0.2
Non-OECD	7330	8428	9451	10418	11317	12172	12978	2.6	2.2	1.9
OPEC	878	970	1087	1204	1316	1428	1538	2.2	2.0	1.9
BRICS	4536	5351	6025	6641	7200	7725	8212	2.9	2.3	2.0

Source: ERI RAS

By the end of the period under review China, which is currently comparable to the USA in terms of energy consumption, will be the largest market – more than double the size of the US market. Very importantly, the main growth of energy consumption in China will occur during the current decade, after which the growth rate will slow down significantly – from 10 per cent in 2010 to 1 per cent per year by the end of the period (an average annual rate of 2.1 per cent). After 2025, the growth in demand in Asia will shift to India (with an average annual growth rate of energy consumption of 2.8 per cent) and the countries of south-east Asia. The other developing countries will increase their energy consumption by one and a half times by 2040, which will account for 30 per cent of the global growth of primary energy consumption. The Middle East and Africa will become large-scale energy consumers.

The demand for different types of fuel and electricity was arrived at by coordinating the figures for electricity, gas, petroleum products, coal intensity of GDP, and primary energy consumption. Calculations show that demand in the period from 2010 to 2040 will grow for all forms of energy: oil by 19 per cent, coal by 36 per cent (mainly in the period to 2020), gas by 64 per cent, nuclear energy by 72 per cent, and renewable energy sources by 92 per cent. The main volume of absolute consumption growth will be for gas (Figure 1.14).

Figure 1.14 – Primary energy consumption by fuel type, Baseline Scenario (2010 and 2040)



Source: ERI RAS

Changes in the fuel mix have a logical character. The crisis of 2008–10 marked the beginning of the fourth stage of global energy development, characterized by another doubling of prices, diversification of fuel mixes, and even more restrained growth of energy consumption (Figure 1.15). The structure of global energy consumption will become ever more balanced. Instead of one type of fuel being dominanant in the mix (which has been the case for the entire recorded history of human energy usage) an evening out of fossil fuels is forecast by 2040 (oil, 26 per cent; gas, 24 per cent; coal, 26 per cent) and non-fossil fuels (24 per cent); this bears witness to the development of inter-fuel competition and improvement in the sustainability of supply.

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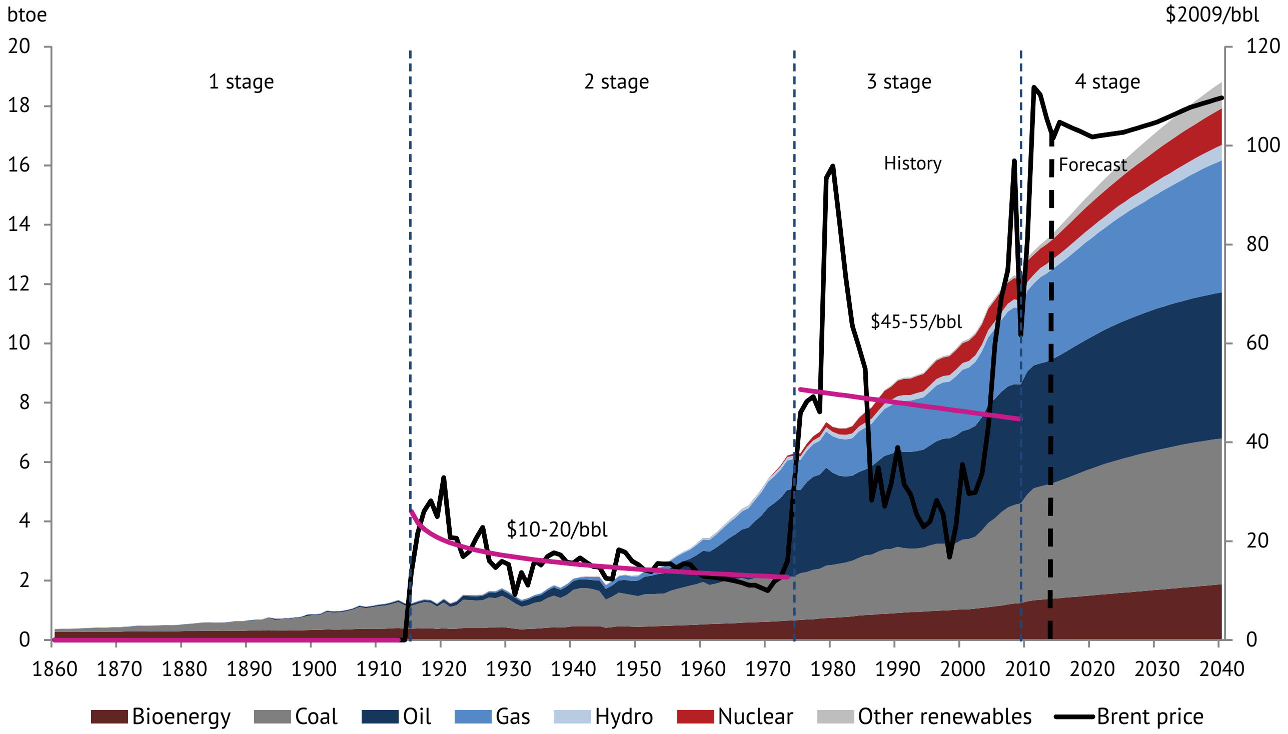
Figure 1.15 – Stages of development of global energy



Source: ERI RAS

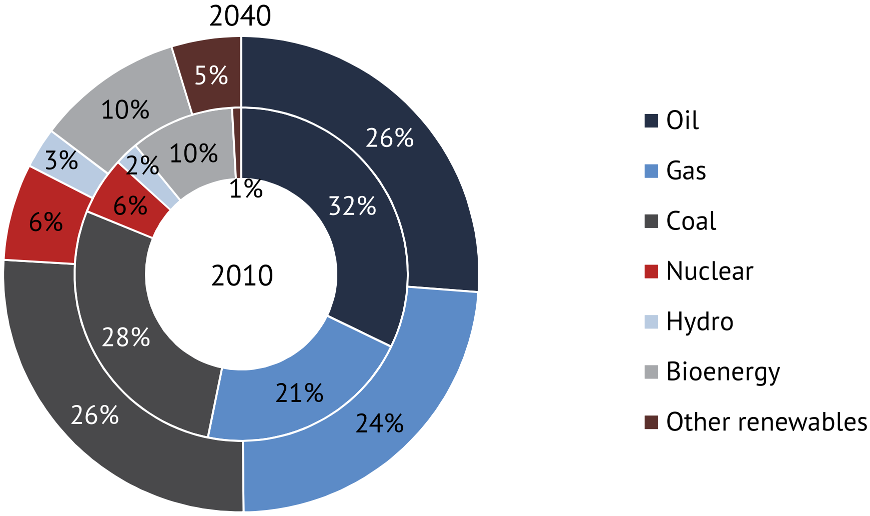
Oil will finally cease to dominate the energy mix, its share by 2040 falling from 32% to 26%, the share of coal will drop from 28% to 26%, while gas will show the largest growth of all fuel types and could expand its share from 21% to 24%.

As was shown in Outlook 2013, in the run up to 2040 it is not expected that there will be a significant reduction in the total share of oil and gas in the world's primary energy consumption – it will remain virtually unchanged (53.2 per cent in 2010 and 49.8 per cent by 2040, see Figure 1.16). However, oil will finally lose its dominance, with its share in 2040 being reduced from 32 per cent to 26 per cent. Gas, in contrast, will have the largest absolute volume of consumption growth, enabling it to significantly expand its niche (though not in all regions of the world). Coal's share will decline from 28 per cent to 26 per cent, mainly for environmental reasons, which will limit its use not only in developed, but also in developing countries.

The highest growth rates in the forecast period will be those experienced by renewable energy sources – due to cheaper technology and increased competitiveness, and active state support. By 2040, the share of renewable energy sources (excluding hydro power, but including biofuels) will account for 14.7 per cent of global energy consumption and 12.5 per cent of electricity generation (compared to 11 per cent and 3.7 per cent in 2010).

Nuclear energy will continue to increase in absolute volumes (particularly in the energy hungry developing countries), but its share will not increase significantly due to security concerns. It is thus only expected to grow from 5.6 per cent in 2010 to 6.6 per cent by 2040.

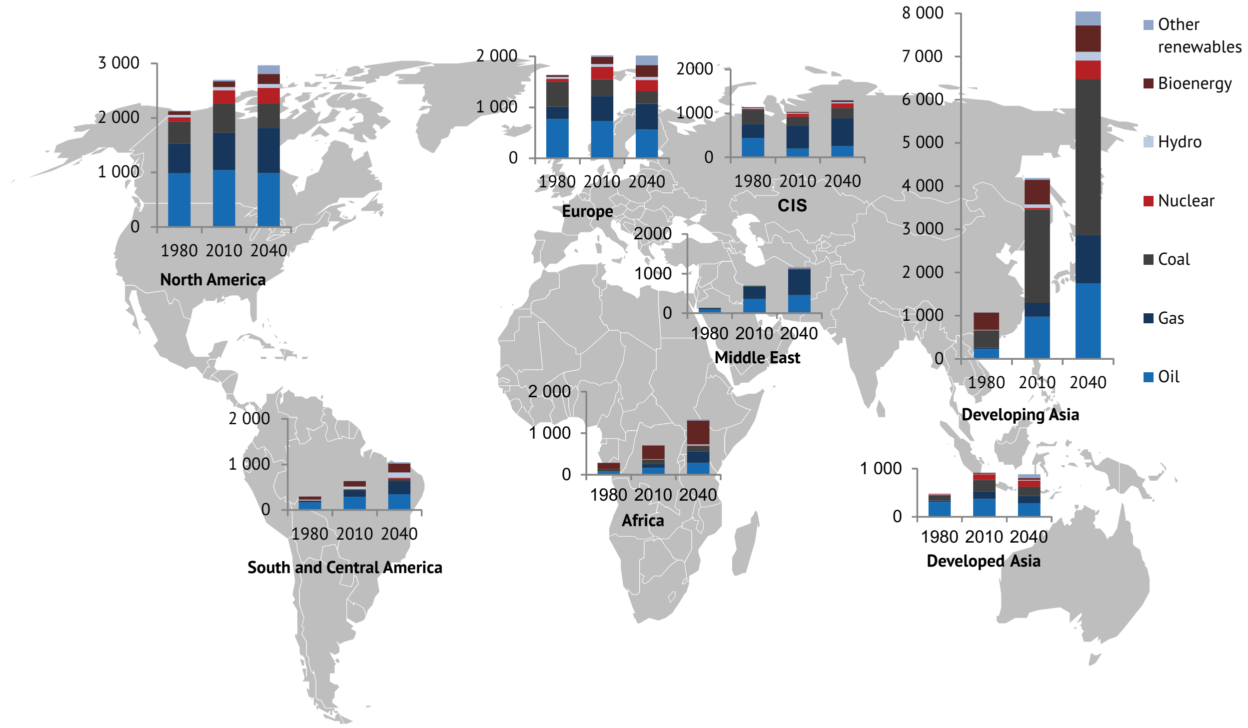
Figure 1.16 – Structure of global primary energy consumption by fuel type in 2010 and 2040, Baseline Scenario



Source: ERI RAS

Obviously, the fuel mixes of different countries and regions will differ markedly (Figure 1.17). The share of oil and coal in developed countries will reduce, while the consumption of gas and renewables will increase. The developing countries of Asia will increase consumption of all fuels, above all coal. The Middle East will significantly increase its consumption of hydrocarbons, especially gas. Africa will show the greatest increase in the use of bioenergy.

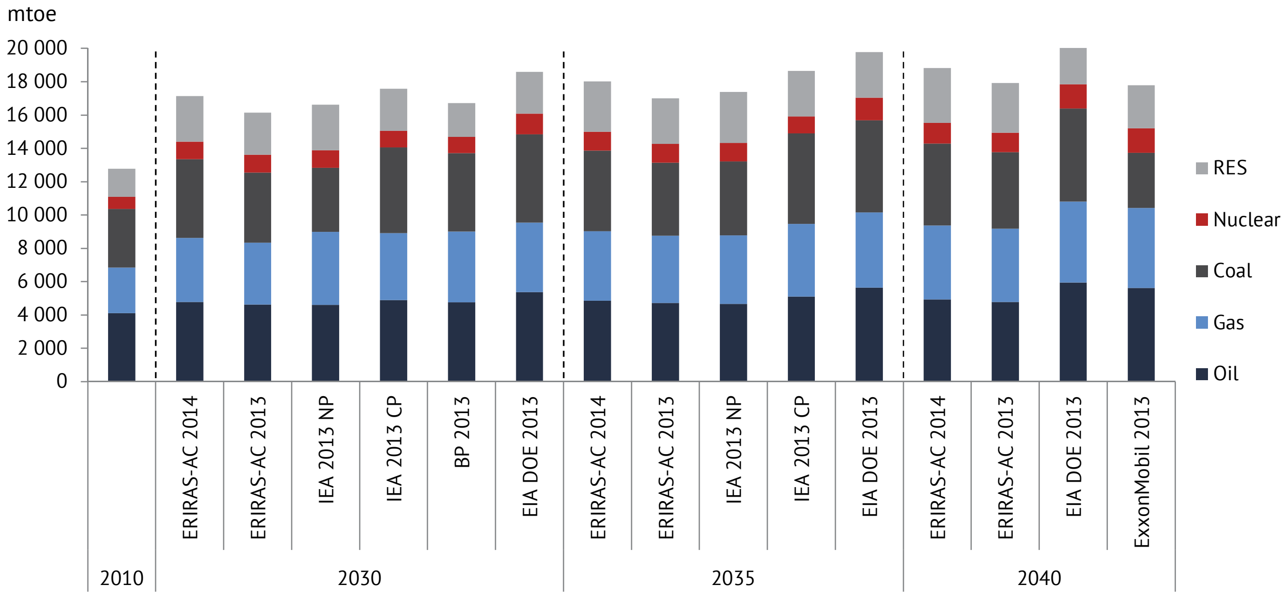
Figure 1.17 – Primary energy consumption by region and fuel type, Baseline Scenario, mtoe



Source: ERI RAS

Against the backdrop of the latest projections by other organizations, that of Outlook 2014 seems quite high (though not the highest) and it therefore assumes the active use of all energy sources and technologies – fossil fuels, and alternatives (Figure 1.18). It is a scenario in which the world must do everything possible to meet its energy needs.

Figure 1.18 – Comparison of latest long-term forecasts of global primary energy consumption by fuel type

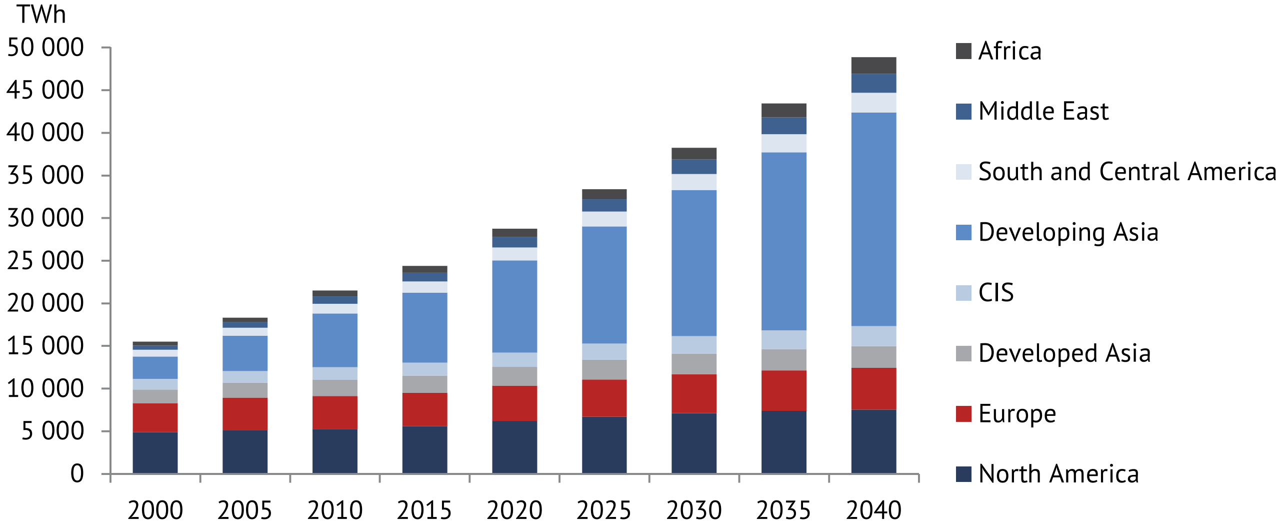


Sources: ERI RAS-ACRF, IEA, USA Department of Energy, BP, ExxonMobil

Electricity Generation

The most important trend in the development of global energy will be the further increase in the share taken by electricity in final energy consumption. Electricity, the most convenient form of energy to use, will displace all others. Demand for electricity, therefore, will grow in all countries of the world without exception, even in the OECD countries in which primary energy consumption is stabilizing. Electric power has a distinct regional character, and, given the absence of inexpensive methods of long-distance transmission, it is mainly produced in the regions where it is consumed. Accordingly, the main increase in electricity production in the world (87 per cent) will be in developing countries (Figure 1.19) – with the highest growth rates being seen in the developing countries of Asia, the Middle East, and Africa.

Figure 1.19 – Global electricity production by region, Baseline Scenario

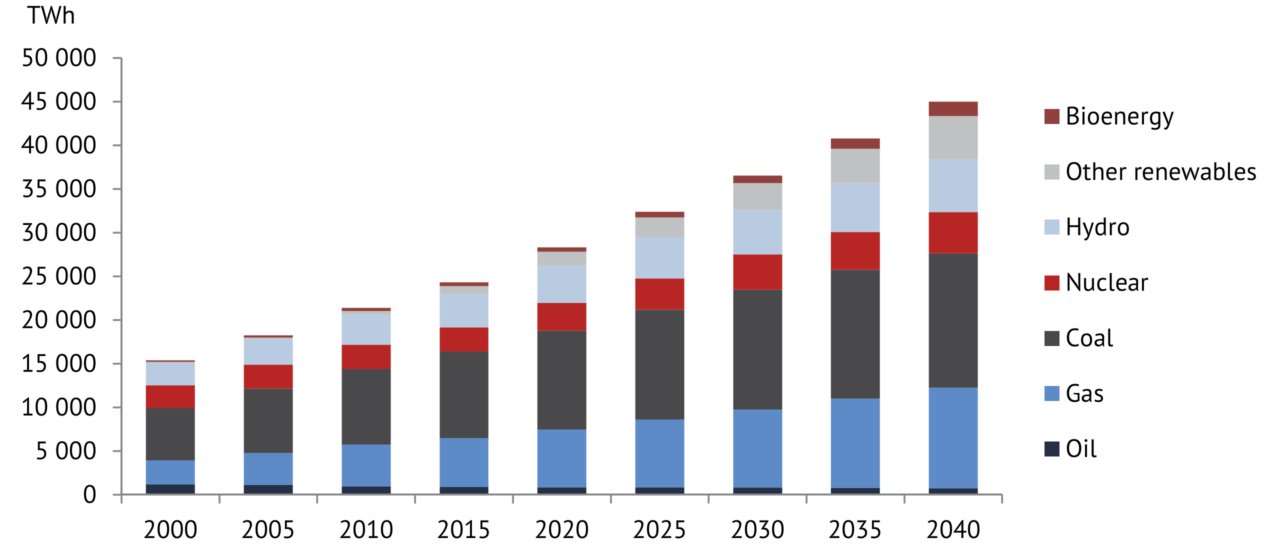


Source: ERI RAS

Correspondingly, the proportion of primary energy used for electricity production will increase, to 46 per cent by 2040 compared with 36 per cent in 2010. Electricity generation is the sector in which the main competition between all fuel types takes place, and this competition will only increase. Improvements in new technologies will lead to lower unit costs for renewable energy sources, while the rising costs of traditional energy resources, on the contrary, will push up the cost of gas and coal-fired generation, bringing all technologies into a fairly narrow competitive range.

The mainstay of global electricity generation – thermal – will continue to provide more than 70 per cent of the total, even in 2040 (Figure 1.20).

Figure 1.20 – Global electricity production by fuel type (2000–40)

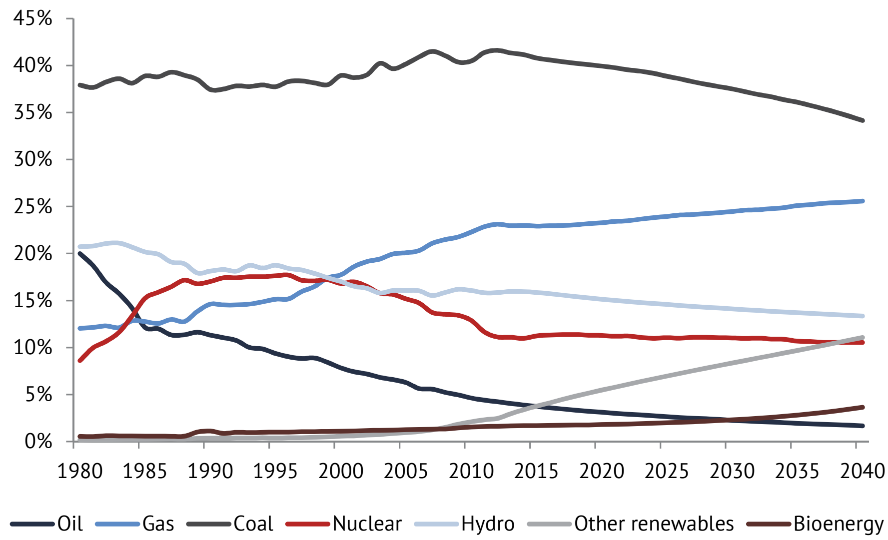


Source: ERI RAS

Coal-fired generation will retain its dominant role for the whole period being examined, providing the greatest increase in production of electricity compared to all other fuels; even by 2040, coal will provide 38 per cent of output, though environmental constraints will lead to a marked slowdown in its growth and a reduced share in the fuel mix (Figure 1.21).

Gas consumption in the global electricity generating industry will double, with its share in 2040 exceeding 24 per cent. The role of gas in electricity generation will vary greatly by region, depending on emerging regional gas prices which affect its competitiveness.

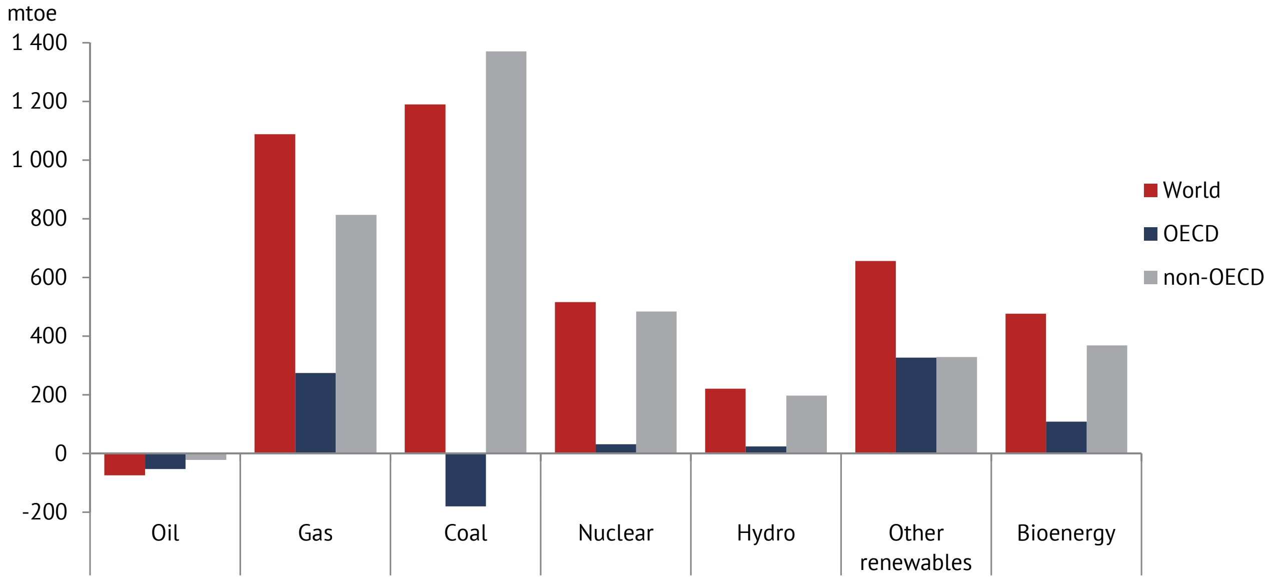
Figure 1.21 – Generation by fuel type, Baseline Scenario (1980–2040)



Source: ERI RAS

Use of non-fossil energy resources will grow rapidly – until 2040 they will provide more than a third of growth (Figure 1.22), and their combined share in electricity production will exceed 28 per cent.

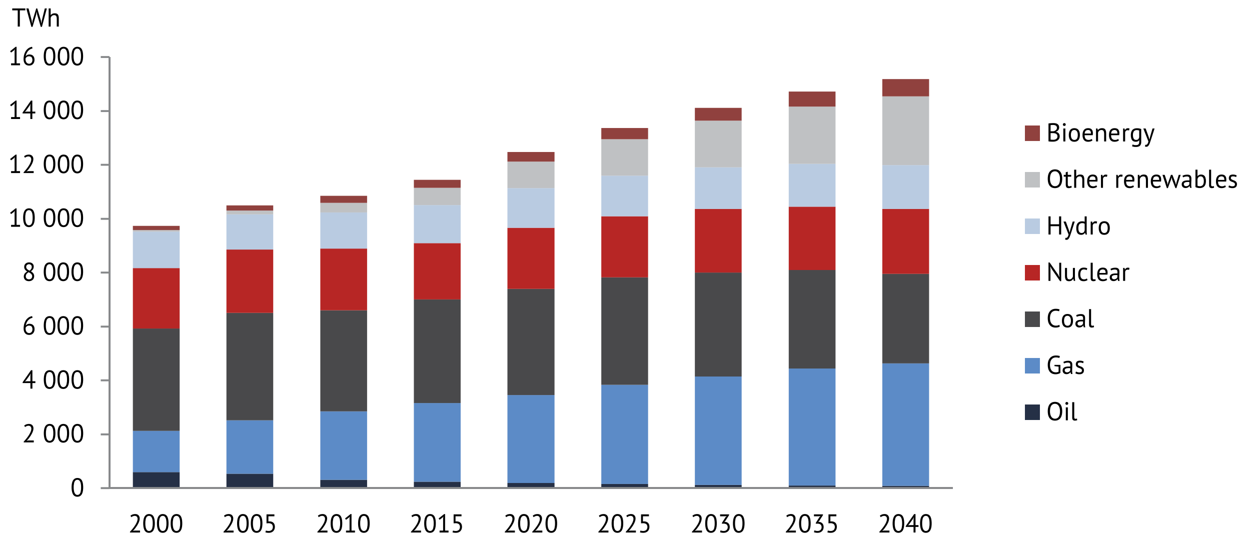
Figure 1.22 – Growth in use of different fuel types in electricity production, Baseline Scenario



Source: ERI RAS

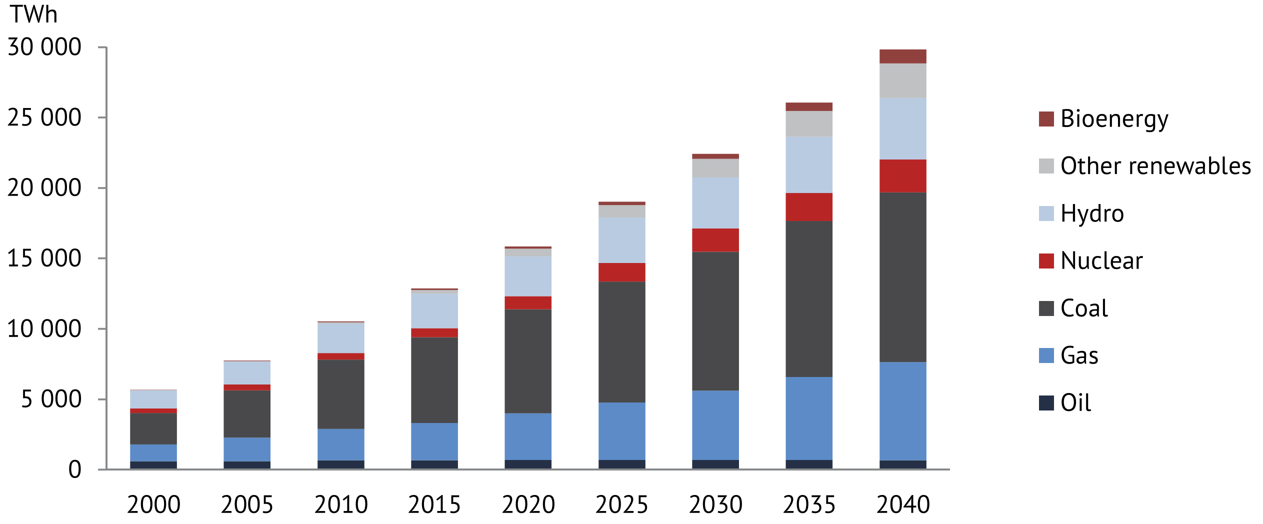
The developed countries will, above all, promote non-carbon generation (Figure 1.23). Developing countries, while retaining a high dependence on coal, will rapidly increase the use of gas and renewable energy sources in electricity generation (Figure 1.24).

Figure 1.23 – Electricity production by fuel type in developed countries, Baseline Scenario



Source: ERI RAS

Figure 1.24 – Electricity production by fuel type in developing countries, Baseline Scenario



Source: ERI RAS

Liquid fuels market

Demand for liquid fuels

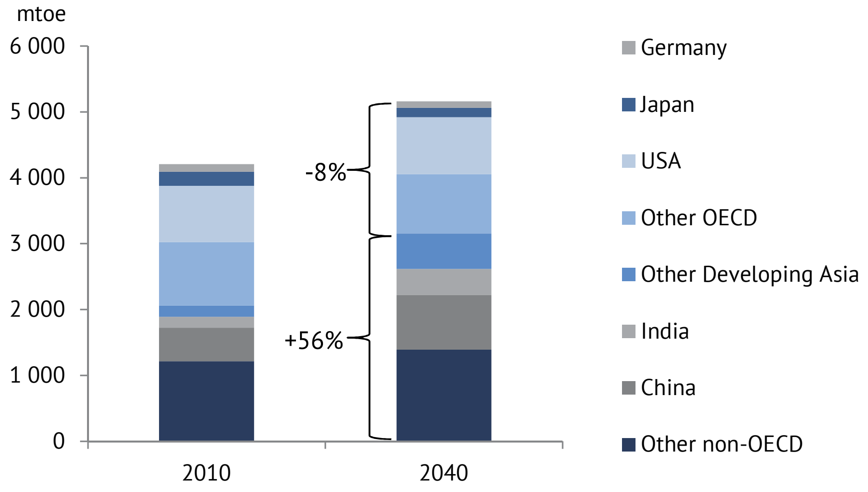
Demand for liquid fuels (oil products, biofuels, and fuel produced by gas-to-liquids and coal-to-liquids technology)[12] will grow at a slower rate compared to that of other fuels, and will slow towards the end of the period under review.

A combination of two techniques was used to forecast the demand for liquid fuels: for oil, the oil intensity of individual economies was used, together with a determination of the demand for oil as the sum of demands for different oil products (LPG, gasoline, naphtha, diesel, fuel oil, kerosene, and other oil products); the demand for different oil products was determined through the capacity trends of the economies of individual countries for each relevant product. Demand for biofuels and other liquid fuels has been identified as a scenario assumption with an additional recalculation of competition between fuels.

By 2040 in the Baseline Scenario, world demand for liquid fuels will have risen by about a quarter in comparison with 2010, reaching 5160 mtoe (Figure 1.25). This is 60 million tonnes more than in Outlook 2013, and is due to slightly higher figures for expected global GDP growth rates (an annual average of 3.5 per cent as opposed to 3.4 per cent in the previous year), as well as a refinement of total oil demand resulting from a consideration of demand for a mix of oil products in different countries – taking into account the peculiarities of formation of the oil product mix and current energy policies in individual countries and regions of the world.

12 Gas-to-liquids (GTL) – technology for the production of motor fuels from synthetic gas, based on the Fischer–Tropsch process; compressed natural gas (CNG) – the compression of natural gas for use as motor fuel; coal-to-liquids (CTL) – technology for the production of synthetic motor fuels from coal, based on the Fischer–Tropsch process.

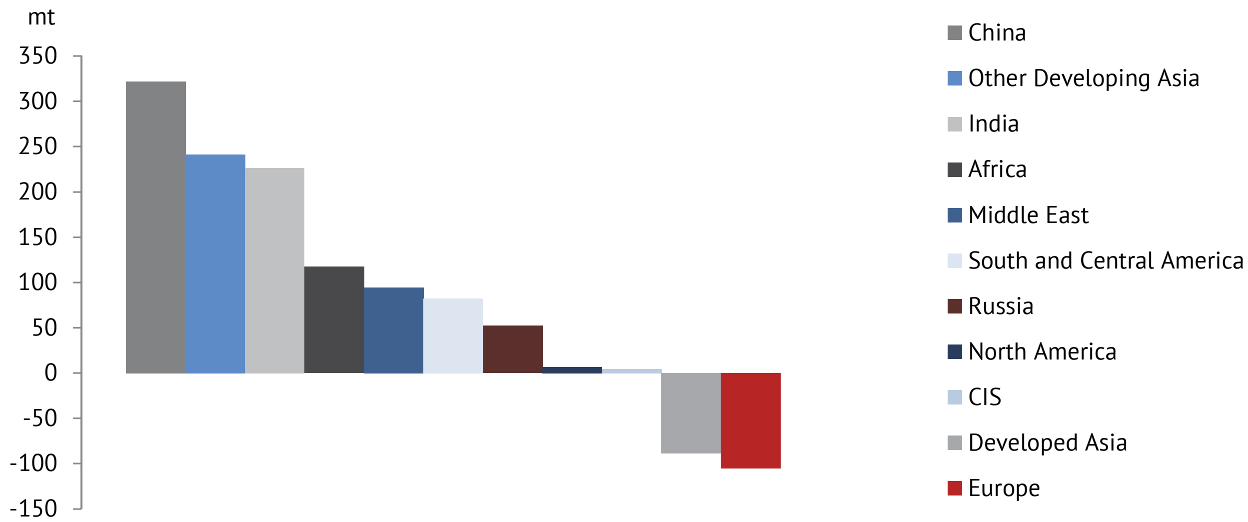
Figure 1.25 – Demand for liquid fuels for regions and largest countries in 2010 and 2040, Baseline Scenario



Source: ERI RAS

It is clear that the main increase in global demand for liquid fuels will be from developing countries. Consumption in non-OECD countries will be nearly 60 per cent higher in 2040 than in 2010 (Figure 1.26). It is important to note that in absolute terms, China alone will provide an increase in demand of 320 million tonnes of liquid fuels.

Figure 1.26 – Demand growth for liquid fuels for 2010–40 for regions and largest countries



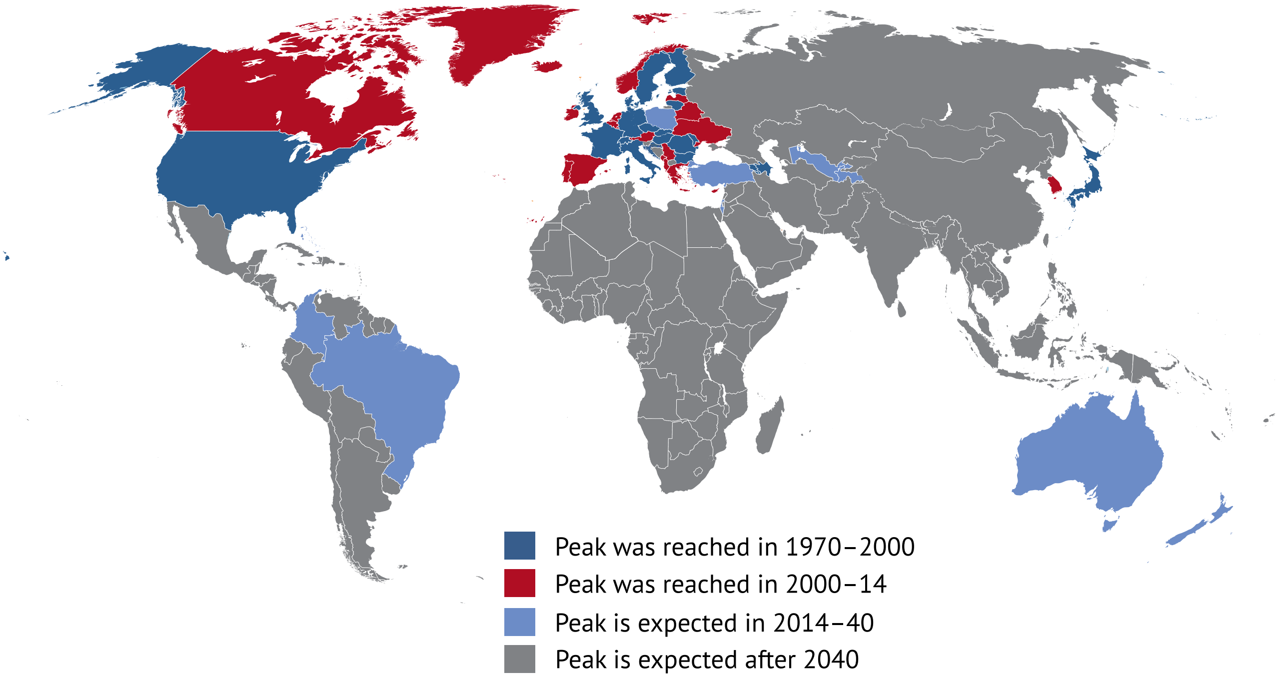
Source: ERI RAS

The developed countries demonstrate the opposite trend, with a long-term reduction in demand for liquid fuels in Europe and the developed countries of Asia, and a particularly significant Japanese reduction in demand (by 70 million tonnes by 2040 compared with 2010).

Demand in North America, which has its own supplies of accessible and cheap oil resources, will grow, albeit only slightly, by 2.3 per cent compared to 2010, regardless of efforts to diversify the region's fuel mix and to develop efficient technologies.

An important feature of the oil market is the fact that oil demand in most developed countries has already reached its peak; in the USA, Japan, South Korea, and most European countries, peak demand was passed before the beginning of the twenty-first century. It should be noted that among all the OECD countries, only Australia (peak expected in 2025), Poland (2030), Turkey (2040), and Israel (2040) are yet to reach this point. Among European countries, only Slovenia, Bosnia, and Macedonia will fail to reach peak demand in the period under examination.

Figure 1.27 – Peak oil demand by country



Source: ERI RAS

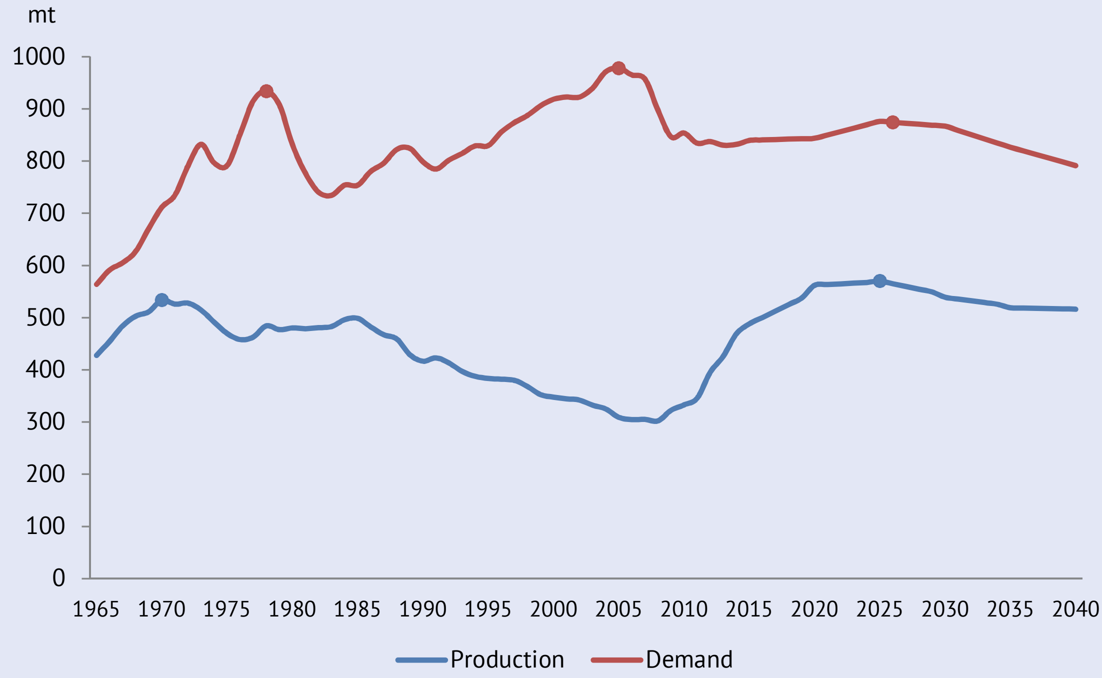
The USA's five oil 'peaks'

In the USA, it is possible to identify two peaks in oil consumption: the first in 1978 (935 million tonnes) and another, higher, peak in 2005 of 980 million tonnes (Figure 1.28). Falling oil consumption after 1978 was due to the large-scale introduction of energy conservation measures. These were a response to the sharp rise in oil prices which had resulted from the unstable military–political situation in the Middle East – one of the main suppliers of oil to the USA at the end of the 1970s.

With the stabilization of the situation in the Middle East before 2005 there was a substantial recovery of oil demand in the USA, which was stimulated by high rates of economic growth. The overall upward trend of growth in oil demand then broke down under the influence of increasing energy efficiency and the switch to alternative energy sources, and oil consumption began to decline.

In the forecast period, in light of the availability of cheap shale oil resources in the USA, it is expected that there will be a partial recovery in oil demand following the recessionary slump of 2008–10, with demand increasing until 2025 and then again receding – which will effectively be a third peak in oil demand in the USA (Figure 1.28).

Figure 1.28 – Oil production and consumption peaks in the USA (1965–2040)



Source: ERI RAS

Figure 1.28 also shows that the US oil industry is, in a sense, characterized by peaks – in both production and demand. The classic peak in oil extraction in the country's conventional oilfields (which was predicted in the 1950s by M. King Hubbert) was passed in 1972, after which production declined in the USA until 2007 (the year when mass commercial exploitation of shale oil deposits began). In the forecast period in the Baseline Scenario, new resources will provide the USA with production growth until 2025, after which there will be a decline. This will form the second peak in oil extraction in the USA, 53 years after the first. It is important to bear in mind that access to new extraction technologies could even push this second peak of production beyond 2040.

It is an interesting fact that, despite the peaks of production, demand for oil in the USA did not decrease, but instead grew at quite a rapid pace in the 1970s and 2000s. In other words, there was no correlation between the production and consumption of oil; however, the beginning of large-scale commercial exploitation of relatively cheap shale oil deposits is currently stimulating growth in demand.

By 2040 demand for liquid fuels in China and the USA will draw level.

The key liquid fuels consuming regions in the forecast period will be developing countries in Asia; their share of global consumption will increase from 23 per cent in 2010 to 34 per cent by 2040. A key factor in demand growth will be China, whose demand will increase by more than 320 million tonnes by 2040 compared to 2010 levels, which will practically bring China level with the USA in terms of liquid fuel consumption.

Demand for liquid fuels from India, Asia's second largest economy, will also more than double by 2040: in the Baseline Scenario it will reach 390 million tonnes a year. A significant increase in demand is expected in the countries of Africa – up 70 per cent compared to 2010 levels. Demand in the countries of South and Central America, the Middle East, and the CIS will grow by a third over the forecast period (Table 1.7).

Table 1.7 – Liquid fuel consumption by region and world's largest countries, Baseline Scenario, million tonnes

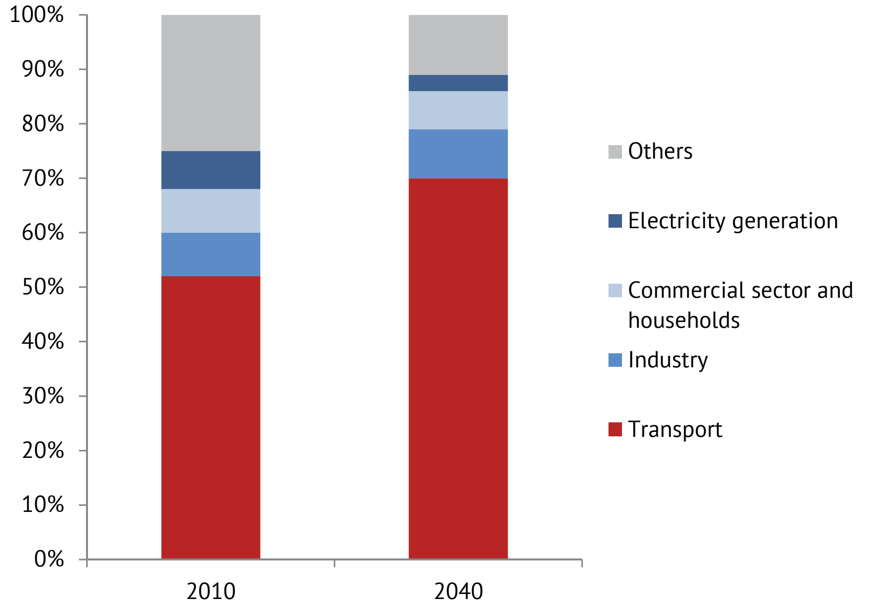
	2010	2015	2020	2025	2030	2035	2040
North America	**1068**	**1063**	**1081**	**1126**	**1129**	**1100**	**1075**
Canada	88	87	90	92	93	94	94
Mexico	101	105	107	109	111	113	114
USA	879	872	884	925	925	893	866
South and Central America	**309**	**326**	**345**	**363**	**377**	**389**	**392**
Brazil	125	136	142	148	155	161	162
Chile	16	18	19	20	21	21	21
Venezuela	44	39	41	43	44	45	45
Others	124	133	143	152	157	162	164
Europe	**749**	**691**	**689**	**683**	**672**	**658**	**643**
EU-28	**679**	**625**	**621**	**614**	**604**	**592**	**578**
France	86	81	79	78	75	73	69
Germany	120	114	112	109	106	102	99
Italy	73	64	62	61	60	59	59
Spain	71	62	61	59	59	59	60
Great Britain	77	72	72	72	71	70	69
Turkey	32	32	33	34	34	34	34
Others	290	266	270	270	267	261	253
CIS countries	**202**	**224**	**236**	**247**	**252**	**256**	**259**
Kazakhstan	17	15	15	16	17	18	19
Russia*	147	169	180	189	193	196	199
Others	38	40	41	42	42	42	41
Developed Asian countries	**373**	**366**	**357**	**343**	**326**	**307**	**286**
Austria	45	47	48	48	47	46	45
Japan	213	207	197	183	169	155	141
New Zealand	7	7	7	7	6	6	6
Korea	108	106	106	106	104	100	94
Developing Asia	**975**	**1104**	**1259**	**1377**	**1507**	**1635**	**1763**
China	511	583	650	685	724	773	832
India	166	183	221	259	307	353	392
Others	298	338	388	433	476	509	539
Middle East	**366**	**361**	**436**	**418**	**436**	**450**	**460**
Iran	89	80	84	88	91	94	95
Iraq	34	36	41	46	48	51	52
Saudi Arabia	131	132	144	153	160	164	168
Others	112	113	167	131	137	141	145
Africa	**165**	**181**	**201**	**224**	**245**	**265**	**282**
Algeria	17	18	20	21	21	22	22
Libya	16	17	18	21	23	24	25
Nigeria	13	15	18	21	24	27	30
South Africa	24	28	29	30	31	32	33
Others	95	103	116	131	146	160	172
WORLD	**4207**	**4317**	**4603**	**4781**	**4943**	**5059**	**5160**

* - consumption of liquid fuels in Russia in this case takes into account the consumption of non-monetized products, including exports.

Source: ERI RAS

The structure of global liquid fuel demand by sector in the forecast period will undergo some changes due to increased competition between relatively expensive liquid fuels and other forms of energy. Accordingly it is expected that there will be a reduction in the heat and electricity generation sector's share in the overall consumption of liquid fuel due to the replacement of oil-fired power stations by coal and gas stations, as well as by those relying on renewable energy sources. In the domestic sector, liquid fuels will also be replaced by other energy resources. They will retain their share in the industrial sector primarily due to the growth of petrochemical production in the world as a whole, but here also it will be tough for petroleum products to compete with alternative energy sources, above all with natural gas (Figure 1.29).

Figure 1.29 – Liquid fuel demand by economic sector, Baseline Scenario



Source: ERI RAS

The transport sector will remain the key consumer of liquid fuels, with demand for motor fuels by 2040 amounting to more than 70 per cent of the total demand for oil.

The transport sector is practically the only sector that will provide growth in demand for oil and petroleum products between now and 2040.

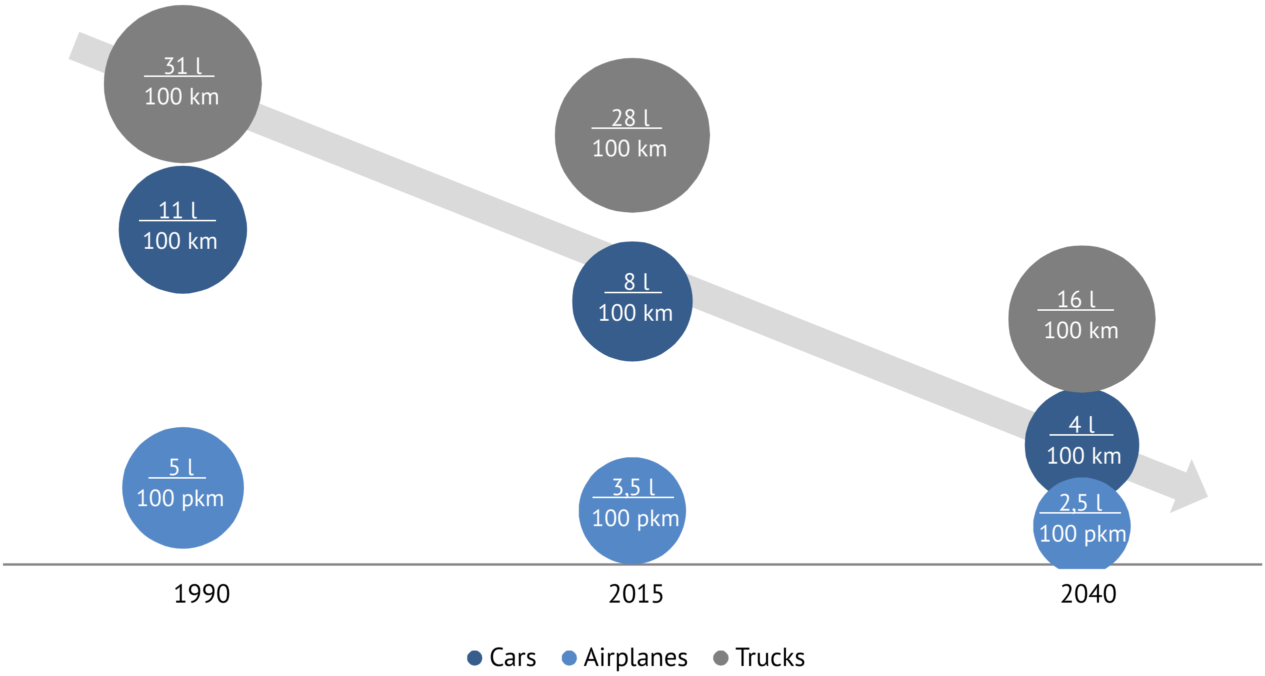
Despite the increase in the number of cars and the needs of transportation (both freight and passenger), measures to modernize and increase efficiency will constrain global growth of demand for liquid fuels. This is illustrated by the way in which the specific fuel consumption of the aviation sector has decreased over the last decade by 30 per cent, due to the use of more modern materials in aircraft construction, increased efficiency of jet engines, and modern airliners' improved capacities for both freight and passengers. By 2040, on the basis of Boeing's[13], projections, ERI RAS expects specific fuel consumption in aviation to be reduced by 30 per cent.

Energy efficiency is also crucial for road transport. The specific fuel consumption of lorries declined by 10 per cent between 1990 and 2010

13 'Operational Fuel Efficiency', IATA, www.iata.org/whatwedo/ops-infra/Pages/fuel-efficiency.aspx

according to CAFE (Corporate Average Fuel Economy) figures[14]. By 2040 consumption is expected to decline by another 43 per cent owing to the renovation of the global cargo fleet and improvements in the efficiency of internal combustion engines and transmissions, but above all by reducing the weight of heavy freight lorries and developing low-tonnage transportation. A significant reduction in the fuel consumption of cars is also expected – by 50 per cent in comparison with figures for the 2010s – through the use of composite materials and the reduction of energy losses 'from tank to wheel' (Figure 1.30)[15].

Figure 1.30 – Reduction in specific fuel consumption for light vehicles, freight vehicles, and air transport 1990–2040



Sources: EPA, Boeing, ERI RAS

The transport sector: prospects for changes in the energy mix

Oil products, while being dominant, are far from being the only fuel type that meets the demand for energy in the transport sector. In 2010, nearly 5 per cent of the demand for transport was met by non-petroleum fuels: liquid synthetic fuels from gas, coal, biomass, and natural gas, as well as electricity. In the Baseline Scenario it is expected that the share taken by non-petroleum fuels in the transport sector's total energy demand will increase to 11 per cent of by 2040.

The main demand growth will come from the most common substitute for oil products – biofuels – whose consumption in transport will be 230 million tonnes by 2040, compared with 60 million tonnes in 2010 (Figure 1.31). The success of biofuels will result from active government support in developed countries as well as the relatively high oil prices in the Baseline Scenario.

14 'EPA and NHTSA Set Standards to Reduce Greenhouse Gases and Improve Fuel Economy for Model Years 2017–2025 Cars and Light Trucks', Regulatory Announcement, US Environmental Protection Agency, www.epa.gov/otaq/climate/documents/420f12051.pdf.

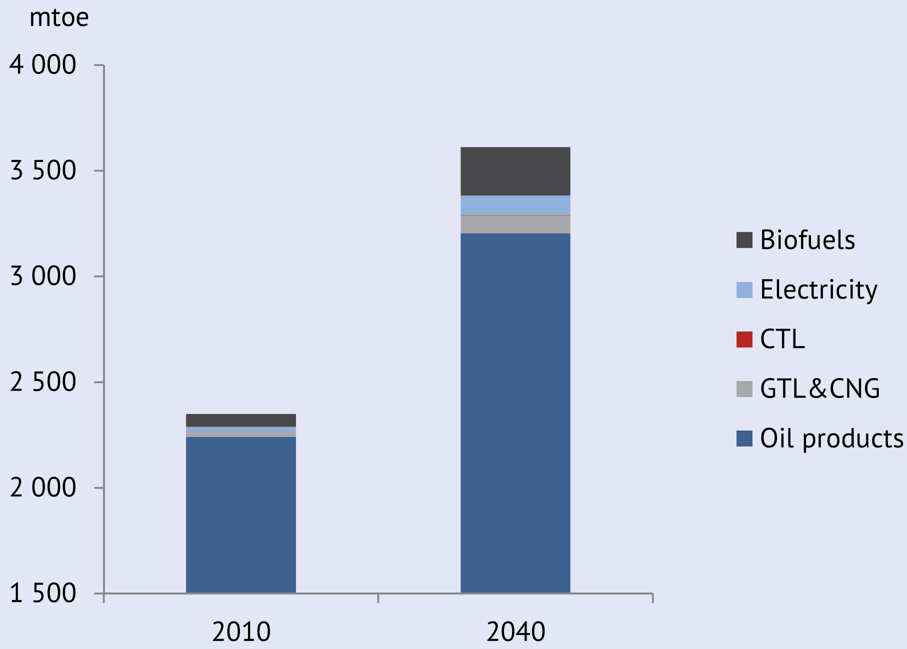
15 For more detail see Global and Russian Energy Outlook to 2035, under the direction of A. A. Makarov and L. M. Grigoriev, ERI RAS/REA, 2012, pp. 26–27.

A significant increase in demand is also expected for natural gas-based motor fuel, with its consumption in the transport sector growing by more than three times (up to 85 million TOE) by 2040 – the main growth in demand being in Asia–Pacific, as well as Iran, the USA, and the European Union countries.

Development of electric vehicles and rechargeable hybrids will help increase the share of electricity to 2.5 per cent of the total consumption of energy for transport by 2040[16].

The motor fuel substitute that will be least in demand will be fuel produced by coal-to-liquids (CTL) and gas-to-liquids (GTL) technologies, due to the relatively high production costs (current CTL and GTL projects are considered to be cost effective only when the price of oil is more than $100–120 dollars a barrel).

Figure 1.31 – Demand for energy in the transport sector, Baseline Scenario



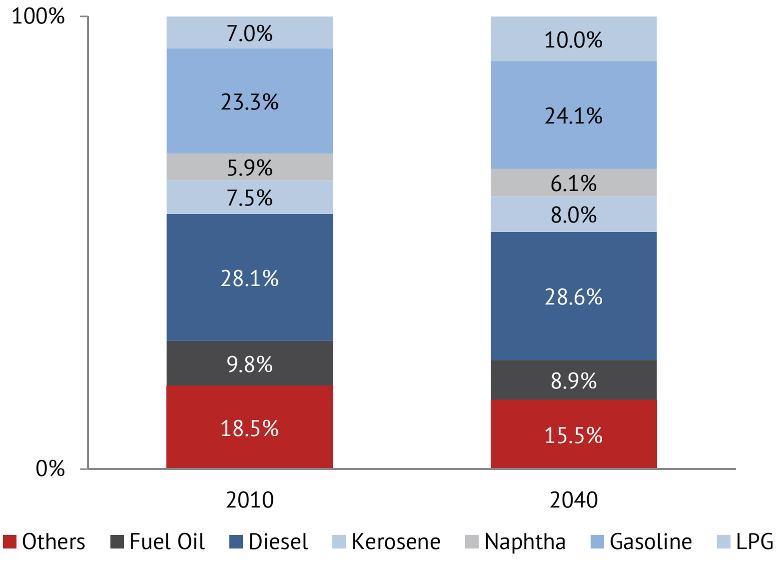
Source: ERI RAS

The transport sector, as a key segment of the demand for liquid fuels, will also determine the structure of regional and global demand for petroleum products.

By 2040, demand for petroleum products in the world as a whole will have grown by 20 per cent (to 4.93 billion tonnes) compared with 2010, and moreover the overall structure of demand for petroleum products in 2040 will not have changed significantly. The greatest growth in demand will be for gasoline and diesel fuel as key motor fuels. The share of LPG will increase, first and foremost due to its increased use in the petrochemical industry and as motor fuel, as will the share of all light motor fuels (diesel, gasoline, and aviation fuel), while the share of dark petroleum products will fall, mainly due to the replacement of fuel oil in electricity generation (Figure 1.32).

16 For more detail on the prospects of alternative motor fuels see Global and Russian Energy Outlook to 2035, under the direction of A. A. Makarov and L. M. Grigoriev, ERI RAS, 2012, pp. 76–84.

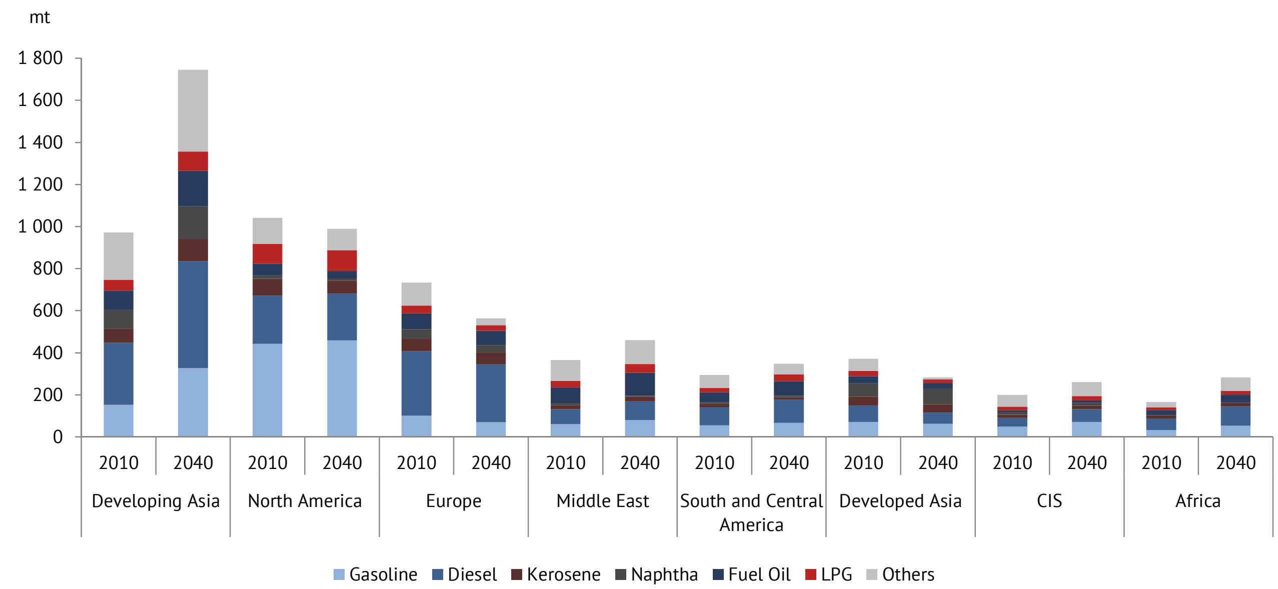
Figure 1.32 – Global demand for oil products, 2010 and 2040, Baseline Scenario



Source: IEA statistics, ERI RAS

The pattern of demand for petroleum products in different parts of the world is rather uneven (Figure 1.33). For example, in North America, motor gasoline is expected to predominate during the forecast period, with its share in total demand for petroleum products increasing from 42 per cent in 2010 to 46 per cent by 2040. In Europe, by contrast, it is expected that the shift to diesel for road vehicles will continue, with its share increasing from 42 per cent in 2010 to 49 per cent in 2040. Such imbalances in the structure of demand result in a position where regions need to import additional volumes of key oil products, due to their inability to harmonize their own refining capacities to the production of such volumes of gasoline (USA) and diesel fuel (Europe).

Figure 1.33 – Demand for oil products by region, Baseline Scenario



Source: ERI RAS

In other parts of the world the fuel mixes are relatively balanced, but there are still regional peculiarities:

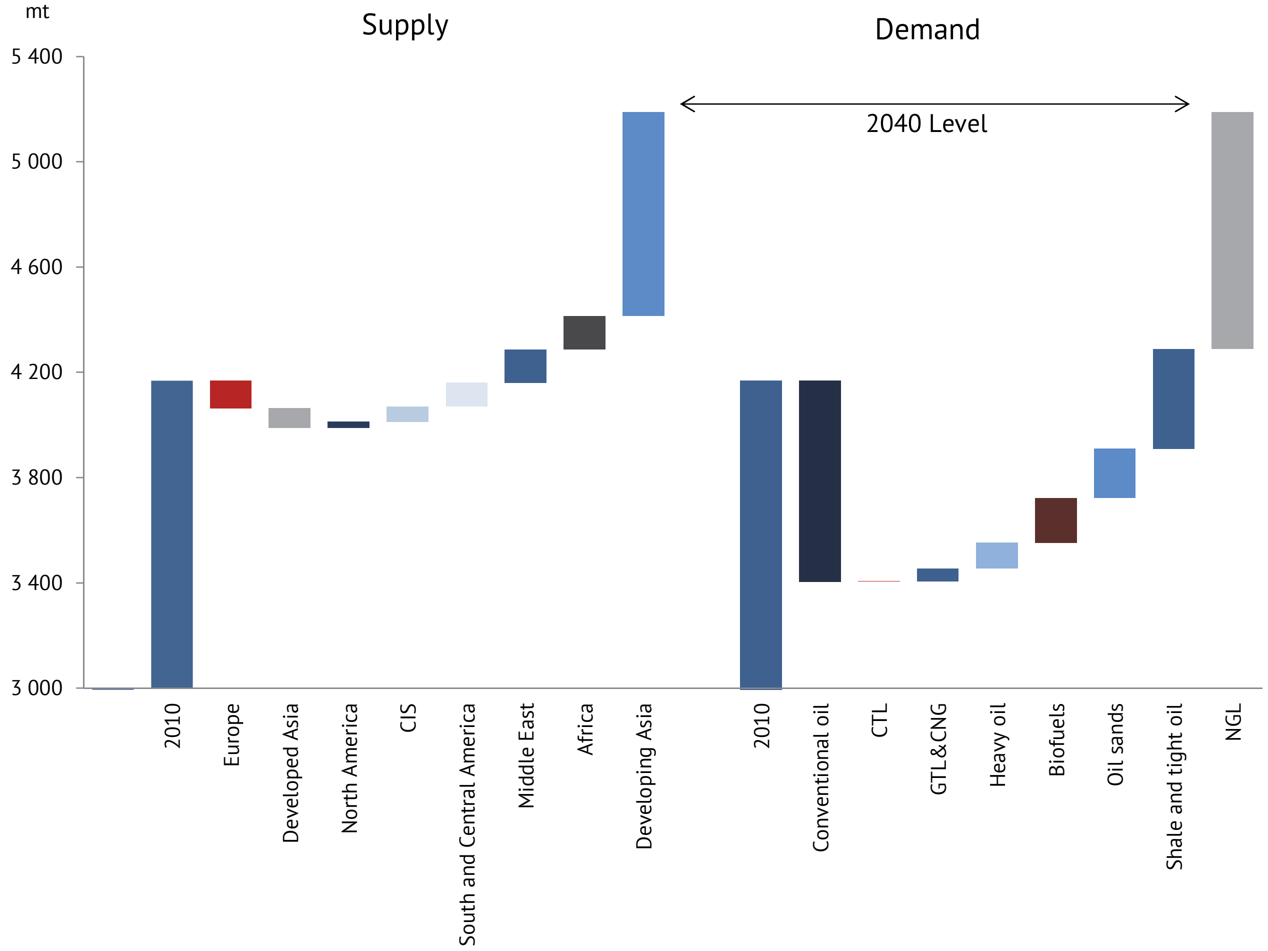
- In the Middle East the share of fuel oil is quite high compared to other regions (24 per cent by 2040). The high demand is explained by the high level of maritime transport, which includes exports of hydrocarbon from the region;
- In the CIS countries, on the contrary, there is an almost complete displacement of fuel oil from the energy mix, due to the decommissioning of oil-fired power stations, while the demand for fuel oil as a fuel for shipping remains practically unchanged;
- The developed countries of Asia – particularly Japan and South Korea – are characterized by a high proportion of naphtha and LPG, which are primarily used by the large petrochemical plants located in the region;
- In Africa, South and Central America, and the developing countries of Asia significant structural changes in the mix of petroleum products consumed are not expected – the key motor fuel for all of these regions is diesel (30 per cent of total oil demand), while gasoline will account for 19 per cent of total consumption by 2040.

Liquid fuel supply

In the Baseline Scenario world demand for liquid fuels will be largely provided for by oil and NGL (natural gas liquids) extraction, while non-petroleum fuels (fuels produced by GTL, CNG, CTL technologies, and biofuels) will account for only 5.6 per cent of the total supply of liquid fuels by 2040, with the major part (230 million tonnes) being accounted for by the production of biofuels (Figure 1.34).

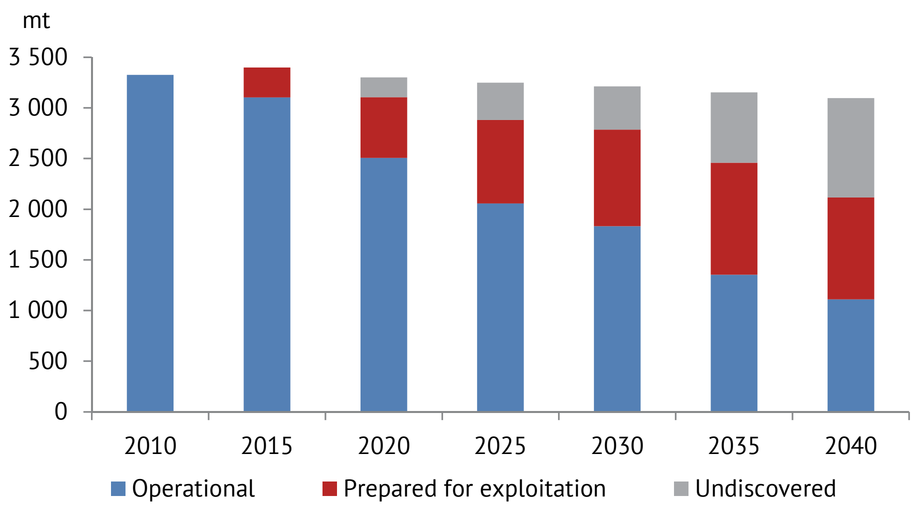
Conventional oil (excluding NGL) production will drop to 3.1 billion tonnes by 2040 from the current 3.4 billion tonnes, and the long-discussed 'conventional oil peak' will occur in the period from 2015 to 2020. The drop in its extraction will be due to the gradual working-out of reserves of the largest existing fields. To compensate for this, by 2015 the world will need to increase production to 295 million tonnes from fields which are already known but as yet undeveloped, and by 2020 it will need to add an additional 200 million tonnes from new fields. Overall, by 2040, production from existing fields is expected to decline to 1.1 billion tonnes, resulting in a cumulative drop in conventional oil production of 300 million tonnes compared to 2010 (Figure 1.35).

Figure 1.34 – Balance of demand for liquid fuels by region and supply of liquid fuels by type in 2040, Baseline Scenario



Source: ERI RAS

Figure 1.35 – Conventional oil production by field type (2010–40)



Source: ERI RAS

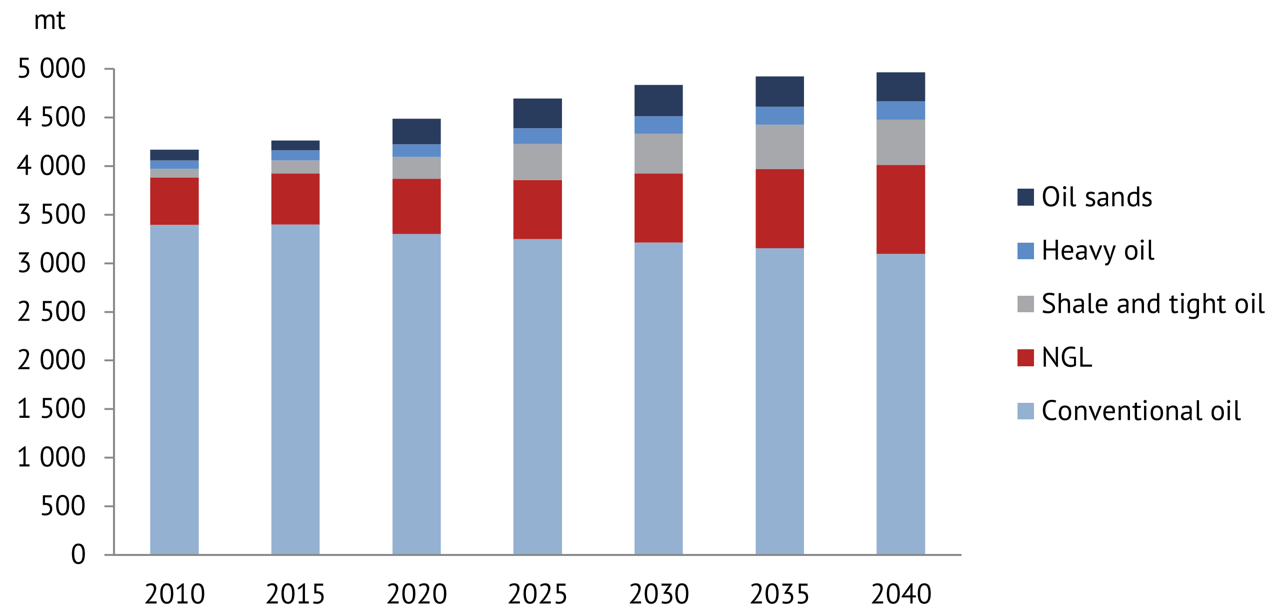
Despite the expected decline in conventional oil production in the period to 2040, the world will not face a shortage of supply of oil fuels. Falling extraction in conventional oil fields will be offset: by increasing extraction of NGL (425 million tonnes increase in production by 2040), and by exploiting unconventional oil (tar sands, high viscosity oil, oil shale plays[17]).

NGL production, by 2040, will amount to almost 20 per cent of the total volume of oil supply. This increase in production will be stimulated by the development of large-scale gas production in all regions of the world without exception, and it is important to note that in the key oil-producing region – the Middle East – NGL will provide more than 70 per cent of production growth.

Unconventional deposits, above all oil shale plays which will produce 470 million tonnes by 2040, will be a key source of oil production growth to 2040.

Total production of unconventional oil by 2040 will be 950 million tonnes, almost half of which (470 million tonnes) will be from of oil shale plays, including oil reservoirs with low permeability (light tight oil) and, to a lesser extent, synthetic oil produced from kerogen (Figure 1.36). The undisputable leader in the production of unconventional oil for the entire period under consideration will be the USA (Figure 1.37).

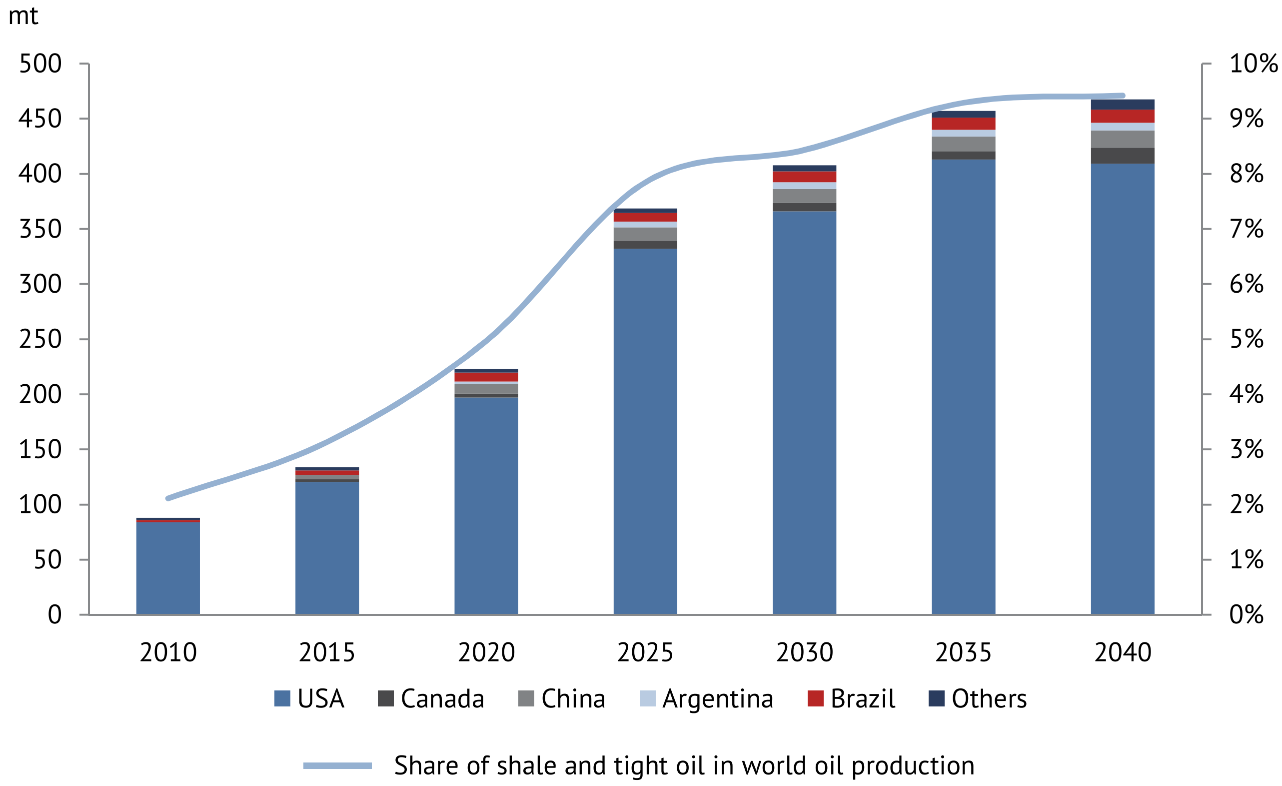
Figure 1.36 – Oil production by type, Baseline Scenario (2010–40)



Source: ERI RAS

17 For more about oil shale and other unconventional oils see the ERI RAS papers by:
E. Grushevenko and D. Grushevenko, edited by A. A. Makarov, T. A. Mitrova, and V. A. Kulagin 'Oil shale plays – a new challenge to the energy market?', Moscow. 2012;
E. Grushevenko and D. Grushevenko 'Unconventional Oil Potential Tends to Change the World Oil Market', Energy Science and Technology, CSCanada Vol.4, № 1, 2012;
E. Grushevenko and D. Grushevenko 'Unconventional oil: potential and prospects', Development Strategy, January–February, 2012.

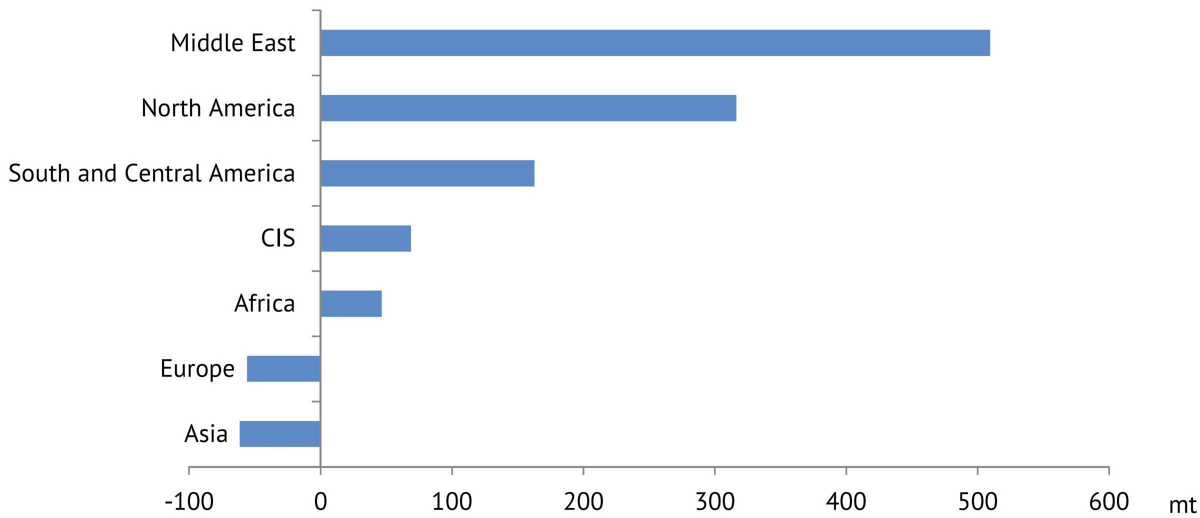
Figure 1.37 – Shale and tight oil production by country, Baseline Scenario



Source: ERI RAS

Overall, the Middle East will remain the key global producing region and, in the Baseline Scenario, will provide production growth of half a billion tonnes of crude oil. Production in the region will increase by 45 per cent (from 1.215 million tonnes in 2010 to 1.755 million tonnes in 2040). This huge increase will be achieved primarily via fields in Iraq (an increase of 270 million tonnes), Saudi Arabia (an increase of 80 million tonnes), and other OPEC members in the Middle East (190 million tonnes) (Figure 1.38).

Figure 1.38 – Oil production growth by region 2010–40, Baseline Scenario

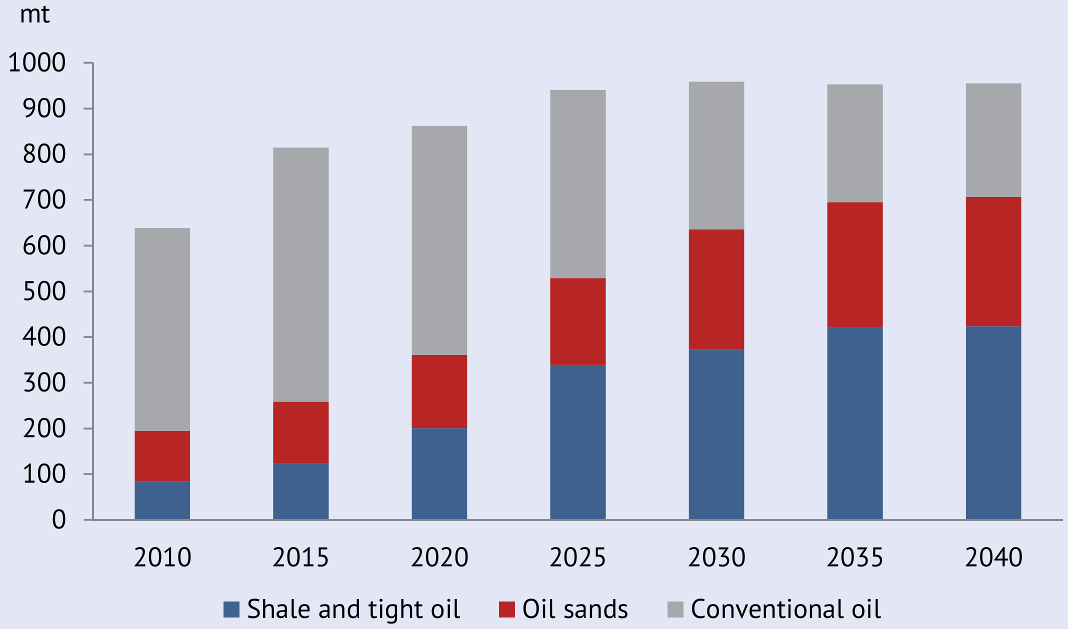


Source: ERI RAS

Oil production in North America

North America is undoubtedly the leader in the development of unconvential sources of oil – both shale and tight oil and tar sands. Development of these two types oil has allowed the region to break the trend of declining production and to ensure production growth for a significant period of time. In the Baseline Scenario, non-traditional sources will account for about 75 per cent of total oil production in the region by 2040 (Figure 1.39), and the production growth of shale oil will continue right up to the end of the forecast period, but with a marked slowdown in growth after 2030 following the depletion of key shale plays.

Figure 1.39 – Oil production in North America by type



Source: ERI RAS

The success of unconventional oil in the region results from the relatively low cost of production. Breakeven prices[18] for most shale plays in the USA and Canada are $75–90 per barrel, and $60–110 per barrel for projects to develop sands in Canada.

Production in South America will increase by more than 40 per cent to 540 million tonnes by 2040 (from 380 million tonnes in 2010), mainly due to the commissioning of projects to develop offshore fields in Brazil (in the Baseline Scenario production in the country will reach 263 million tonnes). Venezuela will also play a significant role in regional oil production, with growth occurring due to development of reserves in the Orinoco Belt. In the Baseline Scenario production will amount to almost 170 million tonnes by 2040.

In the Baseline Scenario, extraction in the CIS countries will continue to grow, albeit at a much slower pace than that seen in the first decade of the twenty-first century, from 665 million tonnes in 2010 to 710 million tonnes in 2040. The decline in extraction after 2015 from the region's main producer, the Russian Federation, will be offset by increased production in Kazakhstan (from 80 million tonnes in 2010 to 170 million tonnes in 2040).

18 Breakeven price – the oil price at which it becomes profitable to work a deposit

Production in Africa will exceed 540 million tonnes by 2035 (against 480 million tonnes in 2010), after which it will decline slightly to 530 million tonnes due to the depletion of deposits in Nigeria, Angola, and Egypt. In the Baseline Scenario, another key producer in the region, Libya, will maintain stable production growth until 2040.

A decline is expected in all European countries except Norway. Total production in the region will decline from 195 million tonnes in 2010 to 130 million tonnes in 2040. According to Outlook 2014, Norwegian oil production will grow until 2020 due to the commissioning of recently prospected areas of the North Sea shelf, but it will then decrease until the end of the forecast period.

The Asian region will not be able to maintain production either – not even at the 2010 level of 400 million tonnes. In the Baseline Scenario oil production in the region will decrease to 340 million tonnes by 2040 (Table 1.8).

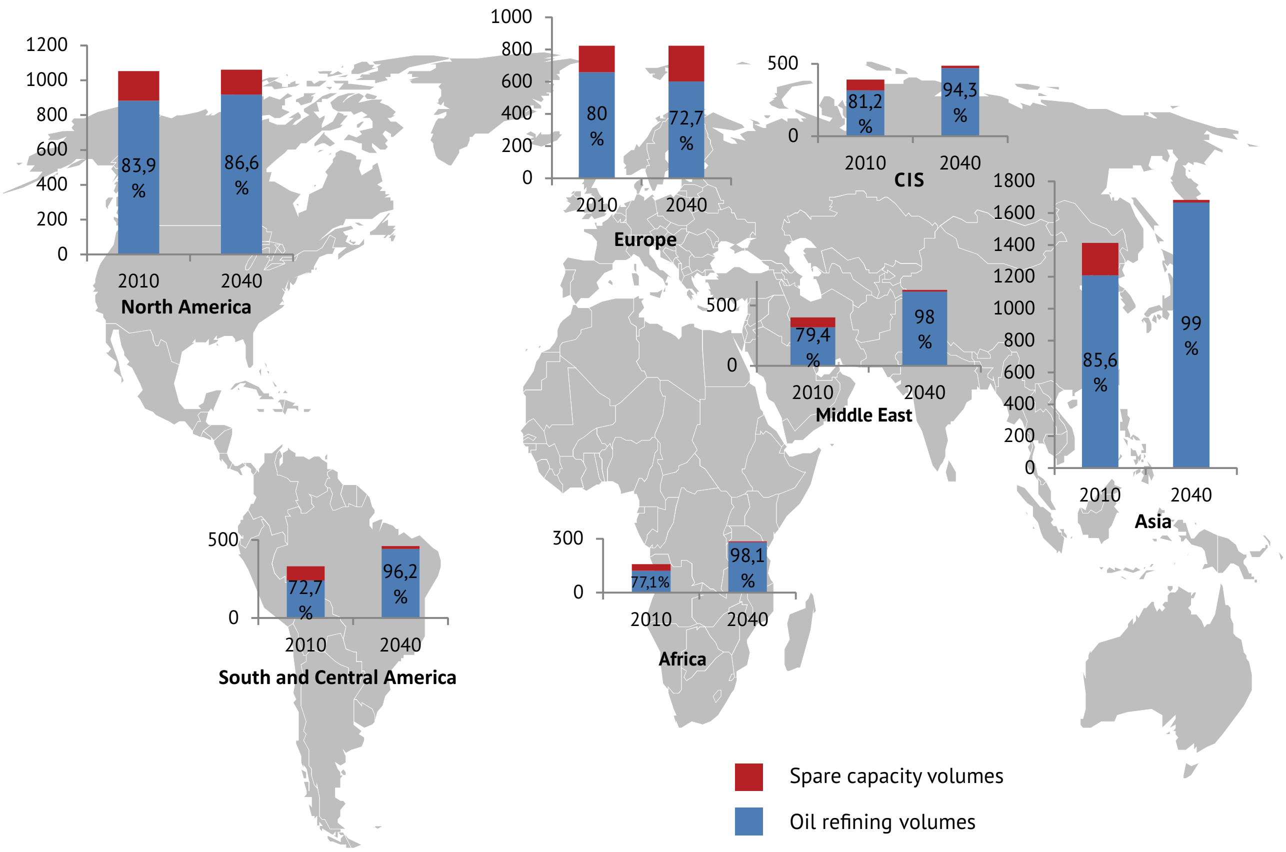
Table 1.8 – Oil production for regions and largest countries, Baseline Scenario, million tonnes

	2010	2015	2020	2025	2030	2035	2040
North America	**639**	**815**	**862**	**951**	**962**	**956**	**956**
Canada	160	191	194	281	343	357	360
Mexico	146	135	107	100	80	80	79
USA	333	488	562	570	539	519	516
South and Central America	**378**	**430**	**471**	**515**	**522**	**533**	**541**
Venezuela	146	156	156	161	165	166	167
Brazil	111	161	213	248	254	259	263
Ecuador	26	17	16	15	16	24	29
Others	95	96	86	91	88	85	81
Europe	**196**	**146**	**163**	**155**	**140**	**133**	**132**
Norway	99	81	98	96	83	80	79
Great Britain	63	41	38	36	36	33	32
Others	35	24	28	22	20	20	21
Former USSR	**665**	**681**	**673**	**672**	**683**	**698**	**712**
Russia	505	522	513	505	491	476	468
Kazakhstan	82	82	82	95	118	146	167
Azerbaijan	51	51	52	50	52	52	53
Others	28	25	26	22	23	23	25
Asia	**402**	**358**	**387**	**381**	**363**	**343**	**341**
China	203	190	221	205	194	176	177
India	41	43	41	37	36	31	30
Australia and New Zealand	25	24	24	27	28	31	34
Others	133	101	101	113	105	106	100
Middle East	**1217**	**1349**	**1466**	**1519**	**1643**	**1715**	**1755**
Iran	209	165	175	180	180	186	194
Iraq	122	247	289	296	369	389	391
Saudi Arabia	474	506	533	521	525	538	556
UAE	133	161	170	167	173	170	162
Others	280	270	300	355	397	431	452
Africa	**481**	**486**	**465**	**516**	**521**	**543**	**527**
Egypt	35	32	30	31	33	31	31
Libya	78	87	89	85	100	111	120
Nigeria	121	133	114	111	84	89	84
Angola	91	72	70	94	100	94	90
Others	156	162	161	194	204	218	203
OPEC	**1667**	**1843**	**1940**	**2013**	**2143**	**2242**	**2245**
OPEC's share, %	42	43	43	43	44	46	45
Non-OPEC	**2311**	**2421**	**2547**	**2695**	**2691**	**2679**	**2719**
World	**3978**	**4264**	**4487**	**4708**	**4834**	**4921**	**4964**

Source: ERI RAS

In the Baseline Scenario, the global oil industry will be adequately served by refining capacities, with a total growth from 4.5 billion tonnes in 2010 to 5.4 billion tonnes by 2040, and with the main growth in capacity occurring in the developing countries of Asia, the Middle East, and Africa. It is important to point out that it is in these regions in particular that there will be the greatest increase in refinery utilization, which will reach around 98 per cent. The same acute situation in relation to free refining capacity may also arise in South and Central America by the end of the forecast period (Figure 1.40).

Figure 1.40 – Current and predicted capacities of oil refineries (million tonnes) and their level of utilization (%)



Source: ERI RAS

The forecast structure of global oil refining capacity leads us to expect construction of new refineries in the developing countries of Asia, while refineries are gradually retired in Europe.

The intense utilization of oil refineries will probably lead to the announcement of plans for the construction of new refineries in these developing countries by the middle of the forecast period. At the same time, the decline in utilization of refineries in Europe is likely to lead to the decommissioning of some plants by 2020–5.

International Trade

In the Baseline Scenario, there will be significant changes in the inter-regional trade of crude oil by 2040 compared with 2010. Major shifts are predicted in North America, which will go from being a net importer of crude oil to a net exporter by the end of the period under review (due to the production of unconventional oil). By 2040, according to the Baseline Scenario, oil deliveries to the region will only come from Africa (primarily Nigeria and Angola) and South America (Venezuela and Brazil), while the region will export to countries in Asia–Pacific.

A significant reduction in deliveries of crude oil to Europe (compared with 2010) is also expected: from 600 million tonnes in 2010 to 500 million tonnes in 2040, due to falling demand in the region, low profit margins, and declining volumes of European oil refining capacity. The most significant impact of reduced export niches in Europe will be on suppliers in the CIS (the supply of crude oil from these countries will fall by more than 120 million tonnes by 2040 compared with 2010), while other suppliers (Africa, the Middle East, and South America) will be able to increase their exports to the European market.

In 2040 over a half of inter-regional crude oil deliveries will be to the Asia–Pacific region.

Asia–Pacific will be a key regional importer in the forecast period. Demand for crude oil imports will increase by 350 million tonnes compared with 2010, and all key producers will focus their efforts on capturing this market. The CIS countries, losing their export niche in the European market, will increase supplies to Asia–Pacific (primarily to China and other countries in north-east Asia) from 75 million tonnes in 2010 to 100 million tonnes in 2040. Countries in the Middle East are expected to become key suppliers to the region, and will provide up to 73 per cent of crude oil deliveries to Asia–Pacific (or more than 960 million tonnes in absolute terms) by 2040 (Tables 1.9 and 1.10).

In the Baseline Scenario, the dependence on imported oil in all key importing regions, except North America, will continue to increase. As of 2020, due to increased domestic production, North America will be able to do without crude oil imports from other regions, although the key country in the region – the USA – will depend on its neighbour, Canada, for more than a third of its supplies right up to 2040 (Table 1.11).

European dependence on crude oil imports will drop slightly in the period to 2020, though this will not be due to progress in energy conservation, but to the growth of production in Norway resulting from the commissioning of new fields and the expected decline in European refining. Overall, by the end of the forecast period, despite the stagnating demand for oil, Europe will only increase its dependence on imports from 73 per cent of total crude oil consumption in 2010 to 77 per cent by 2040.

Table 1.9 – Inter-regional crude oil trade flows in 2010, million tonnes, Baseline Scenario

		Destination						
		North America	South America	Europe	CIS	Middle East	Africa	Asia–Pacific
Source	North America	0	38	25	2	0	3	19
	South America	115	0	16	0	0	1	44
	Europe	49	5	0	8	2	15	13
	CIS	39	1	295	0	0	1	75
	Middle East	91	6	117	0	0	15	708
	Africa	125	17	129	0	1	0	112
	Asia Pacific	11	11	15	0	0	6	0

Sources: compiled by ERI RAS based on IEA, BP data

Table 1.10 – Inter-regional crude oil trade flows in 2040, million tonnes, Baseline Scenario

		Destination						
		North America	South America	Europe	CIS	Middle East	Africa	Asia–Pacific
Source	North America	0	0	0	0	0	0	180
	South America	44	0	53	0	0	0	0
	Europe	0	0	0	7	0	20	10
	CIS	0	0	173	0	0	0	101
	Middle East	0	0	118	0	0	47	961
	Africa	93	0	155	0	0	0	71
	Asia Pacific	0	0	0	0	0	0	0

Source: ERI RAS

Table 1.11 – Share of net oil imports in total oil consumption in key importing regions, Baseline Scenario

	2010	2015	2020	2025	2030	2035	2040
North America	38%	16%	4%	0	0	0	0
USA	61%	36%	29%	30%	35%	35%	35%
Europe	73%	72%	68%	72%	75%	77%	77%
Asia	69%	75%	75%	76%	78%	79%	80%
China	54%	60%	63%	65%	69%	71%	71%
India	74%	81%	82%	84%	85%	87%	87%
Japan	99%	100%	100%	100%	100%	100%	100%

Source: ERI RAS

High import dependence will continue in the Asian region, with supplies from other regions providing up to 80 per cent of total oil consumption in Asia–Pacific. Due to the inadequacy of raw material security in China and India (the region's two largest economies) high projected demand for oil will lead to an increase dependence on imports in these countries. For example, in China up to 71 per cent of demand will be met by oil supplies from abroad by 2040, while in India the figure will exceed 87 per cent.

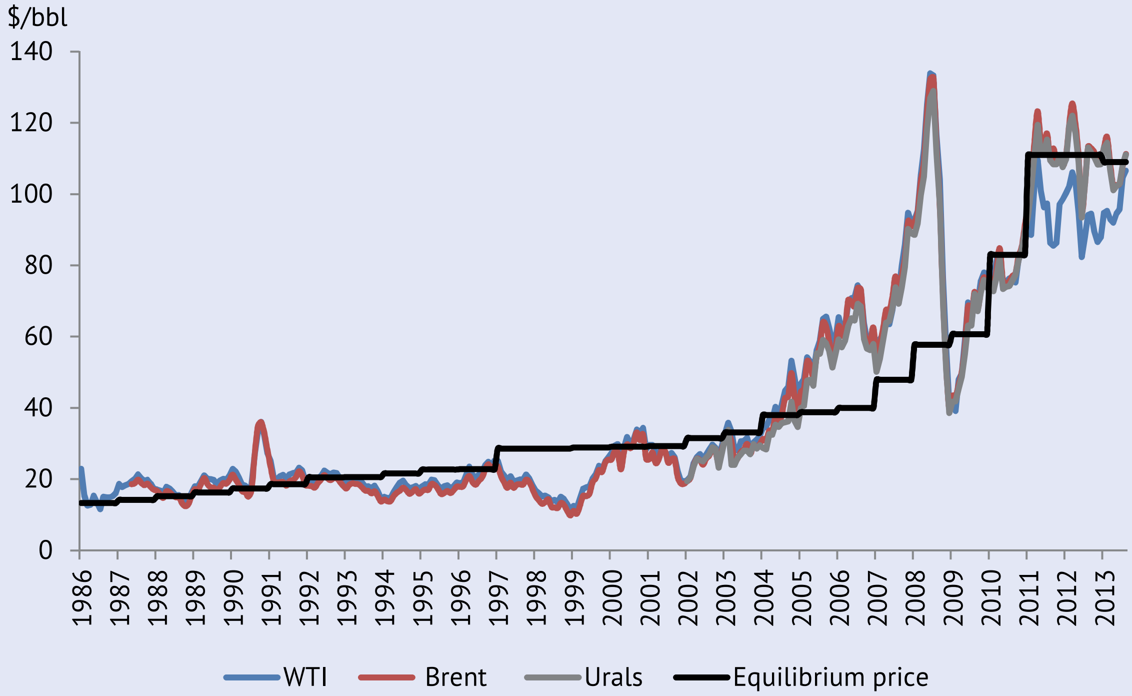
Oil equilibrium prices[19]

In the Baseline Scenario, oil prices are not expected to differ significantly from the level specified in Outlook 2013. After the relatively stable average price of $111 a barrel was established in the global market in 2011–12, the average annual price of oil had already dropped to $108 a barrel by 2013, under the influence of growing shale production in the USA; it is expected that this trend for declining prices will continue in the market for some time.

Oil prices: five years of predictability after the crises

Oil prices are highly volatile and depend to a large extent on the situation prevailing in the financial markets. As was noted in Outlook 2013, fundamental factors started determining oil prices only relatively recently; a strong correlation between equilibrium and market prices to average values has been observed only since the early 2000s. Nevertheless, in the crisis of 2008 oil prices broke the record for intra-annual fluctuations, first rising to a level of practically $140 a barrel and then suddenly collapsing to $40 (Figure 1.41).

Figure 1.41 – Relationship of market and equilibrium oil prices 1986–2013



Source: ERI RAS

After the fluctuations experienced in the crisis – caused exclusively by the general instability of the financial system in the USA and Western Europe – oil prices, especially the Brent and Urals benchmarks, stabilized while WTI prices, influenced by the growth of shale oil production, decreased relative to prices for other varieties and global equilibrium prices. It is important to note that the stabilization of oil prices on the global market is largely due to a combination of two factors:

1) disclosure of the real costs of production in key countries and regions on key projects, in particular the supply curve of oil began to be regularly published by the IEA, cost behaviours are displayed CERA in their UCCI and UOCI indexes, and the largest investment bank, Goldman Sachs, began to publish annual information on breakeven prices of key new oil projects. All this information flow allowed financial investors to be more precisely guided in determining the prices needed for the consistent supply of oil in the real economy;

19 Equilibrium price – the price at which production from traditional and non-traditional fields and commercially viable proposals for oil substitution will satisfy the demand for liquid fuels (actually – the dynamics of the points of intersection of demand and supply curves for liquid fuels).

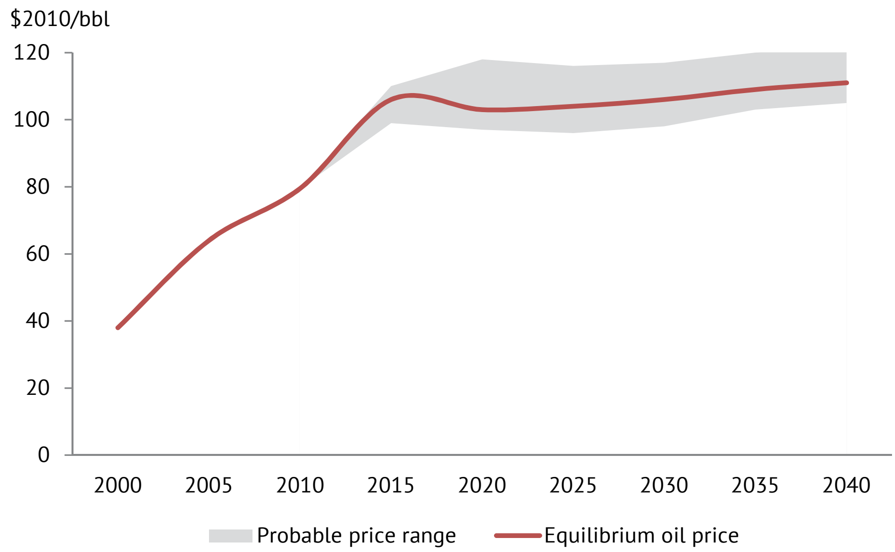
2) limitation of the number of futures positions which could be opened in the USA futures market; this resulted in a substantial reduction in the impact on oil prices of various factors of a speculative nature.

Stabilization of the financial markets meant that even the Arab Spring in 2011, and a serious reduction of production in Libya, prevented the panic on the stock market from unravelling oil prices as had happened in 2008. The maximum price for the entire period was $123 a barrel for Brent, and this price rise was maintained for only a very short period of time. Looking forward, the modern, adequately stable, financial system gives us every reason to assume that oil prices on the world market will fluctuate in a relatively narrow corridor around the equilibrium price calculated in Forecast 2014.

As in Outlook 2013, this study does not forecast the market price of oil, which is simultaneously influenced by many short-term factors, but the equilibrium prices, which are determined by the balance of supply and demand in the oil market. Analysis shows that most oil (more than 4 billion tonnes), can be obtained even at prices below $90 a barrel. This represents a significant part not only of conventional oil and NGL, but also US shale and tight oil plays and Canadian tar sands. However, this 4 billion tonnes is clearly insufficient to cover the growing future demand for oil, forcing a move towards deposits that are more difficult and expensive to extract, in particular those that are found in ultra-deep-water offshore fields, and high viscosity oil. An increase in oil prices from $90 to $105 a barrel[20] will allow an increase in production of 700 million tonnes by 2040, but this will still not permit a large-scale entry into the market for biofuels, or new oil extraction projects – particularly not those in remote offshore locations and at extremely low temperatures. Because of the high costs involved, the entry of such production capacities as these onto the market would imply an increase in oil price to a level of $110 a barrel by 2040.

In the Baseline Scenario, it is expected that equilibrium prices will decline up to 2020 (under the influence of the growth in extraction of relatively inexpensive shale) reaching a level of $103 a barrel. They will then begin to recover as a result of an increase in the extraction costs of shale projects and other deposits, reaching a level of $111 a barrel by the end of the forecast period (Figure 1.42).

Figure 1.42 – Predicted oil equilibrium prices, Baseline Scenario

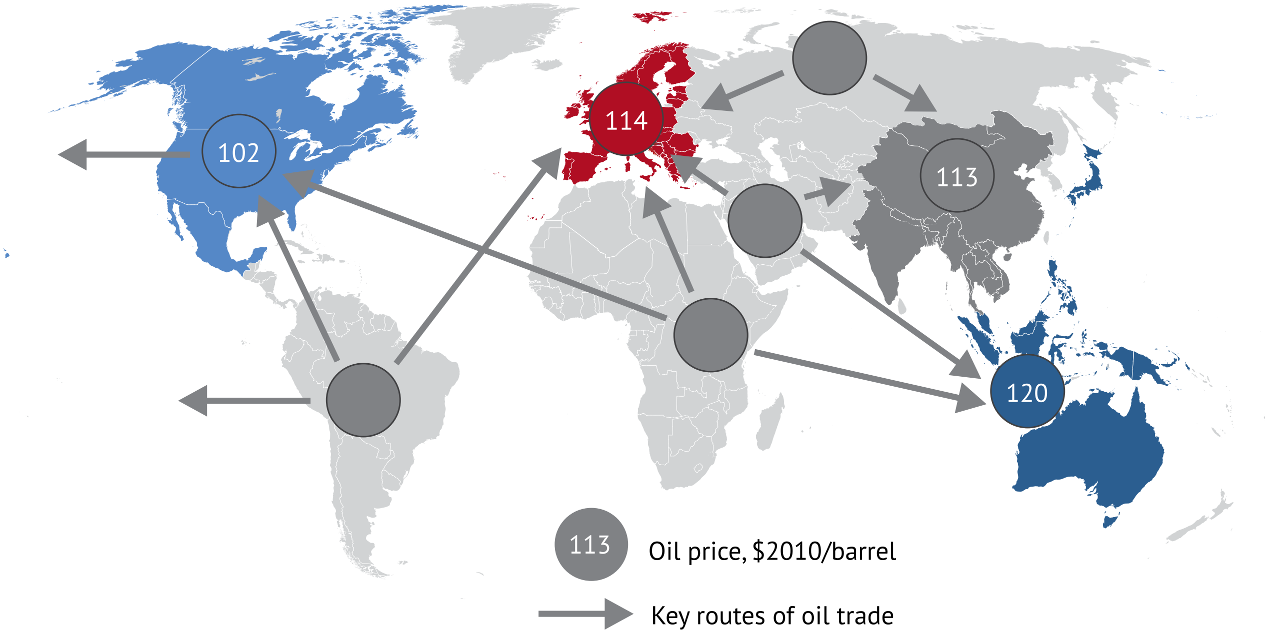


Source: ERI RAS

20 To meet the forecast demand in the long term, the implementation of high-cost oil deposits as well as biofuels would be required, which would mean a rise in oil prices to $110/barrel by 2040.

The nascent regionalization of markets – due to the structure of world trade, the growth of oil production in the USA, and North America's 'self-sufficiency' in oil feedstock – could, in the long term, also lead to a significant regionalization of oil prices, which explains the rather wide limits to the corridor for possible deviations in oil prices from their equilibrium values. But it is also important to understand that, despite the very significant possible fluctuations in oil prices around the 'global average' level, the contemporary contractual structure of the oil market and the close financial relationship between the existing international exchanges will not allow oil prices in different regions of the world to differ wildly, as happens with gas prices (Figure 1.43).

Figure 1.43 – Equilibrium oil prices in different regions, Baseline Scenario



Source: ERI RAS

The nascent regionalization of the global crude oil market could lead to markedly different oil prices in different regions of the world, with the highest prices being in developed Asia.

The lowest prices will come about on the North American market, due to the saturation of this particular regional market with affordable volumes of shale oil; moreover, with North America turning away from imports, oil prices will fall to ever lower levels, and will actually define the lower extreme of the global index grades. It is important to note that even retrospectively one can see a decline in oil prices in the North American market compared, for example, with the European market – with a differential between WTI and Brent crude oil prices in 2012–13 of more than $ 10 a barrel.

According to the Baseline Scenario, prices in all other consumer markets would exceed the equilibrium world price. Therefore in Europe, where the leading suppliers will be Norway, Russia, and Kazakhstan (total shipments of these three countries by 2040 is estimated at 240 million tonnes, or 48 per cent of total European oil imports), oil prices will be determined by the costs of ensuring continuity of production in these countries, and will reach at least $114 a barrel. The only way for Europe to get cheaper oil will be to switch to deliveries from the Middle East and North Africa, which will be quite difficult, not only in terms of energy security, but also because Europe would have to compete with the premium Asian markets for this oil.

Prices in the Asian market are hardly likely to be uniform. In Asia, two major consumer centres are forming to determine pricing: Singapore, which is likely to remain a key trading platform for the island countries of Asia and Australasia; and China, which has all the prerequisites to become the largest centre for determining pricing for mainland Asia. The Asian mainland market will be saturated with crude oil at prices that are lower than those in the European market due to the reorientation (from West to East) of exports flows from the CIS countries, as well as the significant capacity of the region's largest markets (the Indian and Chinese markets) which can provide a decent profit for the countries of the Middle East and Africa (because of relatively high prices and the enormous volume of deliveries). We should also not forget that the major Chinese companies have been actively pursuing expansion into foreign markets for some time; this, in the long term, will allow China to saturate the market with its own oil (produced by Chinese companies abroad) at prices lower than those that could be created by the influence of market factors alone in the region.

The highest prices relative to the global average will come about in the Asian non-mainland market, a relatively small market compared to Europe or the Asian mainland and, moreover, the most remote from the key centres of oil production. In fact, countries in this region will find themselves in the position of being 'low-priority consumers', forced to gather the leftovers from the global oil market at any affordable price.

The players' positions

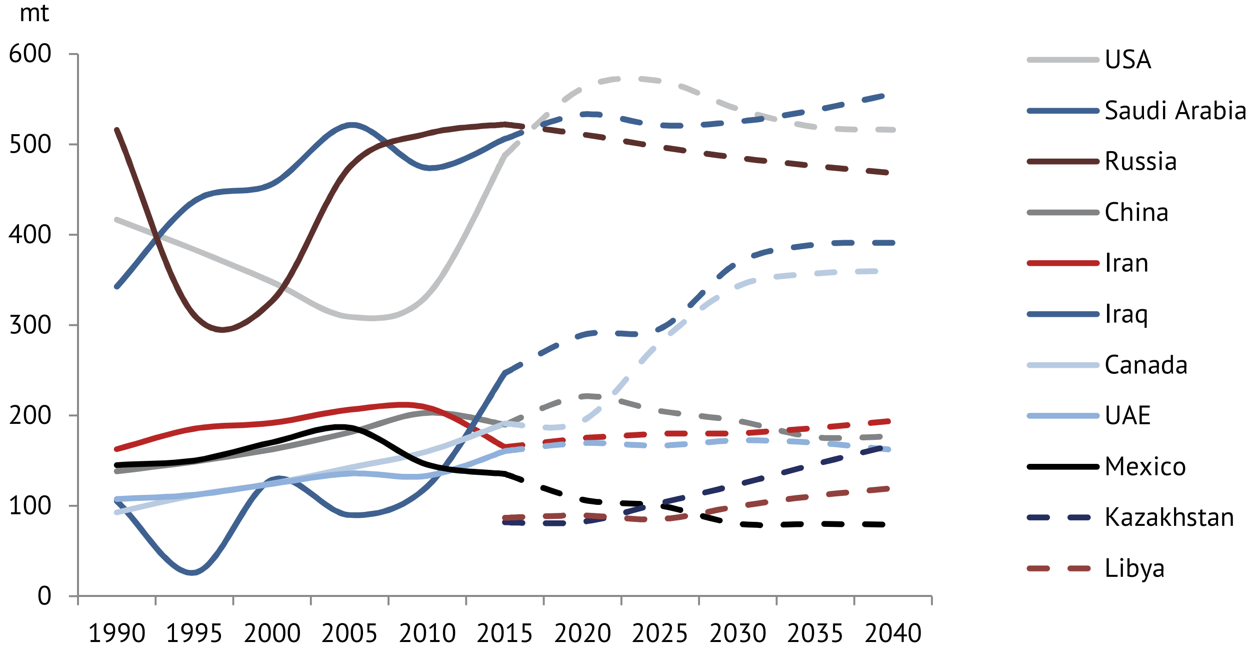
As far as the positions of the key players in the oil market to 2040 are concerned, there are not expected to be any significant shifts in the status quo, with Saudi Arabia, Russia, and the USA retaining the main role as producers, and the USA and China as consumers

Between 1990 and 2010, the largest oil producers could be divided into two groups:

- *the super producers,* of which there were three – Russia, Saudi Arabia, and the USA (Figure 1.44); their production levels at that time fluctuating between 310 and 520 million tonnes;
- *the major producers,* which included China, Iran, Iraq, Canada, the UAE, and Mexico; none of whom have ever produced more than 210 million tonnes.

In the forecast period to 2040 no significant changes will occur in the super producers group. The countries that make up the group do not change, the volume of production is in the range of 450–550 million tonnes.

Figure 1.44 – The world's major oil producing countries, Baseline Scenario



Source: ERI RAS

By 2040 the group of major producers undergoes significant changes. First of all, an intermediate group emerges consisting of two countries – Canada and Iraq – with respective levels of production of 360 and 390 million tonnes by 2040, which comes close to the super producers group. Secondly, the largest group of major producers (with production levels of 100–200 million tonnes by the end of the forecast period in the Baseline Scenario) will not now include Mexico, but will include Libya and Kazakhstan, with production levels of 120 and 165 million tonnes respectively.

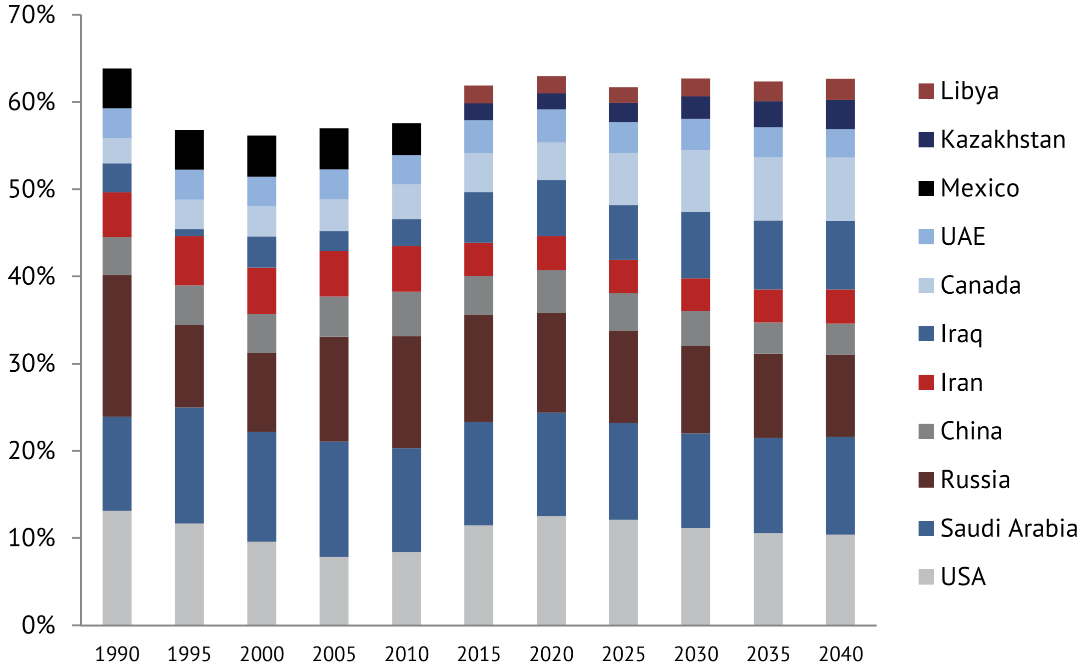
Over the past 20 years, the share represented by the largest oil-producing countries has not fallen below 55 per cent of global oil production, being at its highest in 1990 at 64 per cent (Figure 1.45), while the Herfindahl–Hirschman Index concentration was 650, indicating a low degree of concentration in the market. In the forecast period, their share will be stable and by 2040 will represent 63 per cent, with a decrease in the Herfindahl–Hirschman Index to 530.

As for demand, since 2005 the following have clearly stood out:

- *the super consumers* – the USA and China. In the Baseline Scenario these countries retain their positions until the end of the forecast period, while China will draw level, in terms of consumption, with the USA (Figure 1.46);

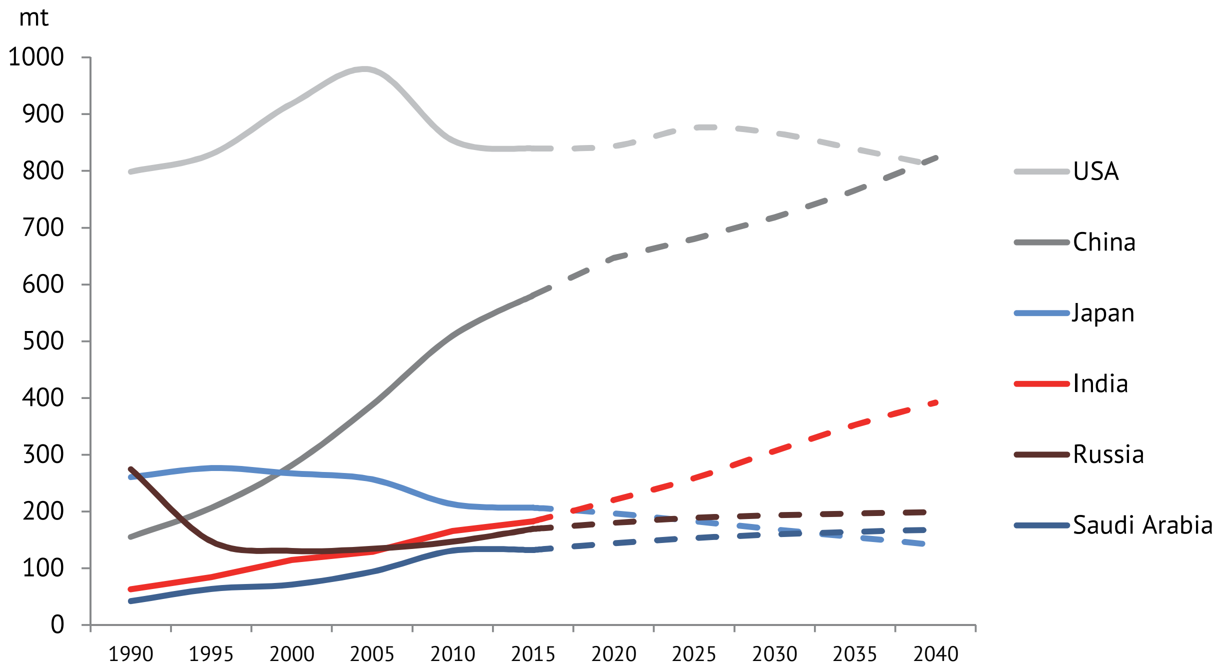
- *the major consumers* – India, Japan, Russia, and Saudi Arabia. In these countries, demand is much lower than that of the super consumers. By 2040 India, the most significant representative of this group, will have a level of demand that is half that of China or the USA.

Figure 1.45 – Major oil producing countries' share of global production, Baseline Scenario



Source: ERI RAS

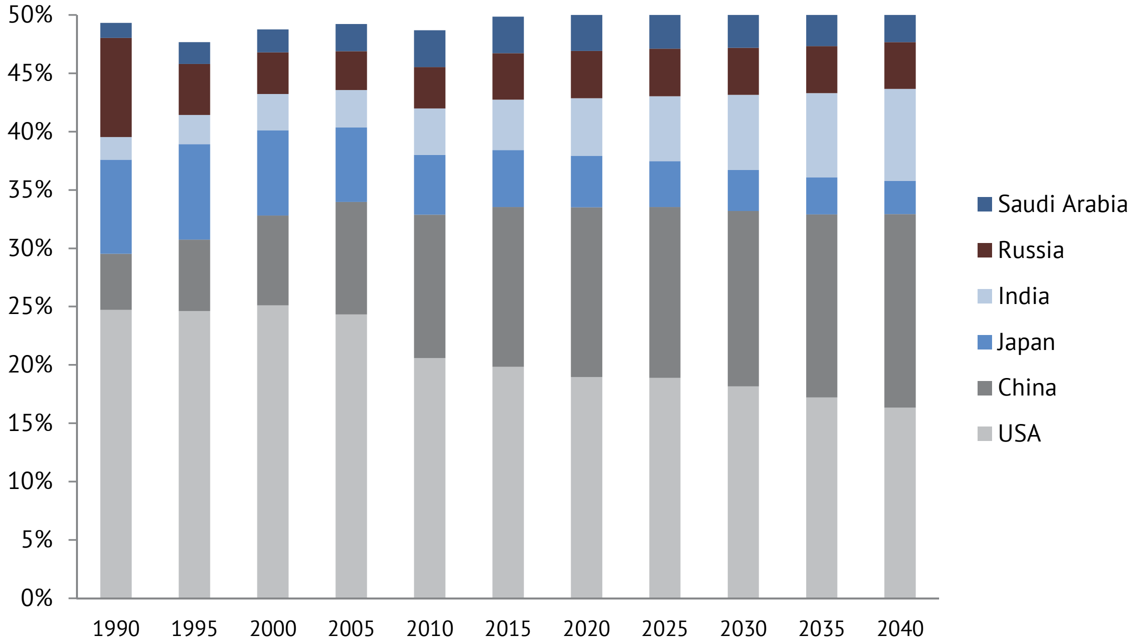
Figure 1.46 – The world's major oil consumers, Baseline Scenario



Source: ERI RAS

The six major oil consumers' share of global demand is also quite stable (Figure 1.47), in the range of 49–51 per cent.

Figure 1.47 – Share of major oil consuming countries in global demand, Baseline Scenario



Source: ERI RAS

In fact, in terms of the most important players in the oil market, no revolutionary changes are expected before 2040; this indicates the stability and maturity of the oil market, together with its significant systemic consistency.

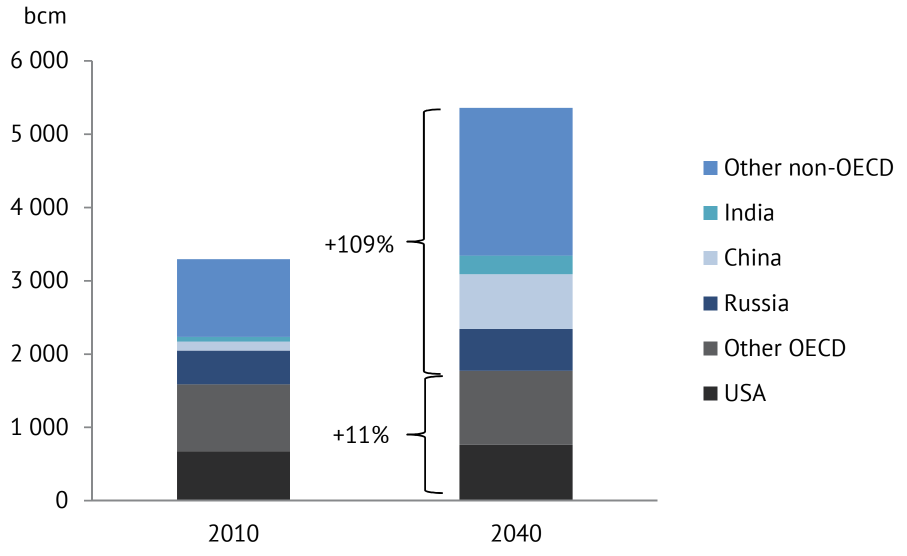
The Gas fuel market

Demand

In the period 1980–2010 gas actively gained its niche in the market, and demand for it has grown on average by 2.7 per cent per year. A forecast of the future dynamics of gas demand was obtained by a mutual agreement of the gas capacity figures of individual economies' GDP and primary energy consumption, with subsequent optimization through mutual substitution of competing fuel types in power generation, and a corresponding adjustment to country forecasts. The forecast obtained by this method for the next 30 years showed markedly slower growth, at an average of 1.6 per cent per year; nonetheless this means that gas can be considered the fastest growing fossil fuel.

By 2040 in the Baseline Scenario global gas demand will have grown by more than 60 per cent compared with 2010, reaching 5.34 trillion cubic metres (Figure 1.48), which is virtually identical to last year's forecast. Higher figures for GDP have been offset by supply-side constraints and higher prices, which in turn have inhibited the growth of consumption. We continue to assert that the next quarter century will be a 'gas era', though not for all regions of the world.

Figure 1.48 – Regions and major countries gas demand by in 2010 and 2040, Baseline Scenario



Source: ERI RAS

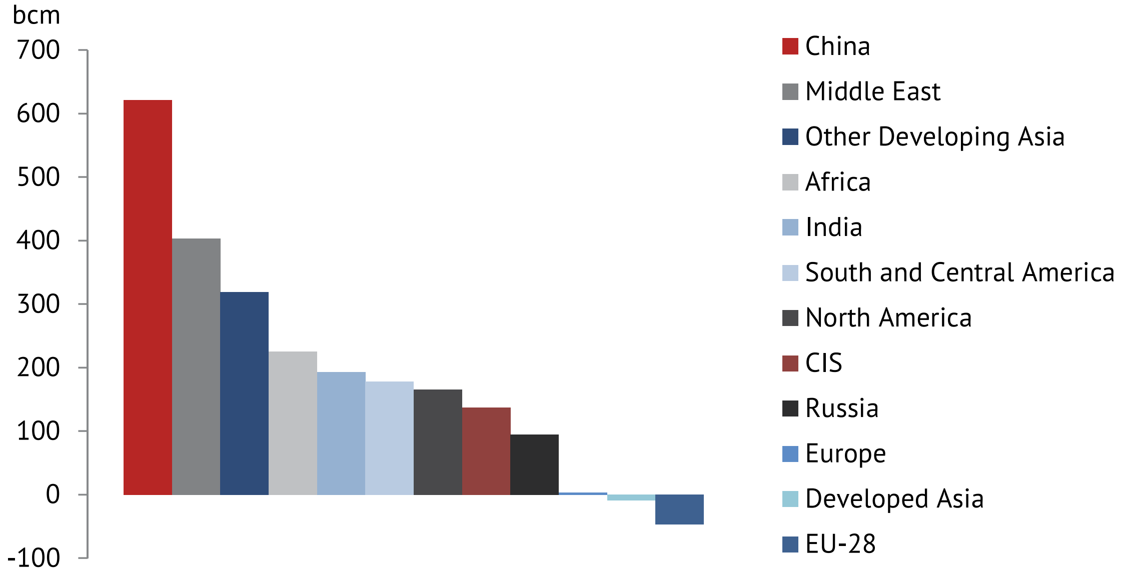
Gas demand will grow several-fold in developing countries, while moderate growth in demand is predicted in North America, and in Europe and some CIS countries there will be a deliberate reduction. The driver of global demand will be China, with a six fold increase in its gas consumption for the period until 2040.

Growth in gas consumption for the period to 2040 is mainly provided by the developing countries, whose demand will increase by 90 per cent over 30 years. In some regions, the increased demand for gas is dramatic in nature, with China alone increasing its consumption by 620 bcm (Figure 1.49) – this figure is more than such major gas-consuming markets as Europe or Russia consume now. Other developing countries in Asia and the Middle East, where gas demand will double by 2040, also show impressive growth, as does Africa, where it will triple.

The developed countries show far more moderate growth and, moreover, in Europe and especially in the developed countries of Asia, there is a net reduction in consumption levels. This is seen particularly clearly in the European Union, which by 2040 will have reduced its consumption of gas by almost 50 bcm as a result of both sluggish economic growth against a backdrop of active energy conservation and, to a greater extent, of policies aimed at the promotion of alternative fuels. Outlook 2014 expects that the EU will use all the tools of state energy policy to reduce the share of gas in its energy mix. Not just regulation, but also inter-fuel competition will contribute to reducing demand in Europe, where gas-fired generation is unattractive when there are high gas prices, lower prices for steam coal and CO_2, as well as subsidized renewable energy resources.

The situation is radically different in North America which will, due to the availability of affordable local resources, see an increase in gas consumption of 20 per cent by 2040. Moreover, gas will expand its presence not only in electricity generation but also in the transport sector and as a feedstock for the chemical industry and gas processing.

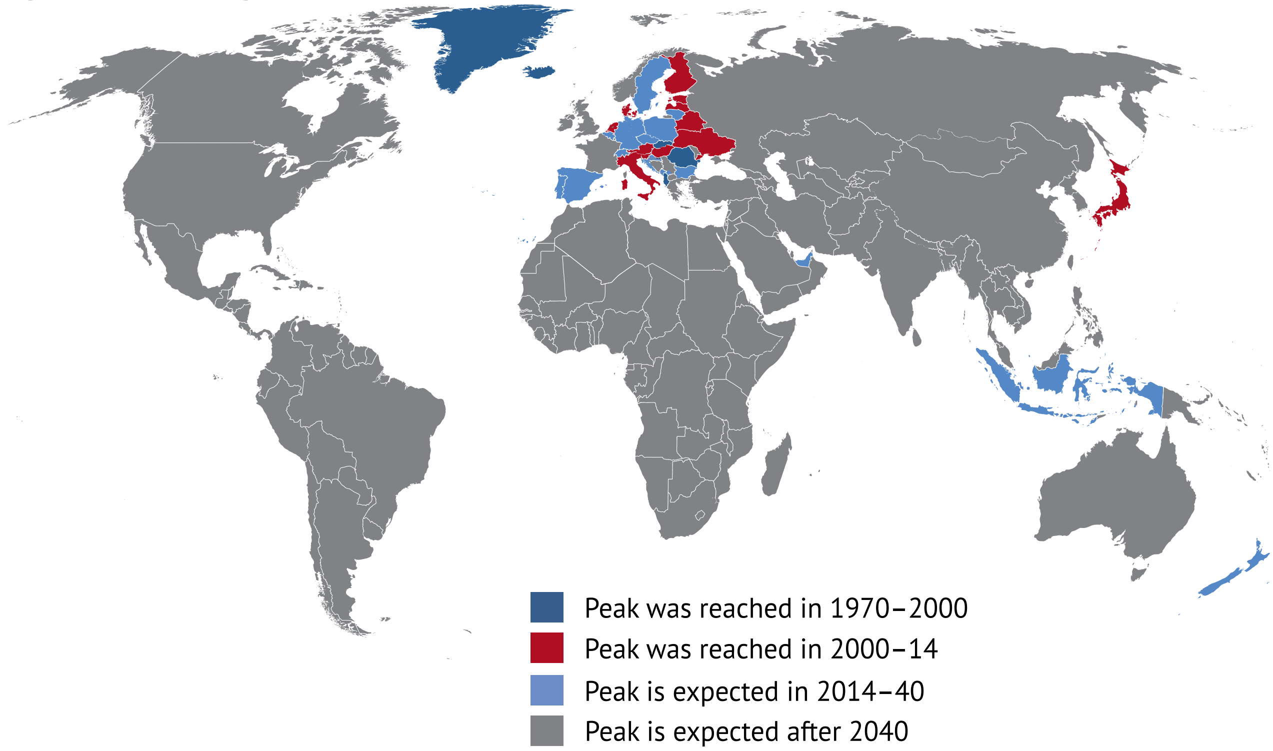
Figure 1.49 – Regions' and major countries' gas demand growth 2010–40, Baseline Scenario



Source: ERI RAS

Unlike the oil market, it is still difficult to see peak demand for gas even for the world's largest economies in the foreseeable future, which gives us every reason to call the twenty-first century the Age of Gas. Only a small number of countries, mainly long-term EU members (Austria, Belgium, France, Germany, Italy, the UK, and the Netherlands) and a number of CIS countries (Ukraine, Belarus, Armenia, and Georgia) have reached peak gas demand so far (Figure 1.50).

Figure 1.50 – Peak gas demand by country



Source: ERI RAS

Due to energy saving measures, many developed countries – the USA and Canada and most European countries – will reach peak gas demand in the forecast period. In the Asia–Pacific region, South Korea and Japan will begin to reduce their demand for gas by the middle of the forecast period (demand dynamics will depend to a large extent on decisions made about the future fate of nuclear energy). The rest of the world will increase gas consumption.

The main demand growth will occur in the developing countries of Asia (Figure 1.51), whose share in global demand will grow from 7 per cent to 25 per cent over the period being examined. China, with its six-fold increase in demand (which is not an exaggeration) will be the main driver of the global gas market, providing 14 per cent of global demand by 2040 and occupying second place after the USA for gas market capacity. India and Brazil will quadruple their gas consumption, while Africa and the Middle East will respectively triple and double theirs.

High growth rates are predicted for south-east Asia, with growing demand for gas here coming, above all, from electricity generation. The fight against growing CO_2 emissions, which is becoming increasingly important in this 'coal' region, is a major incentive for the expansion in gas use. However, there is a danger that the developing countries of Asia could replicate the experience of Europe. The most important issue for countries that do not have their own gas reserves, and that are forced to import increasing volumes, is how competitive this imported gas will be in power generation. The increasing expense of export projects targeting Asia–Pacific may undermine the attractiveness of gas and lead to a partial loss of demand in this region.

Table 1.12 – Regions' and major countries' gas demand, Baseline Scenario, bcm

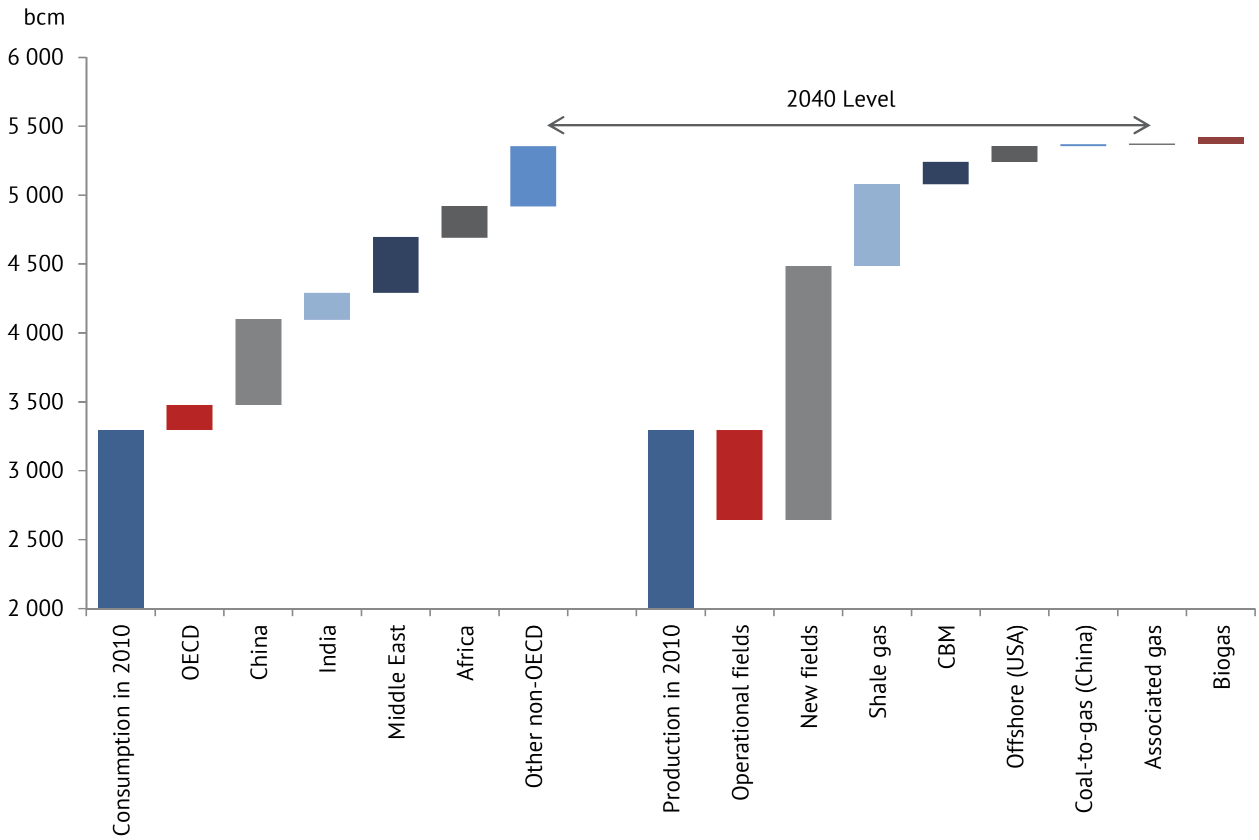
	Gas demand, bcm							Growth rate, %		
	2010	2015	2020	2025	2030	2035	2040	2010–20	2010–30	2010–40
North America	**833**	**914**	**966**	**942**	**960**	**1000**	**998**	**1.5%**	**0.7%**	**0.6%**
USA	675	738	772	731	738	769	762	1.4%	0.4%	0.4%
Europe	**594**	**560**	**579**	**602**	**596**	**605**	**598**	**-0.2%**	**0.0%**	**0.0%**
EU–28	543	498	507	529	513	508	496	-0.7%	-0.3%	-0.3%
Developed Asia	**178**	**199**	**176**	**180**	**183**	**177**	**169**	**-0.1%**	**0.1%**	**-0.2%**
Japan	99	123	91	87	83	80	69	-0.9%	-0.9%	-1.2%
CIS	**657**	**665**	**707**	**727**	**748**	**767**	**794**	**0.7%**	**0.7%**	**0.6%**
Russia	459	476	507	522	537	544	554	1.0%	0.8%	0.6%
Developing Asia	**390**	**576**	**696**	**869**	**1023**	**1143**	**1330**	**6.0%**	**4.9%**	**4.2%**
China	125	271	365	486	587	676	746	11.3%	8.0%	6.1%
India	62	93	122	146	169	205	255	7.0%	5.1%	4.8%
South and Central America	**154**	**169**	**188**	**223**	**257**	**292**	**332**	**2.0%**	**2.6%**	**2.6%**
Brazil	28	33	34	53	72	91	113	2.1%	4.9%	4.8%
Middle East	**385**	**465**	**531**	**591**	**657**	**721**	**788**	**3.3%**	**2.7%**	**2.4%**
Africa	**105**	**125**	**158**	**197**	**237**	**281**	**331**	**4.2%**	**4.2%**	**3.9%**
World	**3295**	**3668**	**4011**	**4329**	**4661**	**5027**	**5340**	**2.0%**	**1.7%**	**1.6%**

Source: ERI RAS

Supply

Unlike the oil market, where unconventional oil will play the main role in meeting additional energy demand, the gas industry looks more conventional. In the Baseline Scenario, growth in global gas demand will be mainly met by the development of new conventional gas fields (Figure 1.51).

Figure 1.51 – Gas supply and demand balance in 2040, Baseline Scenario

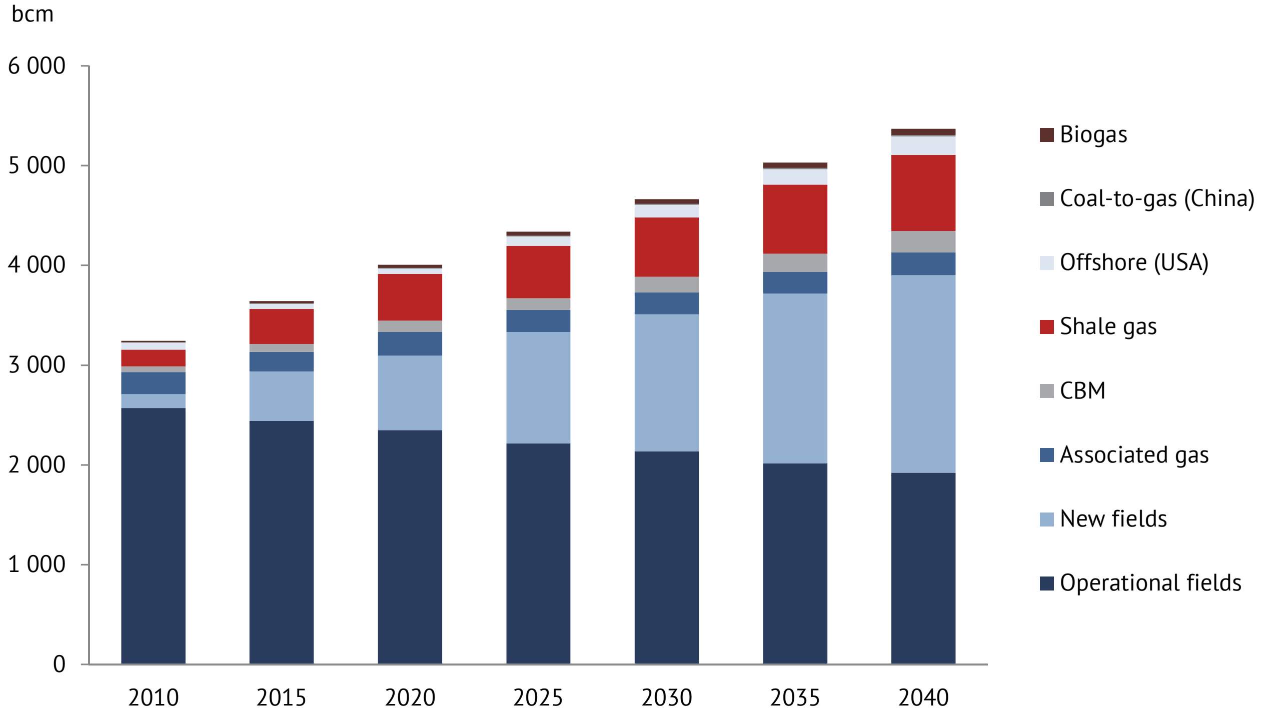


Source: ERI RAS

By 2040, about 80 per cent of the supply of gas will be provided by conventional gas deposits (compared with 93 per cent in 2010 – Figure 1.52). At the same time, for the whole duration of the period we are examining, extraction of unconventional gas will expand at an ever-greater rate, accounting for almost 20 per cent of global gas supply by 2040 (shale gas: 14 per cent; coalbed methane: 4 per cent; and biogas: 1 per cent).

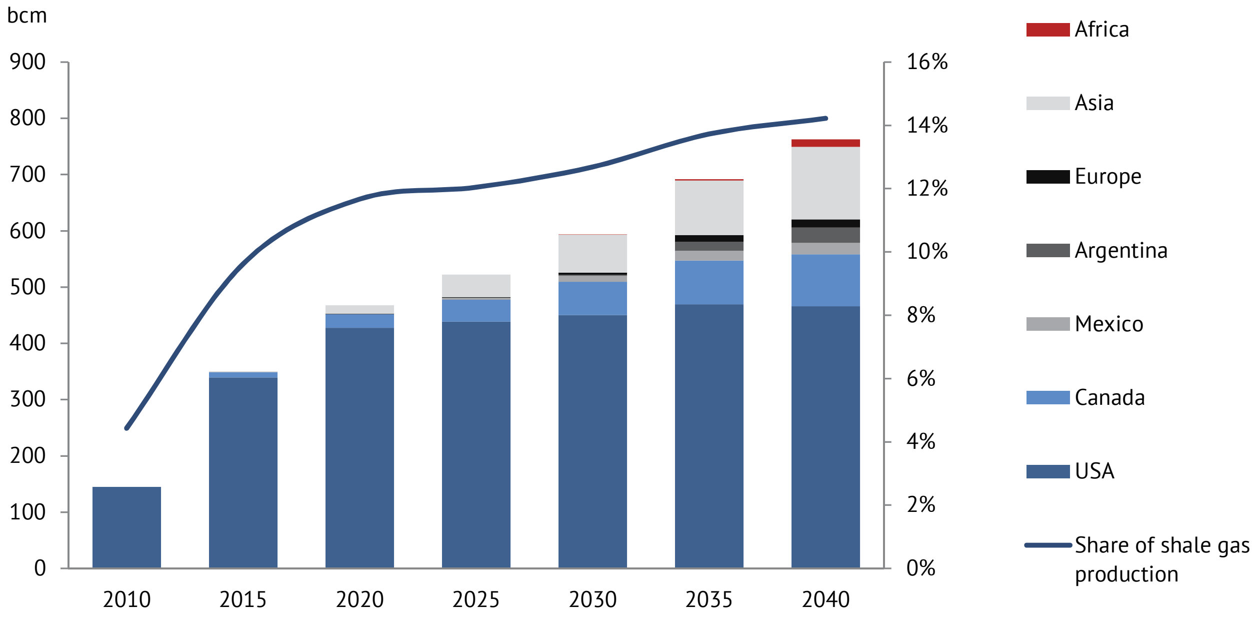
North America will continue to dominate global shale gas extraction; the USA will already have practically stabilized production by 2025, while Canada and Mexico will significantly increase their volumes of shale gas production after 2025 (Figure 1.53). After 2025, significant growth in shale gas production is also predicted in the Asian region, primarily in China (where technological issues should have been resolved by that time, and which will be responsible for up to 17 per cent of global shale gas production by the end of the period in question). In other countries – Argentina, India, South Africa, and Europe – shale gas extraction by 2040 will not exceed 7 per cent of global production, this is due not only to geological and economic factors, but also to regulatory restrictions.

Figure 1.52 – Gas production by type, Baseline Scenario



Source: ERI RAS

Figure 1.53 – Regions'and major countries' shale gas production, Baseline Scenario

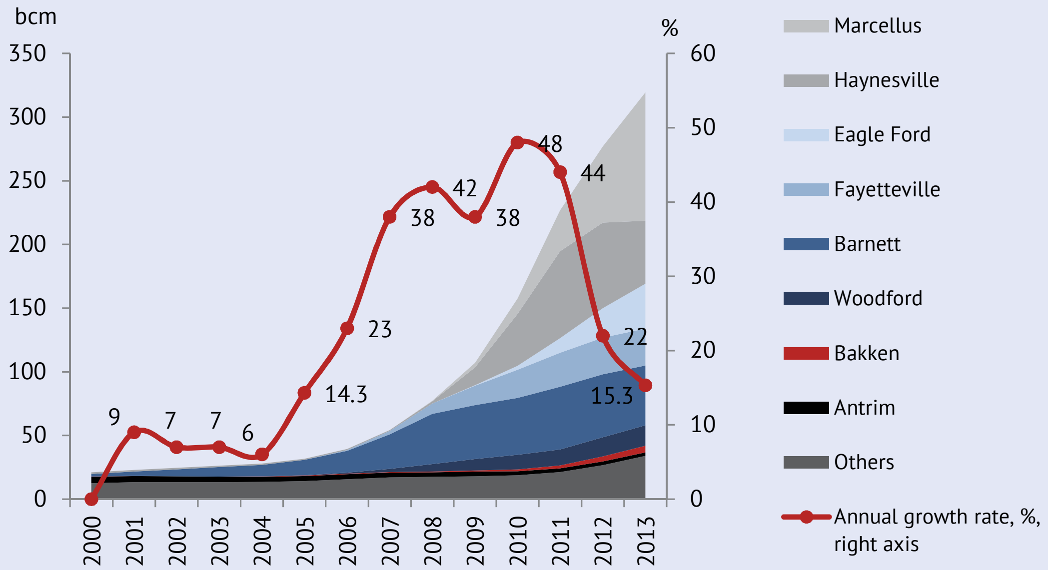


Source: ERI RAS

Shale gas production in North America: contradictory tendencies

The future dynamics of shale gas extraction in the USA have provoked much discussion. Conventional gas production peaked here in 2000, and the entire production growth witnessed in recent years has been provided by unconventional gas. However, the 'shale revolution', which has become a key event of the last decade in the gas industry and has caused much discussion and many changes in world market conditions, is now showing a contradictory dynamic. The total volume of shale gas extraction in 2013 rose to a record 320 bcm, but the pace of growth has slowed significantly in the last three years (Figure 1.54). Of the large plays, production at Barnett was reduced in 2013 by 5 per cent after two years at maximum level, while results at Haynesville for 2013 showed a drop of 28 per cent after peak production of 68 bcm in 2011. Two other plays, Woodford and Fayetteville, are virtually stagnant. In the end the main increase in shale gas production in the USA has been provided by two of the newest plays – Eagle Ford and, for the most part, Marcellus.

Figure 1.54 – Shale gas production of main USA plays, bcm, and annual growth, %



Source: ERI RAS

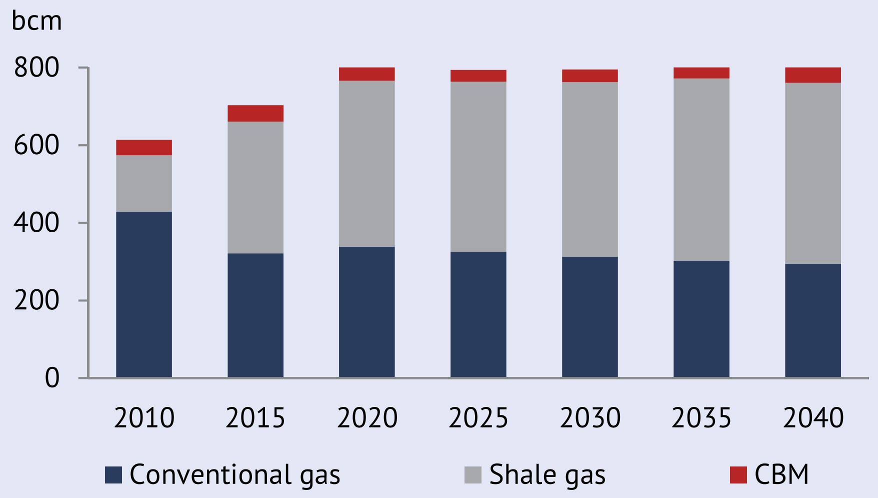
There are three possible explanations for this dynamic:

1. Shale deposits have a short life cycle, with the productivity of new wells falling sharply in the first year and practically to zero in the course of three years, with constant drilling of new wells being required to maintain production.
2. The company may be constraining production under conditions where the domestic market is overcrowded and prices are low, and extraction levels will rise again by the time exports commence.
3. The economics of shale gas extraction in the current climate of low prices are such that operators will shift their attention to the liquid hydrocarbon sector and reduce drilling new wells for 'dry' gas.

Developments in the next two to three years should be enough to show which of the explanations is true, although it seems that all three are partly true. In any case, it seems that this segment of the gas business will be subject to sharp fluctuations – the warning signs are becoming more and more apparent, especially in the financial sector of companies engaged in the extraction of shale gas. A whole series of companies (Chesapeake, Devon, BP, BHP, Encana) have, in recent years, written off $35 billion dollars worth of assets that fell short of expectations. An EIA DOE study of results for 2012 shows a negative trend of return on capital for companies operating predominantly with gas. The accounts of many companies with shale oil and gas assets show a negative trend for cash flow per share.

However, despite the volatility of prices and production volumes in the Baseline Scenario, the USA will increase the production of shale gas until it plateaus at 440–470 bcm per year by 2025–30 (Figure 1.55), and total production will stabilize (and will begin to decrease slightly by the end of the period). As a result, the USA, which several years ago moved up to first place in the world in terms of gas extraction, will be unable to maintain this position through to the end of the forecast period, and Russia will once again be the top producer by 2035.

Figure 1.55 – Gas production in the USA, Baseline Scenario

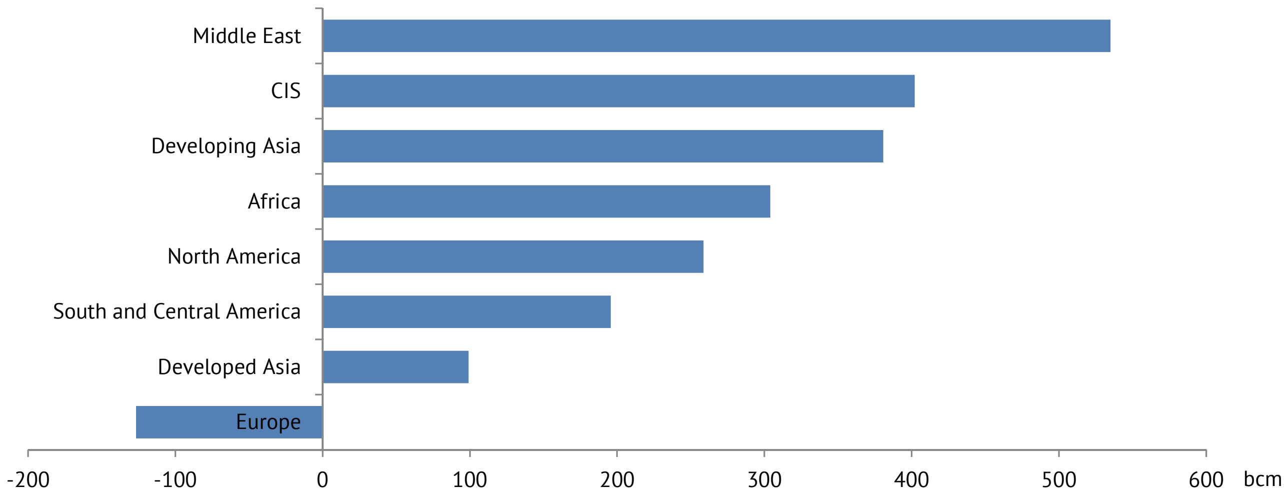


Source: ERI RAS

In the Reference Scenario almost all available gas reserves are in demand (except for the most expensive types of unconventional and offshore production). The most significant increase in supply will be provided by China, the USA, Russia, Iran, Australia, Saudi Arabia, and Turkmenistan

In the Baseline Scenario there will be demand for almost all accessible gas reserves (apart from the most expensive types of unconventional and offshore production). As a result, all regions of the world (except Europe) will significantly increase production (Figure 1.56). North America's growth will show a noticeable increase, due to shale gas production, but this does not compare with the expansion of production predicted for the Middle East, which amounts to more than half a trillion cubic metres. And Iran has a crucial role to play here: even the Baseline Scenario assumes the lifting of sanctions and the arrival of large-scale foreign investment in the country's oil and gas sector, resulting in a growth of 85 per cent in Iran's production volumes by 2040. Qatar will also increase production (+73 per cent) and Saudi Arabia will more than double the volume of gas produced.

Figure 1.56 – Growth of gas production by region 2010–40, Baseline Scenario



Source: ERI RAS

There will be an increase of almost 50 per cent in the region that has traditionally led in gas production – the CIS – with the main growth predicted for Russia, Kazakhstan, and Turkmenistan (which will double its production). The African region will more than double production by developing new reserves in East Africa (Mozambique, Tanzania), as well as in Central and North Africa.

Australia will also more than double its supply, to become one of the largest suppliers of gas to world markets. However, most of the new fields will be offshore or unconventional (in particular coalbed methane) with high costs.

In South and Central America, Brazil has large production potential, and will significantly increase its production, while Argentina will increase production by 50 per cent.

Gas production will continue to decline in Europe, with the region losing 40 per cent of its output by 2040. At the same time, geological problems and a rapid decline in production at the largest deposit in the Netherlands will deprive of Europe of the greater part of its flexible supply. Only Norway will be able to maintain current production levels for the whole of the period under review, due to the development of new offshore fields, but it will be unable to significantly increase them. New discoveries in the Eastern Mediterranean may solve the issue of gas supply to coastal countries, but it will also be unable to compensate for declining production across Europe as a whole.

Table 1.13 – Gas production by region and major countries, Baseline Scenario

	Gas production, bcm*							Growth rate, %		
	2010	2015	2020	2025	2030	2035	2040	2010–20	2010–30	2010–40
North America	**814**	**909**	**1015**	**1010**	**1039**	**1076**	**1073**	**2.2%**	**1.2%**	**0.9%**
USA	604	703	803	794	795	808	802	2.9%	1.4%	0.9%
Europe	**315**	**265**	**219**	**198**	**185**	**192**	**188**	**-3.6%**	**-2.6%**	**-1.7%**
Developed Asia	**58**	**87**	**118**	**121**	**123**	**134**	**157**	**7.4%**	**3.8%**	**3.4%**
Australia	49	80	111	114	118	129	153	8.5%	4.5%	3.9%
CIS	**820**	**902**	**962**	**1043**	**1133**	**1180**	**1222**	**1.6%**	**1.6%**	**1.3%**
Russia	649	683	713	736	772	812	844	0.9%	0.9%	0.9%
Developing Asia	**420**	**480**	**541**	**589**	**684**	**751**	**801**	**2.6%**	**2.5%**	**2.2%**
China	95	143	195	248	312	356	400	7.4%	6.1%	4.9%
India	51	42	54	66	79	83	94	0.5%	2.2%	2.0%
South and Central America	**165**	**171**	**199**	**230**	**270**	**323**	**360**	**1.9%**	**2.5%**	**2.6%**
Brazil	15	10	27	47	69	86	104	6.4%	8.0%	6.7%
Middle East	**474**	**586**	**668**	**771**	**822**	**903**	**1009**	**3.5%**	**2.8%**	**2.6%**
Iraq	5	14	31	68	82	92	100	19.7%	14.8%	10.4%
Iran	143	169	183	192	205	246	311	2.5%	1.8%	2.6%
Qatar	121	163	192	206	205	210	210	4.8%	2.7%	1.9%
Saudi Arabia	81	97	115	135	153	172	193	3.5%	3.2%	2.9%
Africa	**209**	**234**	**270**	**350**	**390**	**451**	**513**	**2.6%**	**3.2%**	**3.0%**
North Africa	161	167	186	210	229	238	251	1.4%	1.8%	1.5%
Central and Southern Africa	47	67	84	140	161	214	262	5.9%	6.3%	5.9%
World	**3274**	**3633**	**3991**	**4311**	**4644**	**5010**	**5323**	**2.0%**	**1.8%**	**1.6%**

* - Calculations are made taking into account use of gas storages

Source: ERI RAS

International Trade

In the Baseline Scenario, inter-regional trade in natural gas will undergo major changes. First of all there is the trend already noted in Forecast 2013: for North America to transform itself from a net gas importer to a net exporter, which by the end of the reporting period will be able to supply the global LNG market with around 70 bcm (Tables 1.14-1.15).

Africa, which has been supplying European and Asian markets for many decades with pipeline and liquefied gas, will more than triple its inter-regional supply in the period to 2040, mainly due to the development of new reserves in Eastern and Central parts of the continent. The Middle East will increase its volume of inter-regional exports by 75 per cent. Despite a very significant increase in production, a huge growth in domestic demand will prevent the countries of North Africa and the Middle East from sending higher volumes to global markets.

Total gas exports, both pipeline and LNG, from CIS countries will increase very substantially – by 2.8 times – allowing the region to remain as leader in the inter-regional gas trade. The developing countries of Asia will have to direct ever larger volumes to meet growing intra-regional demand, which will limit their opportunities to participate in global trade. On the other hand, Australia's emergence as the largest supplier of LNG on the markets will make the region of Developed Asia a major player in the global market. So the supply side will see further intensification of competition among the growing number of producers.

With an increasing number of producers and increased competition between them, the largest centre of consumption in the world, importing increasing volumes of gas from around the world, is clearly taking shape – and it consists of the developing countries of Asia.

At the same time, the largest centre of consumption in the world, importing increasing volumes of gas from all around the world, is clearly taking shape, and this is made up of the developing countries of Asia.

In the period under review, both the volumes of pipeline gas and of LNG will grow dynamically, but in general the share of liquefied natural gas in inter-regional trade will remain higher because pipeline gas usually forms the basis of intra-regional trade.

After a period of slow growth in the supply of LNG in 2012–16, it is expected that there will be a large-scale expansion in liquefaction capacities by 2020. This primarily concerns a number of major projects in Australia and the USA. Large additional volumes of LNG from Russia and the Middle East are expected to emerge on the global market after 2025.

Table 1.14 – Matrix of inter-regional gas trade in 2010, Baseline Scenario, bcm

		Destination									
		North America	South and Central America	Europe	CIS	Developing Asia	Developed Asia	Africa	Middle East	Total pipeline exports	Total LNG exports
Source	North America	0/0	0/0.1	0/0.4	0/0	0/0	0/1	0/0	0/0	0	2
	South and Central America	0/8	0/0	0/7	0/0	0/1	0/1	0/0	0/0.3	0	17
	Europe	0/1	0/0.1	0/0	0/0	0/0.2	0/0.3	0/0	0/0.1	0	1.7
	CIS	0/0	0/0	135/0	0/0	4/1	0/12	0/0	7/0.1	145	13
	Developing Asia	0/2	0/0	0/0	0/0	0/0	6/58	0/0	0/0.2	0	60
	Developed Asia	0/0	0/0	0/0	0/0	0/6	0/0	0/0	0/0.1	6	6
	Africa	0/6	0/3	44/40	0/0	0/3	0/6	0/0	5/0.7	0	58
	Middle East	0/4	0/1	8/37	0.7/0	0/18	0/40	0/0	0/0	50	99
	Total pipeline imports	0	0	179	0	4	6	0	12	201	-
	Total LNG imports*	20	4	84	0	29	119	0	2	-	257

* - Pipeline gas trade/LNG trade

Source: ERI RAS

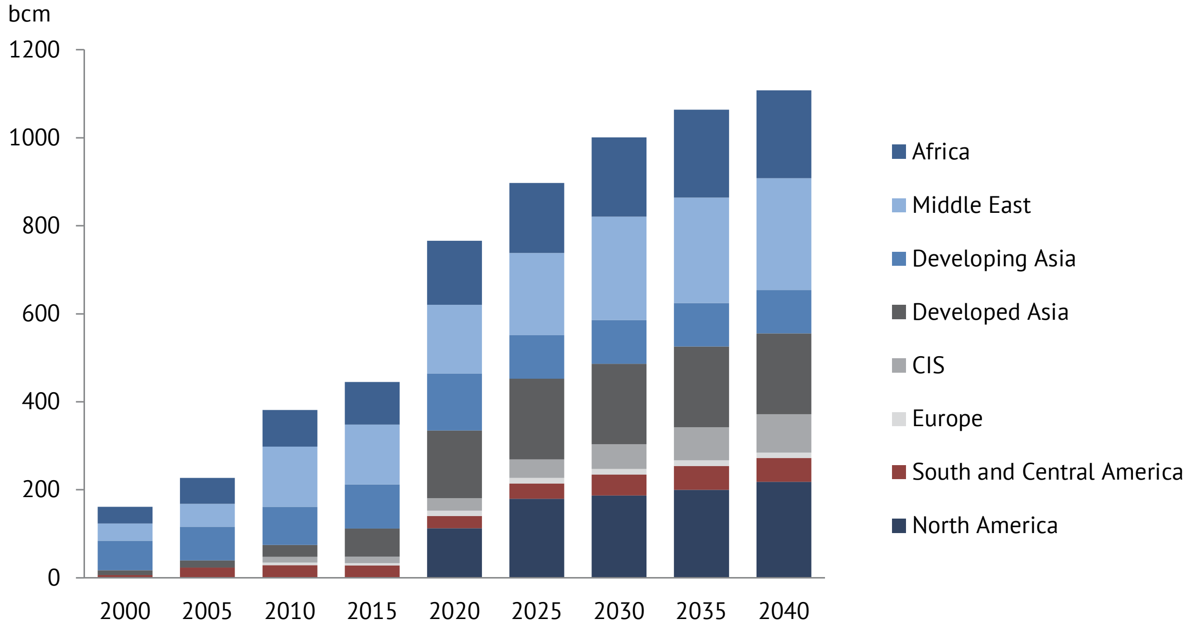
Table 1.15 – Matrix of inter-regional gas trade in 2040, Baseline Scenario, bcm

		Destination									
		North America	Central and Southern America	Europe	CIS	Developing Asia	Developed Asia	Africa	Middle East	Total pipeline exports	Total LNG exports
Source	North America	0	0/1	0/30	0	0/3	0/35	0	0	0	69
	South and Central America	0	0	0/23	0	0/3	0/3	0	0	0	29
	CIS	0	0	181/25	0	186/17	0/41	0	0	368	82
	Developing Asia	0	0	0	0	0	0/10	0	0	0	10
	Developed Asia	0	0	0	0	0/92	0	0	0	0	92
	Africa	0	0	40/57	0	0/83	0	0	0	40	140
	Middle East	0	0	37/18	2/0	54/135	0/15	0	0	93	168
	Total pipeline imports	0	0	258	2	240	0	0	0	501	-
	Total LNG imports*	0	1	152	0	333	104	0	0	-	591

* - Pipeline gas trade/LNG trade

Source: ERI RAS

Figure 1.57 – Expansion of liquefaction capacity, Baseline Scenario



Source: ERI RAS

Interestingly, dependence on gas imports from other regions will decline almost everywhere except in Europe, where they will account for almost 70 per cent by 2040 (Table 1.16). Meanwhile, North America will be able to completely abandon gas imports thanks to the increase in domestic production. Growth of intra-regional production in Asia (in both developing and developed countries) will allow this region to reduce its dependence on outside supplies to around a third, which is a perfectly acceptable level in terms of energy security.

Table 1.16 – Share of net imports of gas consumption by region (%)

	2010	2015	2020	2025	2030	2035	2040
North America	4%	3%	2%	1%	0	0	0
USA	18%	17%	10%	5%	0	0	0
Eupore	37%	43%	47%	53%	62%	67%	69%
Asia	5%	9%	16%	26%	25%	32%	33%
China	22%	17%	24%	47%	47%	49%	47%
India	0%	17%	18%	55%	56%	55%	53%
Africa	97%	96%	97%	98%	98%	98%	99%

Source: ERI RAS

Equilibrium gas prices

In the Baseline Scenario, prices will retain the overall trajectory shown in Outlook 2013, but the actual price levels are revised upwards due to increased costs for most realisable projects. At the same time, rising exports from North America will push prices up, which will gradually slightly narrow the wide gap between prices in some regional markets.

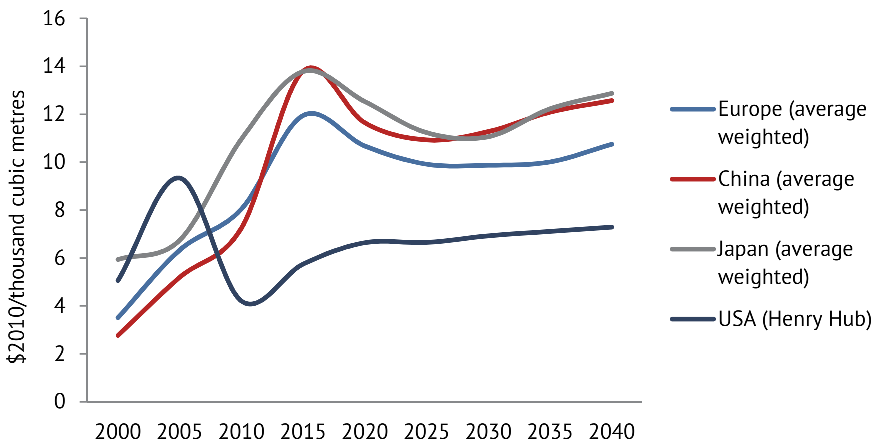
Outlook 2013 described the initial stages of the transformation of various regional gas pricing systems, firstly due to the gradual expansion of competitive trade 'between gas and gas'. There will be further changes in regional pricing mechanisms, in all likelihood towards an increase in the proportion of spot deliveries in all markets. The rapid development of the LNG market and its globalization will exacerbate this process, not only in Europe but also in Asia–Pacific, with high prices pushing consumers to look for any opportunity to cut their bills.

The high costs of gas transportation by pipeline or in the form of LNG prevents the formation of a single global gas price.

Outlook 2014's calculations fully support the assertion in last year's forecast that the significant differentiation of regional gas prices that happened in 2006–8 will be maintained for the entire period under consideration. The main reason for this is the high price of gas transportation which, when intercontinental deliveries are involved, adds more than $150 per thousand cubic metres to the price of gas. High transport costs contribute to the regionalization of markets and do not allow the formation of a single liquid market.

A rather marked increase in prices is expected in all regions of the world by the end of the forecast period (Figure 1.58) due to a need for the introduction of new, more expensive fields to meet demand. Under these conditions, the North American market is stuck in the price range determined by its own production. The lowest prices will remain in the USA for the whole of the forecast period though these, nevertheless, will also increase, especially with the start of large-scale LNG exports.

Figure 1.58 – Predicted average weighted* gas prices by regional market, Baseline Scenario



Source: ERI RAS

* Weighted between the prices of long-term contracts linked to alternative fuel types and spot prices, considering consumption volumes.

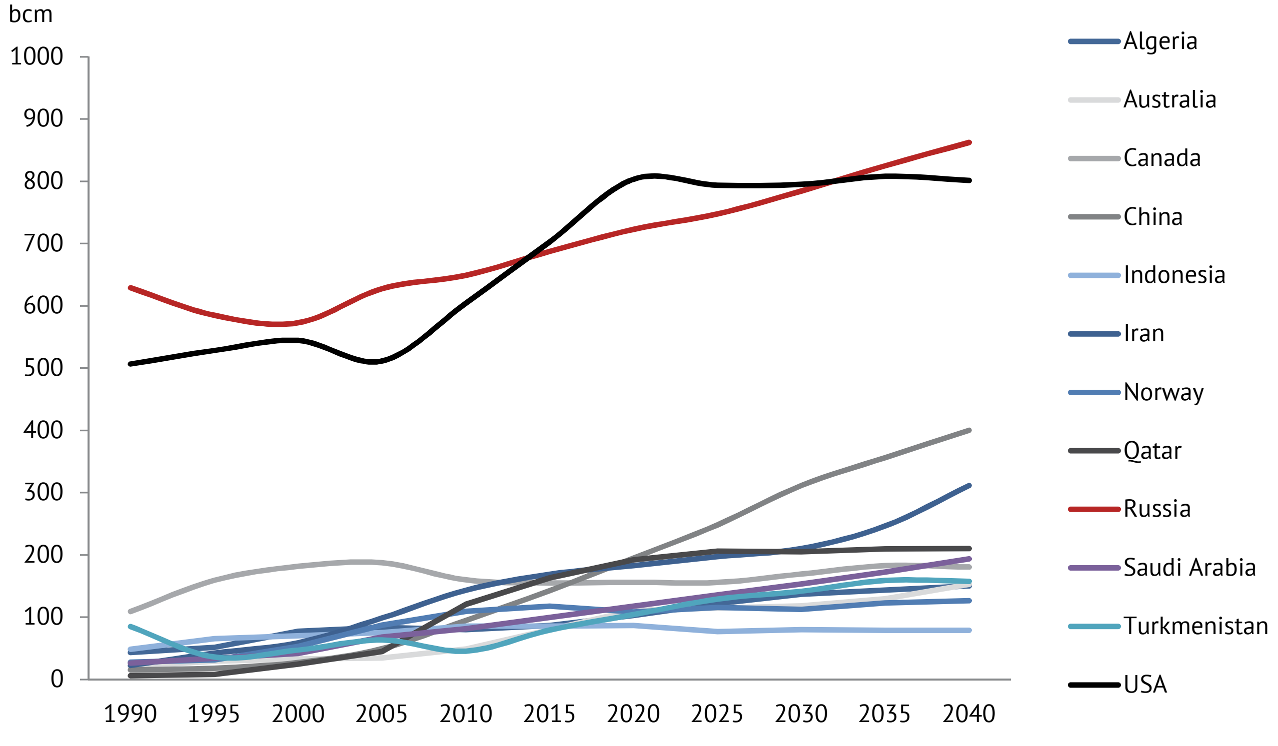
A marked decline in prices due to oversupply of gas in both Europe and the Asia–Pacific region is predicted for the period 2015–30 (particularly for LNG, which will enter the market in large quantities in 2020). Moreover the Asia–Pacific region, with its rapid growth in demand, traditionally has to pay an additional premium, which will stimulate a large number of new production projects, some of which will be quite expensive.

The positions of the main players

One can separate the largest producers in the gas market in the period 1990–2010 into two groups:

- *two super-producers*, Russia and the USA (Figure 1.59), whose production levels fluctuated in the 500–650 billion cubic metres range;
- *the major producers,* which include China, Iran, Qatar, Saudi Arabia, Turkmenistan, Algeria, Australia, Indonesia, Norway, and Canada; none of these countries has produced more than 190 billion cubic metres.

Figure 1.59 – The world's largest gas producing countries, Baseline Scenario, bcm

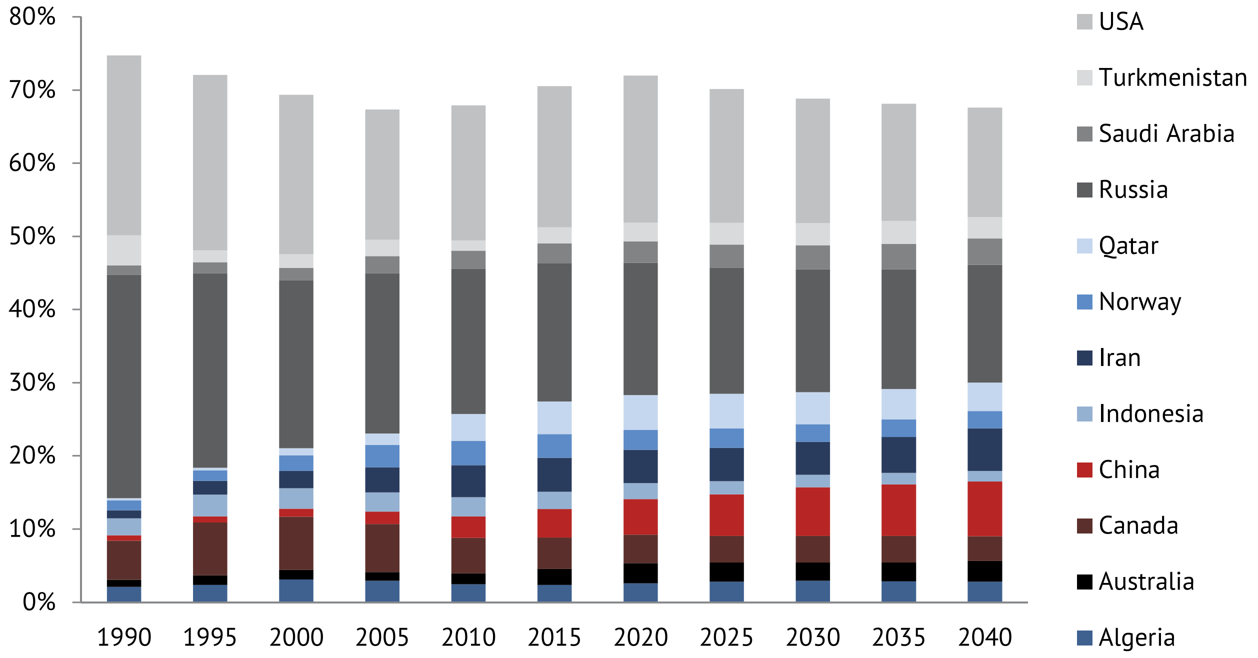


Source: ERI RAS

No changes will occur in the group of super-producers in the period to 2040, its composition does not change, and the volume of production increases to 800–850 billion cubic metres. There are no serious changes to the group of major producers by 2040 except for China, which shows a large increase in production. In the period 1990–2010, the share of the largest gas-producing countries was not less than 67 per cent of global gas production. The maximum was 74 per cent in 1990 (Figure 1.60), at which time the Herfindahl–Hirschman index of market concentration was 1635 – which unequivocally testified to a concentrated market. By 2010, this index had declined slightly to 1405, but the market remained concentrated.

The share of the largest gas-producing countries in the forecast period will increase slightly by 2020 and then begin to decline, and by 2040 will amount to 68 per cent, while the Herfindahl–Hirschman concentration index reduces to 650 – the fall to a level less than 1000 marking the transition to a low-concentration market.

Figure 1.60 – Share of largest gas producing countries in global production, Baseline Scenario



Source: ERI RAS

The main change in the gas market in the period to 2040 will be the rapid growth in China's impact and its emergence as one of the super-consumers.

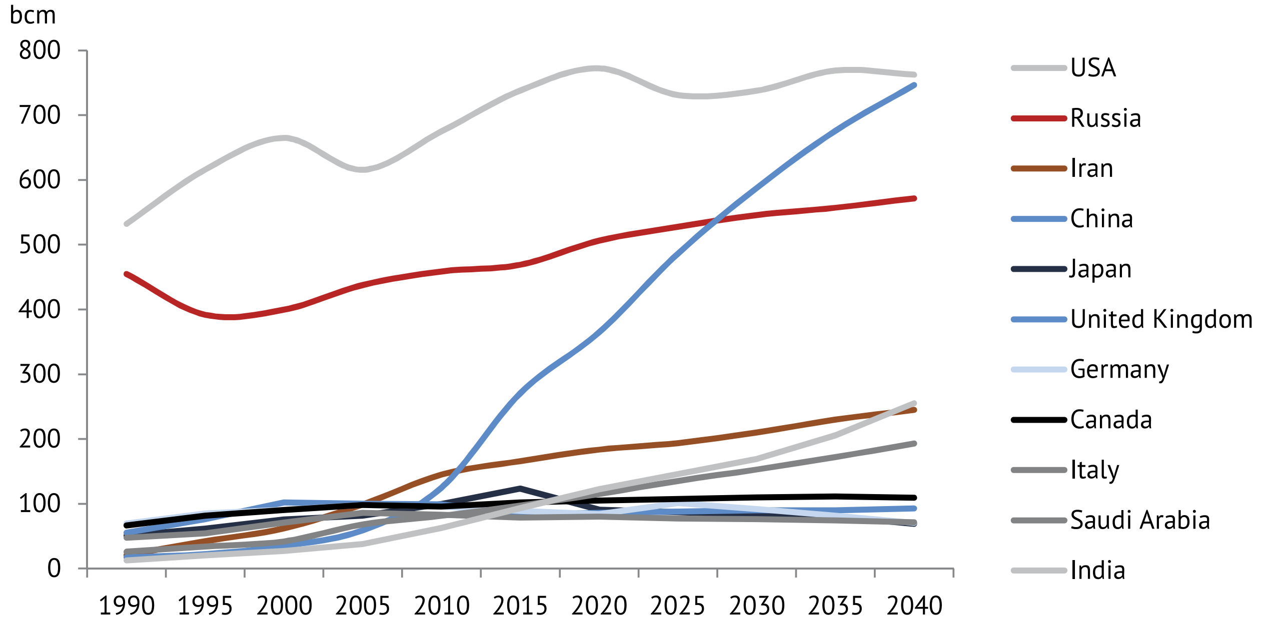
As for demand, the following became clear as of 2000:

- *Super-consumers* – USA and Russia. An important change in the balance of power will be the rapid growth in Chinese demand; by the end of the forecast period this growth will lift China to the level of super-consumer (Figure 1.61).

- *Large-scale consumers* – Iran, China, Japan, Britain, Germany, Canada, Italy, and Saudi Arabia. In these countries demand, both in the past and in the future, is significantly lower than that for super-consumers.

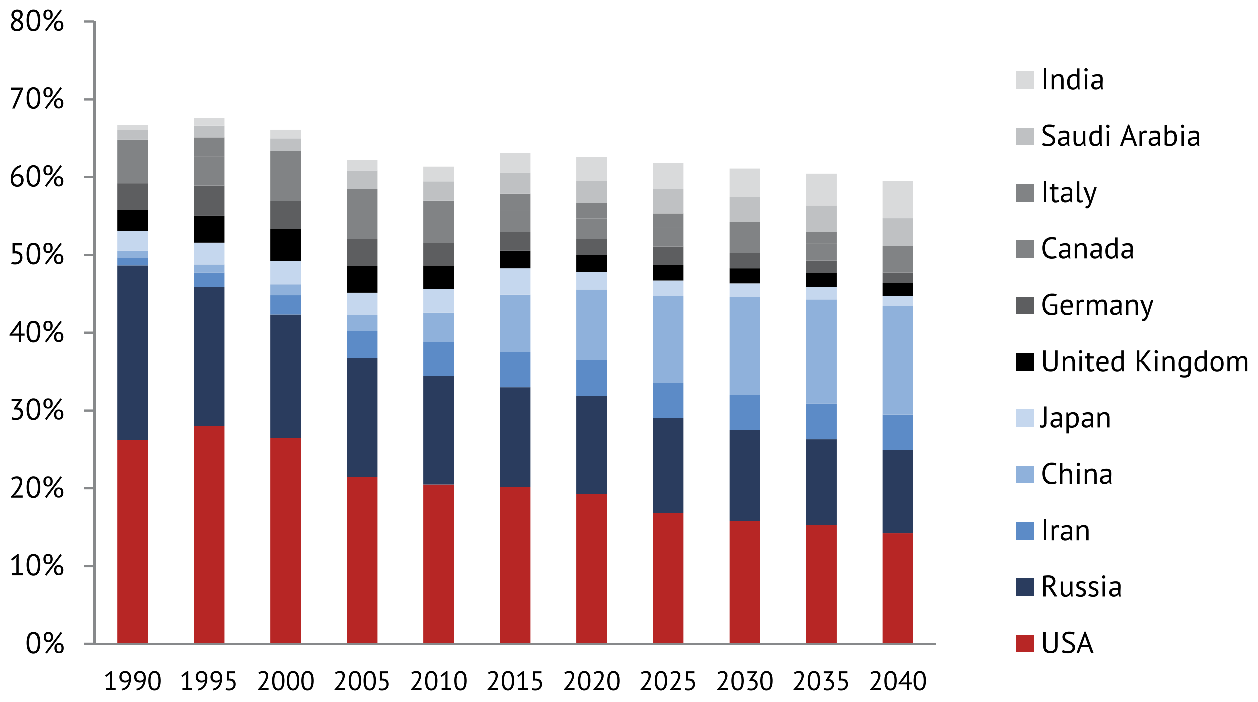
The share of global demand represented by the ten largest gas consumers is also quite considerable (Figure 1.62) but throughout the period under review from 1990 to 2040 it gradually decreases from 75 per cent to 60 per cent. The gas market is gradually becoming more mature and competitive.

Figure 1.61 – The world's largest gas consumers, Baseline Scenario, bcm



Source: ERI RAS

Figure 1.62 – Largest gas consumers' share of global demand, Baseline Scenario



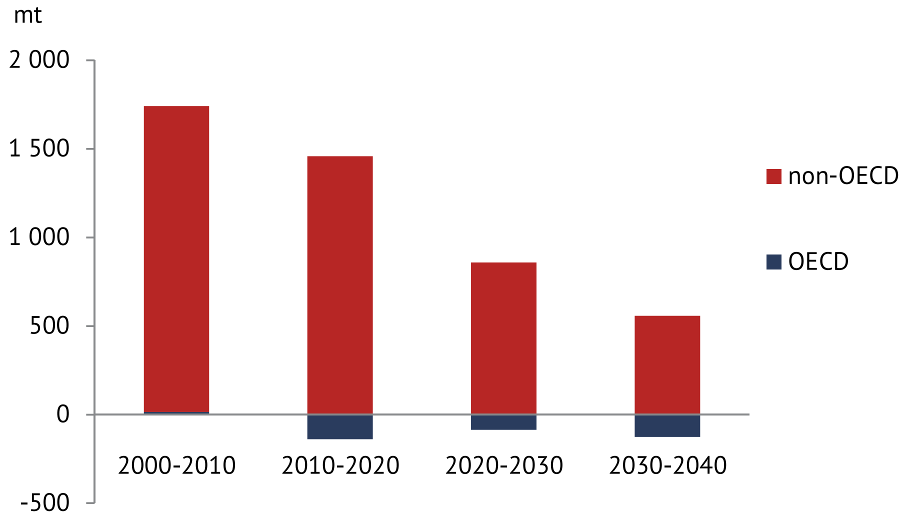
Source: ERI RAS

The Solid fuels market

Demand

Solid fuels (coal, hard biomass[21] etc.) are one of the foundations of global energy supply due to their economic and technological accessibility. In the period to 2040 they continue to dominate the energy consumption of several regions of the world, although growth in their use has begun to slow down (Figure 1.63) against the backdrop of a global slowdown in energy demand growth and because of increasing concern over harmful emissions.

Figure 1.63 – Coal consumption growth by decade, 2010–40



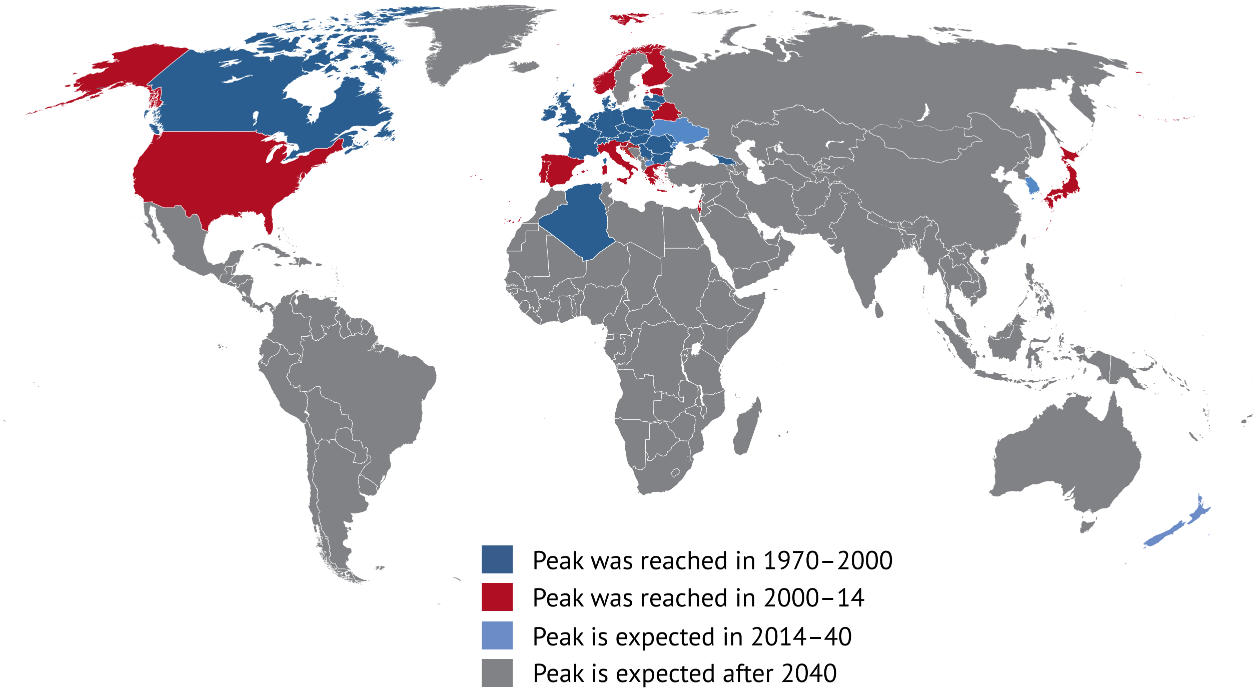
Source: ERI RAS

Practically all European countries have passed the point of peak coal consumption, apart from Bosnia and Herzegovina, Albania, Montenegro, Macedonia, and Turkey. The countries of North America have reached the point of reducing their coal consumption (apart from Mexico, which will pass it by the end of the forecast period), along with New Zealand, Israel, and Japan. By 2040, virtually all OECD countries will have reduced the consumption of this energy source, with the only exceptions being Chile and Australia (Figure 1.64).

China, with its declining capacity to increase coal production and the difficult environmental situation in its largest cities, is also planning to reduce the share of coal in its energy mix. According to the country's State Energy Office plan, the use of solid fuels should be reduced from the current level of 70 per cent to 57 per cent and 43 per cent by 2020 and 2050 respectively.

21 Solid forms of biomass include wood and the products resulting from wood processing (pellets, briquettes), dry and dehydrated plants, etc. For poor countries, traditional biomass still remains the most affordable energy resource.

Figure 1.64 – Peak coal consumption for different countries

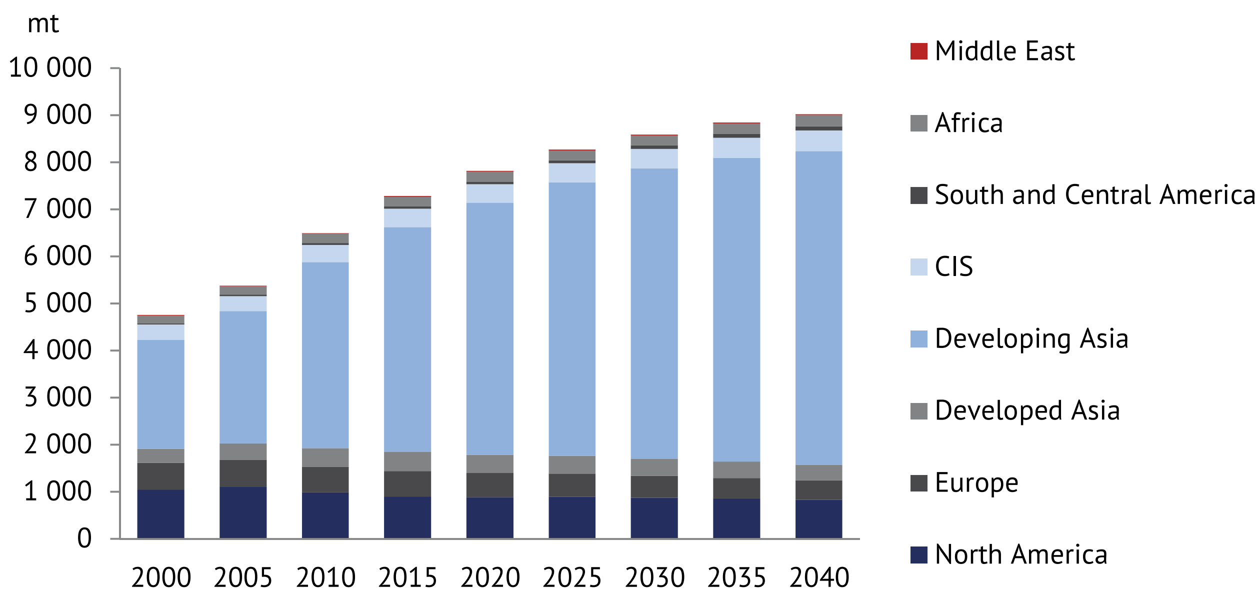


Source: ERI RAS

For India, coal is one of the main ways in which rapidly growing energy needs can be met, which means that by 2040 its use is expected to have increased by 2.4 times compared to 2010.

The developing Asia–Pacific countries (especially China and India) will provide the main increase in the world's coal consumption until 2040, bringing its share to 74 per cent (Figure 1.65).

Figure 1.65 – Coal demand by region



Source: ERI RAS

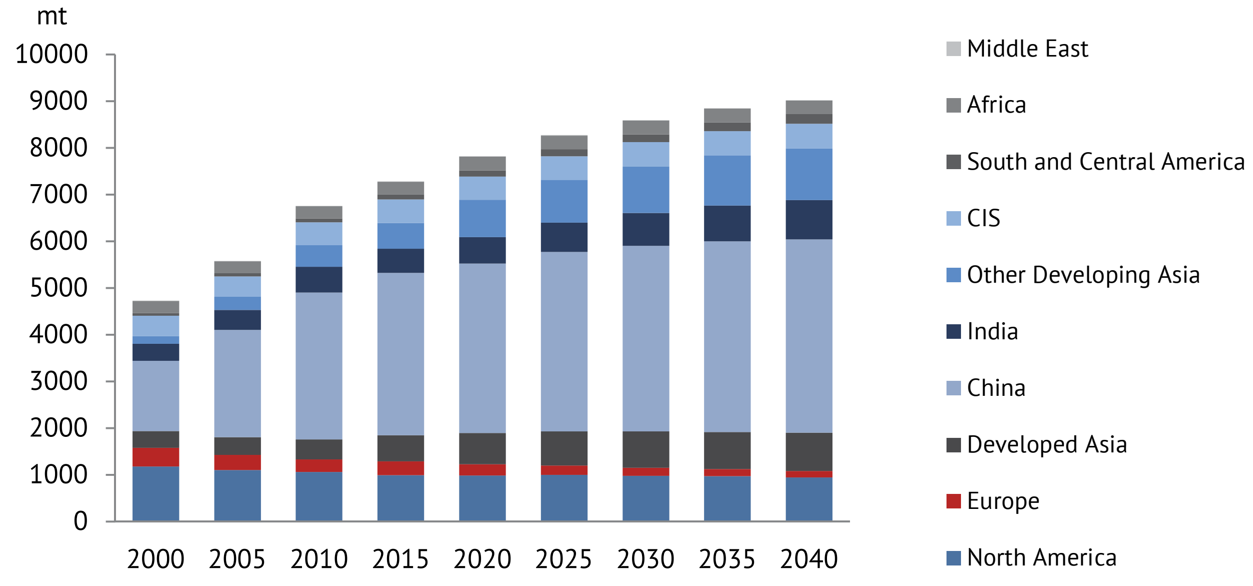
Supply

Coal production is mainly concentrated in just seven countries. In 2010, 84 per cent of world coal production was provided by China (3.14 billion tonnes), USA (983 million tonnes), India (521 million tonnes), Indonesia (345 million tonnes), Australia (424 million tonnes), Russia (321 million tonnes), and South Africa (255 million tonnes).

In the forecast period there will be little change in the major market participants, though their relative positions will change. In Europe, production will fall by almost 5 times due to its high cost and the region's stated energy policy to reduce the use of coal.

The USA, which has the largest coal reserves in the world, will also move towards reducing its share in the energy mix. Indonesia and Australia, which have become the main drivers of significant growth in coal production in the last decade, will continue to increase production, though Australia will increasingly face the problem of the declining viability of new projects due to rising costs. Also in the forecast period, we should expect the appearance of new producers and exporters in the global market, the most promising of which are Mongolia, Mozambique, and Uganda. The developing countries of Asia will continue to dominate the production of coal to 2040 (Figure 1.66).

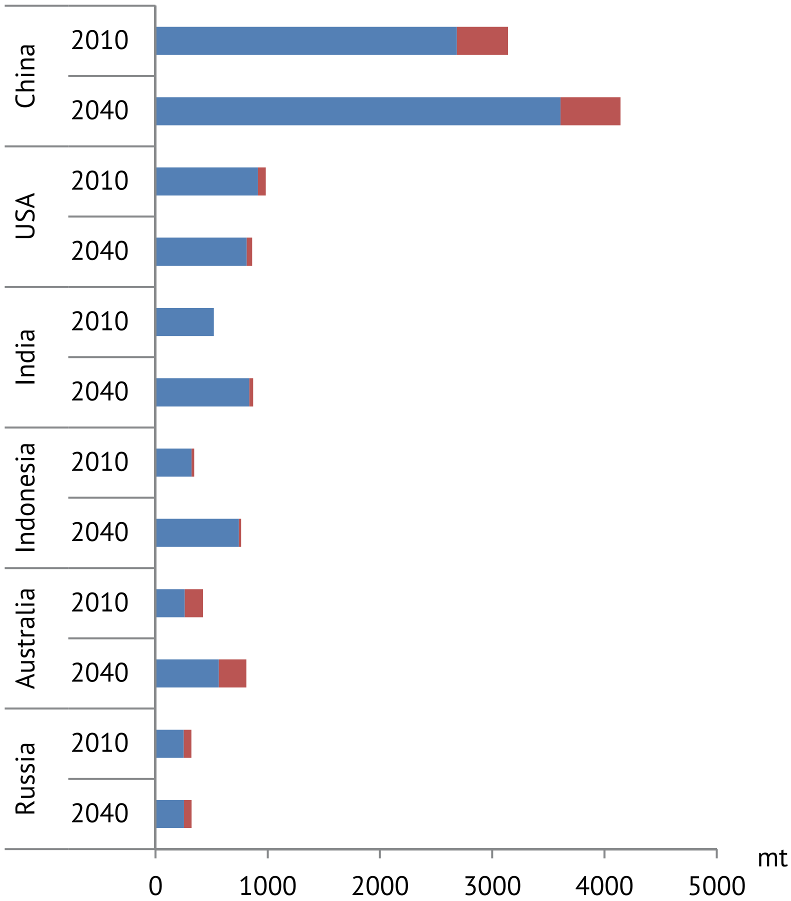
Figure 1.66 – Regions' and major countries' predicted coal production, Baseline Scenario



Source: ERI RAS

The structure of world coal production will be dominated by steam coal, which is mainly used to produce heat and electricity. The more valuable and scarce coking coal, whose range of uses is substantially wider, covering not only its use for energy purposes but also in manufacturing, is a large part of the production structure in China and Australia (Figure 1.67).

Figure 1.67 – Major producers' coal production 2010–40, Baseline Scenario



Source: ERI RAS

International Trade

nternational trade in coal reached a level of 1.142 billion tonnes by 2010. These volumes represent about 15 per cent of the coal consumed in the world. All the world's coal trade is concentrated in two major regional markets: the Atlantic and the Pacific.

In the Atlantic market the main export flows are to the countries of Western Europe, among which the largest volumes go to Britain, Germany, and Spain.

In the Pacific market, which accounts for 57 per cent of maritime trade in steam coal, the main import volumes go to Japan, Korea, and Taiwan. Two of the world's largest exporters of steam coal, Indonesia and Australia, are located in the Pacific Basin, with Australia annually supplying the market with about 300 million tonnes of this energy source and also being key supplier of coking coal, providing more than half of world exports.

The Asian countries' share of global imports of coal will increase by 2040, with India becoming the largest importer.

In the Baseline Scenario, inter-regional trade in coal will reach 0.6 billion tonnes by 2040 and will maintain the connection between the Atlantic and Pacific basins (Figure 1.17).

Table 1.17 – Coal trade flows matrix in 2040, million tonnes

		Destination							
		North America	South and Central America	Europe	CIS	Developed Asia	Developing Asia	Middle East	Africa
Source	North America	0	13	36	0	80	0	0	0
	S. and C. America	0	0	128	0	0	0	0	0
	Europe	0	0	0	0	0	0	0	0
	CIS	0	0	31	0	0	73	0	0
	Developed Asia	17	0	45	0	0	609	0	0
	Developing Asia	0	0	0	0	100	0	18	9
	Middle East	0	0	0	0	0	0	0	0
	Africa	0	0	45	0	0	21	0	0

Source: ERI RAS

Coal prices

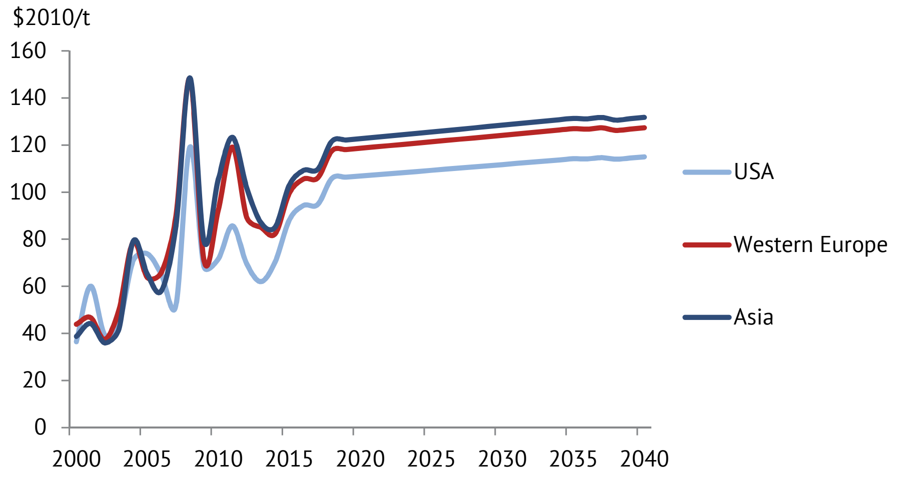
Despite the fact that spot prices for coal are formed regionally, they correlate with each other on the major exchanges. For exporters, prices are more often than not set as quoted on f.o.b. terms at the main ports of shipment (Richards Bay in South Africa, Bolivar in Colombia, and Newcastle in Australia). For importers, prices are for the most part calculated on c.i.f. terms in the so-called 'ARA Triangle' (the ports of Amsterdam, Rotterdam, and Antwerp). Prices are determined by the market on the basis of the balance of supply and demand. Starting in 2008, a rather high level of price volatility was observed on the market, which was caused by the global financial crisis, the accident at the Fukushima nuclear power plant in Japan, flooding in Australia, the expansion of US coal exports due to its displacement from the US market by cheap shale gas, and a host of other factors. A moderate increase in coal prices due to high demand and increasing production costs is expected in the forecast period.

By 2040, the existing trading platforms are expected to remain key in the redistribution of their shares in world trade. In Europe, it is expected that there will be a reduction of trade in the ARA Triangle, while in Asia it is possible that new trading centres could emerge. In the period being examined it is assumed that the market structure will be largely based on long-term contracts with fixed prices, which will be the basis for prices in specific ports (their share will remain at 80 per cent, and spot contracts at 20 per cent).

Despite the sufficient resource base of coal, the introduction of new coal mining capacity is limited by the high capital intensity of new projects, the environmental restrictions on development in a number of countries, and distance from potential markets. But if prices rise and there is demand, production can significantly expand.

The highest prices in the forecast period are expected on the Western European market, which is linked to increased demand for imported coal due to lower domestic production, with the price premium compared to the Asian market[22] being around US$40–50 a tonne in the period 2020–40. The lowest prices are expected in the US market, where there is a surplus of coal arising from the reduction of its share in the electricity generating sector (Figure 1.68).

Figure 1.68 – Past and predicted future coal prices 2000–40[23]



Source: ERI RAS

22 The price of coal for the Asian market is a weighted average of prices for China, India, and Japan.

23 Retrospective coal prices derived from BP data and adjusted taking into account the US GDP deflator for 2000–13.

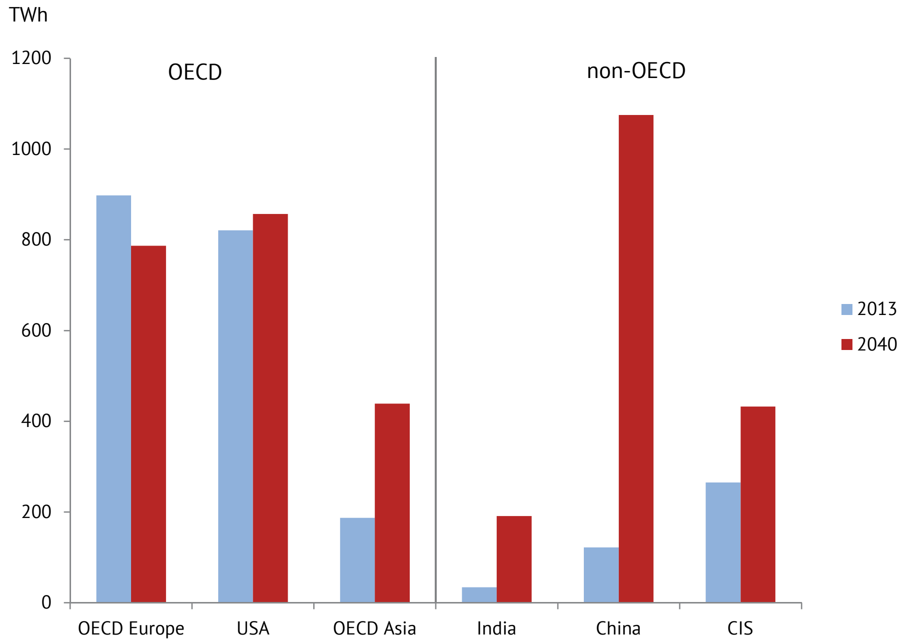
Nuclear Power

Almost the entire growth of nuclear power in the period up to 2040 will be concentrated in developing countries, while developed countries will, on the whole, be replacing a significant number of nuclear power plants as their service life comes to an end.

Nuclear power in the period 2010–40 will occupy third place in the growth rate of global consumption, after renewable energy resources and gas, and for many reasons almost all this growth will be concentrated in developing countries.

It has already been pointed out in Outlook 2013 that there will be a pressing need to replace a significant number of nuclear power plants in developed countries during the period under review due to the projects having come to the end of their working lives. As it stands in 2014, it is worth pointing out that the situation is somewhat simpler, because of the decision on the part of some countries to extend the service life of individual plants. However, the amount of capacity that needs to be replaced remains quite high, with over 60 per cent of the capacity of currently operating generating units needing to be phased out in the period to 2040. Against this background, developing countries, for many of whom the question of decommissioning nuclear power plants will only become an issue in the second half of the twenty-first century, will be able to increase their share in global nuclear energy production from 17 per cent to 49 per cent (Figure 1.69); almost three-quarters of this increase will be provided by China and India.

Figure 1.69 – Nuclear power plants' electricity production by region

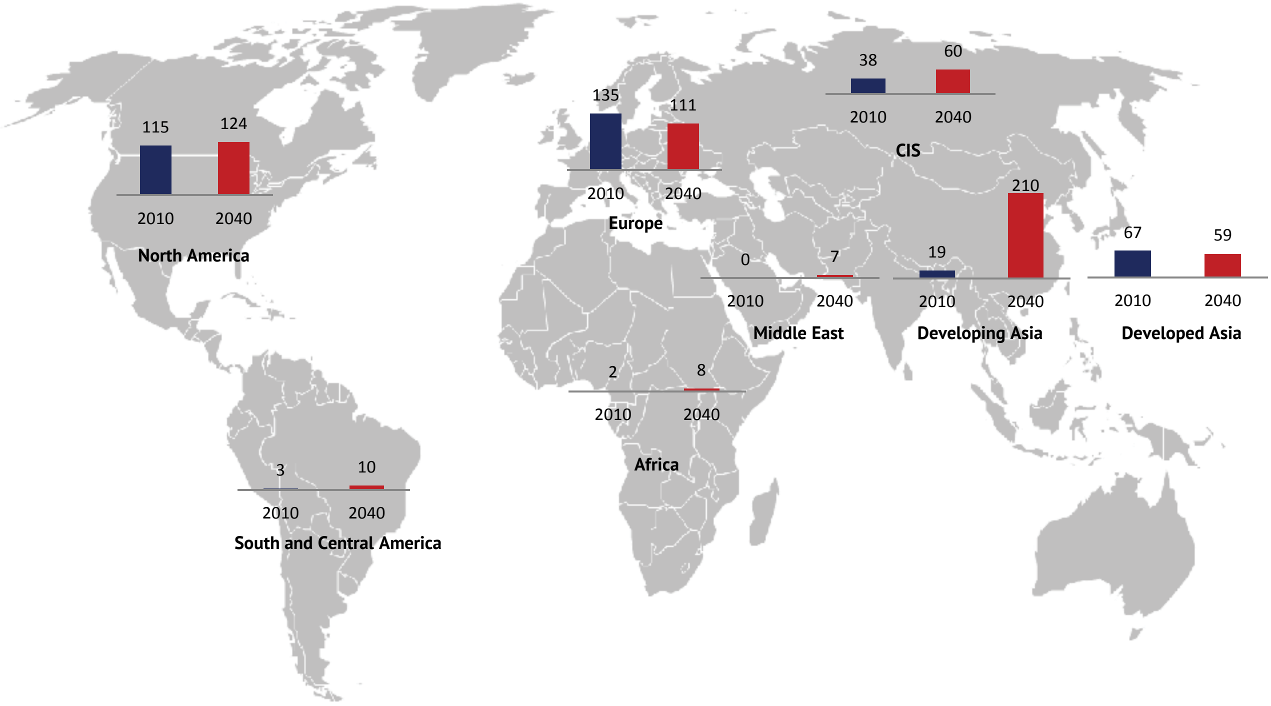


Source: ERI RAS

It is assumed that only Japan and Korea, of the developed countries, will be able to significantly increase production of nuclear energy by 2040 in comparison with 2013. In Japan this will happen as a result of the partial return to operation of capacity that had been suspended after the Fukushima accident, though given the continuing difficult situation in the vicinity of the damaged reactors, a great deal of uncertainty remains about the country's future policy in this area.

It is expected that North America, will maintain a fairly stable volume of capacity throughout the period under review, and that there will be a reduction in Europe resulting from political decisions and public opposition to nuclear power in a number of EU countries (Figure 1.70).

Figure 1.70 – Capacities of nuclear power plants by region in 2010 and 2040, GW

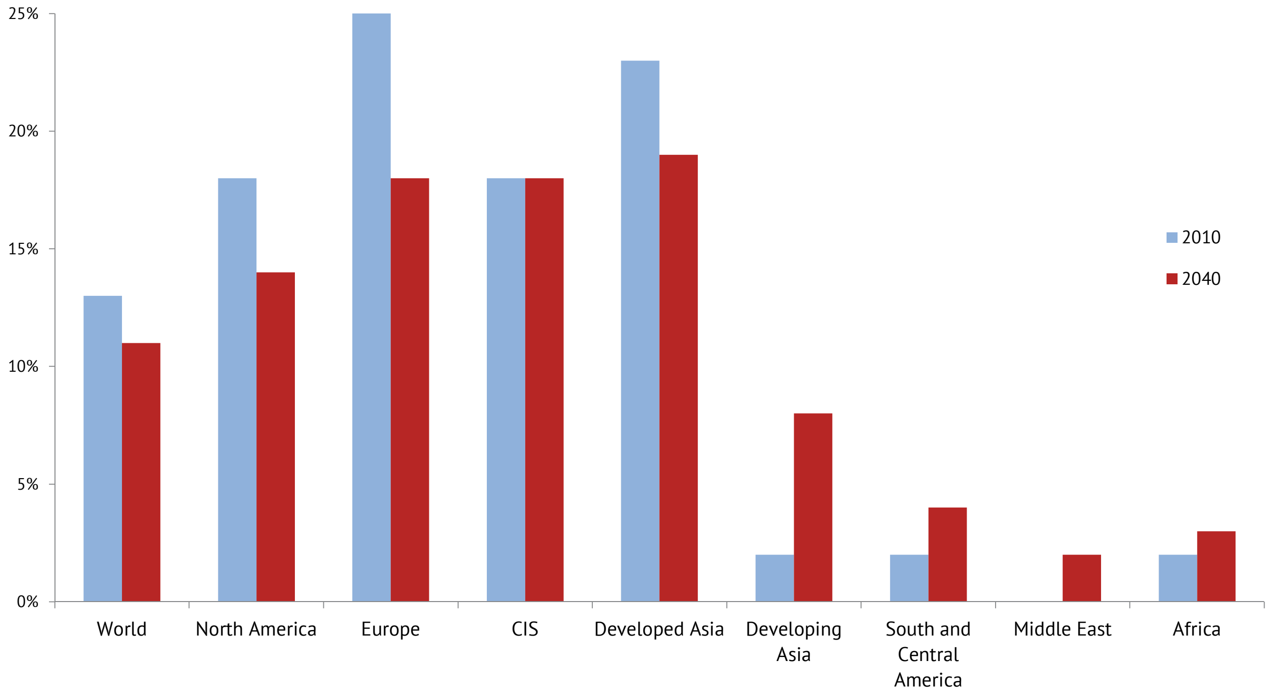


Source: ERI RAS

The stabilization and reduction of nuclear capacity in OECD countries will, to some extent, be offset by an increase in the efficiency of plants, due to the replacement of equipment at existing units and the optimization of network operations.

Globally, the share of nuclear generation in electricity production will be reduced, but in four regions, North America, Europe, the CIS, and the developed Asian countries (the traditional leaders of the nuclear industry) it will remain at a high level (more than 10 per cent - Figure 1.71). These nuclear power plants will be able to operate with stability at base-load demand, but in combination with the significant growth in renewable electricity generation, some countries will have to pay greater attention to the development of reserve and peak power capacities (hydrocarbon-based) and to electricity storage.

Figure 1.71 – Share of nuclear generation in global and regional electricity production, 2010 and 2040



Source: ERI RAS

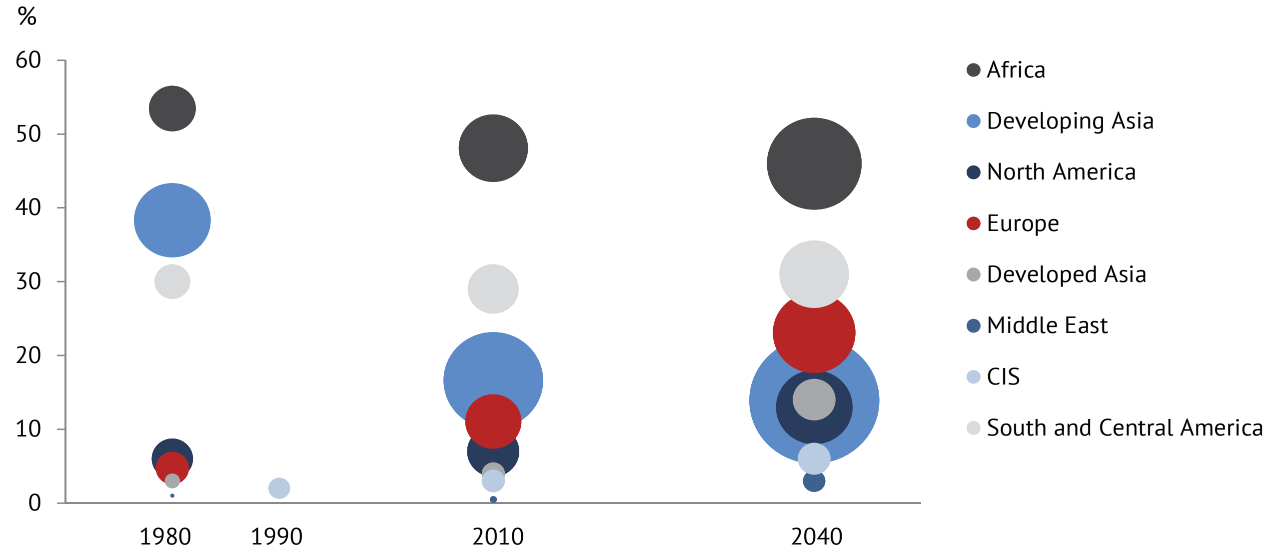
Renewable Energy Resources

In the period to 2040 renewable energy resources[24] will have the highest growth rates of all forms of energy. While there will be an overall increase in energy demand of 47 per cent in the period under review, consumption of renewable energy resources will increase by 93 per cent; this is not only because of the planned large-scale development of capacity based on renewable energy, but also because of their relatively low baseline values.

The share of all renewable energy in the global energy mix will increase from 13 per cent to 17 per cent. Moreover, analysis shows, paradoxically, that for the past 40 years the major renewable energy resource producing regions (Africa, the developing countries of Asia, South and Central America) have been reducing or stabilizing the proportion of renewable energy in the energy balance of their region, rather than increasing it (Figure 1.72). The point is that the share of solid biomass consumption, which has traditionally been widely used in these regions, is gradually declining due to more intensive development of other, more technologically advanced, energy resources. This trend will continue in the period to 2040.

24 For the purposes of this study renewable energy resources include biomass (bioethanol, biodiesel, wood pellets), hydro, waste, biogas, landfill gas, solar, wind, tidal, geothermal, wave, etc.

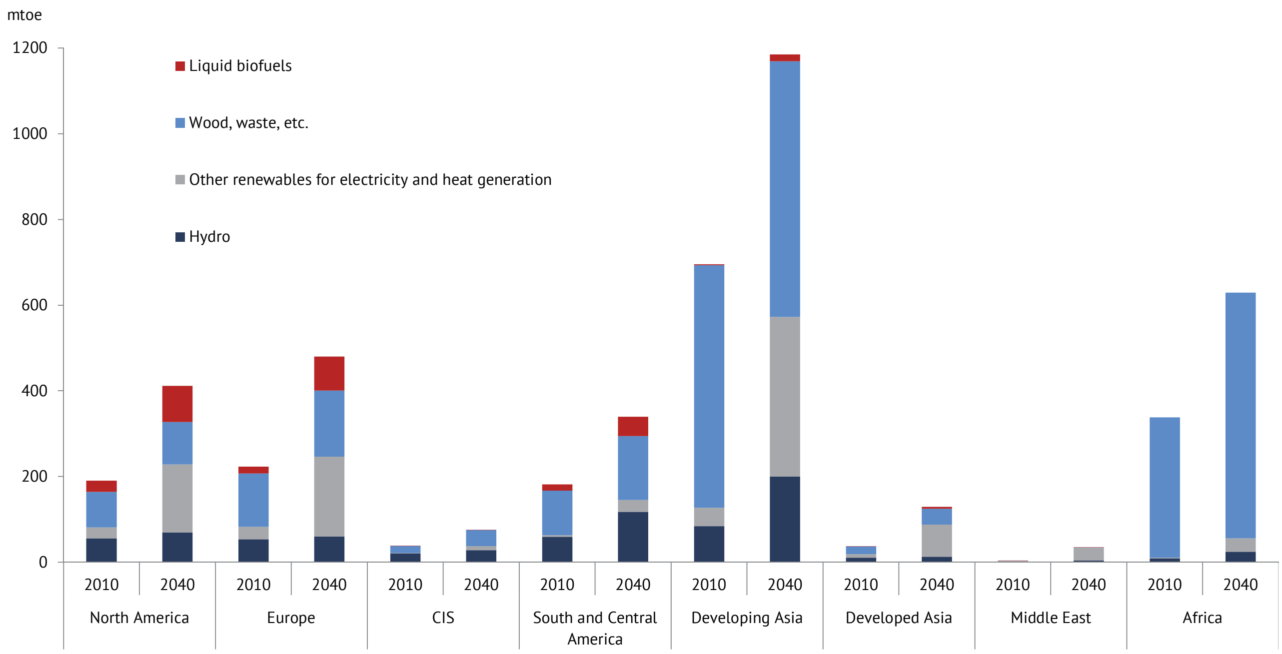
Figure 1.72 – Share of renewable energy sources in regions' energy mix (y axis) and consumption volume (size of circle)



Source: ERI RAS

A relatively significant adjustment in the structure of renewable energy resource utilization is therefore predicted. If regional consumption is currently dominated by solid biofuels (wood, waste, etc.) and hydropower, then by 2040 (mainly in OECD countries) wind, solar, and other forms of energy for the production of electricity and heat (except for hydropower) will come to the forefront (Figure 1.73). It is these types of renewable energy that will show the main increase in the renewables sector of five of the eight regions under review, and they will, in the world as a whole, provide nearly 50 per cent of the increase in total renewable energy consumption.

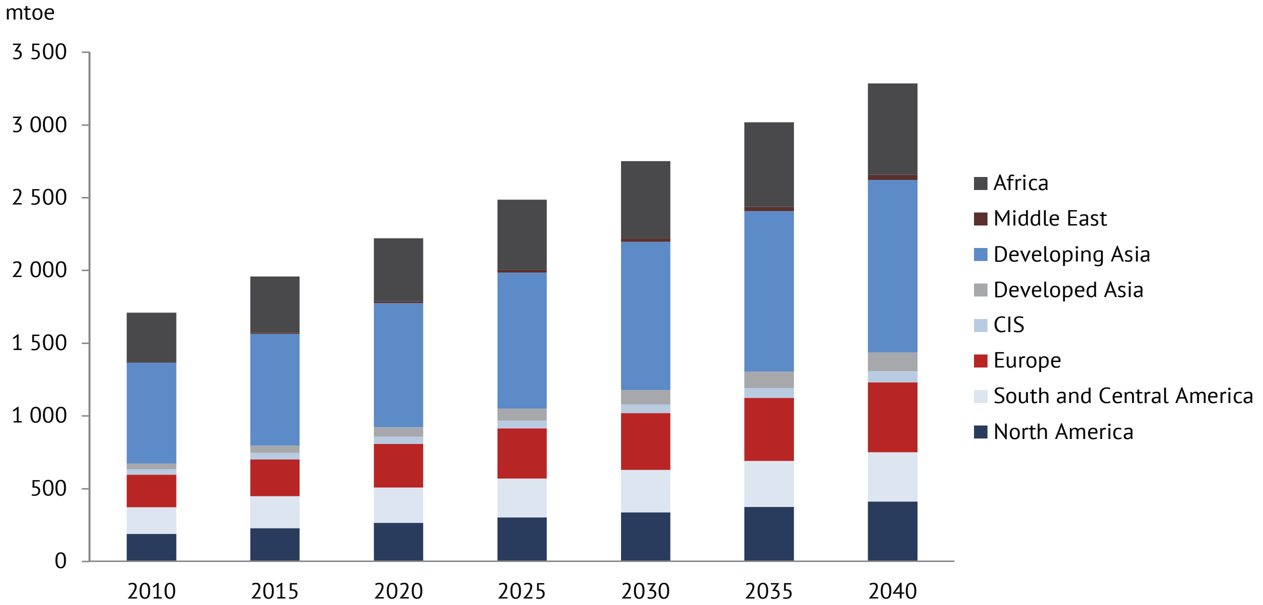
Figure 1.73 – Dominant types of renewable energy sources by region and consumption growth



Source: ERI RAS

The greatest increase in renewable energy consumption by 2040 will be in the developing countries of Asia (about 31 per cent), while the highest growth rates will be seen in the Middle East and the developed countries of Asia, largely due to low initial figures. Of the major consumers, a more than twofold increase is forecast for Europe and North America (Figure 1.74).

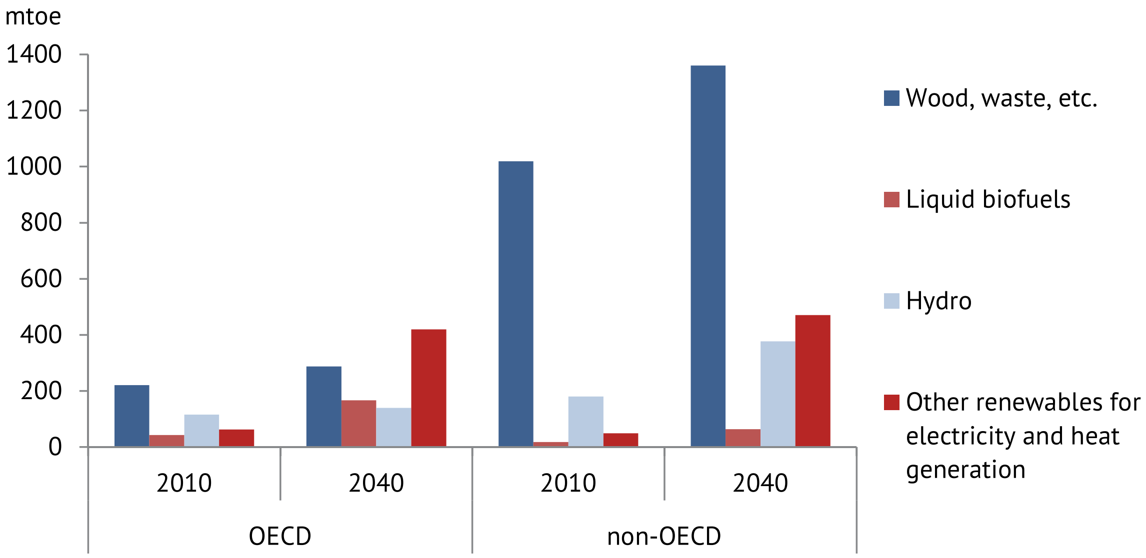
Figure 1.74 – Forecast renewable energy sources consumption by region (2010–40)



Source: ERI RAS

In the period up to 2040, the consumption of renewable energy in developed countries will increase by about 130 per cent, in particular because of new renewable sources (solar, wind, etc.) which are expected to show an almost sevenfold increase (Figure 1.75). In developing countries, consumption of renewable energy will increase by 80 per cent, while new renewable energy sources will show an impressive (almost tenfold) increase, which will raise their share in the consumption of renewable energy to 21 per cent.

Figure 1.75 – Renewable energy sources' consumption by type, OECD and non-OECD

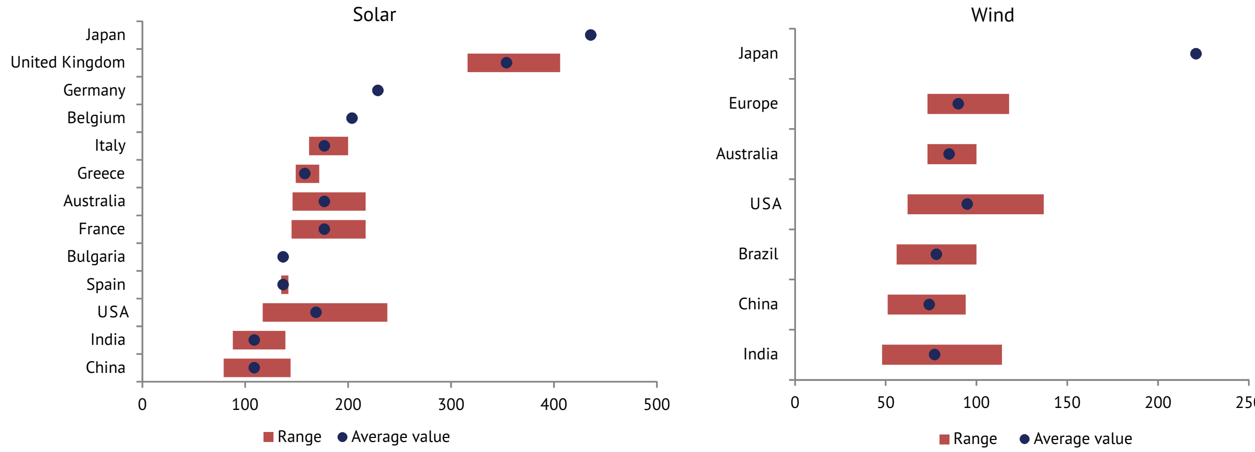


Source: ERI RAS

High growth rates of renewable energy production are largely dependent on substantial state support which, in a number of countries, is making renewable energy attractive even in cases where their economic output indices (without accounting for support mechanisms, taxation, etc.) are more than 50 per cent worse than those of fossil fuels[25]. In the period to 2040 many types of renewables will continue to require such support, despite anticipated technological improvements.

In assessing the economic efficiency of renewable energy production, it is important to take regional peculiarities into account. Such features as: natural climatic conditions (intensity of solar radiation, wind speed, soil composition, etc.), the cost of labour and materials, the possibility of attracting investment, together with other factors, lead to a range of indicators for the attractiveness of different technologies (Figure 1.76). It is clear to see that the greatest variation is observed in the production of electricity from solar energy, which is mainly determined by the country's distance from the equator.

Figure 1.76 – Levelized cost of electricity production based on solar and wind power plants on land



ERI RAS according to Bloomberg New Energy Finance data;
WEC, World energy perspective – cost of emerging technologies, 2013.

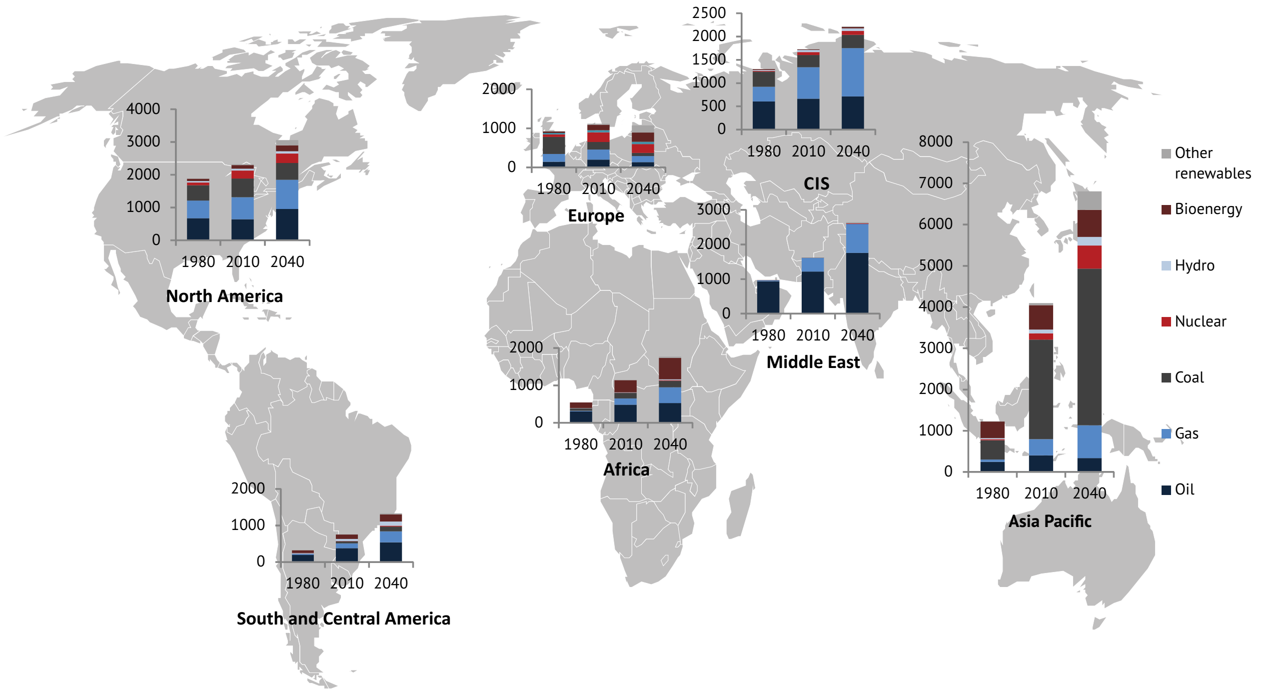
The rapid growth in the use of new forms of renewable energy in electricity generation poses additional problems to the whole energy sector because of the need for backup and storage methods to ensure the flexible operation of the energy system. In addition to the day-to-day variations in generation of electricity at facilities powered by renewables, a seasonal element must also be taken into account; this is reflected in the different intensities of solar radiation and wind strength at different times of the year. Because of this, monthly average capacity utilization may vary by a large factor. In fact, it results in an additional hidden increase in investment for the energy sector which is often overlooked when comparisons are made directly with the cost of electricity production from a variety of sources.

25 A more detailed description is given in the Global and Russian Energy Outlook up to 2040, under the direction of A. A. Makarov and L. M. Grigoriev, ERI RAS, Moscow 2013. pp. 60–61.

Primary Energy production

In the Baseline Scenario global production of energy resources will increase by almost 50 per cent. The main growth will be in the developing countries of Asia, Latin America, Africa, and the Middle East; the only region which will reduce its primary energy production is Europe (Figure 1.77), where the domination of hydrocarbons in the production of primary energy will gradually reduce as a result of rapid development in the production of renewable energy sources and nuclear power.

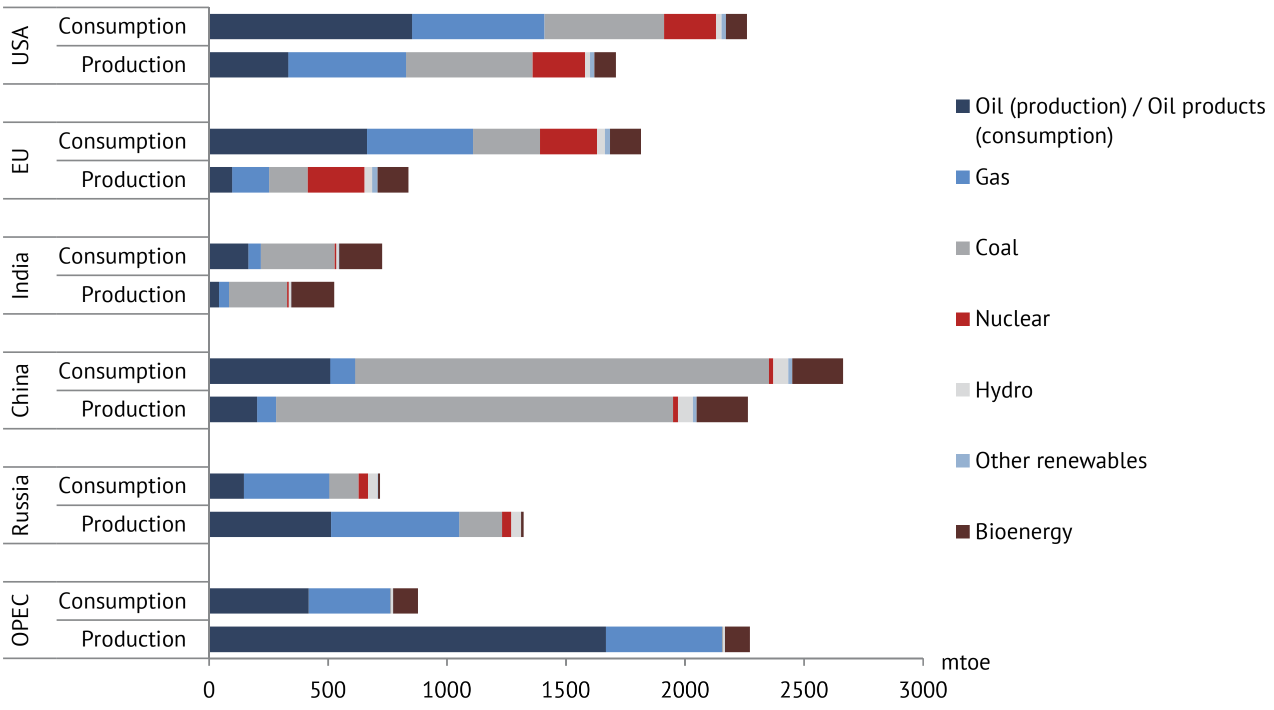
Figure 1.77 – Primary energy production by region and fuel type, Baseline Scenario, mtoe



Source: ERI RAS

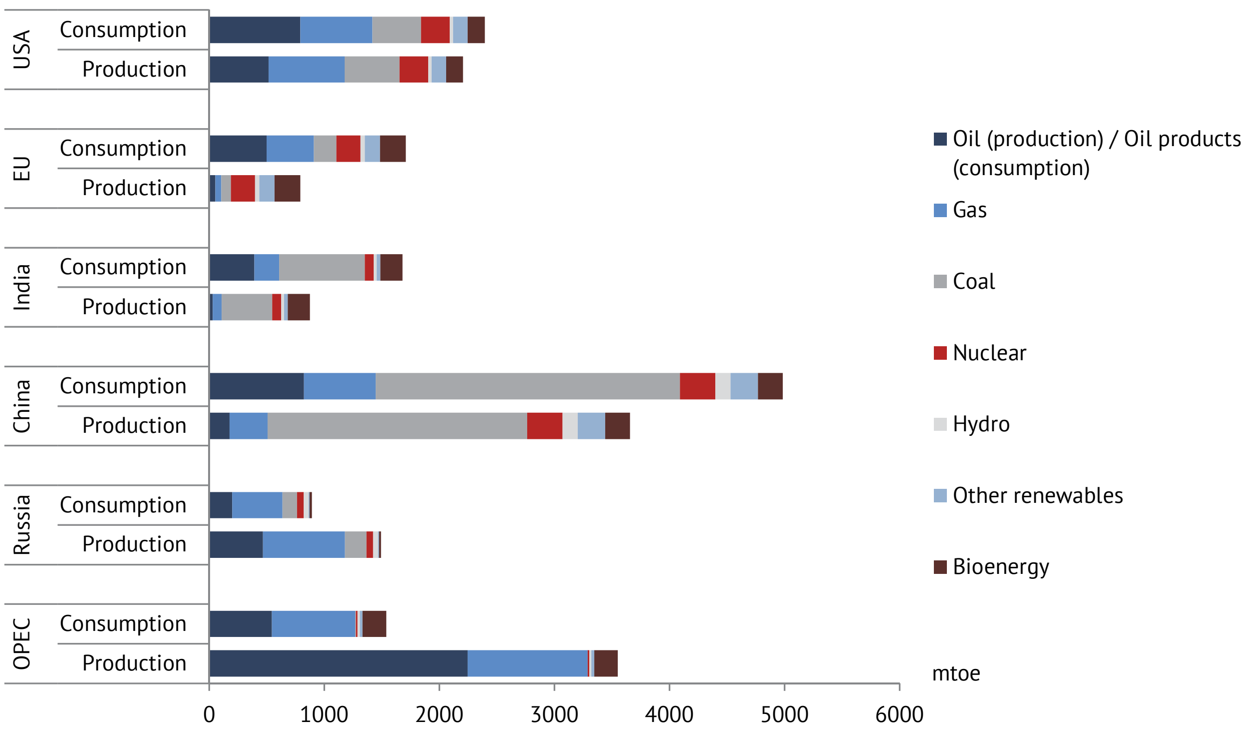
In 2010 Chinese primary energy production volumes had almost drawn level with those of the world's biggest producer, OPEC, and by 2040 will have exceeded them, making China both the world's leading producer and consumer of primary energy. The USA will remain the second largest consumer, with its consumption by 2040 amounting to 40% of China's. The fastest growth rates in primary energy production and consumption during the forecast period will be seen in India (up 1.7 times and 2.3 times respectively), while the USA and the EU will have the most diversified patterns of energy consumption among the leading players in the energy markets. Russia will retain its position in the rankings for production and consumption of primary energy (Figure 1.78 and Figure 1.79).

Figure 1.78 – Production and consumption of energy resources by key players in the energy markets in 2010, Baseline scenario



Source: ERI RAS

Figure 1.79 – Production and consumption of energy resources by key players in the energy markets in 2040, Baseline scenario



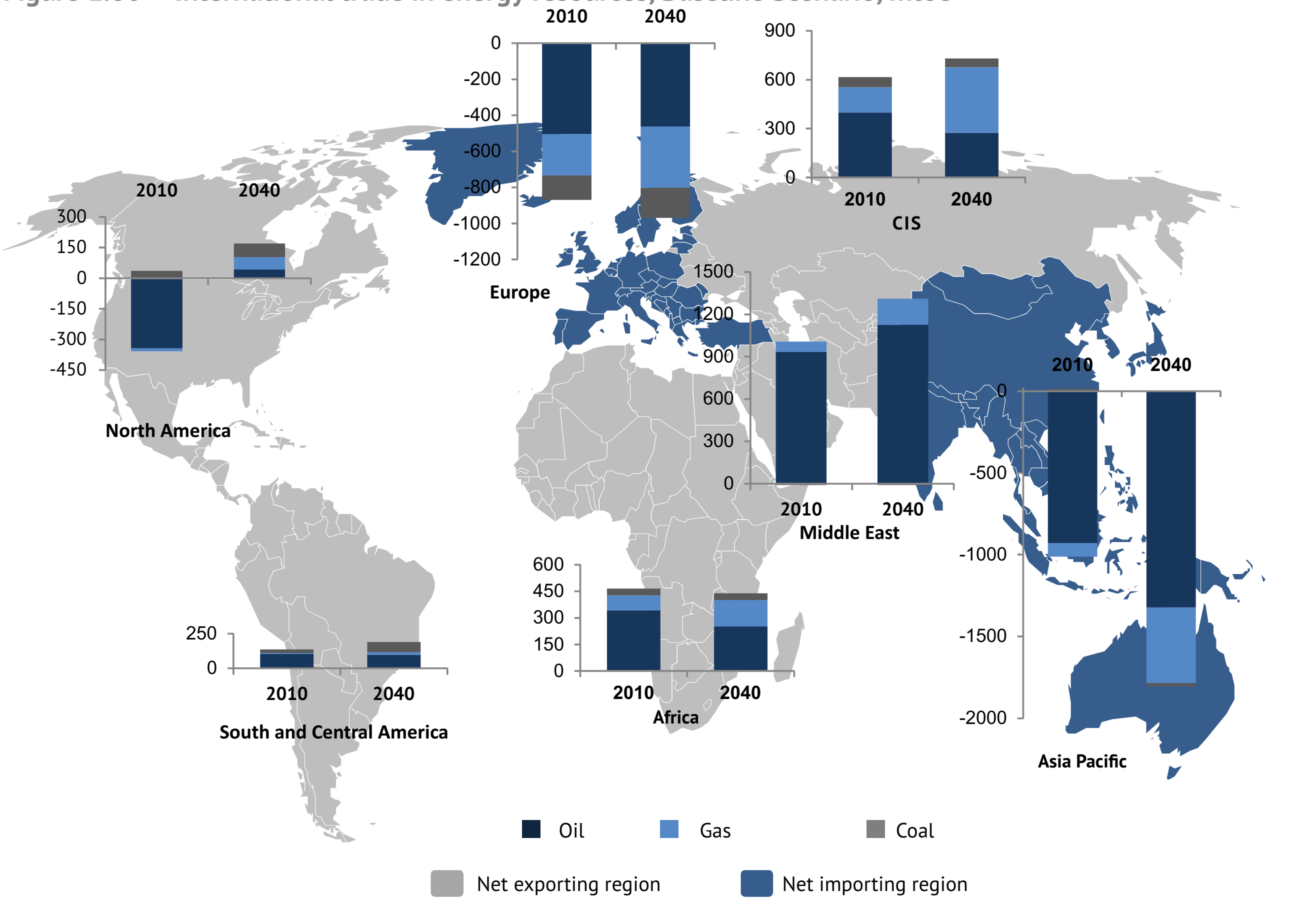
Source: ERI RAS

International Trade

Global trade in energy resources faces serious transformations in the period to 2040, with the main role in changing the directions of supply being played by the growing self-sufficiency of North America (resulting from its production of unconventional oil and gas resources). On the other hand, the rapid rates of growth in energy demand from the developing countries of Asia will require substantial increases in deliveries to the Pacific and Indian Ocean basins.

By 2040 North America will have changed from being a net importer of oil and gas to being a net exporter. Imports of energy resources in Europe will increase by an insignificant amount (with a reduction in oil imports and an increase in gas imports). The developing countries of Asia will expand their oil imports very rapidly (Figure 1.80). By 2040 the CIS region will have very slightly reduced its net oil exports, but will have increased its exports of gas.

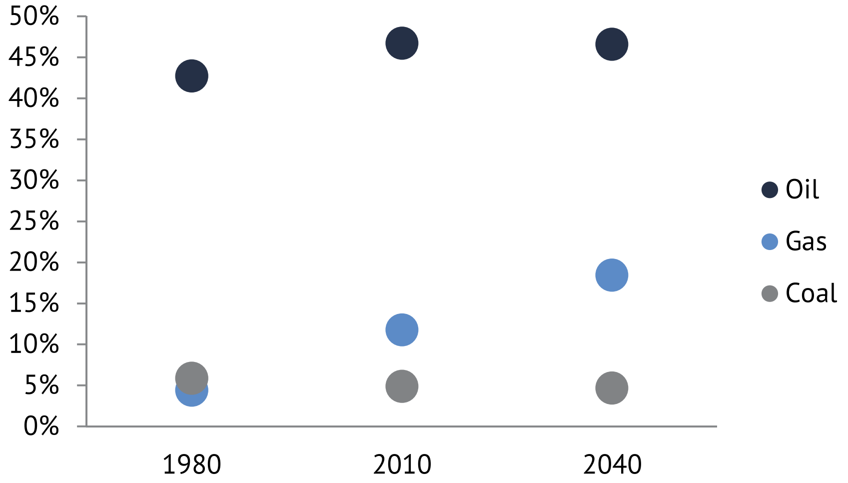
Figure 1.80 – International trade in energy resources, Baseline Scenario, mtoe



Source: ERI RAS

Moreover, while the share of total oil production represented by internationally traded oil hardly changes (46–47 per cent) between 2010 and 2040, the share of internationally traded gas increases from 12 to 18 per cent of gas production (Figure 1.81).

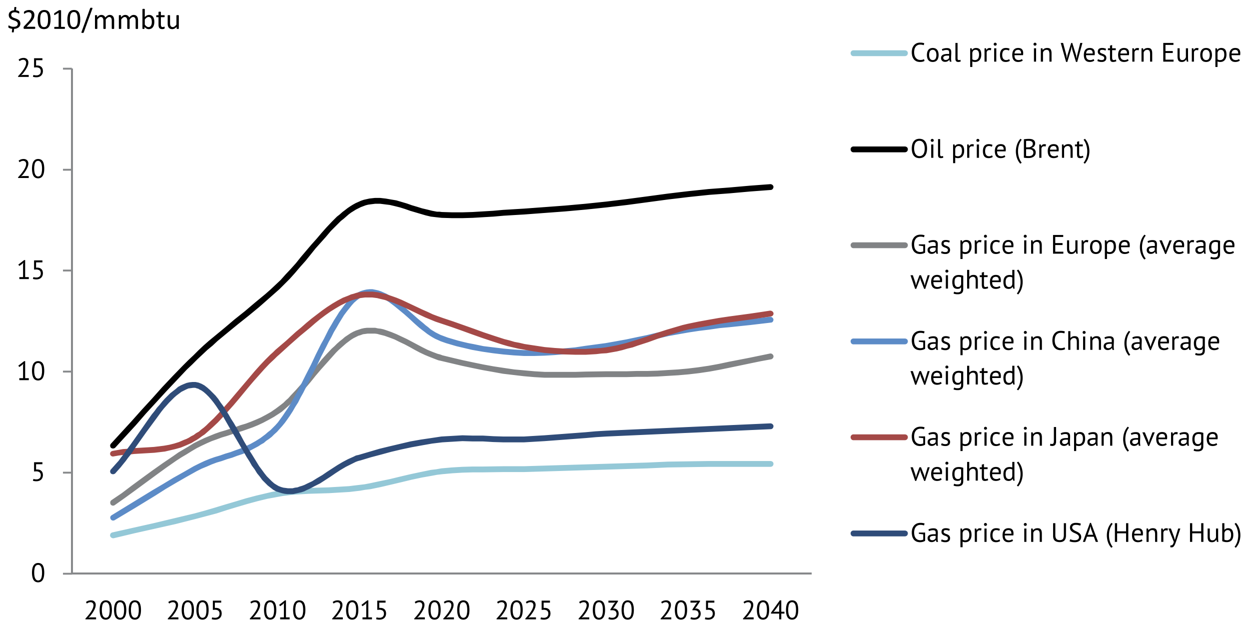
Figure 1.81 – Inter-regional oil, gas and coal trade relative to global production, 1980, 2010 and 2040, Baseline Scenario



Source: ERI RAS

The price differentials between different types of fossil fuels remain practically unchanged, although in the period 2005–15 the differences between gas prices in different regions become greater (Figure 1.82).

Figure 1.82 – Oil, gas (in three regions) and coal prices, Baseline Scenario



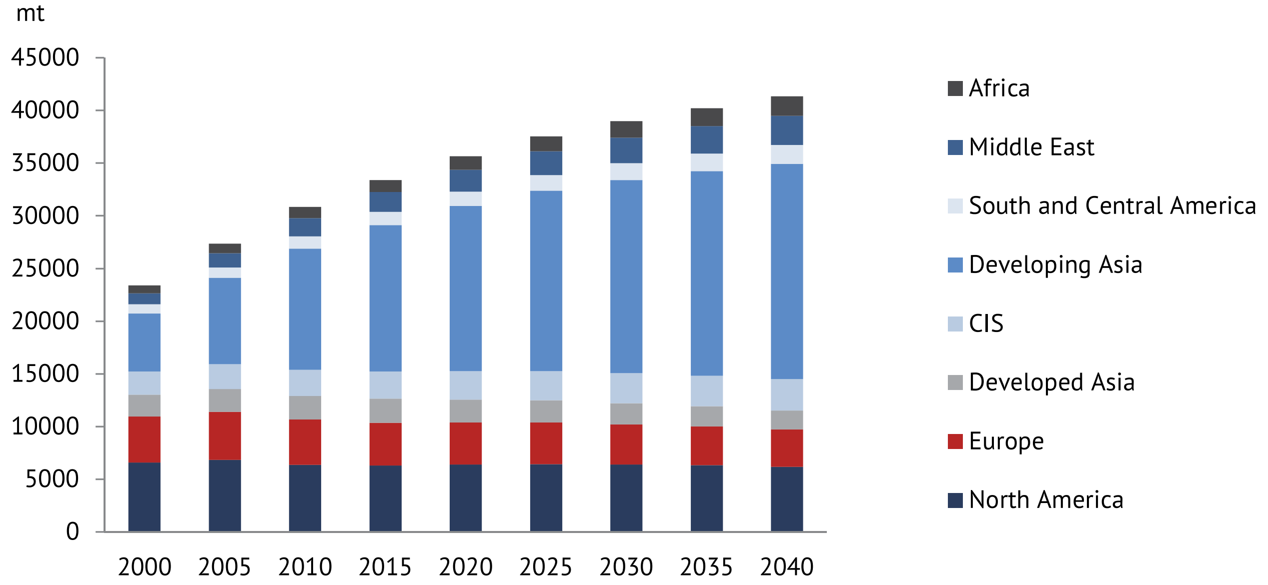
Source: ERI RAS

CO_2 Emissions

Data on greenhouse gas emissions used in international energy statistics and in this prognosis may differ significantly from data provided by the Secretariat of the Framework Convention on Climate Change (UNFCCC)[26].

For the world as a whole, peak emissions of greenhouse gases from burning fossil fuels will not be achieved by 2040 (Figure 1.83). Annual emissions will increase 1.3 fold compared to current levels. At the same time, the annual growth rate of emissions will be reduced. So, if these figures are expected to increase by 12.9 per cent from 2011 through 2020, then from 2021 through 2030 the figure will be 8.1 per cent, and 5.4 per cent from 2031 through 2040.

Figure 1.83 – CO_2 emissions by region



Source: ERI RAS

Cumulative emissions from 2000 through 2040 will exceed 1.4 trillion tonnes. Given this scenario, the stabilization of greenhouse gas concentrations in the atmosphere at 450 parts of CO_2-equivalent per million of air (the figure required to give a 50 per cent possibility of preventing warming by more than 2°C compared to the period before the start of the industrial revolution) is impossible Moreover, even stabilization at 550 ppm (which gives a 25 per cent probability that a warming of more than 2°C does not occur) is hardly attainable under the conditions of Outlook 2014's Baseline Scenario

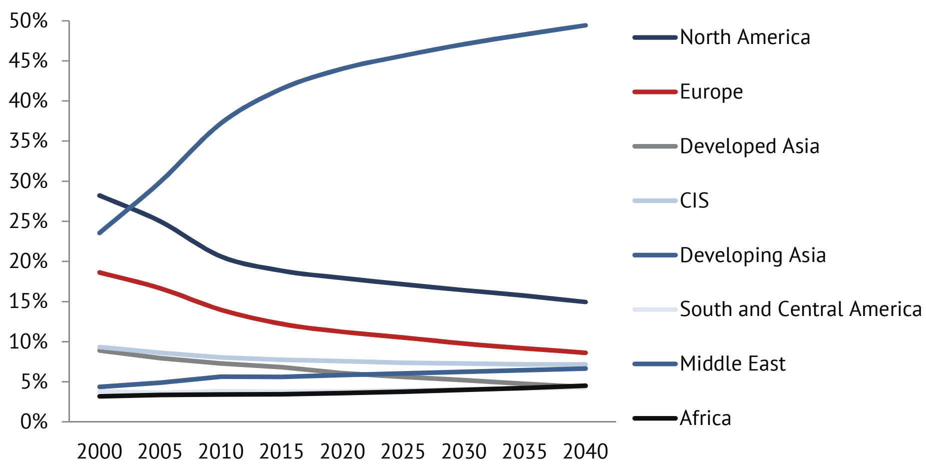
26 UNFCCC data is based on national greenhouse gas inventories, calculated independently by national authorities using approved UNFCCC methodology. However, different approaches to the drawing up of the energy balance, different versions of the UNFCCC guide (1996 or 2006), and different coefficients to account for the emissions produced by burning fossil fuels may be used in different countries. These and other factors, described in detail in the statistical handbook IEA 'CO_2 Emissions from Fuel Combustion' (2013 edition) (pp I.4–I.5), require the use of data adjusted by application of the universal method, as was done for the present forecast.
For this forecast only, emissions of greenhouse gases from burning fossil fuels were considered. CO_2 emissions from industrial processes and emissions from land use, change of land-use and forestry (LULUCF), are not considered. Ways of reducing emissions, such as carbon capture and storage (CCS) were also not considered. For the world as a whole, we have confined our attention to CO_2 emissions. So the emission values presented in the forecast, are not fully comparable with emission inventories that countries prepare in accordance with the UN Framework Convention on Climate Change, or countries' national plans to reduce emissions.

By 2040, OECD countries will account for only 28 per cent of all emissions from burning fossil fuels, compared with 40 per cent in 2011. Peak emissions in these countries will be reached in 2020 and will then begin to gradually reduce. The EU has already set out on the path of long-term emission reductions. However, this reduction will be gradual in nature, and by 2040 emissions will have reduced by only 22 per cent from the current level. The landmark point for the EU's current plans is 2020, by which time it is expected that emissions will have been reduced by 20 per cent compared to 1990s levels. Carbon dioxide emissions from burning fossil fuels will decrease over this period by more than 17 per cent, which makes it highly likely that the task will be fulfilled by 2020. The demand for carbon credits in the European market for trading emission quotas will grow as we approach 2020. This will lead to higher prices, which are currently at an abnormally low level.

The developed countries of Asia will set off on the path of emission reductions in the coming years, primarily due to the recovery of nuclear capacity in Japan and its expansion in Korea. The development of renewable energy will also play a role. In the USA the situation is more complicated. The substitution of coal by gas in in the structure of consumption (resulting from the onset of intensive shale gas production) led to a 10 per cent reduction of emissions as early as 2007. This potential for reduction, however, has already been exhausted. Increasing emissions from the burning of fossil fuels will be resumed because of growing energy demand. Peak emissions will only be reached by 2023. By 2040, emissions from the burning of fossil fuels in the USA will be only 13.3 per cent lower than in 2005. Barack Obama's ambitious plans for a 17 per cent reduction in emissions by 2020, and 83 per cent by 2050 from 2005 levels are probably impossible to achieve. Only the adoption of stringent restrictions on greenhouse gas emissions at the national level might change the overall picture, but such a development is unlikely in the near future.

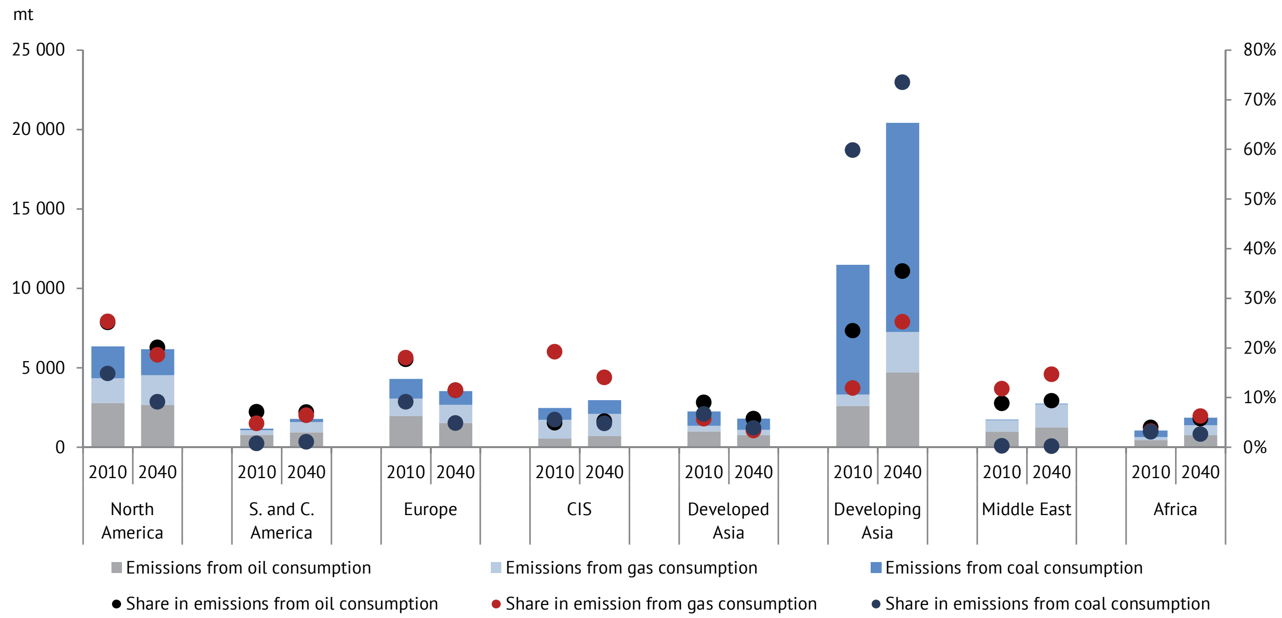
The increasing emission dynamics in the coming decades will continue to be predominantly determined by the developing countries of Asia. Their share of world emissions will exceed 49 per cent by 2040, of which 32 per cent will come from China (Figure 1.84). Annual growth of emissions in China alone in the 2030s will be more than three times the reductions in emissions in all the OECD countries combined. However, by the end of the 2030s China will only occupy the second place for annual growth of emissions in absolute terms, after India. In the list of emitting countries, India's 10.3 per cent share of the world's emissions brings it a close second to the USA. On top of that, the poorest countries of Africa and Asia will show quite a rapid growth of emissions in the coming decades, but their share in total emissions will remain insignificant.

Figure 1.84 – Emissions by region (percentage of global emissions)



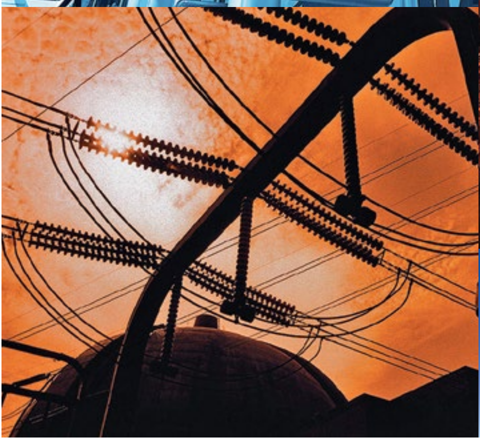
Source: ERI RAS

Figure 1.85 – Emissions by region by fuel type (absolute volume and percentage of global emissions)



Source: ERI RAS

In Outlook 2014 only those state plans to reduce emissions that have already been legally approved have been taken into account. We assume the possibility of the leading nations intensifying their efforts to reduce emissions in the future. However, even if this happens (the probability of such an outcome will increase as a consequence of greater damage from climate change, for example due to the increased frequency and intensity of natural disasters), it is hardly likely to take place in the next decade.



Section 2

IN SEARCH OF BOUNDARIES

SECTION 2. IN SEARCH OF BOUNDARIES

Given the instability of the global energy markets, it becomes important to analyse the potential changes that could substantially affect the position of the key players and the very structure of the markets themselves. This section discusses the possible significant deviations (associated with significant changes in supply and demand for hydrocarbons) of markets from the Baseline Scenario. The objective of these scenarios is to test the boundaries of the stability of the oil, gas, and coal markets, as well as those of the global energy system as a whole.

The New Producers Scenario

In recent years it has become increasingly popular to predict an imminent sharp drop in oil prices – influenced by the appearance of significant amounts of additional supply. In Outlook 2013, the potential impact of a technological breakthrough that would result in the accelerated development of oil shale plays was examined, and it was shown that even with the rapid testing and approval of the most advanced technologies, production from the 'shale revolution' would not lead to a long-term fall in oil prices below 90–95 $2010 per barrel.

In the past year new possibilities have arisen for increasing the volume of supply of hydrocarbons at relatively low cost that could eventually lead to lower prices for oil and gas. The New Producers Scenario assumes the very highest possible (realistic) production of oil and gas by new players and evaluates the impact of this additional supply of hydrocarbons on global energy markets.

Oil

The main driver capable of having a significant impact on world oil markets has been identified as the considerable potential in three countries – Brazil, Iraq, and Iran – for increased oil production, compared to the current levels and the levels specified in the Baseline Scenario.

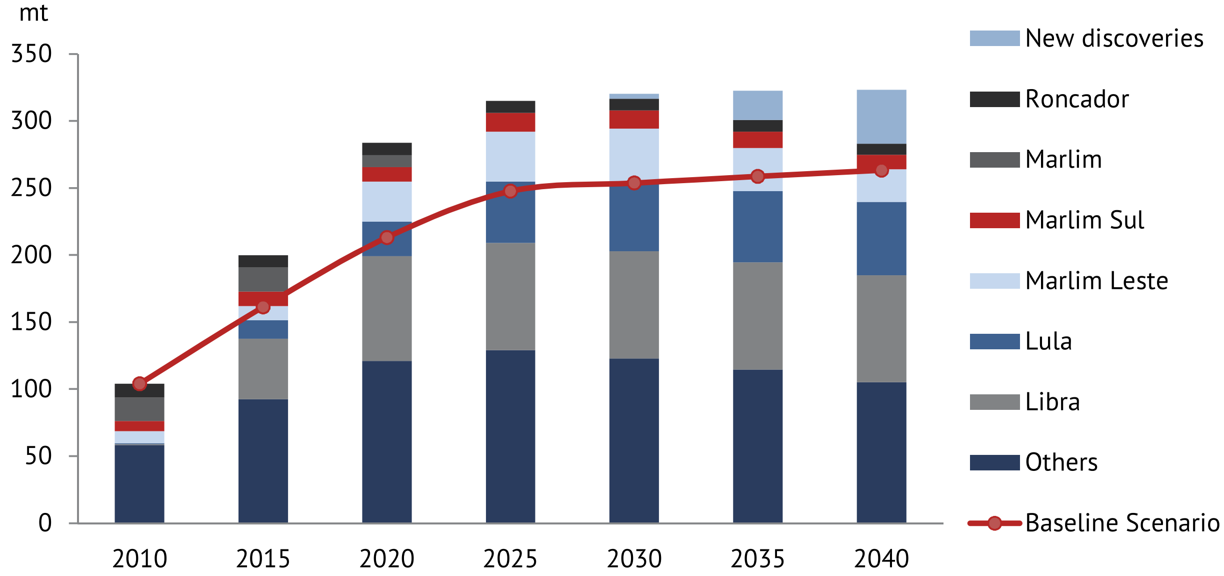
There is not expected to be a significant increase in production in the forecast period from such a potentially major producer as Venezuela – with no more than 20 million tonnes allowed for in the Baseline Scenario (provided that oil prices are in the range above 100 $2010 per barrel). This is due to the high barriers facing foreign innovative mining companies hoping to enter the country's market, and the high costs of oil extraction in the Orinoco Belt.

Commercial volumes of oil production from the Arctic shelf are also not expected in the forecast period, due to the extremely high prices (up to 200 $2010 per barrel) that would be required to run these projects given the current level of technology.

In contrast, oil production in **Brazil** may reach 320 million tonnes by 2040, subject to the accelerated commissioning of the country's key fields; this is 60 million tonnes higher than in the Baseline Scenario (Figure 2.1). The main increase in production can be achieved from ultra-deepwater fields in the oil

and gas basins of Santos and Campos. At the same time, as of 2030, just two fields in the Santos Basin – Lula (Tupi) and Libra – will be able to provide more than 40 per cent of all oil production in the country.

Figure 2.1 – Brazilian oil production, Baseline Scenario and New Producers Scenario



Source: ERI RAS

Another important fact is that the Brazilian offshore fields are quite inexpensive. Goldman Sachs[1] estimates the breakeven price for all new deposits within the Santos Basin to be 50 $2010 per a barrel, which makes Brazilian oil among the most competitive in the world market.

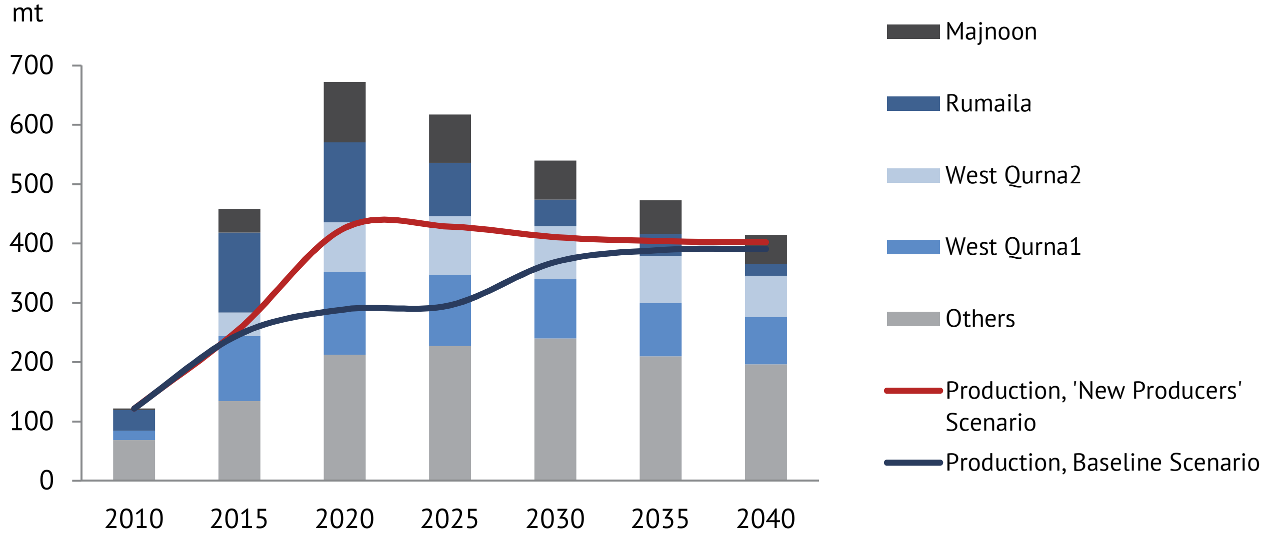
A substantial increase in output compared with the Baseline Scenario could be achieved in **Iraq**, subject to the stabilization of the conflict between Iraq proper and Northern Kurdistan. It is important that Iraq can significantly increase production – not in the distant future, but in the next five to six years. In terms of proven reserves, potential oil production in Iraq could reach 670 million tonnes by 2020, with a subsequent decline to 415 million tonnes by 2040 (Figure 2.2).

Nonetheless, even in the New Producers Scenario, Iraq's potential is not revealed in full because of the relatively high costs of production at new projects (70–90 $2010 per barrel). In the New Producers Scenario, Iraq's oil output reaches 425 million tonnes by 2020 and then gradually declines to 405 million tonnes by 2040, while maintaining a significant amount of spare production capacity. This spare capacity could make Iraq a second 'swing producer' in OPEC after Saudi Arabia in the period 2015–35, with spare production capacity of between 70 and 245 million tonnes per year[2] which, besides providing Iraq with an exponential increase in revenues from exports, could also give the country extra muscle in the geopolitical arena.

1 '330 Projects to Change the World', Goldman Sachs, 2011.

2 OPEC's current spare capacity is estimated at 400 million tonnes.

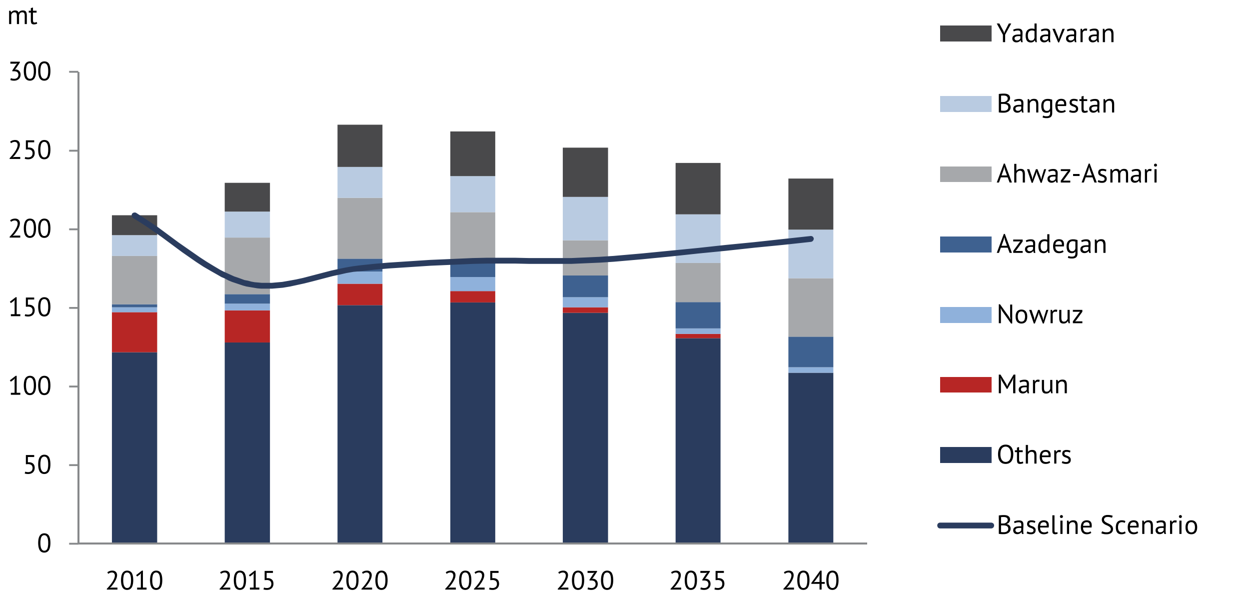
Figure 2.2 – Iraq's theoretical potential oil production and production forecast in the Baseline Scenario and the New Producers Scenario



Source: ERI RAS based on MEED Projects data

The third producer with significant potential for increasing production in the next several years is Iran. If economic sanctions on the country are lifted in the near future, oil production could increase to 265 million tonnes by 2020 with a subsequent reduction to 230 million tonnes by 2040 (Figure 2.3). It is important to note that much of the increase in production in Iran will be provided by the development of oil and gas fields, while the economics of Iran's gas industry will largely determine the potential increase in the production of gas condensate.

Figure 2.3 – Iranian oil production, Baseline Scenario and New Producers Scenario



Source: ERI RAS

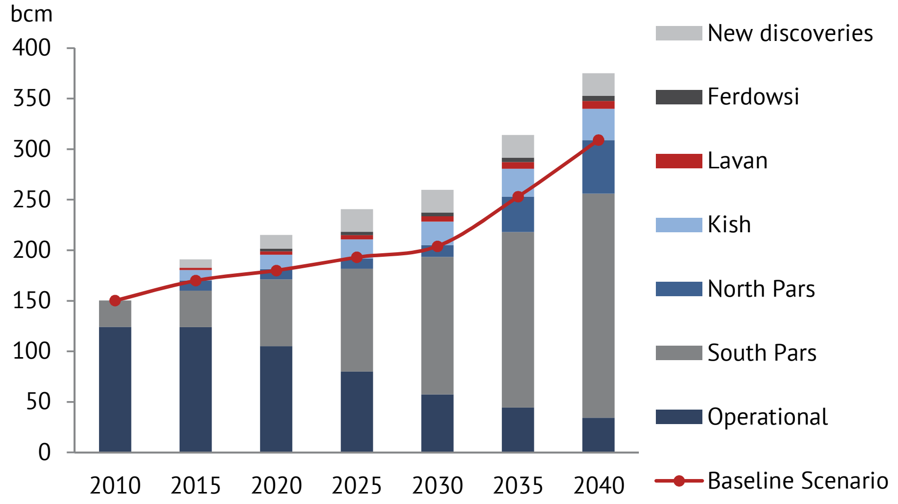
Gas

There are also a number of producers on the global gas market today that have significant potential to increase natural gas production. Among these, it is particularly worth highlighting Iran, Qatar, Australia, the countries of East and South Africa[3], and Turkmenistan. The USA, Iraq, and Argentina also have considerable potential for growth, but this is almost completely covered in the Baseline Scenario and therefore these countries are not examined in the New Producers Scenario.

The most significant contribution to increased global supplies of natural gas could be made by **Iran** whose potential, thanks to the opening of the South Pars field, is huge (its reserves represent approximately 5 per cent of global reserves). However, economic sanctions against Iran (imposed by the UN and leading Western countries) are hampering the development of the country's gas industry. The key factors influencing the dynamics of natural gas production in the forecast period will relate to: how soon restrictions on Iranian exports might be lifted, and how easy it will be to attract foreign companies with high technological, managerial, and financial capital. In the most favourable scenario for the period from 2010–40, gas production could be increased almost two and a half times, reaching 370 bcm, which is 60 bcm higher than in the Baseline Scenario (Figure 2.4). Most of the growth, as already mentioned, can be achieved by using the potential of the South Pars field which, by as early as 2030, could provide more than half of the country's total gas production.

It is also significant that the breakeven price for Iran's new fields is below 50 $2010 per thousand cubic metres which, together with the country's fortunate geographical position, makes gas from these projects highly competitive both on the European and on the Asian markets.

Figure 2.4 – Iranian natural gas production in the Baseline Scenario and the New Producers Scenario

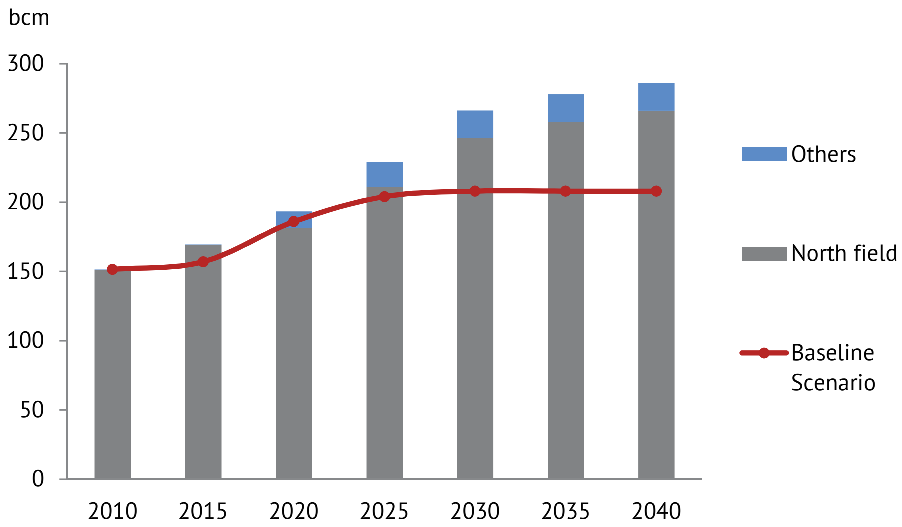


Source: ERI RAS

3 East and South Africa usually includes: Mozambique, Tanzania, South Africa, Kenya, Cote d'Ivoire, Uganda, and Madagascar.

Qatar also has a higher potential output, when compared with the assessment in the Baseline Scenario. The growth of natural gas production in this country could accelerate significantly if the moratorium on launching new projects in North Field is lifted; this is the largest field in the world and provides almost all of Qatar's gas production. Moreover, there are serious reasons for considering that new fields will be opened by 2020, with particularly high hopes for the Knuff formation. In total, natural gas production in Qatar can exceed 285 bcm by 2040, which is 75 bcm higher than in the Baseline Scenario (Figure 2.5). It should be noted that the breakeven price of Qatar's fields is an average of 45 $2010 per thousand cubic metres, which even with liquefaction and transport costs added in makes Qatari gas one of the most competitive sources of supply.

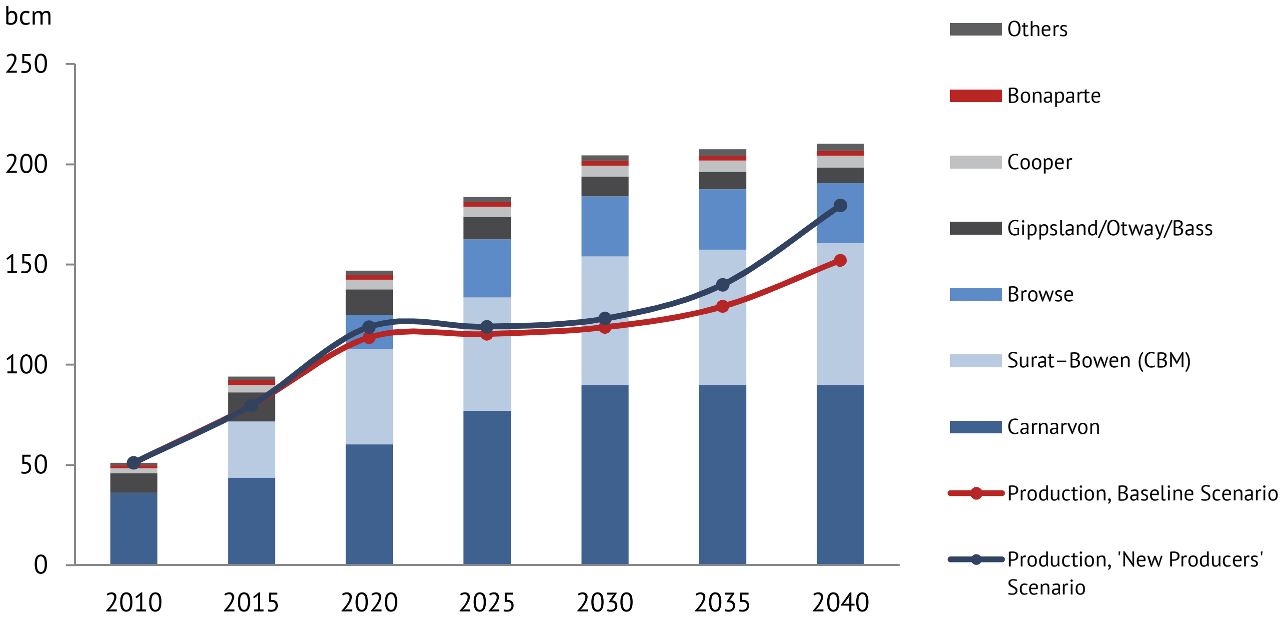
Figure 2.5 – Qatari natural gas production in the Baseline Scenario and the New Producers Scenario



Source: ERI RAS

Australia has good prospects for increasing its gas production. At present, the Carnarvon offshore field off the country's north-west coast accounts for virtually all of Australia's production. As other offshore fields are commissioned and reach nominal capacity, and with the starting up of coalbed methane extraction in the Surat–Bowen Basin, gas production in Australia may exceed 175 bcm by 2030 and subsequently stabilize at about this level, thus exceeding the Baseline Scenario forecast by 25 bcm. However, we must note that the majority of Australian projects (see Figure 2.6) are export-oriented in the form of LNG, and with liquefaction and transportation costs included the breakeven price will vary from 290-400 $2010 per thousand cubic metres. This means that high prices on Australia's target Asian gas market need to be maintained to ensure the projects' investments are recouped.

Figure 2.6 – Australian theoretical potential oil production and production forecast in the Baseline Scenario and the New Producers Scenario



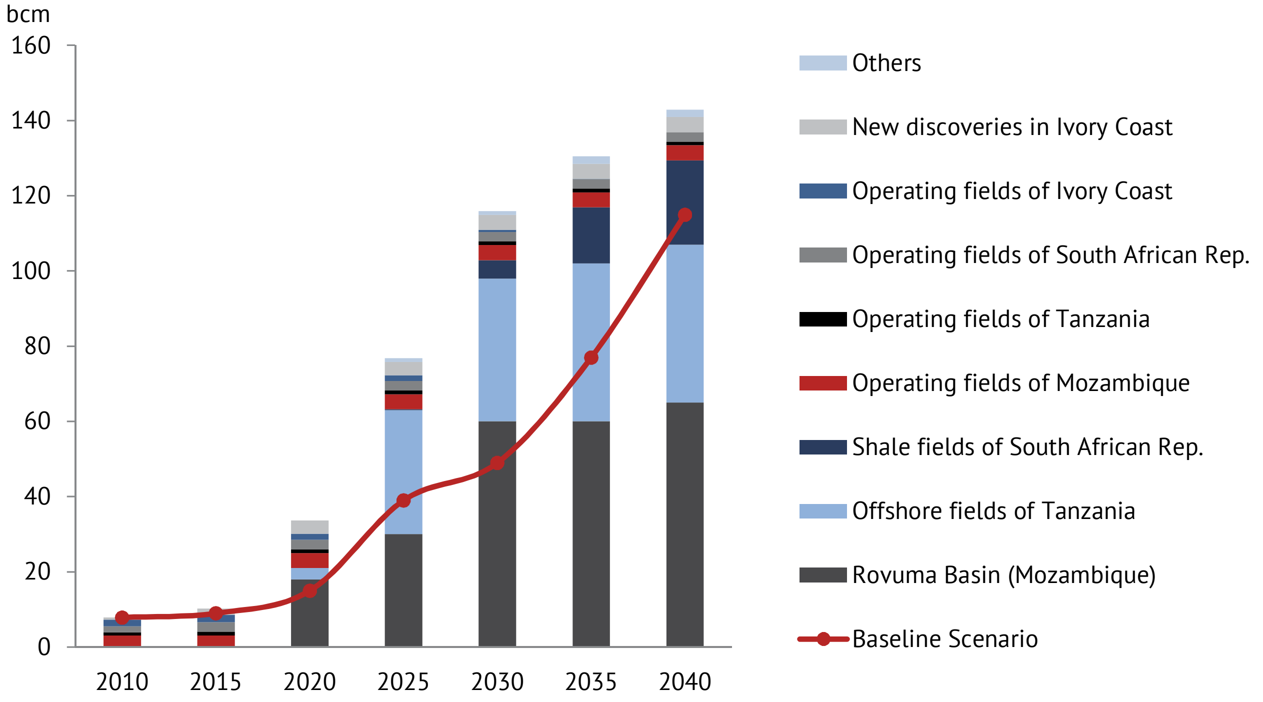
Source: ERI RAS

Eastern and Southern Africa can become an important new gas producing region in the world. Although in 2010 the region's total gas production was just over 7 bcm (which played practically no role in the global aggregate supply) production could exceed 130 bcm by 2040 (Figure 2.7). given favourable circumstances. The main contributors to this growth will have to come from deposits in Mozambique's Rovuma basin, Tanzania's offshore fields, and South Africa's shale deposits. Together, they could provide about 95 per cent of production in the region by 2040.

Due to low domestic demand, gas projects in Mozambique and Tanzania are focused primarily on exporting LNG to the Asian market, which at present provides producers with a price premium. It has been announced that the first LNG volumes from these countries may enter the market as early as 2018, although given that the regulatory environment necessary for the implementation of projects in the countries of the region is currently at an early stage of development, this would appear to be unrealistic. Due to the fact that there are also new LNG projects in Qatar and Australia which are targeting the Asian market, and these also expect to significantly increase exports, Mozambique and Tanzania will come up against strong competition in this market. Given that the breakeven price for the two East African countries' offshore projects is quite high (120–370 $2010 per thousand cubic metres) it will not be a simple task to achieve the potential volumes of gas production. Nor can political risks be discounted: despite the fact that the situation in these countries is currently stable, high inflation and unemployment may cause social unrest in the future, especially after 2017 when Mozambique and Tanzania will begin a new political cycle and elections will be held.

The breakeven price of South Africa's shale projects is 230–330 $2010 per thousand cubic metres, but these projects are focused on the domestic market, where demand is quite high, and this increases the country's chances of achieving its potential production volume. Technological and environmental difficulties that may arise during the implementation of projects for the extraction of shale gas could be an obstacle in achieving this.

Figure 2.7 – Natural gas production in East and South Africa in the Baseline Scenario and New Producers Scenario

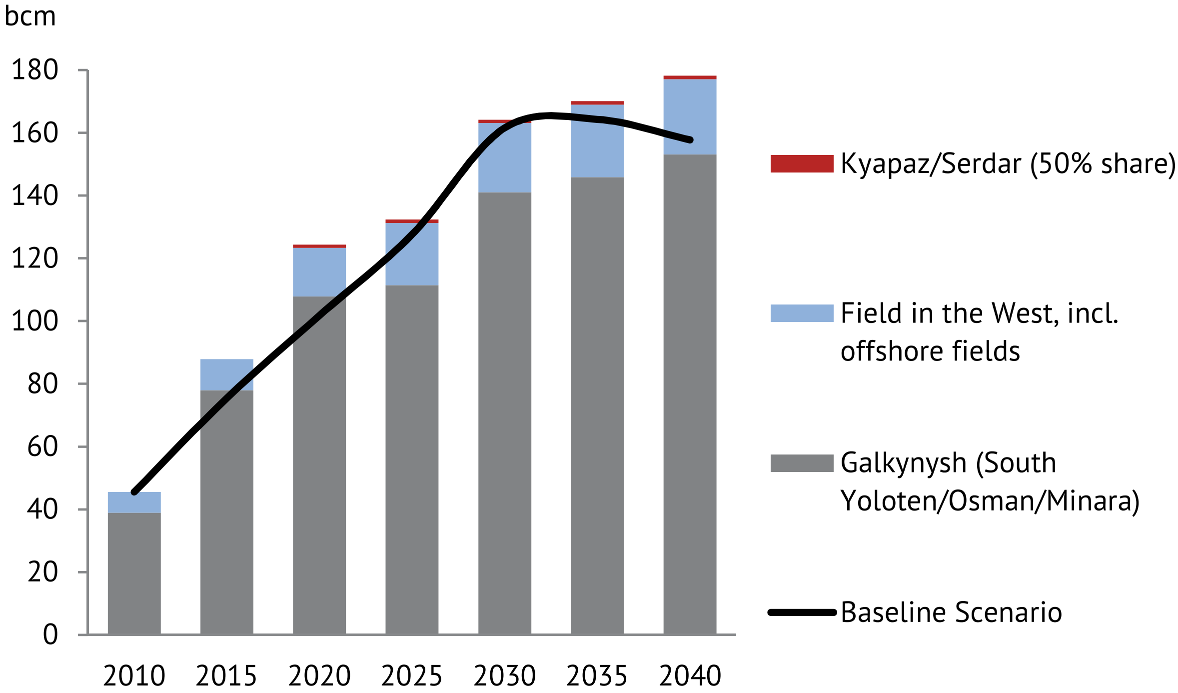


Source: ERI RAS

Substantial growth in natural gas production could be achieved from 2010 through 2040 in **Turkmenistan**. This country's main hopes lie in the South Yolotan, Osman, and Minara fields, which were unified as the super-giant Galkynysh field in accordance with a presidential decree on 18 November 2011, in order to increase the efficiency of their development. According to an audit by the British company Gaffney, Cline and Associates, initial geological reserves at Galkynysh come to more than 26 trillion cubic metres, a figure that could, after more detailed study, even be revised upwards. With confirmation of these figures, the Galkynysh field will become the second largest in the world for volume of reserves after the South Pars/North field, which is jointly operated by Iran and Qatar. Turkmenistan also has promising potential for increasing the gas production at fields on the western shelf of the country, which are already in the active phase of development.

In the New Producers scenario, Turkmenistan could increase gas production to 177 bcm in 2040 if it were to intensify the development of the Galkynysh field, and this would exceed the figure in the Baseline Scenario by 20 bcm (Figure 2.8).

Figure 2.8 – Potential natural gas production in Turkmenistan, 2010–40

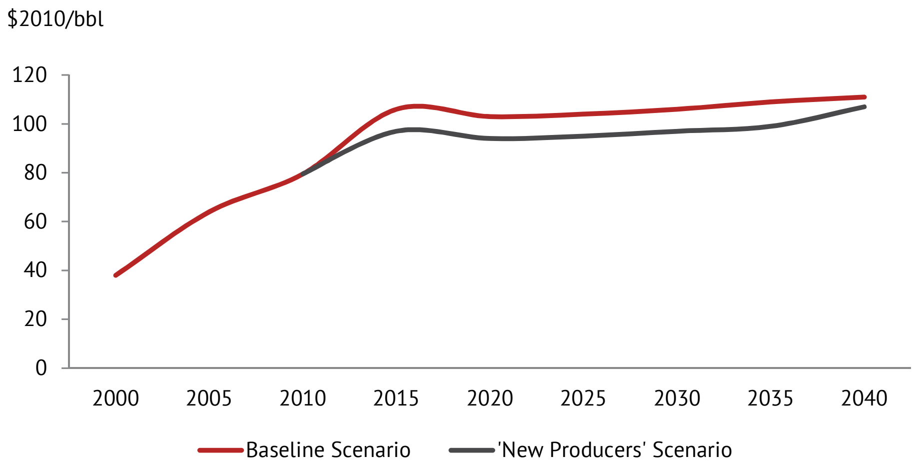


Source: ERI RAS

Influence on prices

Increased production of relatively cheap oil from fields in Brazil, Iraq, and Iran will reduce the price of oil relative to the Baseline Scenario in the period 2015–35 by about 10 per cent (9–10 $2010 per barrel), but in 2040, with the decline in production in these countries, prices will recover almost to the level (4 $2010 a barrel less) of the Baseline Scenario (Figure 2.9).

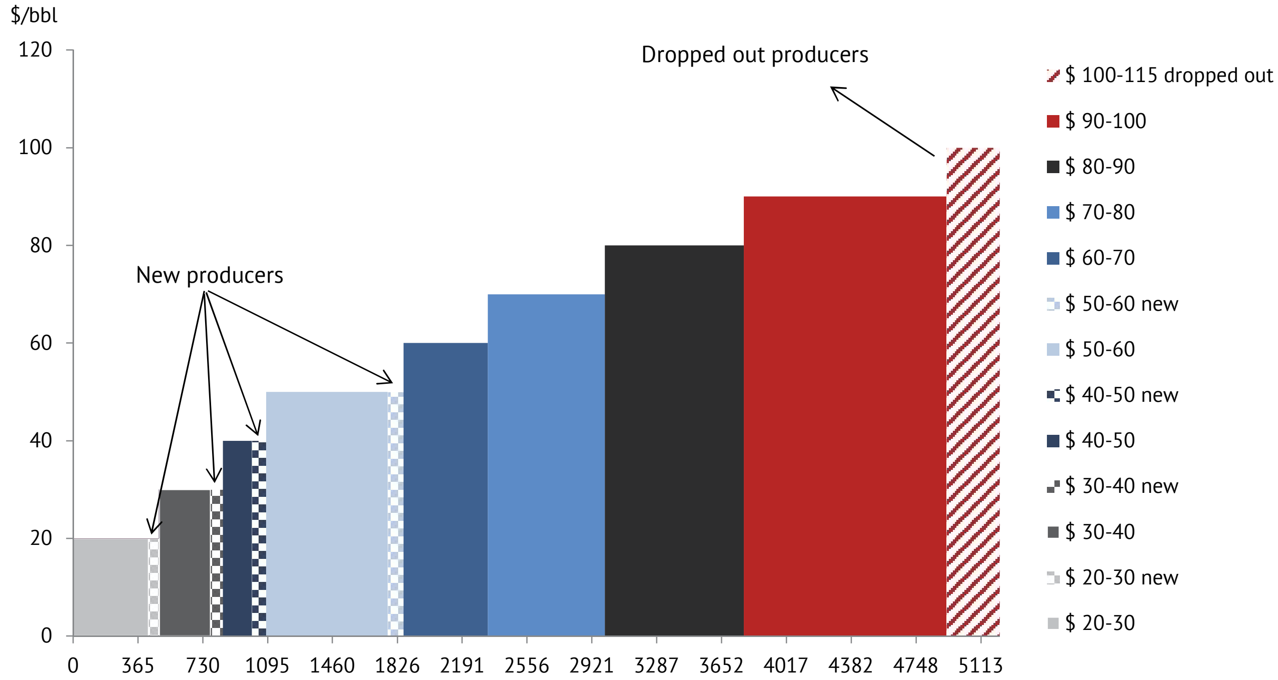
Figure 2.9 – Equilibrium oil prices in the Baseline Scenario and New Producers Scenario



Source: ERI RAS

It is important to note here that not one of these countries, nor even all of them together, are able to cause a collapse in oil prices to an average annual level of 50–60 $2010 per barrel. The total increase in production, with costs ranging from 20 to 60 $2010 per dollars a barrel from the three producers concerned, will actually widen the supply curve in its initial segment and replace only some of the producers with low-priority overheads. It cannot, however, replace sufficient volumes of oil to seriously reduce prices (Figure 2.10).

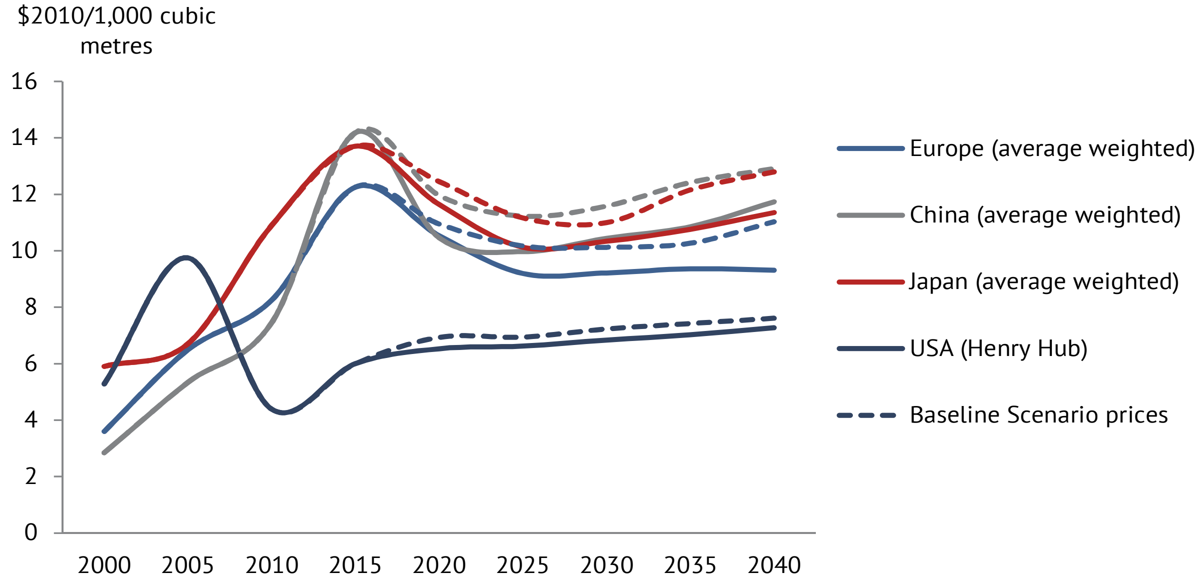
Figure 2.10 – Changes in the oil supply curve in 2020 should the New Producers Scenario be realized



Source: ERI RAS

The situation in the gas market is quite similar. A collapse in prices does not occur (Figure 2.11), although the price of gas in this scenario is under simultaneous pressure from both ‘gas on gas’ and through the formula for pegging prices to oil prices. However, the impact varies widely between different regional markets: while the North American market feels almost no change, the difference from Baseline forecast prices in Asia–Pacific and China will be 9–13 per cent. It is, however, the European market where the effect is most keenly felt, with a 20 per cent reduction in prices compared with the Baseline Scenario.

Figure 2.11 – Equilibrium gas prices, New Producers Scenario



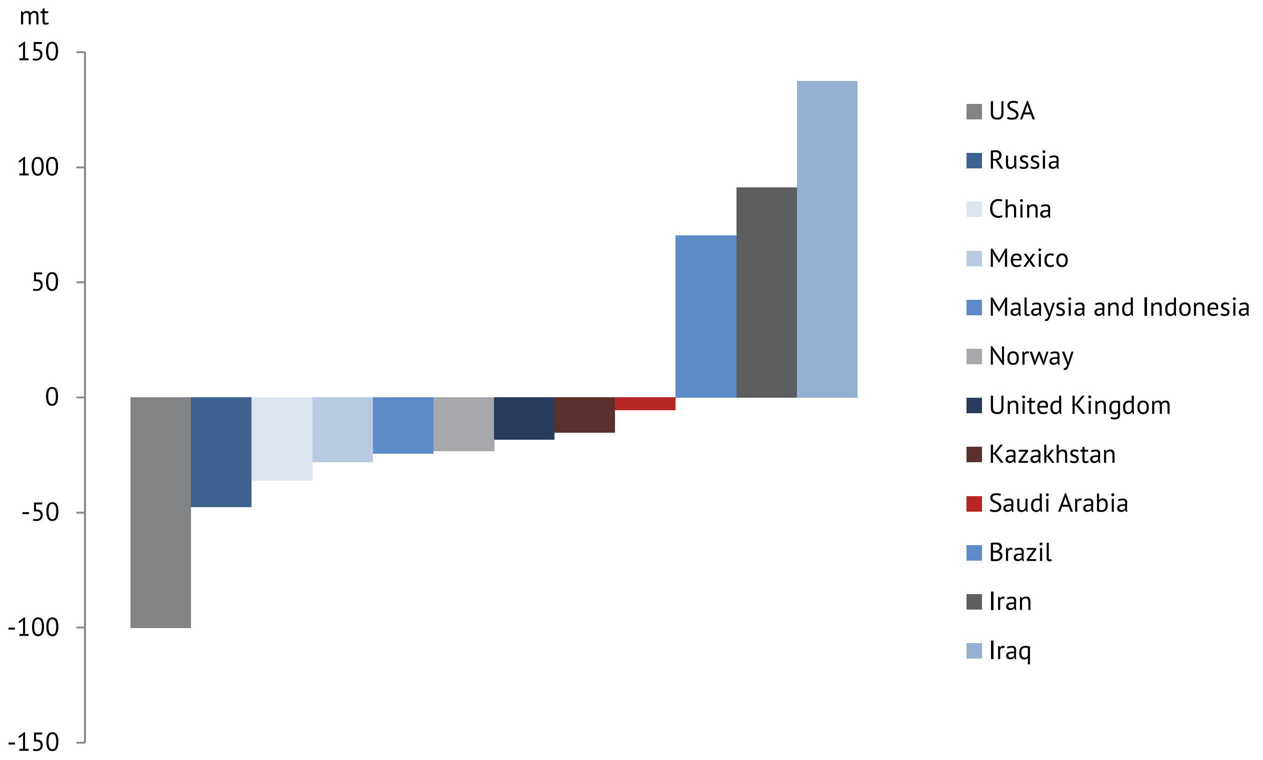
Source: ERI RAS

At the same time (as for the oil market) the new producers' increased output of gas squeezes the traditional suppliers' most expensive production from the market. By 2040, therefore, the losses in this scenario will be shared between North America (–57 bcm, of which 45 bcm is produced in the USA), the CIS countries (–87 bcm, of which about 70 bcm will be Russian gas), and Australia (–10 bcm), with Iran being the main winner (+120 bcm).

Impact on major players

The increase in oil production in Brazil, Iran, and Iraq will have the greatest impact on other market participants in the short term, until 2020. An increase of 300 million tonnes in the production of these producers compared with the Baseline Scenario in 2020 will lead to a commensurate reduction in the production of ten major producing countries: the USA, Russia, China, Mexico, Malaysia, Indonesia, Norway, Great Britain, Kazakhstan, and Saudi Arabia (Figure 2.12). Half of this decline will be in Russia, as a producer with trailing costs in the industry (–47 million tonnes) and the USA, as a producer whose production level depends largely on the rapid commissioning of shale projects (–100 million tonnes).

Figure 2.12 – Changes in oil production in 2020 in major producing countries in the New Producers Scenario compared to the Baseline Scenario



Source: ERI RAS

The decline in oil production in the USA projected in the New Producers Scenario is almost entirely in oil shale plays (–75 million tonnes), due to the high sensitivity of oil shale projects to changes in oil prices.

The high sensitivity of oil shale plays to changes in oil prices is a result of the technical process of production – the need to constantly increase the amount of drilling, which is the most cost-intensive part of the whole production process. In fact, if oil prices begin to decline, a company producing shale oil in the short term can 'pump out' oil from already drilled wells without starting new drilling operations, in anticipation of a favourable pricing environment. Thus, companies holding licences in areas with low oil content and relatively high extraction costs[4], are sensitive to a reduction in price of 9 $2010 per barrel, and this will lead to a reduction in drilling, which in turn leads to a decrease in oil production in the USA.

After 2020, when the new producers will be closer to peak production, the situation will stabilize, and by 2040 the additional increase in production compared with the Baseline Scenario will decline to 100 million tonnes.

4 Production costs of shale oil plays lie in the range 55–110 $2010 per barrel.

In the New Producers Scenario, oil-importing countries are the main beneficiaries, due to lower purchase costs, as are producers with relatively low production costs – that is to say, those self-same new producers. The losers turn out to be high-cost producers, in particular producers in the CIS countries, Asia–Pacific, and Europe. In addition, this scenario reduces the USA's self-sufficiency in oil resources and reduces its impact on the global oil market.

The likelihood of the New Producers Scenario playing out is, to a large extent, dependent on how the main players on the global hydrocarbons market – the USA, Saudi Arabia, and China – behave in the short term.

The USA, which suffers to a greater extent from the consequences of the New Producers Scenario than the other players, can try to influence the position of new players by increasing its own production, perhaps even at a loss, if only to prevent new oil from the Middle East and Brazil from getting to the market. It is important to understand that the USA could theoretically take such a step, which is contrary to market principles. The main increase in US production can be provided mainly by shale deposits and offshore Gulf of Mexico. The rapid development of offshore production and shale plays may provoke protests from environmental and public organizations, and also bring down oil prices in the short term to a level low enough to lead to a decrease in the revenues of US companies.

Saudi Arabia's behaviour is also important in the playing out of the New Producers Scenario. A key member of OPEC can prevent new oil volumes from reaching the market by sharply increasing its own production. Of course, such behaviour will have a negative effect on relations between Saudi Arabia and the other members of the oil cartel. In our opinion, it is unlikely that Saudi Arabia will intervene in the market by utilizing its spare production capacity, as it loses very little in terms of its own income and export volumes compared to other producers, so there is no commercial reason to enter into conflict with its partners in OPEC, though it is quite possible that the USA could put pressure on Saudi Arabia, forcing it to increase supply to the market, and thus block oil from Iran and Iraq.

The likelihood of the New Producers Scenario depends as much on the actions of China in the global oil and gas market as it does on those of the USA and Saudi Arabia. We should also note that during the entire forecast period from 2020, annual oil production in China will be, on average, 40 million tonnes lower compared to the Baseline Scenario. In this scenario – against a background of lower oil prices – costly new production projects will not be introduced, particularly not shale projects. However, China's own decline in oil production is not a critical factor due to the significant presence of Chinese oil and gas companies in extraction projects abroad, particularly in oil projects in Iran and Iraq (Table 2.1). In fact, China's policy in the production and trading of oil is beginning to resemble US policy in the late twentieth century in engaging in producing and importing from regions with relatively cheap raw materials while simultaneously preserving its own resources.

Table 2.1 – Chinese involvement in Iranian and Iraqi projects

Country	Field
Iran	North Azadegan (CNPC)
Iran	Zagros Basin (CNPC)
Iran	Yadavaran(Sinopec)
Iraq	Al-Akhdab (CNPC)
Iraq	Rumaila (CNPC)
Iraq	Halfaya (CNPC)
Iraq	Missan (CNOOC)

Source: ERI RAS

Of course, in the New Producers Scenario, oil production in China is markedly reduced in comparison with the Baseline Scenario – 45 million tonnes lower by 2040 – which, from a formal point of view, should negatively affect the country's energy security. Nevertheless, there is a very Chinese policy that may have a decisive influence on the balance of power. China can maintain and expand the active development of its own extraction projects in Iraq and Iran while temporarily mothballing its own production capacities. Support of production projects in the Middle East can, in conjunction with a guaranteed Chinese market for Iranian and Iraqi oil, neutralize the possible actions of Saudi Arabia by sharply increasing production. If China is going to implement such measures, it is the USA that could be affected most of all, and an additional blow will be dealt to producers with high costs.

If indeed China does maintain its own production, along with the USA and Saudi Arabia, the impact of the new producers on the global oil market and on oil prices will be negligible, and this scenario will not materialize.

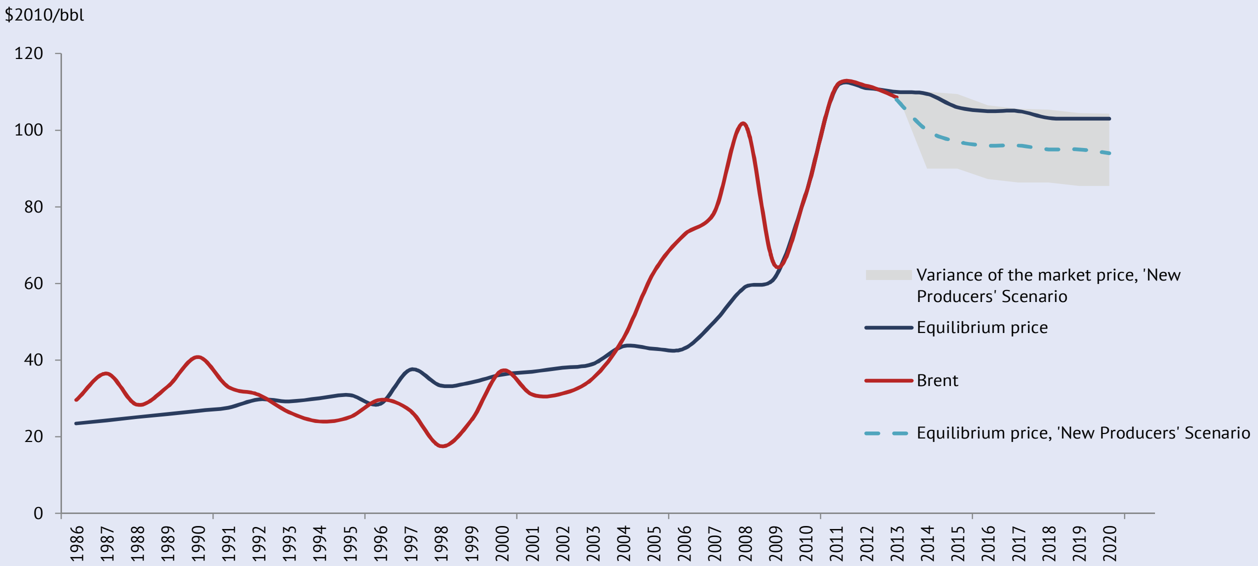
The likelihood of this scenario coming to pass, and the factors we have examined that could prevent it, indicate that the oil market is, as before, still not fully subject to the laws of economic logic, and is largely controlled by the geopolitical decisions of certain key players. Nevertheless, there are currently no market players that can significantly reduce the price of oil below 90 $2010 a barrel, and indeed any such reduction is likely to be short-lived and due more to the influence of speculative factors and investors than to the fundamental factors of the real oil market.

What is the threat of low prices?

In the more than quarter-century history of the oil exchange market, differing periods of equilibrium and market prices for crude oil have been observed. During periods when the market price exceeded the equilibrium price, the large-scale introduction of energy-efficient technologies would begin, with consumers switching over to alternative energy sources and taking other measures which, slowly but surely, would reduce both demand for oil and its price. There have also been periods when the opposite was true, when the market price was below the equilibrium price; these periods led to decreasing investments in geological exploration, reduction in the growth of reserves, and the beginning of the lively 'peak oil' debate.

Precisely such a period was seen in the oil industry between 1992 and 2004. The maximum differential between equilibrium and market prices reached 15.8 $2010 per barrel in 1998 (Figure 2.13), while the growth rate of global oil reserves showed negative values. As of 2004, oil prices began to rise sharply (2005–8) and in 2008 the difference between oil's market price and the equilibrium price was 42.6 $2010 per barrel, but now in favour of the market price.

Figure 2.13 – Equilibrium and Brent oil prices



Source: ERI RAS

In fact, since 2005, the global oil industry has been operating with a fairly high margin of safety pricing; this has allowed prospecting in remote and inaccessible new geographic areas and the exploitation of technically difficult oil reserves that had previously been unattractive to investment. After the 2008 crisis, the equilibrium price of oil and the market price had practically drawn level, but in 2013 and in the first quarter of 2014 market prices began to decline relative to the equilibrium price, under the influence of the volumes of shale oil on the market, together with speculative expectations of a sharp rise in production of cheap traditional oil from Iraq and Iran.

The maintenance of downward pressure on oil prices, on a wave of exaggerated speculative expectations of future large volumes of cheap supply, could certainly disrupt oil prices quite seriously until 2020 (the lower price limit, should the New Producers Scenario come about, could be 85 $2010 per barrel).

What would 85 $2010 per barrel (or 18 $2010 per barrel gap between this price and the Baseline Scenario price) mean?

- This is the price at which traditional reliable producers not subject to geopolitical risks (in particular those in the CIS countries and Europe) will be unable to provide uninterrupted long-term investment in the growth of commercially recoverable reserves, and will not be able to bring costly new projects to market.
- It means a reduction of more than 20 per cent in the cost of oil products to the end consumer in Europe; in other words, a level of discount at which the consumer will abandon costly biofuels in favour of oil-based motor fuels, defeating the European Commission's plans for the implementation of renewable energy.
- It means a reduction of production drilling at unconventional fields in North America that are highly sensitive to prices, and thus an immediate slowdown of production in the region, because in spite of the importance of the USA's geopolitical plans, viability is much more important to investors.
- A fall in oil prices means a deficit of global oil supply in conditions of a sharp downturn of energy conservation. This means that if oil prices do fall, in the wake of sharply increased volumes of potentially accessible (though still not actually confirmed) volume of supply, then 10 years later there will be a second wave of oil price increases, as occurred in the mid-2000s, only now not from the level of 30 $2010/barrel, but from 85 $2010/ barrel.

In the short term, the impact of this scenario on the situation facing consumer countries is insignificant – a 10 per cent price reduction is likely to be simply absorbed by energy-intensive industries, but would be too small to lead to a revision of projects or large-scale changes in efficiency. The EU and Japan would receive substantial relief on balances and the industrial use of oil and gas, but it would be insufficient to spark a return of energy-intensive industries in these countries.

The consequences of this scenario are much more serious for producers. One of the factors determining the price of oil on the supply side is the need for hydrocarbon-exporting states to finance budget expenditures and for an influx of foreign currency to pay for imports. Since the oil market is not completely competitive and prices can be changed by the independent actions of the largest suppliers, or by the coordinated policies of groups of producers, the governments of oil-exporting countries are able to influence production levels and prices directly with supplier companies, by means of policy measures, or by tax and customs tariff policy measures. Therefore, if oil prices are at a level that is not to the liking of an oil-exporting country's government there is a high probability that the state will attempt to influence them.

What are 'threshold' oil prices?

We assume that officially announced estimates of threshold prices for oil are often politically motivated, and because of this, alternative estimates are necessary. When calculating the minimum allowable oil prices, we proceed from the following assumptions:

1) Oil-exporting states finance their budgetary commitments from natural resource royalties on oil, described as the country's foreign currency earnings from oil sales in the foreign market, as well as, possibly, revenue from other export-oriented contributing industries (gas, fish, fruit, and so on), if any.
2) The proportion of oil revenues required to fund state obligations is proportional to the percentage of oil export revenues in total exports.
3) Domestic markets are not a source of finance for budget obligations because of the need to maintain the lowest possible prices for domestic consumption (while covering the costs of oil companies).
4) When necessary, states can withhold the export earnings of the oil company in full, particularly through tax and customs tariff policy measures, assuming a loss to the oil companies in the short and medium term.

Therefore the oil industry's financing of public spending can be described by the following equation:

State spending [dollars] × (oil exports [dollars/total exports [dollars]) = oil exports [barrels] × price of exported oil [dollars/barrel] × deduction coefficient.[5]

In this case, the minimum allowable price of oil is defined as follows:

Allowable price of exported oil [dollars/barrel] = state spending [dollars] × (oil exports [dollars]/total exports [dollars]) / (oil exports [barrels] × deduction coefficient).

Obviously, the minimum allowable price of exported oil will then be achieved with the maximum possible deduction coefficient. And this is the value we use in the calculation. We treat oil exports as being total exports of oil and oil products. It is assumed that the average price of exported oil products is equal to the price of exported oil[6].

5 The share of oil export earnings deducted for budgetary purposes.

6 This is not a speculative notion: in Russia in 2012, for example, the average oil export price was $754 per tonne, while the figure for oil products was $750 per tonne.

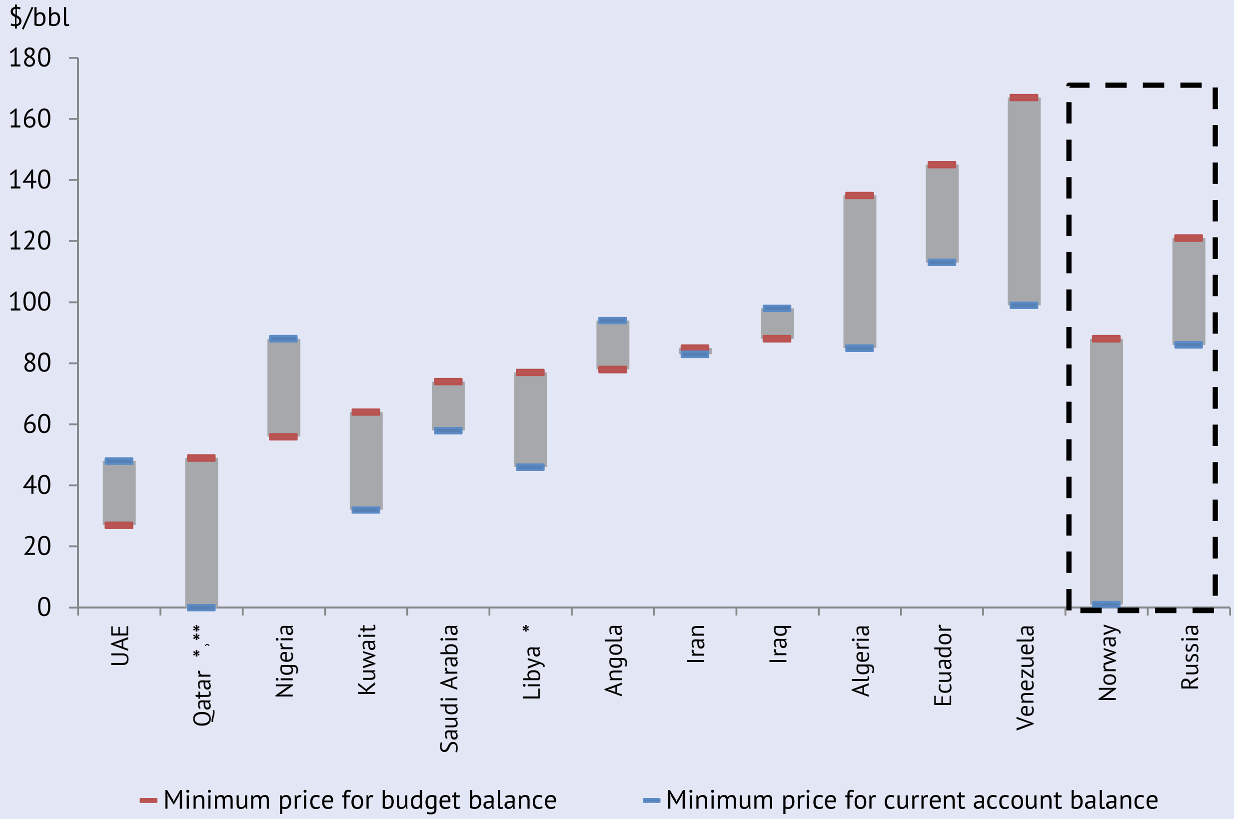
The second element in assessing the minimum allowable price of oil for oil exporters, which must also be taken into account in the analysis, is the country's balance of payments. A positive current account balance allows an increase in gold and foreign currency reserves without substantial capital inflows from abroad. In this situation, the emergence of a temporary (cyclical) budget deficit for oil exporters may be more easily financed, in particular by foreign loans. If the country gets into a situation of twin deficits (state budget and current account balance), the risk of default increases. In this regard, the price of oil, which provides a positive current account balance, is another line of defence for oil exporters.

To determine the minimum acceptable price according to current account balance, we estimate the size of the reduction in the price of exported oil such that the positive current account balance (as a rule, for oil exporters it is positive) is zeroed:

Allowable price of exported oil [dollars/barrel] = actual oil price [dollars/barrel] – (Current account balance [dollars] / oil exports [barrel])

The results of the calculations are shown in Figure 2.14 and 2.15.

Figure 2.14 – Minimum acceptable oil price for oil producing countries, 2012

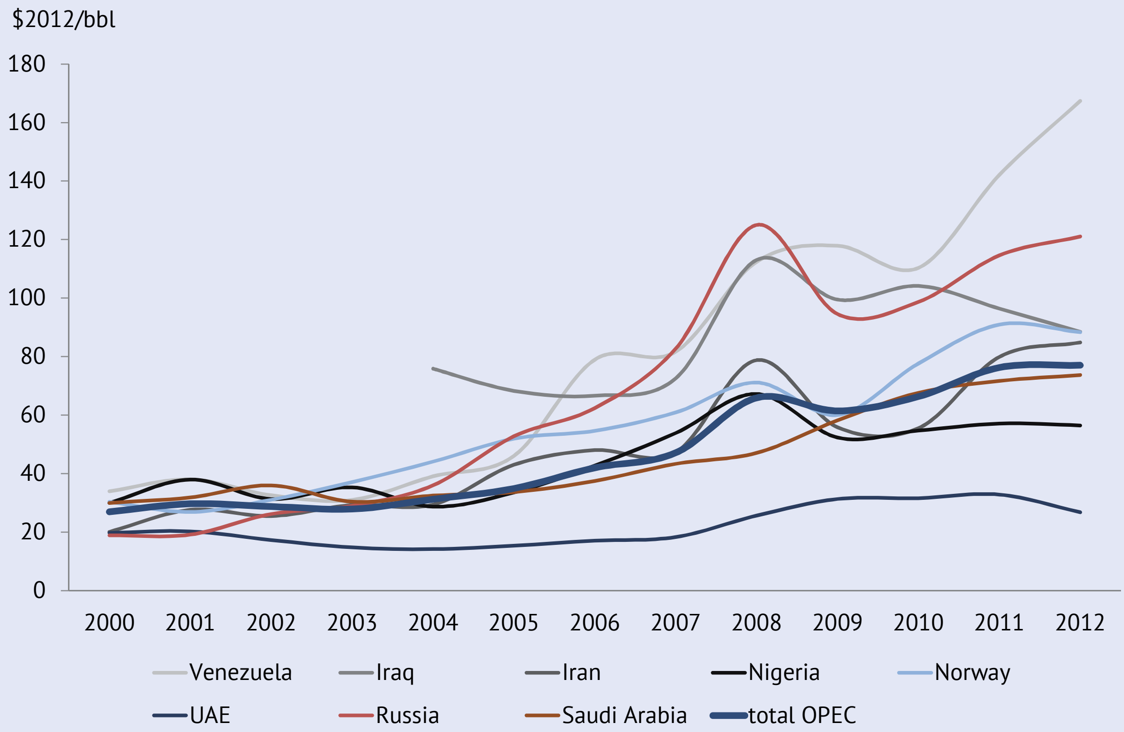


Source: ACRF's calculation

* - Because of the apparent inconsistency of IMF and OPEC data for Qatar and Libya's oil export volumes in monetary terms, the average export price of oil is taken as Dubai's oil price;

** - The current account balance for Qatar remains positive even with a zero oil price

Figure 2.15 – Minimum acceptable oil price (in real terms) for oil producing countries' budgets



Source: ACRF's calculation

The Gulf monarchies traditionally impose fewer demands on oil prices than do their OPEC partners, who are subject to greater political risks and who carry out active and sometimes even populist fiscal policies, or who are forced to spend more on defence and security than they can really afford. This is the situation with the Latin American OPEC members, as well as Algeria, Iran, and Iraq. To some extent this also applies to Russia.

The Other Asia Scenario

Events in the developing countries of Asia will have a huge impact on the global economy and the energy industry. But there are currently good grounds to believe that events in China and India may play out towards a somewhat different scenario than is generally expected, and one of the reasons for this may be the situation in the coal market.

Coal is the main element in the energy balances of the two fastest-growing consumers of energy in the world – China and India – and although it has traditionally been considered that their needs will be met mainly by domestic production, a more detailed analysis shows the high risk of these countries reaching peak production within the next decade, and there being a coal shortage.

It is important to note that, against a background of difficult environmental conditions, China is pursuing very ambitious goals to curb consumption (and therefore the production of coal). However, stabilization of the production by as early as 2025 will require not only increased consumption of gas, nuclear energy, and renewables, but also increased imports of coal, leading to radical changes in world trade in both the coal and gas markets.

Analysis of various studies shows that the maximum expected range of coal production in China will be reached sometime between now and the end of the forecast period, with the majority of experts focusing on the period 2020–30, see Table 2.2. The Chinese authorities' Twelfth and Thirteenth Five-Year Plans (2011 to 2020) involve the net increase of coal production capacity of 0.7 billion tonnes in 10 years. If this is the case, China will already have reached a level of 4.1 billion tonnes by 2020, actually reaching the maximum threshold. One must point out that the rate of production growth has already decreased substantially. According to the IEA, coal production in China will increase by 0.7 per cent per year from 2012 through 2020, which means a strong slowdown compared to the growth of production in 1990–2011, when it increased annually by about 6 per cent[7].

7 IProduction taking into account fuel value grew by 6.2% per year; production in physical terms, excluding fuel value, by 5.8%.

Table 2.2 – Estimated times of peak production and maximum production volumes in China

Source	Year of peak production	Peak production, billion tonnes	Estimate of total recoverable reserves (URR), billion tonnes
12th Chinese 5 Year Plan	2020–5	4.1	
IEA WEO 2013	2025–30	3.7–3.8[8]	230
Wang J., Feng L., Davidsson S., and Hook M., 2013[9]	2024	4.1	223.6
Hook M., Zittel W., Schindler J., and Aleklett K., 2010[10]	2020–25	3.1-3.3	161
Tao Z. and Li M., 2007[11]	2027	3.3	223
	2029	3.8	223
	2033	4.2	223
Lin B. and Liu J., 2010[12]	2025	3.8	189
	2027	3.7	189
Patzek, T.and Croft, G., 2010[13]	2011	2.8–2.9	147
Li M., 2008[14]	2030	3.8	250
Li M., 2010[15]	2039	6.1	380
Mohr S., Evans G., 2009[16]	2010	2.4	127.9
	2017	2.4	156.7
	2010	2.3	136.1

Source: ACRF

It should be noted that the most extreme estimates for peak coal and volume of reserves (Menke Li, Li M., 2010) are based on the use of a recovery rate of 100 per cent, which in China is actually about 55 per cent. According to a recent 'consensus' of the various studies, coal production is expected to peak around 2025, with peak production of between 3.7 and 4.1 billion tonnes[17].

A number of other factors having an impact on China's coal industry limit the expansion of its production. In particular, of 96 of the largest state-owned mines, 71 per cent already suffer from lack of water, and for 40 per cent this shortage is a serious impediment. A significant portion of coal production is located in the arid north of the country. The authors (Wang, Feng, Davidsson, and Hook, 2013) indicate that water scarcity may make it impossible to exceed annual production levels of 3.8 billion tonnes. There are also difficulties in transporting coal due to an overloaded rail system, whose traffic exceeds the global average four times over.

The other major Asian consumer of coal is **India**, where the share of coal in the energy mix is growing rapidly due to the decline in the share of traditional biofuels; it has already reached more than 40 per cent.

8 Taking into account the current calorific value of coal mined in China, 2860–70 mtce.

9 Wang J., Feng L., Davidsson S., and Hook M. 'Chinese coal supply and future production outlooks', Energy, 2013, # 60, pp. 204-14.

10 Hook M., Zittel W., Schindler J., Aleklett K. Global coal production outlooks based on a logistic model // Fuel. 2010. # 89. P. 3546 – 3558.

11 Tao Z. and Li M. 'What is the limit of Chinese coal supplies – A STELLA model of Hubbert Peak', Energy Policy, 2007, # 35, pp. 3145–54.

12 Lin B. and Liu J. 'Estimating coal production peak and trends of coal imports in China', Energy Policy, 2010, # 38, pp. 512–19.

13 Patzek T. and Croft G. 'A global coal production forecast with multi-Hubbert cycle analysis', Energy, 2010, # 35, pp. 3109–22.

14 Li M. 'Peak Energy and the Limits to China's Economic Growth: Prospect of Energy Supply and Economic Growth from Now to 2050', PERI Working Papers, 2008, # 189.

15 Li M. 'Peak Energy, Climate Change, and the Limits to China's Economic Growth', Paper Submission to The Chinese Economy, 2010.

16 Mohr S. and Evans G. 'Forecasting coal production until 2100', Fuel, 2009, # 88, pp. 2059–67.

17 Power and Energy, Planning Commission, Government of India. http://planningcommission.nic.in/sectors/index.php?sectors=energy

Domestic production is actively growing, but lags behind demand. Under these conditions imports are growing. Whereas in the early 2000s imports provided only 5 per cent of the domestic demand for coal, in 2012 it was already about 20 per cent. Deliveries are made from Australia, Indonesia, and South Africa.

India's 11th Five Year Plan initially aimed at increasing domestic coal production to 680 million tonnes per year by 2011–12, then this goal was reduced to 630 million tonnes per year, but ultimately, this plan failed, and production in 2012 amounted to only 595 million tonnes (The aim of the Tenth Five Year Plan – to produce 430 million tonnes – was significantly over-fulfilled, with production reaching 490 million tonnes in 2007).

According to estimates by the Indian Government's Planning Commission, the country will need about 2.5 billion tonnes of coal per year by 2031–2, which is more than three times current consumption (about 750 million tonnes). These forecasts exceed the level of various expert estimates. In particular, the IEA predicts consumption of only 1.4–1.7 billion tonnes per year by 2035.

There are also rather significant differences between the various estimates regarding peak coal production in India. While some experts believe that peak production should have already been passed, others see it happening after 2040 (Table 2.3). However, almost all agree that the country will become the leading importer of coal in the world at some point between now and 2040. At the same time, depending on the production and demand situation, there is the risk of a coal shortage in the country.

Table 2.3 – Estimates of when peak coal production will be reached and maximum level of coal production in India

Source	Peak production year	Peak production volume, billion tonnes
Patzek, Croft, 2010	2011	0.7
Mohr, Evans, 2009	2032	0.8
	2037	0.9
	2038	1.0
Hook et al., 2010	2020–40	1.0
	after2040	1.5
IEA WEO 2013	after 2035	-

Source: ACRF

Therefore, against the backdrop of continued rapid growth in energy demand in China and India, in the event of these countries stabilizing or reaching peak production, there will be an unavoidable energy shortage, which will have to be covered by imported coal or other energy sources.

To assess the possibilities for additional supplies to China and India, the situation in the world's major coal producing countries was analysed.

Globally, the coal resource base is quite extensive. However, the introduction of new production capacity is limited by the high required capital intensity of many coal projects, as well by different countries' energy policies. Nevertheless, with growth in demand and market prices, a large number of countries are capable of increasing their exports. These include Australia, Indonesia, South Africa, Russia, and the USA.

The **USA** has the largest coal reserves in the world and, in principle, could completely cover the shortage arising in this scenario. However, production has recently been reduced, primarily due to the decline in domestic demand for coal. Given this, the USA has a good chance of increasing exports of coal for the whole of our forecast period to 2040. But two factors will play a key role. The first is the cost of production and transportation, and the second is the feasibility of increasing coal production from the point of view of energy policy. To date, energy trade between the USA, India, and China has been almost non-existent, and providing for the growing energy needs of China while increasing environmental risks to itself, especially with the need to expand its west coast ports, is something the USA would hardly want to do.

Indonesia has been seeing booming coal production and exports in recent years. Since 2009, domestic coal consumption has stabilized at 60 million tonnes per year, while production had increased by about a half (from 290 to 440 million tonnes per year) by 2012, which meant that exports could be increased from 230 million tonnes in 2009 to 380 million tonnes in 2012. However, in the long term Indonesia is expected to slow its production growth, while it is anticipated that rapid growth in domestic demand will place an additional limitation on export capacity. This consumption growth also corresponds with the government's plans to increase the share of coal in domestic primary energy consumption from 24 per cent in 2011 to 30 per cent by 2025[18] (or up to 33 per cent according to the estimates of the relevant ministry)[19].

Another major supplier of coal to the world market is **Australia**, which is increasing production more smoothly than Indonesia: from 2000 to 2012 production increased from about 300 to 420 million tonnes per year which, given stable total domestic consumption, made it possible to increase coal exports from 190 to 300 million tonnes per year. Analysis of the different estimates of the prospects for coal production in Australia shows that peak production is not expected between now and 2040, but a deceleration in production growth is almost inevitable (Table 2.4). At the same time, Australia is capable of increasing supplies to the world market, though it will experience some difficulties with port and rail capacities.

Table 2.4 – Estimates of year and volume of peak coal production in Australia

Source	Year of peak production	Peak production volume, billion tonnes
Patzek, Croft, 2010	2042	1.0
Mohr, Evans, 2009	2052	0.8
	2065	0.9
	2066	1.0
Hook et al., 2010	2040–50	1.1
	2065–70	2.0
IEA WEO 2013	2035	0.6

Source: ACRF

18 Indonesia-Investments website: www.indonesia-investments.com/doing-business/commodities/coal/item236

19 Overview of Indonesia's Energy Sector and Recent Development in the Coal Sector, Ministry of Energy and Mineral Resources – Directorate General of Mineral and Coal: http://coal.nic.in/Indonesia.pdf

Coal production in **South Africa** has, in recent years, stabilized at a level of around 250 million tonnes. According to various estimates, the average expected increase in coal production in South Africa is 300 million tonnes, with no possibility of a substantial increase in export volumes above this capacity.

Colombia could double coal production and exports in the period to 2040: in recent times its inexpensive coal has been in demand on the European market, but on a global scale these volumes are not capable of having any substantial impact. According to our estimates, the country could possibly increase its supply of coal to international markets from 80 to 150 million tonnes per year.

Mongolia could also increase production, and by virtue of its proximity to China, together with Chinese investments in the country, it is one of the most convenient sources for China's coal imports. Mongolia is estimated to be able to increase production by 2–3 times compared to 2012 (35 million tonnes).

Russia has the best opportunities of increasing the production and export of coal, with the main limitation being the cost of transportation to its main consumers. But with the required demand and a continued high level of coal prices, the country is able to increase its exports several times over[20].

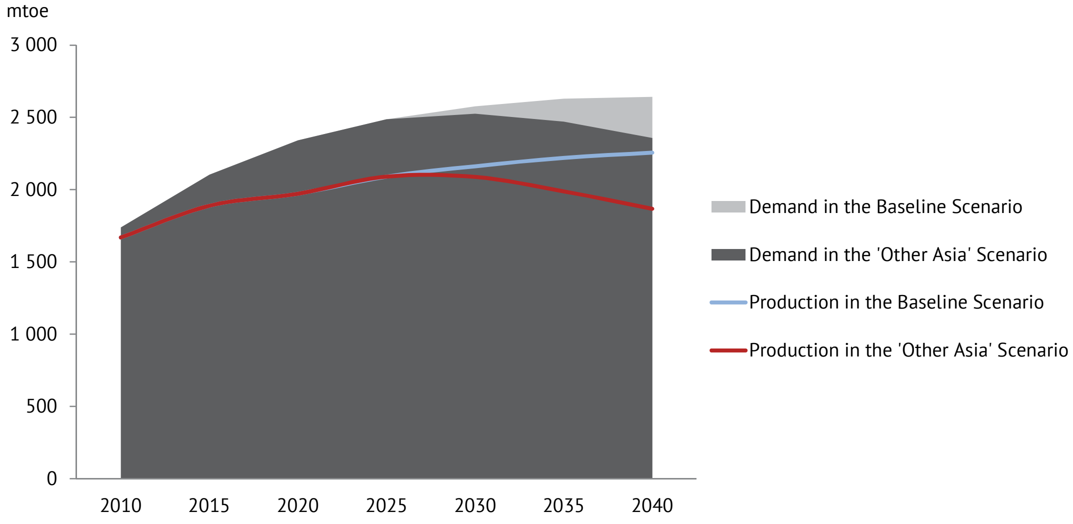
The calculations in the Other Asia Scenario are mainly based on the following assumptions:

- Coal production in China grows at a slower rate to a level of 2090 mtoe in 2025, then declines (see Figure 2.16);
- Production in India stabilizes in 2025–8, and having reached 330 mtoe also starts to decline slightly (see Figure 2.17).

The reduced possibilities for domestic production of coal, and an increased need to replace it with more expensive sources, will hinder the economic competitiveness of China and India in the global market. Added to this is the rapid rise of labour costs which has been seen in China in recent years. As a result, the attractiveness for business (based on cheap labour and energy resources) in these two developing Asian countries as global manufacturers, is reduced. Business will begin to relocate to other regions that can offer better conditions in terms of labour or energy supply. As a result, the Other Asia Scenario changes the structure of the world economy. The GDPs of China and India decline, but those of the USA, Africa, south-east Asia, and Russia grow (Figure 2.18). GDP grows in some countries due to the transfer of a proportion of enterprises from China and India, and in others due to increased exports of energy resources. Both factors work immediately in favour of south-east Asia and Africa. As a result, the Chinese economy decreases by 11 per cent by 2040 (compared with the Baseline Scenario), and the Indian economy by 9 per cent, while the US economy will grow by 9 per cent, the African and south-east Asian economies by 20 per cent, and the Russian economy by 21 per cent.

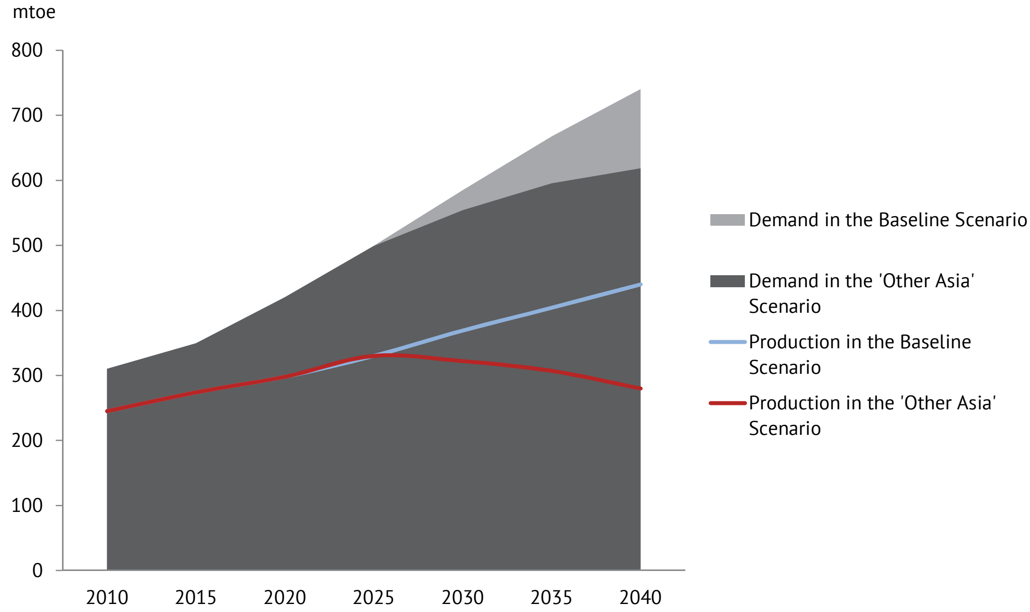
20 According to the long-term programme for the development of Russia's coal industry to 2030, resource potential would allow Russia to increase exports to 200 million tonnes per year by 2030, and up to 500 million tonnes in the run up to 2040.

Figure 2.16 – Coal production and consumption in China, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

Figure 2.17 – Coal production and consumption in India, Baseline Scenario and Other Asia Scenario

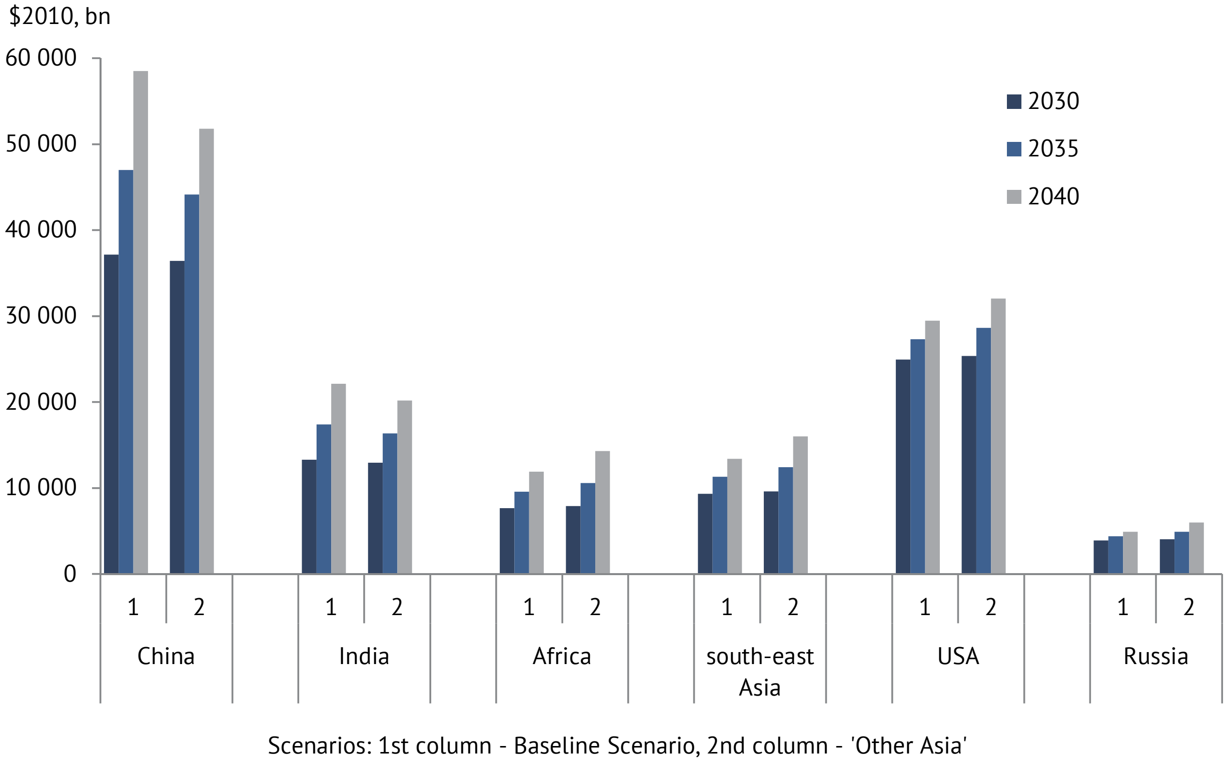


Source: ERI RAS

The decline in coal production in comparison with the Baseline Scenario is partly compensated for by a decrease in energy consumption in China and India as a result of slowing GDP growth. The remaining difference in consumption may be covered by increasing the use of nuclear energy and renewable energy sources, as well as by increased coal and gas imports from other regions. China's energy consumption in the Other Asia Scenario drops by 148 mtoe (about 3 per cent), and India's by 66 mtoe (about 4 per cent). Energy consumption will increase by 112 mtoe in other regions of the world.

In the Other Asia Scenario, gas consumption in China and India increases by almost 200 bcm (60 and 140 bcm respectively), which exceeds their consumption in the Baseline Scenario by 19 per cent. The need for coal imports by these countries increases by 275 million tonnes (210 and 65 million tonnes respectively).

Figure 2.18 – Changes in GDP, countries and regions



Source: ERI RAS

This scenario has a significant impact on global trade flows. In comparison with the Baseline Scenario, North America will increase its gas exports by 20 bcm, the Middle East by20 bcm, South and Latin America by 30 bcm, Russia by almost 80 bcm, and Australia by 50 bcm while Africa, in contrast, reduces total exports by 5 bcm due to the growth of domestic demand (though its exports to emerging Asia increase by 10 bcm). A significant reorientation of supplies takes place within the Asian region.

In the coal market, China and India will take additional volumes from Indonesia, Australia, Russia, Africa, and South and Central America, while Europe, Japan, and South Korea replace part of their diminished coal supply with deliveries from the USA and Russia.

The playing out of the Other Asia Scenario leads to higher prices for gas and coal in regions of the world. The price of gas will increase by about 10–15 $2010/thousand cubic metres in the Atlantic basin and by 25–30 $2010/thousand cubic metres in the Pacific basin. Coal prices increase by 10 per cent in the Atlantic basin and 24 per cent in the Pacific basin.

This is a scenario in which, by the end of the period, the world is faced with severe resource constraints. This creates very favourable opportunities for oil and gas producing countries. A detailed description of the impact of the Other Asia Scenario on Russia is presented in Section 3.

Section 3
RUSSIAN ENERGY

SECTION 3. RUSSIAN ENERGY

External conditions in the development of Russian energy

The transformations of global energy markets expected in the coming quarter-century are, on the whole, clearly positive, but pose severe risks for Russia's energy sector and even its economy.

The forecast of the evolution of global energy markets has shown the possibility of significant changes, not only in market conditions but also in long-term development trends; these have serious implications for the energy industry and even for the entire economy of the Russian Federation, one of the leaders in global energy.

Russia in the global energy markets

Russia is the fourth largest producer of energy in the world (after OPEC, China and the USA) and the sixth largest consumer of (after China, the USA, the EU, OPEC and India) among the key players in the energy markets (Figure 1.78), representing 10 per cent of global production and 5 per cent of global energy consumption. Russia is consistently ranked first in the world for gas exports, second for oil exports (though by 2040 it will be third after Saudi Arabia and Iraq), and third after Australia and Indonesia for coal exports. With an energy production volume of some 1.47 billion toe, Russia exports 630 million toe, representing 16 per cent of global interregional energy trade, making Russia the absolute world leader in energy exports.

Energy resources exports volumes

Russian energy exports will decline and stagnate until the mid-2020s, after which they will recover due to diversification in the Asia–Pacific market, which will be particularly successful in the Other Asia Scenario.

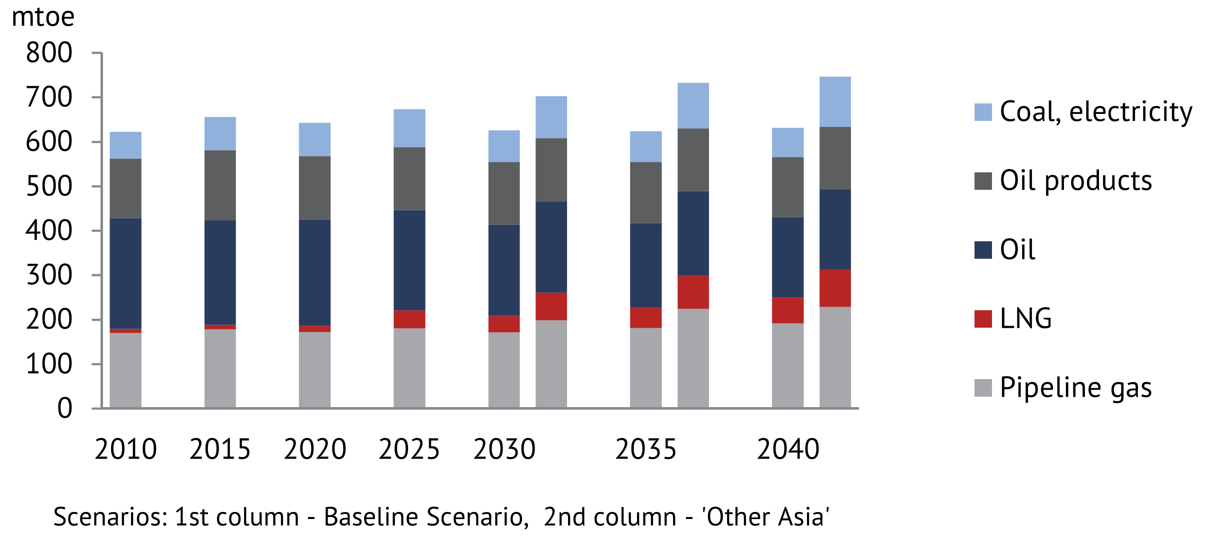
The Baseline Scenario of world energy development brings the risk for Russia of a reduction in energy exports; this will begin after 2015, with total exports returning to 2010 levels (Figure 3.1) only in 2030–40. After 2015–20 the growth (seen in recent years) in the share of oil and petroleum products in the country's energy exports, will come to an end because of the increasing share of gas and increased export volumes of coal and electricity.

The Other Asia Scenario is more optimistic for the Russian Federation – the increased capacity of foreign markets and the expansion of demand for Russian energy resources from the direction of Asia give a significant boost to the development of all sectors of the energy industry. In this scenario, there is a projected increase in Russian energy exports of 20 per cent by 2040 compared to 2010 levels.

Crude oil exports differ little in the different scenarios – in both the Baseline Scenario and the Other Asia Scenario they decline throughout the period under review, and by 2040 are reduced by almost 30 per cent. Exports of petroleum products will peak in 2015 and will then gradually decrease until they reach 2010 levels by as early as 2040, mainly due to the decrease in exports of fuel oil and non-marketed petroleum products.

In contrast, exports of natural gas, even in the less favourable Baseline Scenario, will increase by almost 40 per cent by 2040. However, this does not compensate for the loss of revenue from reduced sales of oil fuel. In the Other Asia Scenario, with its higher demand for gas exports, natural gas exports will grow by nearly 75 per cent by 2040. In both scenarios the share of gas in total energy exports will increase from 29 per cent to 40 per cent in the period from 2010 to 2040.

Figure 3.1 – The Russian Federation's net exports by energy resource type, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

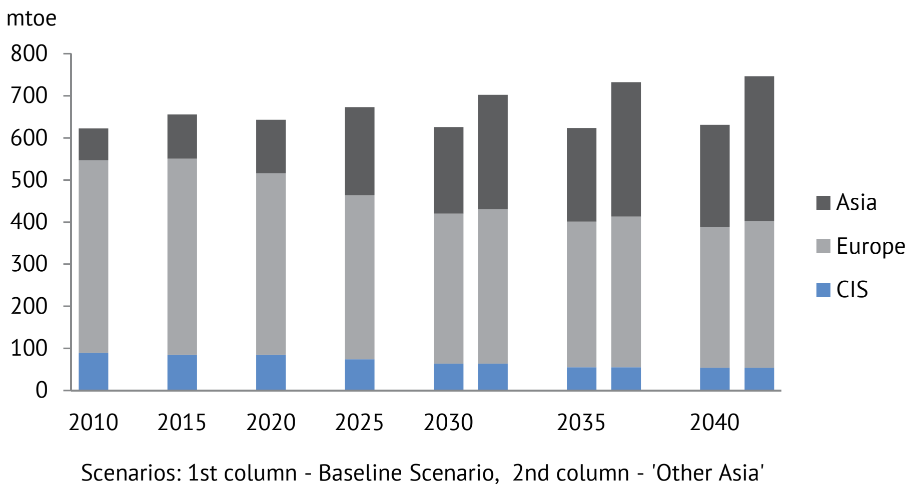
In the Baseline Scenario, coal exports will continue to rise until 2025 (17 per cent compared to 2010), stabilize for the period to 2030, and then decrease 10 per cent by 2040 due to the deterioration of world markets and the continued growth of production and transportation costs of Russian coal. In contrast to this, the Other Asia Scenario suggests a radically different situation on foreign coal markets, in which there will be a demand for far greater volumes of Russian solid fuel, and in which coal exports increase by an unprecedented 87 per cent by 2040.

The geography of Russian energy supplies also differs markedly in the two Scenarios. In both scenarios, the main direction of diversification of exports will be the development of new energy markets, primarily in the Asia–Pacific region. The intensity of this process, however, will be different: in the Baseline Scenario by the end of the period, 38 per cent of exports will go east, while in the Other Asia Scenario it will be 46 per cent (Figure 3.2). TNonetheless, European markets will continue to be central to Russia in the coming period, though Russia's role here will gradually decrease with regard to all energy sources. However, the dynamics of this reduction will vary by type of fuel.

Despite the decline in Russian crude oil supplies to Europe to 2020, Russian suppliers will retain up to 40 per cent of the European market for crude during this period (Table 3.1). This 'stability', however, will not have anything to do with a gross increase of Russian supplies in this direction but with a reduction in the total volume of import needs of the European market under the influence of three key factors:

- a significant reduction in the volume of 2020 European low-margin refining;
- an increase in European production through the introduction of new Norwegian fields;
- a decrease of European demand for oil products.

Figure 3.2 – Net export of Russian energy resources by direction, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

After 2020, Russian oil supplies will start to concede their market niche to Middle East market suppliers with their cheaper resources.

Russian natural gas will, in the short term, even slightly strengthen its position in the European market: in 2015, due to a shortage of gas, Russian supplies will provide a maximum share of imports and consumption in Europe, but then there will be a protracted decline in this share, and only after 2035, with the arrival of the next wave of supply shortages, will Russia begin to recover its position.

Table 3.1 – Share of Russian supplies to the European market, Baseline Scenario (%)

	2010	2015	2020	2025	2030	2035	2040
Crude oil							
Russia's share of Europe's total crude oil consumption (refining)	29	29	29	22	18	15	14
Natural gas							
Russia's share of Europe's total gas consumption	22	29	26	22	25	28	30
Coal							
Russia's share of total European coal consumption	13	15	15	13	11	10	8
Electricity							
Russia's share of total European electricity consumption	0.41	0.40	0.38	0.36	0.35	0.33	0.32

Source: ERI RAS

The reverse applies in the relationship of Chinese consumers and Russian suppliers, with supply volumes growing steadily, but Russian market power does not even come close to the levels that have already been reached on the European markets (Table 3.2).

Due to the growth in capacity of the key transportation artery – ESPO [Eastern Siberia–Pacific Ocean pipeline] Russian oil will provide up to 12 per cent of the total import demand in China by 2025. At the same time, it is important to note that despite the increase in the absolute volume of Russian oil supply to China, the share of the Chinese market after 2025 will begin to decline due to very significant growth in China's demand for raw materials for its own oil refining, which will be stimulated by massive global growth in the consumption of oil products.

Table 3.2 – Russia's share of supplies to the Chinese market, Baseline Scenario (%)

	2010	2015	2020	2025	2030	2035	2040
Crude oil							
Russia's share of China's total crude oil consumption (refining)	5	9	10	12	11	11	10
Natural gas							
Russia's share of China's total gas consumption	0	0	2	6	5	7	7
Coal							
Russia's share of China's total coal consumption	1	1	1	1	1	1	1
Electricity							
Russia's share of China's total electricity consumption	0.04	0.02	0.05	0.09	0.12	0.14	0.14

Source: ERI RAS

The effect of possible sanctions on Russian exports of oil, gas, and oil products: 'The damage will be mutual'

With the geopolitical tensions that have arisen between Russia and the West, the issue of the possibility of economic sanctions being imposed on Russia, including in the energy sector, is being increasingly raised. While not considering this to be a realistic scenario, we nevertheless assessed the possible consequences of a situation in which the European Union fully abandons gas, oil, and petroleum products from the Russian Federation, and where American and European companies stop supplying oil and gas drilling and other equipment to Russia.

Of course, a reduction in exports to Europe (and this is more than 100 million tonnes of petroleum products, more than 180 million tonnes of oil, accounting for nearly 75 per cent of total exports of liquid fuels from the Russian Federation, together with 130 bcm of gas – which is about 60 per cent of total gas exports) would seriously affect the country's budget. Furthermore, by limiting access to technology, the Russian oil and gas industry would be forced to make additional investments in its own production facilities or increase purchases from China, thus expanding the energy partnership between the two countries. This will have a negative effect on costs for the development of new projects, and in some cases lead to the postponement of their commissioning. This will be most painful for the advanced refining of oil and gas, as well as for LNG production projects – the deadlines for commissioning the first projects will be postponed for a decade and the introduction of new schedules will be slower than originally planned, because it will be necessary to establish domestic production of equipment for gas liquefaction production lines.

However, the negative effects of possible sanctions will inevitably be mutual. The abandonment of Russian supplies will unavoidably lead to an increase in European oil prices in the short term. It is important to note that the increase in oil prices in this case will be, for the most part, speculative, and in economic terms the global market will, without a significant increase in production costs, be able to cover the Europeans' shortage of crude oil. In addition, the abandoned Russian oil supplies in the short term could only be replaced by additional production in unstable countries in the Middle East and North Africa. These countries will need to provide up to 70 per cent of total European demand for imported oil (and if the sanctions affect Kazakh oil transported through Russian territory by the CPC, then up to 80 per cent). Such imports from the region, where at any time there is a risk of armed confrontation, in no way meets the objective of European energy security and uninterrupted energy supply.

Of course, possible sanctions could substantially affect the economic well-being of Russia in the three to five years following their imposition, but in this case the Russian economy would 'pivot' completely to China, providing supplies of crude oil to be refined in huge quantities in China. Of course, this would require significant investment in transportation infrastructure (primarily in expanding the capacity of the ESPO), and possibly also (during the first years after the introduction of sanctions) the provision of transit corridors for exports to China (through Kazakhstan for example), but in as little as five years it would allow the Russian economy to completely turn to the East, and in such an event Europe would have almost completely lost a reliable partner and supplier of raw materials.

Suspension of gas supplies would have even more painful consequences for European consumers. There is no gas capable of replacing Russian shipments on the market, and Europe would have to switch to coal and more expensive oil products for power plants and to supply the domestic market, but these opportunities would be limited (technically – no more than 70 bcm). Part of the demand would remain uncovered and there would be a likelihood of serious power outages in Eastern and Central Europe, while at the same time gas prices on the European market would double to 800 $2010/thousand cubic metres; as Europe would have to enter into tough competition for additional LNG with consumers from the Asia–Pacific region, prices would rise not only in Europe, but also on the Asian LNG market.

For Russia, the redirection of gas supplies to the Asian market will require much more investment and time than the expansion of ESPO. Meanwhile, the world gas markets, which are already facing shortages, will be facing a significant shortage of supply. In this case, the Altai pipeline would be brought into operation as quickly as possible, allowing part of Western Siberia gas to be redirected to China (though, of course, it would be impossible to completely restore supply volumes).

Prices

A managed and scheduled transition to the gas and coal prices on the highly competitive European market in domestic energy markets is among the most important conditions for the efficient development of the Russian economy and energy sector.

Prices on foreign markets are important for the Russian fuel and energy complex, not only in terms of foreign currency earnings, but also because of their influence on the level of domestic prices. Since Russia is a major exporter of energy resources, it cannot but take into account external prices in its domestic pricing policy. However, the energy market in Russia has, since the 1990s, been characterized by an imbalance in price levels. Prices for oil sector products, the most integrated with the foreign market, have been virtually freed from the direct influence of the state and are formed on the basis of netback. The coal industry has also long been dominated by a similar way in which market prices are set. In contrast, gas prices are still regulated by the government, whose policy has changed three times over the past

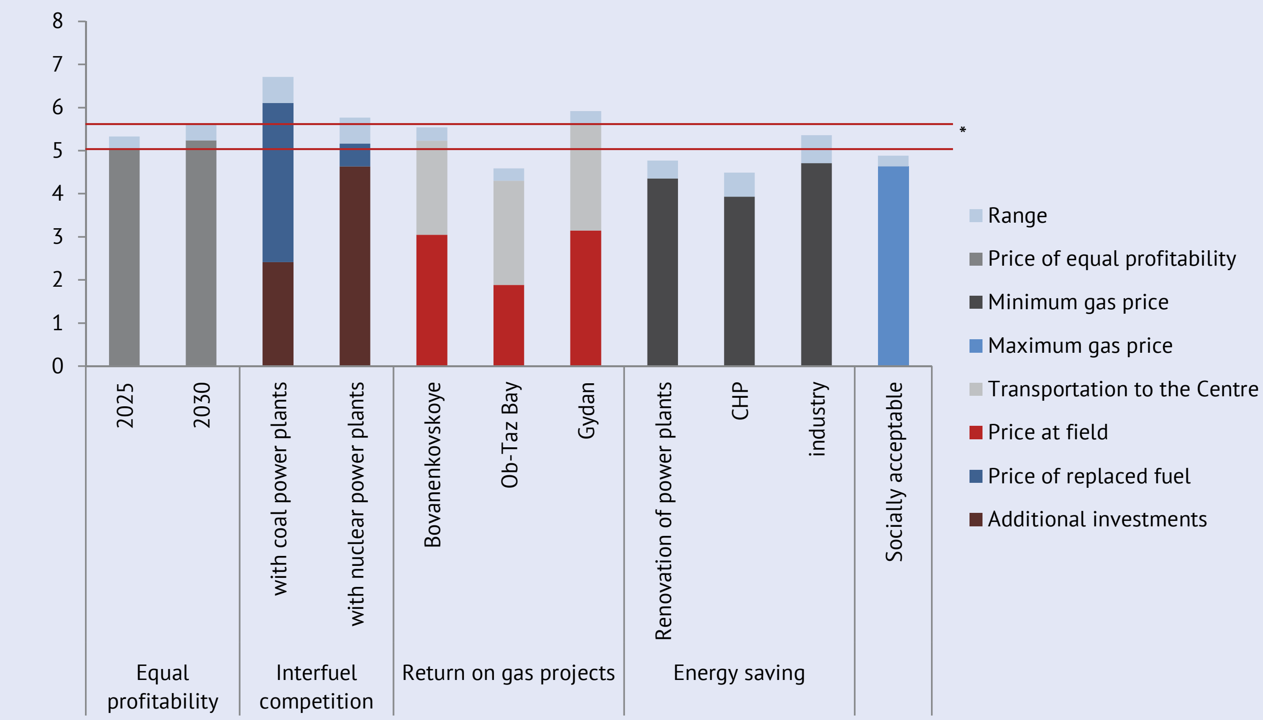
two decades – from strict price regulation (to ensure social stability and industrial competitiveness) to constantly increasing growth in 2002–13, and finally again to the freezing of prices due to a slowdown in economic growth.

Future pricing policy in the gas industry needs to define the principles for establishing competitive gas prices on the domestic market and deadlines for the transition from today's regulated gas prices to a competitive level. Analysis of the proposed pricing mechanisms, and possible options for forming domestic regulated and free gas prices, show that the prices obtained by the different methods fall in a fairly narrow range, reflecting a balance between the interests of various stakeholders (Figure 3.3). At the same time, prices of equal profitability to those on the highly-competitive European market appear optimal for the country's economic development and satisfy all the required criteria, providing for both an economically correct evaluation of gas supply and demand on the domestic market, and for the implementation of genuinely effective investment projects.

In search of optimum gas prices: a combination of criteria

The discussion about fair gas prices has been going on in Russia for many years and usually involves a number of requirements: they must be within the means of industrial consumers and the public, but also reflect the competitive advantages of gas, stimulate energy saving, and provide an acceptable rate of return for producers. An attempt to combine all of these criteria is shown in Figure 3.3.

Figure 3.3 – Wholesale gas prices in the centre (Moscow) according to differing pricing methods



Source: ERI RAS

*The red lines show the range of prices coinciding with a mutually agreeable price equal to the weighted average yield on European prices

The first two columns of Figure 3.3 shows the results of calculations for **equal profitability prices** in the Central region (Moscow and the Moscow region) for 2025 and 2030 (the possible dates for a possible 'soft' transition of domestic prices to levels that are equal in efficiency to export prices.

Columns 3 and 4 show the results of calculations for **interfuel competition prices** on the condition that the production cost of electricity by a large gas-fired power station (at equal profitability prices – columns 1 and 2) is the same as the cost of production from coal (column 3, prices calculated for mines in the Kuznetsk Basin as 'cost plus'), and for nuclear power plants (column 4). As can be seen, coal power plants in the Moscow region are not competitive with gas (the area in which they are efficient is eastward from the Urals), while nuclear power plants can compete with gas thermal power plants, maintaining a level of gas prices on the principle of equal profitability to export prices.

Columns 5–7 shows the results of the calculation for the **self-financing prices** (including income from IRR = 12–13 per cent and gas transportation to the Moscow region) of the main areas of growth in gas production in the zone of UGSS (Unified Gas Supply System). As can be seen in Figure 3.3, these prices on major gas fields are able to provide strong support to prices equal to the yield on the European market, creating the stability of the whole Russian gas market's pricing system.

Columns 8 to 10 show the **prices that encourage energy efficiency**, and show the adequacy of the levels of gas prices for such large-scale energy-saving measures as 1) the reconstruction of thermal power stations with the installation of steam gas equipment and an increase of their efficiency by 15 per cent, 2) the development of cogeneration (combined heat and electricity production) based on gas turbine and steam gas equipment, and 3) substitution of gas by coal and fuel oil in various industrial processes.

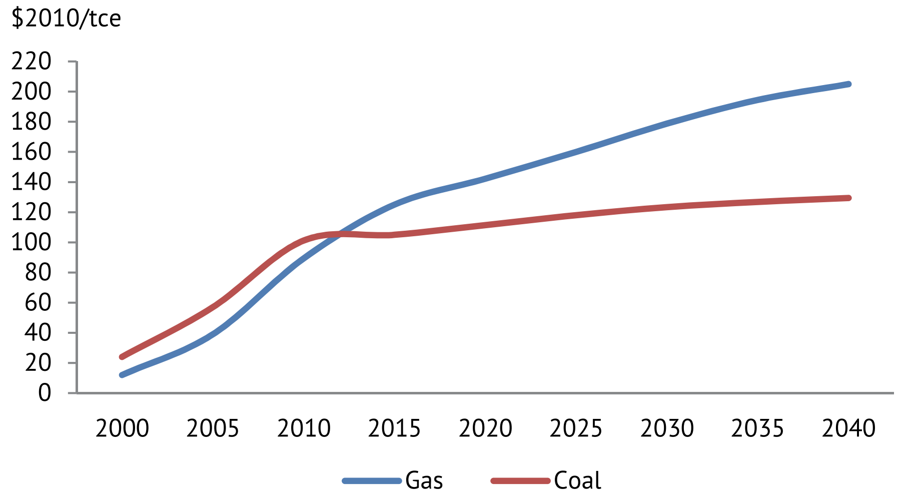
Column 11 shows the results of calculations of gas prices in which the share of energy costs (including gas-produced electricity and heat) in household income grows at the same rate as increases in housing costs. The range of these **'socially acceptable prices'** are actually somewhat lower than prices arrived at for equal profitability with exports.

In both scenarios it is assumed that price capping is introduced in order to carry out as gentle a transition as possible to a gas price level that simultaneously addresses the three principles of competitive pricing: 1) 'cost-plus' from the gas fields, 2) interfuel competitiveness of gas with coal for thermal power plants and nuclear power plants, 3) equal profitability of domestic prices and export prices (for the territory of the unified gas-supply system – to the average weighted or spot price on the European market). Methods for aligning gas price levels could be, on the one hand, a reduction in export duties (such as increasing domestic prices of equal yield), and on the other, adjusting the tax on mineral resources production (for example the cost of the gas field's remuneration).

The reduction of European market prices forecast in Section 1 (and, respectively, the estimated equal yield price) after 2015, would allow for increasing the price of gas in Russia in line with the pace of 'inflation +' to reach a level of equal yield in 2025–7. Of course, there is no guarantee that the government will choose this particular path of compromise, which would balance the interests of stakeholders, but this approach does seem to be the most balanced. At least, this was the method that was laid out in the Russian Ministry of Energy's draft Energy Strategy for Russia to 2035.

A relatively steady increase in domestic gas prices, ahead of inflation by 1–2 percentage points over 10–12 years, set by the state, would bring prices equal to the weighted average yield of prices on the European gas market. This would mean that the price of gas in the main areas of consumption would be 35–60 per cent higher than coal prices (Figure 3.4) and would encourage energy conservation, as well as development of the coal industry, nuclear energy, and renewable energy sources.

Figure 3.4 – Gas and coal prices in the Central region of Russia



Source: ERI RAS

Economic development

The Russian economy in the last decade

As of 2000, the Russian economy was characterized by dynamic growth – with the growth rate of Russian GDP almost twice the global average. According to World Bank data, in 2000–12 it averaged (in 2005 dollars) 5.2 per cent, whereas the corresponding growth rates of the other Big Eight countries came to 0.4–2.2 per cent, while the global average was 2.7 per cent. The global crisis gave an unexpected and serious shock to the Russian economy, and for a period of five years knocked it off its trajectory of rapid development. The Russian economy is fairly stable, although it grew more slowly after a significant decline in GDP in 2009, and on attaining the pre-crisis level of GDP (in national currency in real terms) in 2012, growth virtually stopped. The economic slowdown was caused by, among other things, the deterioration of external markets. In 2013, the volume and value of exports of manufactured goods and foodstuffs began to decrease. According to the Russian Ministry of Economic Development (MED) the average export price index in the first half of 2013 decreased by 3.4 per cent, whereas for the corresponding period of the previous year it had increased by 5.3 per cent. The deterioration in the financial performance of export-oriented enterprises was accompanied by a slowdown in the domestic market and a reduction in investment in fixed assets, along with negative dynamics of state capital investment and slowing corporate lending. A 7 per cent GDP growth rate at the start of the twenty-first century fell away, and the official forecast of long-term socio-economic development of the Russian Federation for the period to 2030, carried out by the Ministry of Economic Development in November 2013, proposed a rate of economic growth that was two to three times lower.

In the forecast period, Russia's energy sector withdraws somewhat from its 20-year-long role as the engine of the Russian economy: providing an active infrastructure function, stimulating economic growth not only with revenues from energy exports but also in terms of enabling consumer access to its products at acceptable prices, and supplying the needs of related sectors.

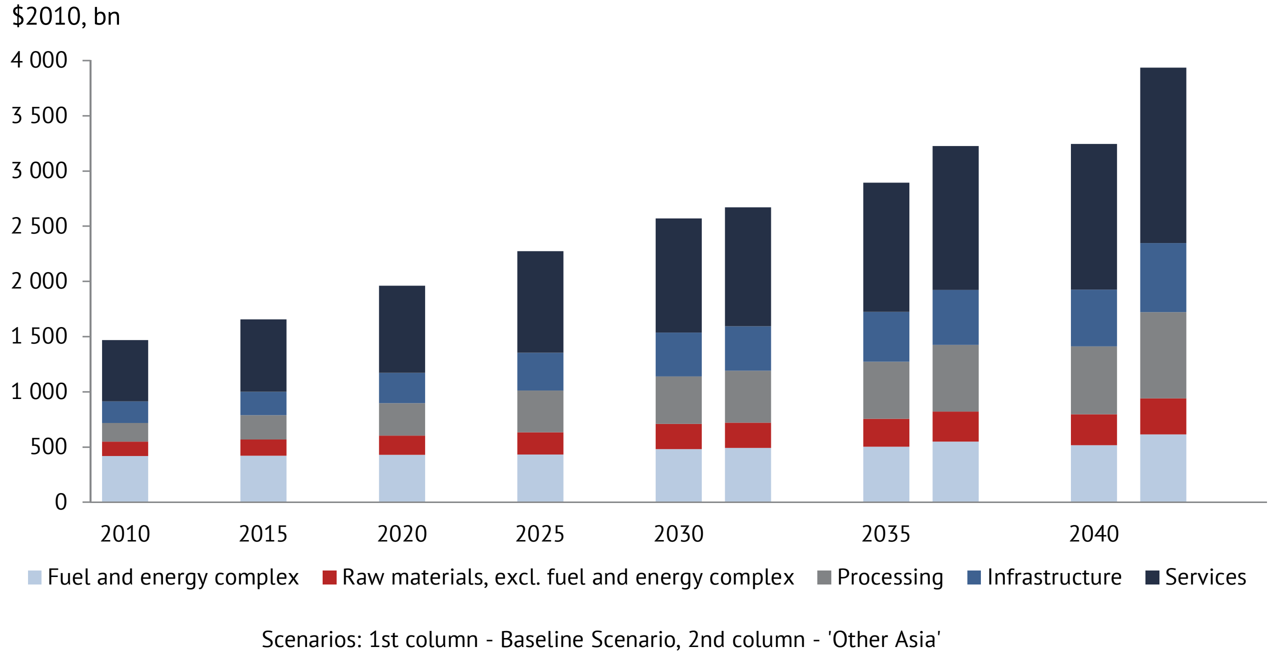
The prevailing conditions on external markets play an important part in the development expectations of the entire Russian economy.

The scenario of very restrained dynamics – relating to Russia's GDP – adopted in Outlook 2014's Baseline Scenario (Figure 3.5), is similar to the risk analysis scenario in Russia's Energy Strategy for the period to 2035. This position is due to unfavourable market conditions for Russia on foreign markets, a reduction in the attractiveness of investment, and delays in the implementation of major innovation programmes for the development of various sectors of the Russian economy.

The Other Asia Scenario posits more favourable conditions for development after 2025, thanks to the expansion of export opportunities and the ability to attract new industries, especially in the Far East and Siberia. In this scenario, Russia's economy will grow by 2.7 times by 2040.

The fuel and energy sector has been the main driver of the Russian economy and it can perform the same role in the current decade, but in the run up to 2040 its contribution to GDP will fall to 16 per cent (from 29 per cent in 2010).

Figure 3.5 – Dynamic and structure of Russian GDP, Baseline Scenario and Other Asia Scenario



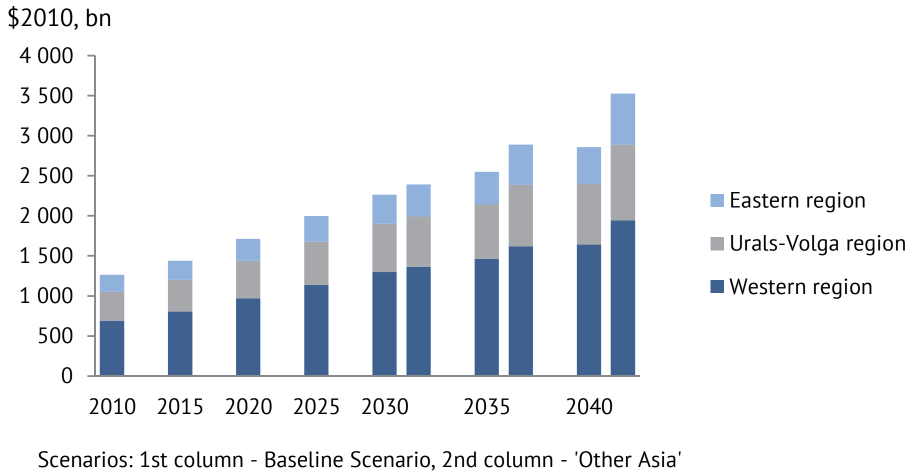
Source: ERI RAS

Russian GDP behaves differently from a geographical point of view in the scenarios being examined, currently showing a great deal of diversity in this regard. Only 16.6 per cent of GDP is produced in the east of the country (in the Siberian and Far Eastern federal districts), while the Central district alone provides more than a third of GDP.

In the Baseline Scenario, the economy of Russia's western zone (Central, North-Western, Southern, North-Caucasian, and Crimean federal districts) will be the country's largest, increasing 2.5 times in comparison with 2010 and raising its share of the country`s GDP from 55 per cent to 58 per cent by 2040 (Figure 3.6). The economy of the Urals–Volga zone (Urals and Volga federal districts) will grow 2.2 times by 2040, with a slight decrease in its share from 29 per cent to 26 per cent. The share of the Eastern zone of Russia (Siberian and Far Eastern federal districts) in the country's economy remains unchanged.

In the Other Asia Scenario, on the other hand, the Eastern zone of Russia will see rapid development, with its GRP tripling in the period under review due to the emergence, after 2025, of new industrial and multimodal logistics centres. These will be combined with the formation of complexes specializing in energy and raw materials (the Lower Yenisei and Angara, the Republics of Sakha and Tuva), the development of new mining areas in Eastern Siberia, the development of the BAM (Baikal–Amur railroad) zone and adjacent areas, and the realization of major projects in Sakhalin, Khabarovsk, and the Primorsk region.

Figure 3.6 – GRP by territorial zone, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

Domestic primary energy consumption and energy efficiency of the economy

Peculiarities of Russia's energy sector

Thanks to the efforts of generations of Russians, one-ninth of the country benefits from an established and widely diversified fuel and energy sector which produces five times more energy, and sells it at eight times more per capita, than the global average.

The energy sector in Russia is blessed with a host of outstanding strategic advantages, as well as some serious disadvantages, with the latter, in part, arising from the former; the tension between these is a determining factor in the development of the country's energy sector, much of the economy, and even the country's geopolitics.

Indeed, Russia is the largest territory in the world (11 per cent of total landmass) and previous generations have discovered and made possible the exploitation of a disproportionate amount (up to 15 per cent) of the world's fuel reserves within its borders. This area is home to only 2 per cent of the planet's population, who provide 2.9 per cent of world GDP. Of the developed countries, Russia has the highest per capita supply of relatively cheap energy resources. Moreover, Russia's positioning with regard to much of Eurasia, together with its access to three oceans, creates the objective prerequisites for multi-directional export flows of all types of energy resources.

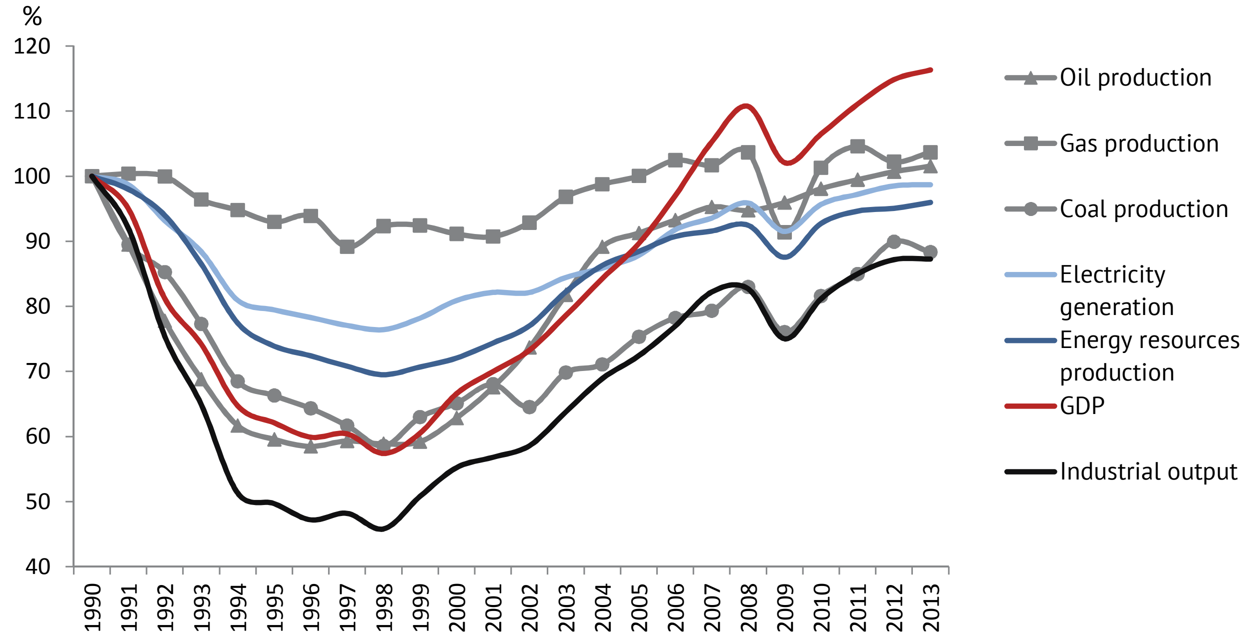
However, Russia is one of the world's coldest countries, lying mostly above 55° latitude north, with permafrost on two-thirds of its territory. Compared with Central Europe, its cold climate increases the cost of energy used in lighting and heating buildings by 20 per cent, and the cost of construction and maintaining the functioning of housing and industrial facilities by 20–25 per cent. In addition, climatic factors are a severe impediment to Russia's ability to exploit renewable sources such as solar energy and biomass.

The aggravating effect of the climate on Russia's fuel and energy network is exacerbated by 8–10 per cent due to: the vast distances (up to 9,000 km from west to east); enormous volumes of freight and passenger traffic (the

world's largest amount of total freight transport, with 98 per cent of it using the most expensive methods of rail, pipeline, and road); and a very low density of population and energy infrastructure (four and seven times lower respectively than in the USA, and seven and nine times lower than in Europe). Particular strain is placed on transport (with increased fuel and energy costs) by the country's extremely uneven distribution of energy production and consumption: for example, the country's largest fuel producer, the Tyumen region, produces 12 to 13 times more than the country's biggest consumer, Moscow and the Moscow region, consumes. Only 18 per cent of the country's regions are supplied by their own energy resources, while others have to bring them in over distances of hundreds and thousands of kilometres.

Partly for these reasons, but mainly because of its hypertrophied raw materials structure and poor organization of the economy, given its significant technological backwardness, Russia consumes 5.5 per cent of global energy resources and its GDP energy intensity (PPP/ruble) is 1.9 times higher than the world average. This is twice the energy intensity of the USA and three times that of the leading European countries (see Figure 3.7). In conjunction with its energy exporting orientation (which accounts for up to half of energy resources produced), the burden on the economy is 4.5 times higher than the global average: investments in energy are as high as 6 per cent of Russia's GDP, compared to 1.3 per cent for the world as a whole.

Figure 3.7 – GDP (PPP), industry, and energy resource production in Russia



Source: ERI RAS

The Russian fuel and energy complex was largely created during the Soviet era, which was at that time the world's largest energy producer and the second largest consumer. After the collapse of the Soviet Union the fuel and energy complex, along with the whole economy, experienced the longest slump in history[1] – with a fall of between 40–50 per cent in the production of basic energy resources. By 2008, most branches of the industry had almost

1 A 17 year socio-economic crisis, longer and almost as deep as 1917–28, and twice as long as the wartime recession of 1941–9.

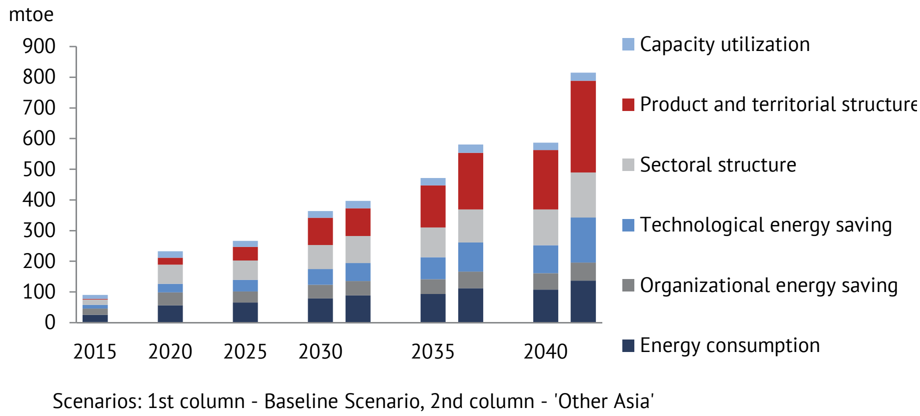
achieved their pre-reform level, and in 2012 had largely offset the decline in the first wave of the global crisis (Figure 3.7). Nevertheless, Russia dropped to fourth place in production, and sixth in primary energy consumption, among the leading players in the energy markets (Figure 3.8) that control more than two-thirds of world energy (Figure 1.78), although it retains first and second place in oil and gas production, as well as leadership in the world trade in hydrocarbons.

Energy saving

Low energy efficiency is the Achilles heel of the Russian economy, not so much because of the cold climate, but because of the country's excessive focus on raw materials and outdated technology in the fuel and energy sphere; it seems that it will not be possible to fully resolve this problem in the next 25 years.

For Russia's energy-intense economy, energy efficiency and conservation issues are key in predicting the development of the internal market. The main components and factors of Russia's potential for energy saving are shown in Figure 3.8. 'Structural energy conservation' (changing the structure of the economy by increasing the share of non energy-intense industry and production) plays a major role in reducing the growth of energy consumption, which in both scenarios will be more than 50 per cent by 2040.

Figure 3.8 – Energy saving, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

Along with such structural energy conservation measures (or economic restructuring), organizational and technological measures ('targeted energy efficiency') will, of course, be taken to save fuel and energy. However, their role in reducing demand growth will only amount to around 20 per cent (about 10 per cent from organizational measures and 10 per cent from the introduction of new technologies).

It must be emphasized that the scale of structural and especially technological energy conservation is largely dependent on the dynamics of domestic prices for fuel and energy. The policy of increasing energy prices will, to a certain extent, encourage energy saving and technological progress in the energy sector, and the diversification of energy supply through the use of solid fuels, nuclear power, and renewable energy sources; it will also increase the financial stability and investment attractiveness of the fuel and energy companies. A decisive role will be played by the price of natural gas, which will provide more than half of Russian energy during the forecast period. Gas

prices largely determine the dynamics of market prices in the coal industry, electricity generation, the supply of heating, and housing and communal services, as well as affecting the prices of fuel oil and feedstock for chemical production.

Levels of energy saving depend on the state of the economy: the Baseline Scenario forecasts less than half the rate of decline in energy intensity than the Other Asia Scenario in which, on account of high GDP growth rates, the existing potential for energy saving will be realized by 2030, after which Russia's level of technology will not lag behind that of the rest of the world. In the Baseline Scenario, a more pessimistic GDP forecast results in less investment in the energy sector, and, accordingly, slower structural improvement of the economy, product mix, and output, as well as a slower renewal of fixed assets, which serves to slow down the reduction of energy intensity. If we add to this the remaining administrative barriers and, most importantly, the lack of long-term money and credits for energy-efficient projects that are accessible to smaller market participants, in conjunction with the recently adopted concept of inhibiting the growth of gas prices, Russia will be stuck in a state of high energy intensity. In addition to this, the 'Other Asia' Scenario foresees an ever greater electrification of the economy.

The result of carrying out structural changes in the economy and implementing energy conservation policies will be to reduce GDP energy intensity by 45 per cent compared to 2010 by 2040 (2 per cent per year) in the Baseline Scenario, and by a factor of two (2.3 per cent per year) in the Other Asia Scenario. The forecast rate of reduction in GDP energy intensity will be 2.8–2.1 times lower than that achieved in 2000–8, when it averaged 5.8 per cent per year. During that period Russia's GDP grew by an average of 7 per cent annually (largely thanks to a 1.6-fold increase in energy exports and a tripling of world prices for hydrocarbons[2]) which cannot be expected in the forecast period. The trends of energy consumption, per capita energy consumption, and forecasts of domestic demand for energy are given in the Appendix.

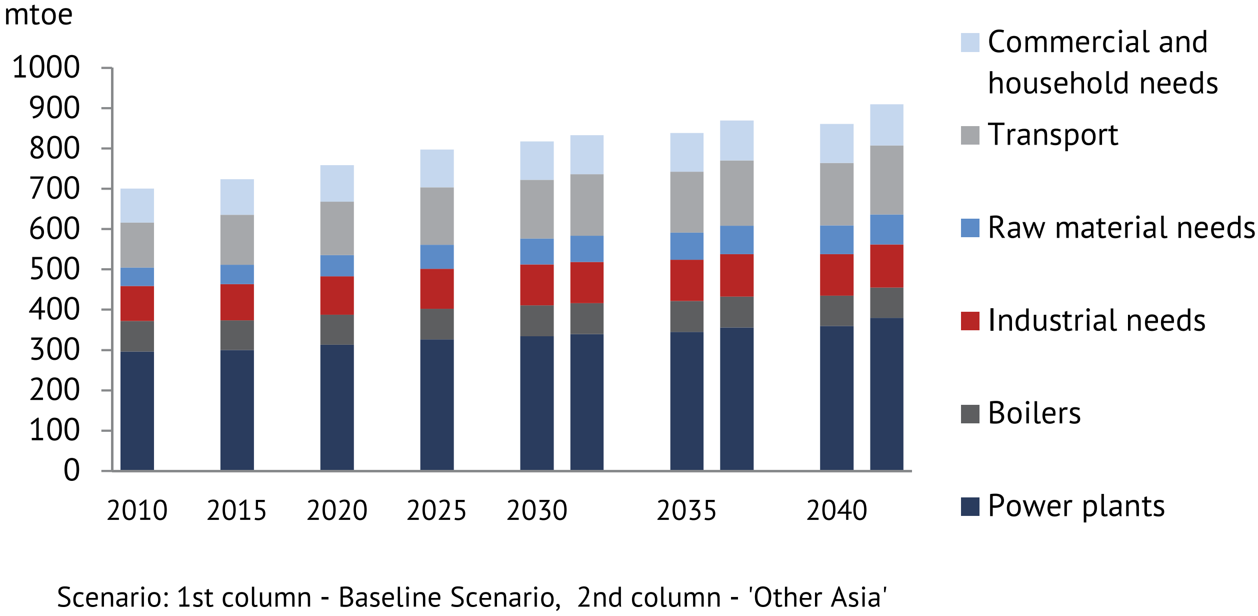
Forecast of energy consumption by usage

The growth of energy consumption in Russia will slow considerably during the forecast period, and absolutely by the end of the period, with the use of electricity and high-quality motor fuel being prioritized.

The country's demand for primary energy will increase by 22–28 per cent from 2010 to 2040, which is to say that the rate of increase in the growth of domestic energy demand will clearly slow (but not halt). The main growth in energy demand will be from power stations, which will retain their share of domestic demand at a level of 42 per cent until 2040. The transport sector will increase its proportion of demand from 16 to 19 per cent by 2040. Industrial and household needs will reduce their share by 1–1.5 per cent due to an increase in the share of fuel use as feedstock from 6.5 per cent to 8 per cent (Figure 3.9).

2 In other words, the reduction of energy intensity was, to a large extent, of a somewhat virtual nature, and did not reflect progress in energy saving.

Figure 3.9 – Use of primary energy, Baseline Scenario and Other Asia Scenario



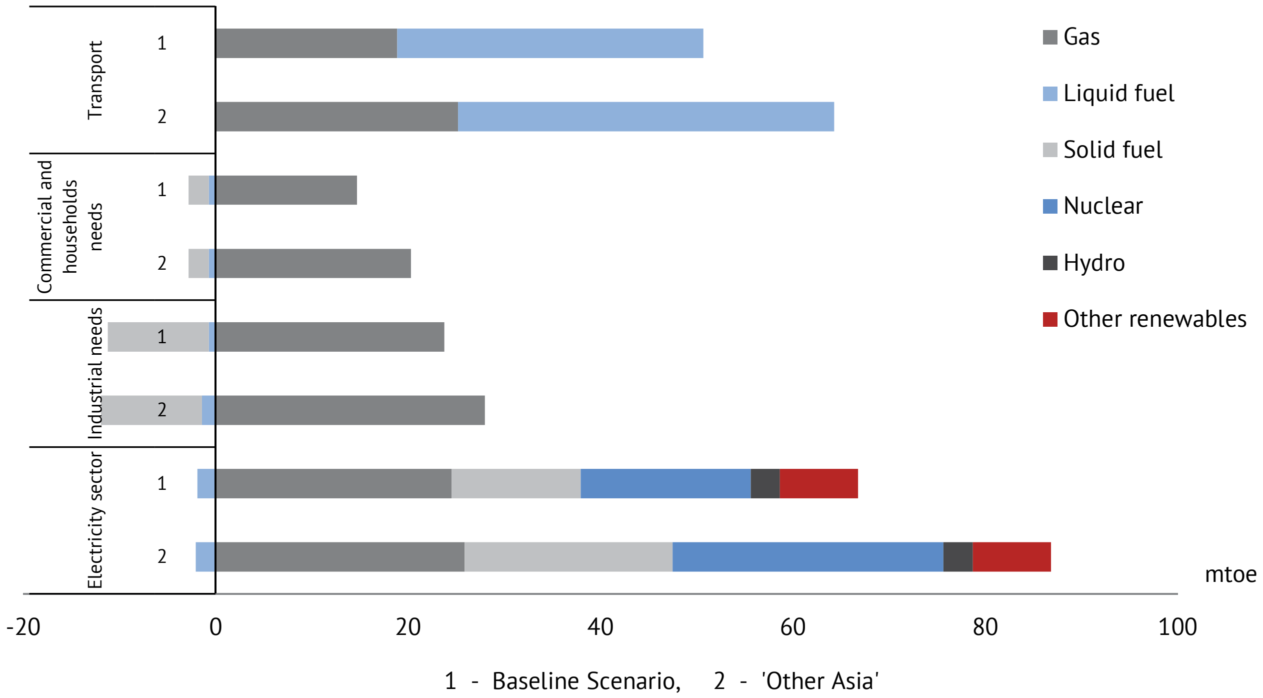
Source: ERI RAS

Natural gas will remain, in both absolute and relative terms, the most widely used energy resource in Russia, providing 51–53% of total primary energy consumption.

Primary energy consumption by type

The consumption of individual fuels will greatly differ in terms of their use, but the main growth for all uses, except for transport, will be provided by natural gas (Figure 3.10).

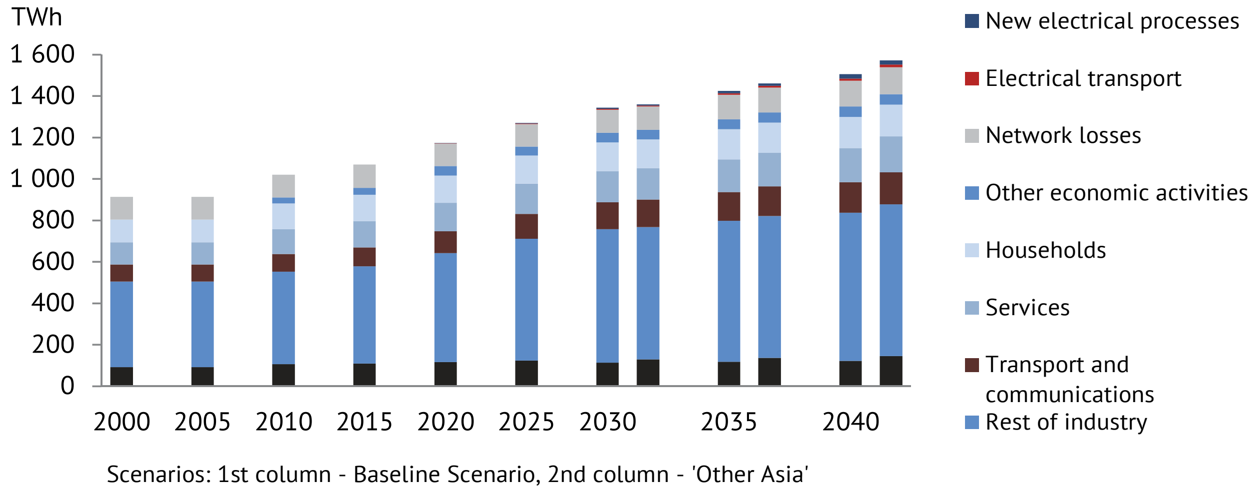
Figure 3.10 – Growth in consumption by sector and fuel type in 2010–40, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

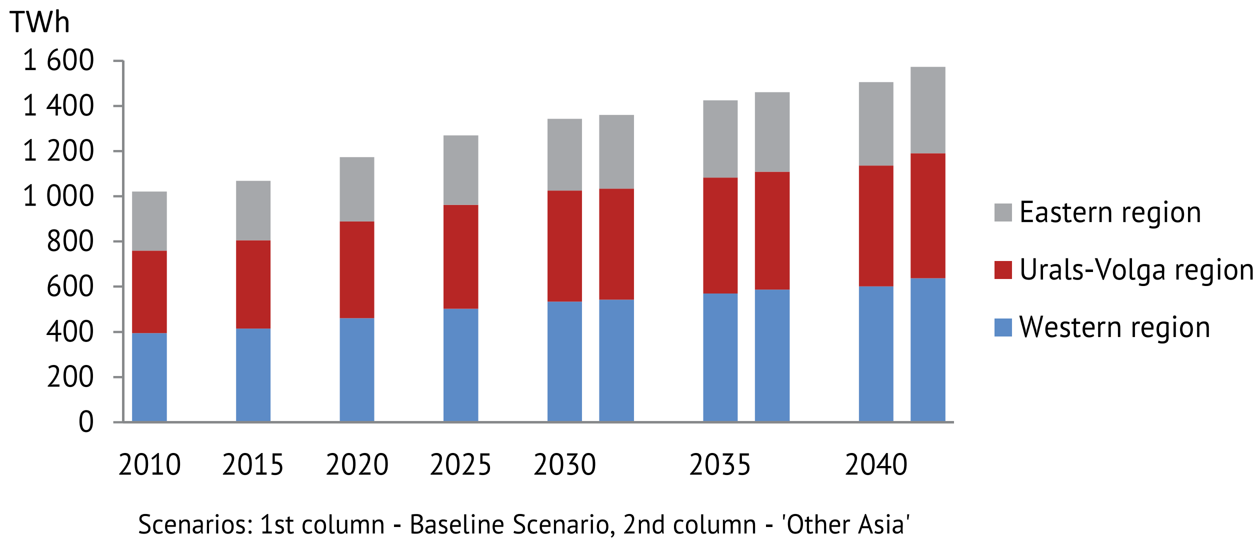
By 2040, electricity consumption will increase by 43–54 per cent. The main growth in demand will be from the manufacturing sector (70 per cent) and the transport and communications sector (80 per cent). Electricity consumption will double in the construction sector, there will also be a 45 per cent increase in demand in the service sector, together with one of 25 per cent in the public utilities sector (Figure 3.11). Network losses will increase by 17 per cent (this is three times lower than the increase in power consumption). Replacement of motor fuel by electricity in rail and road transport will intensify (1–3 per cent of consumption by 2040) while electricity will replace some of the gas that is currently consumed in the operation of gas pipelines (2–3 per cent by the end of the period under review). Demand from industry and public utilities will decrease by 2–3 per cent by 2040. Electricity demand is projected in all territorial zones of the country (Figure 3.12).

Figure 3.11 – Electricity consumption by type of economic activity, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

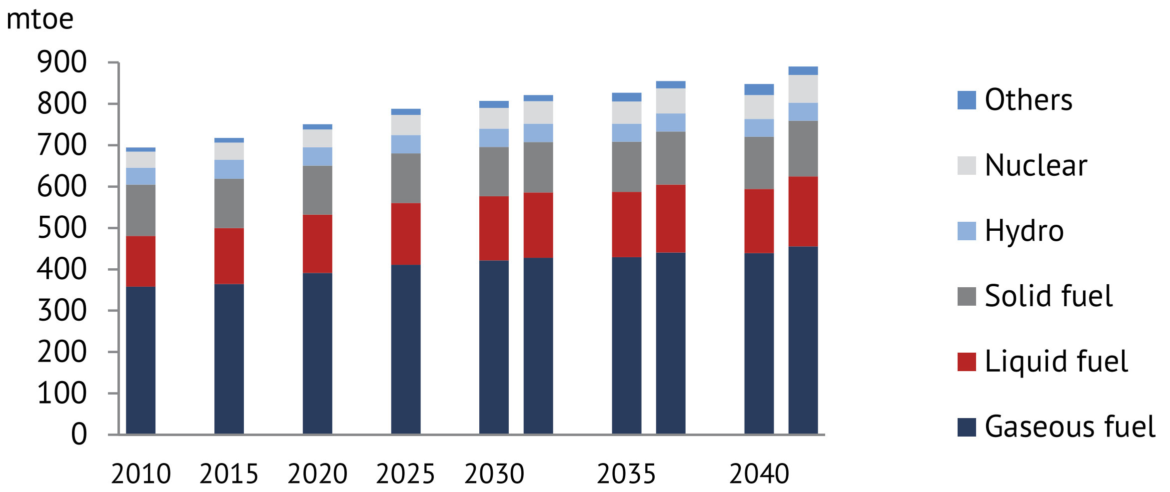
Figure 3.12 – Electricity consumption by territorial zone, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

The resulting structure of domestic energy consumption of primary energy by type is shown in Figure 3.13. The dominant source of energy remains natural gas, which maintains its share of primary energy consumption of 51–52 per cent up to 2040 (Figure 3.14). The share of oil also stabilizes between now and 2035 (18–19 per cent, with a many-fold reduction in the use of fuel oil).

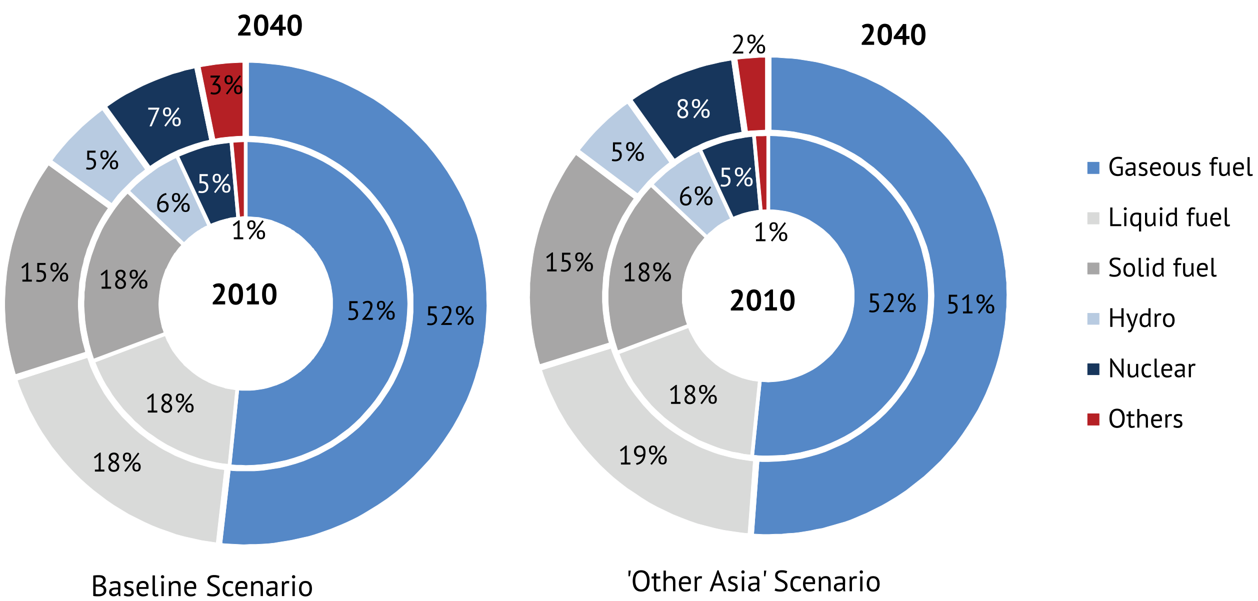
Figure 3.13 – Consumption of main primary energy resources, Baseline Scenario and Other Asia Scenario



Scenarios: 1st column - Baseline Scenario, 2nd column - 'Other Asia'

Source: ERI RAS

Figure 3.14 – Consumption of main primary energy resources, 2010 and 2040, in both scenarios, %



Source: ERI RAS

The use of non-carbon energy resources will increase from 13 per cent in 2010 to 15 per cent by 2040; for the most part, this represents a replacement of solid fuels, whose share will decrease from 18 per cent in 2010 to 15 per cent in 2040, with an absolute reduction in their use by all consumers, with the exception of power stations.

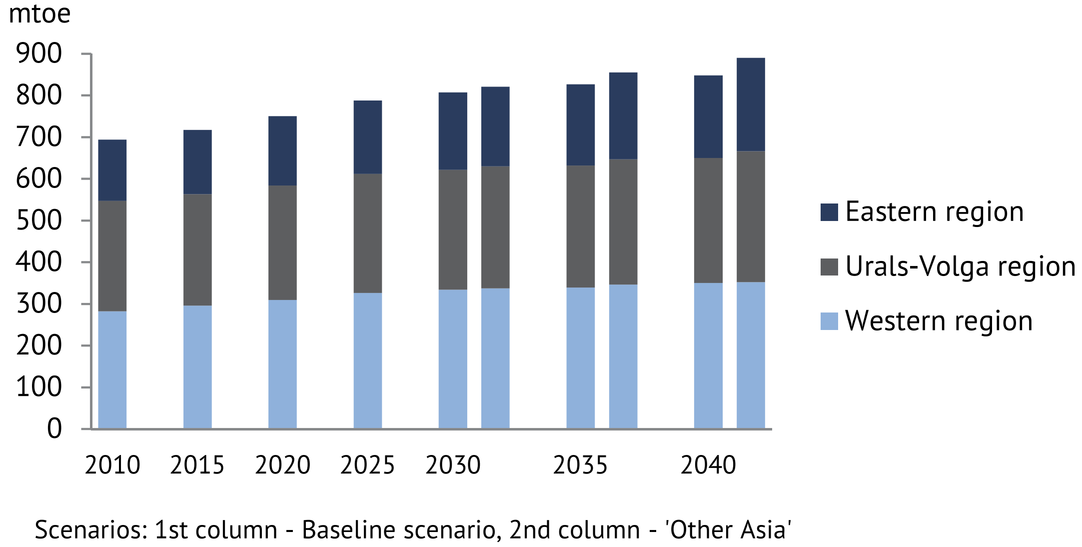
Non-carbon energy sources will largely be represented by nuclear energy (the use of which will increase by 50–80 per cent by 2040, with its share of total energy consumption growing from 5.5 per cent to 6.8–7.6 per cent by 2040). The use of renewable energy sources will increase even more rapidly (between 2.1 and 2.8 times by 2040), but its share of primary energy consumption will still remain very low, at about 2–3 per cent in 2040.

Primary energy consumption by territory

Only the rapid development of the eastern regions in the Other Asia Scenario will be able to slightly shift the perennial imbalance in the geographical dispersion of energy consumption away from the European regions of Russia.

The Scenario forecasts for primary energy consumption by region are shown in Figure 3.15. Energy consumption in the Eastern region grows most rapidly, by 34 per cent in the Baseline Scenario and by 53 per cent in the Other Asia Scenario, thereby increasing the region's share in total energy consumption to 23–25 per cent by 2040. Energy demand in the Western region will grow by 24 per cent by 2040, but the region's share of total demand will remain at about 40 per cent. Moderate growth in consumption in the Urals–Volga region of 13–18 per cent will reduce the region's share of consumption by 3 per cent by 2040.

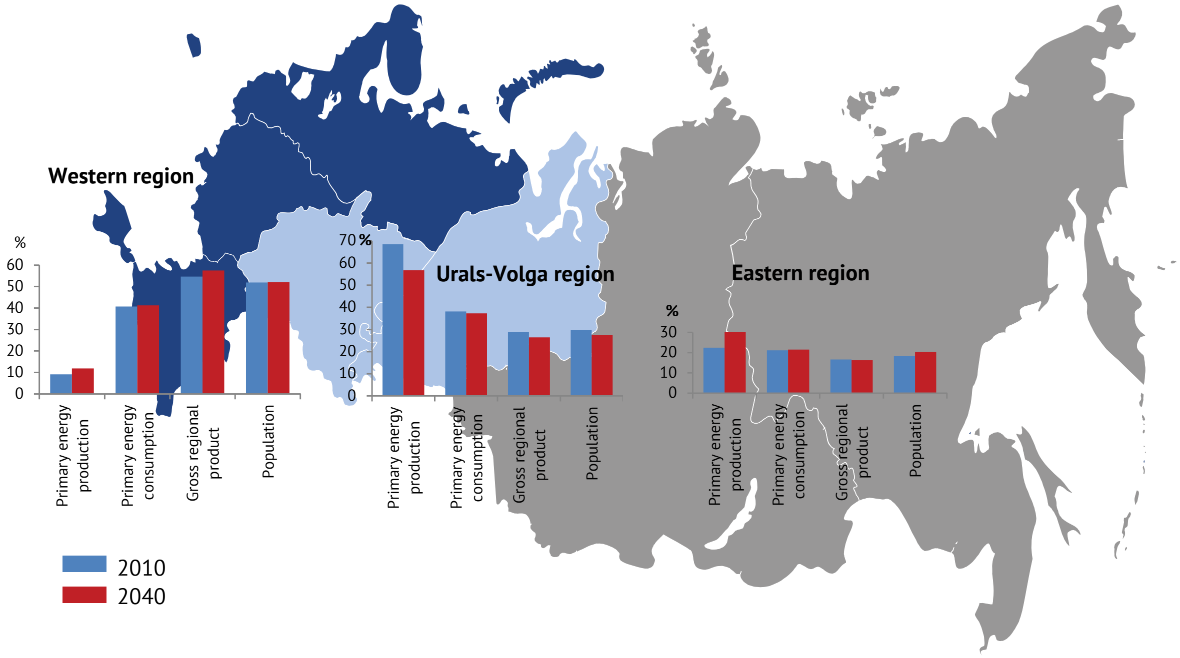
Figure 3.15 – Primary energy consumption by territorial zone, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

Total share of population, GRP, and energy consumption by territorial zone are shown in Figure 3.16.

Figure 3.16 – Proportion of population, GRP, and energy consumption by territorial zone, 2010 and 2040



Source: ERI RAS

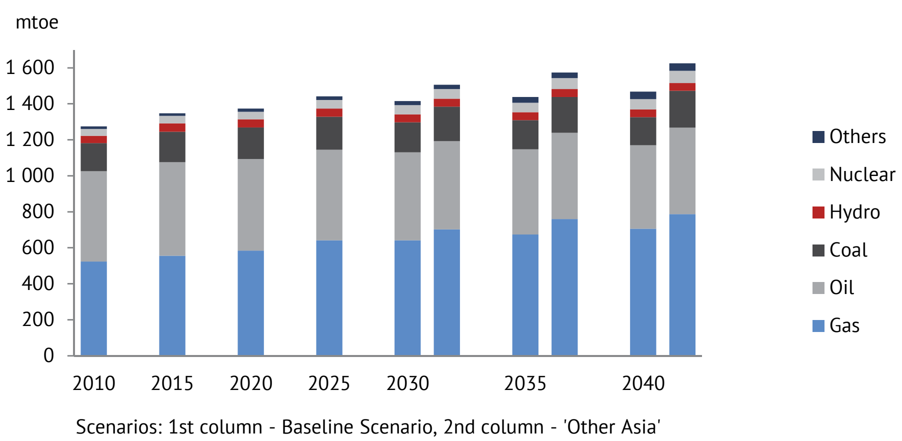
Production of energy resources

Production of energy resources by fuel type

In contrast to the growing diversification of global primary energy production, natural gas production increases its dominance in Russia, while there is a slight increase in the share of non-carbon energy sources.

In the Baseline Scenario, by 2040 the production of energy resources in Russia will increase by only 15 per cent 15% (Figure 3.17). Oil and gas will retain their dominant positions in the production of primary energy with virtually no change in their overall share (80 per cent). A slight decrease in the share of hydrocarbons by the end of the period is fully offset by increased use of non-carbon energy resources (up from 7.3 per cent in 2010 to 9.3–9.7 per cent in 2040), the leading of these being nuclear energy.

Figure 3.17 – Primary energy production by fuel type, Baseline Scenario and Other Asia Scenario



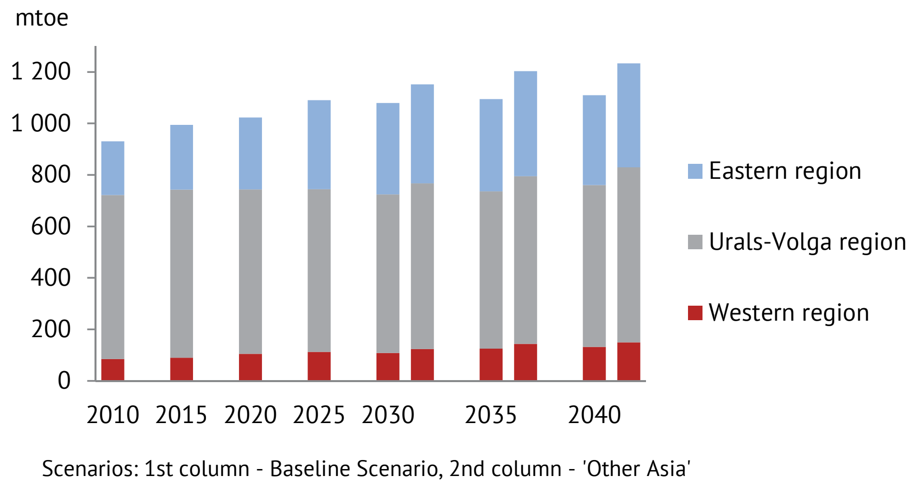
Source: ERI RAS

Production of energy resources by territory

A change in the hugely uneven geographical distribution of energy production in Russia is predicted due to rapid growth of fuel production in Eastern Siberia and the Far East, especially in the Other Asia Scenario.

Production of energy resources by territorial zone in Russia is shown in Figure 3.18. The problem facing Russia's fuel and energy sector is an excessive concentration of production in the Urals–Volga area, with 71 per cent of total Russian production of energy resources in 2010. Although the volume of production will increase by 2040, the region's share will decrease to 61 per cent due to the accelerated growth of the production of energy resources in the eastern zone (by 57–81 per cent).

Figure 3.18 – Primary energy production by territorial zone, Baseline Scenario and the Other Asia Scenario



Source: ERI RAS

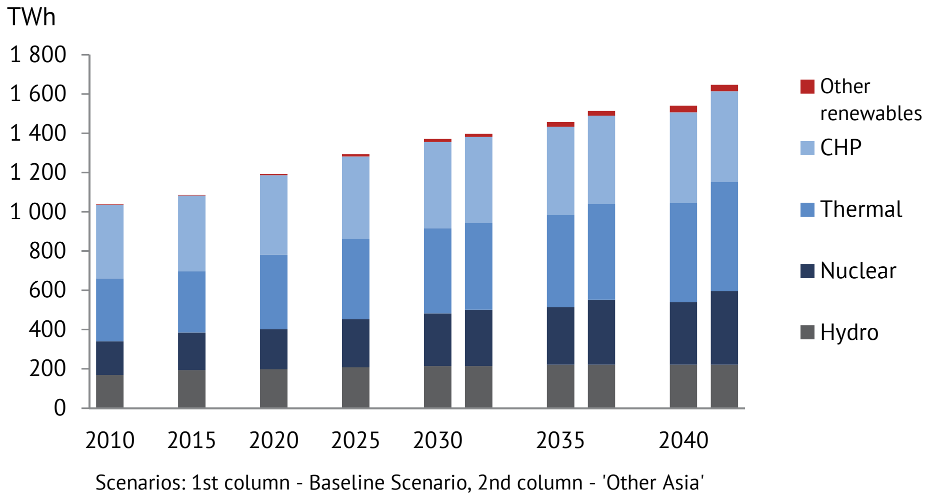
Electricity generation and centralized heating supply

Electric power will grow twice as fast, while the supply of centralized heating will lag behind the growth rate of primary energy production, but both sectors will have a single driver – the advanced development of distributed cogeneration of electricity and heat via unified smart grids.

Russian electricity was also affected by the global financial crisis, although its direct consequence was the removal of the threat of electricity shortages – due to lower demand in 2009 by 4.4 per cent across the country and by even more in the leading regions. The crisis coincided with the decentralization of management of the sector, together with the privatization of the majority of plants with the heavy investment commitments of the newly created private generating companies. This reduced the capitalization of all energy companies, correspondingly diminishing their ability to access credit, the cost of which in turn doubled. Together with slowing growth in electricity demand, this made investment more difficult and distorted the reform of the sector that was initiated in 2008 with the ideology of prioritizing private investment, and caused rapid growth of prices and tariffs for consumers of electricity and heat.

With the forecast needs of the national economy for electricity and the expected size of exports, its production in the country will increase by 2040 by 48–59 per cent (Figure 3.19).

Figure 3.19 – Electricity output, Baseline Scenario and Other Asia Scenario



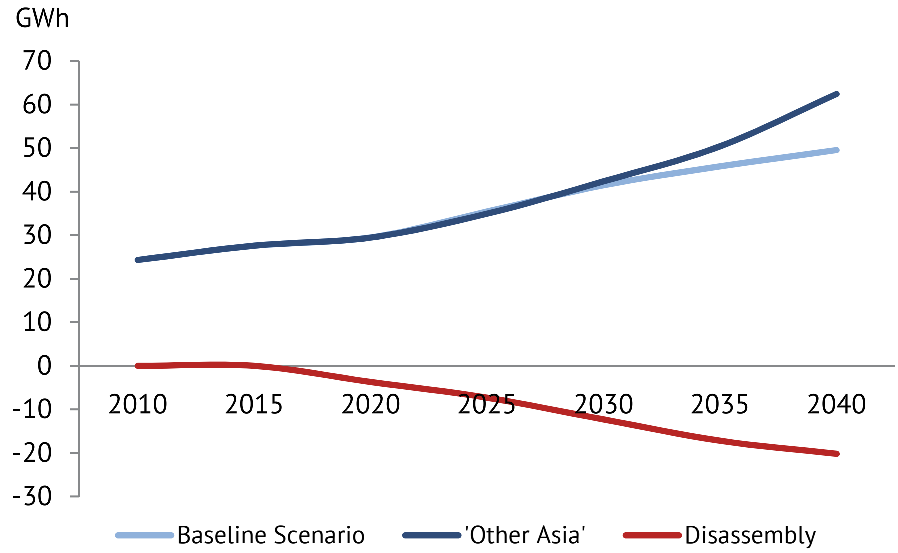
Source: ERI RAS

Thermal power plants will remain the mainstay of Russia's electricity production (62–63 per cent of total electricity production in 2040, compared to 67 per cent in 2010) with advanced growth in the production of condensation power generation (57–73 per cent by 2040) and a moderate increase in production by combined heating and power plants of 23 per cent in 2040 due to slow growth in the demand for the heat they produce.

Hydropower generation will increase, but its share in electricity production will decrease from 16.3 to 13–15 per cent in 2040 due to the almost total utilization of water resources in the main areas of electricity consumption. Top for accelerated growth will be electricity generation from non-conventional renewable energy resources (up 19 times from 2010 to 2040 in both scenarios), though its share in electricity production will only be about 2 per cent in 2040.

Second after condensation power generation for absolute increase in electricity production will be nuclear power, up 1.9–2.2 times by 2040. Nuclear power plays a special role in the Other Asia Scenario due to the electrification of many spheres of activity: nuclear power will allow increased replacement of motor fuel by electricity, and of the gas that is consumed in the operation of gas pipelines, as well as in industry and public utilities. In addition, nuclear power will displace a certain amount of thermal power plants (mostly condensation), freeing up extra gas for export and reducing the cost of electricity for consumers. In 2025–40 the current growth rate of nuclear capacity (Figure 3.20) will double. There will be a 35–40 per cent increase in investment in electricity generation. In addition, each ruble of investment in nuclear energy will increase the country's GDP by 3.5–4 rubles, and the population's income by 0.8–1 rubles. The realization of this technological breakthrough is one of the most important strategic initiatives for the Russian fuel and energy sector in the period under consideration.

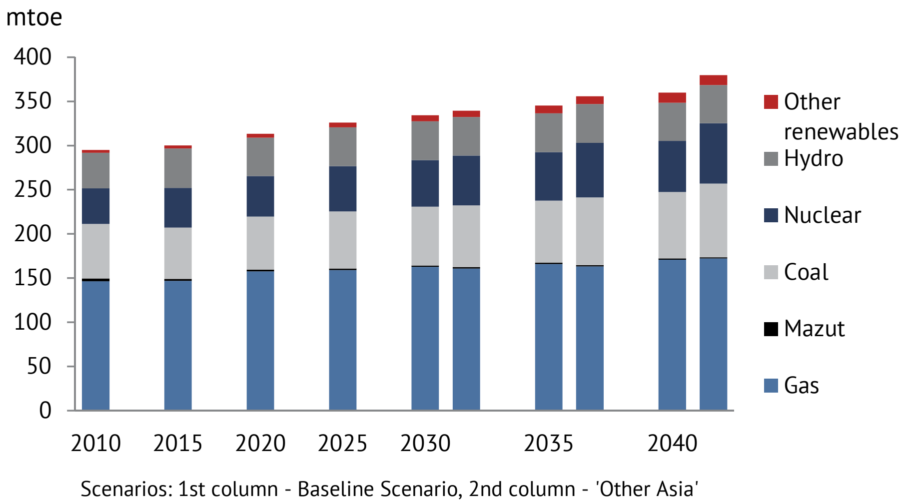
Figure 3.20 – Nuclear power station capacity, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

As the largest consumer of primary energy, power generating stations will increase their consumption by 21–28 per cent by 2040. Of total primary energy consumption, 67–69 per cent in 2040 will be fossil fuels (72 per cent in 2010), an increase of 15–20 per cent (Figure 3.21). The main fuel for power plants will remain natural gas, whose share will stay at a level of 67–69 per cent. The burning of fuel oil will decrease five-fold, and the share of solid fuels will increase from 29 per cent in 2010 to 30–33 per cent by 2040.

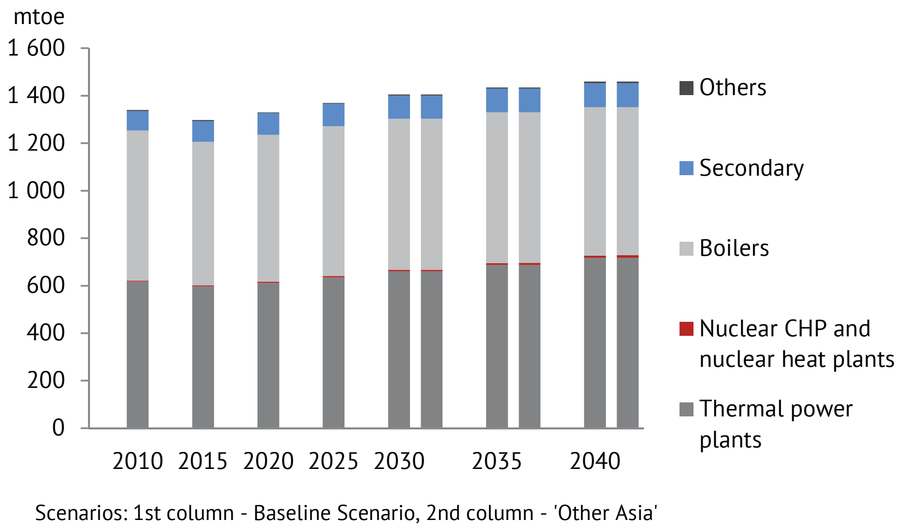
Figure 3.21 – Power stations' primary energy consumption, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

There is expected to be a break in the long-term downsizing of centralized heating supply. The renewed growth of heat consumption will partly be as a result of large-scale housing construction in large towns and the development of heat-intensive sectors of industry, but the main growth will result from the rapid development of widespread cogeneration in medium-sized towns and new developments of multi-storey construction. As a result, demand for centralized heating supply will increase by 7–13 per cent by 2035, and by 12–22 per cent by 2050, with half of this mainly being met by low- and medium-capacity heat generation plants, while the share of boiler plants will be down from 47.2 per cent to 44–42 per cent in 2035 (Figure 3.22).

Figure 3.22 – Heat production, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

The fuel consumption of centralized boiler plants will not exceed the 2010 level until 2025, and will remain at that level until 2040. They will still mainly be fuelled by natural gas, whose share will increase from 74 per cent in 2010 to 78 per cent in 2040. The share of biomass will increase from 2.8 per cent to 4.6 per cent, while the main growth in the use of alternative renewable resources will occur in decentralized heating supply.

The oil sector – production

Russia will remain one of the three leaders of the global oil industry; it will carry out thoroughgoing technological modernization and territorial diversification in all branches of the oil industry, and will dramatically increase the variety, and improve the quality, of its production while fully meeting domestic demand and reorienting itself on a large scale towards the Asia–Pacific market.

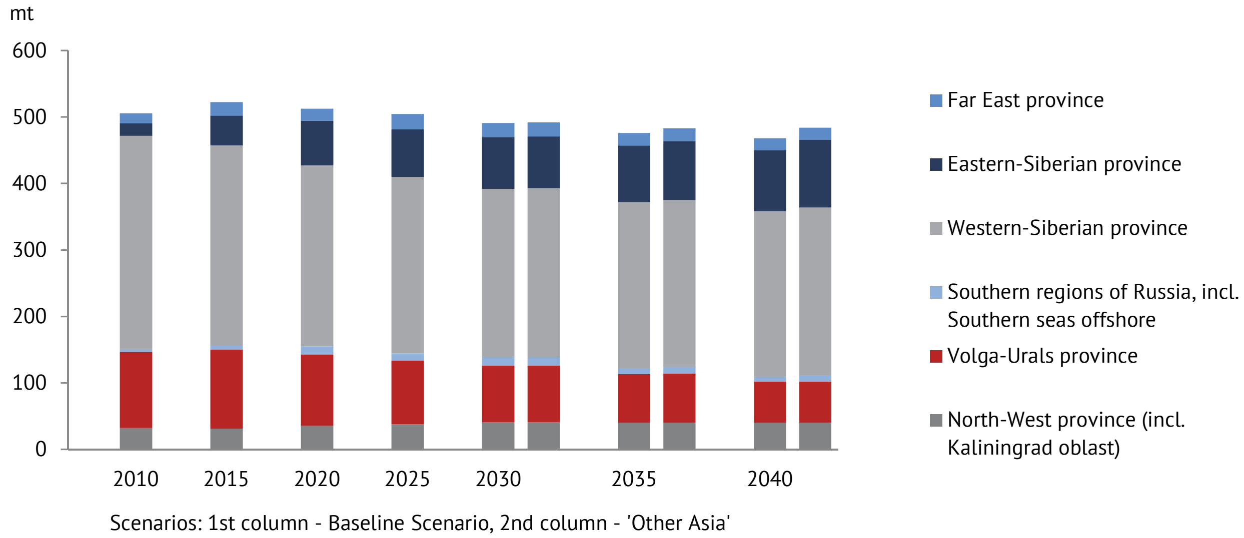
The oil industry suffered less than others from the global financial crisis because, unlike similar previous occasions – when oil prices were high and customs duties ate up the greater part of the companies' profits – tax incentives were introduced which, together with a reduction in prices for consumables due to the devaluation of the ruble, made the economic environment sustainable for the companies. The subsequent rise in global oil prices allowed them to revive their investment programmes.

In Outlook 2014's Baseline Scenario, production of oil and gas condensate in the Russian Federation reaches a peak and gradually declines, from 523

million tonnes[3] in 2013 to 522 million tonnes by 2015, after which it continues to decline, right up to the end of the period, to a level of 468 million tonnes. This reduction in production is, for the most part, brought about by the working out of already exploited deposits in the key oil producing regions of the country (in Western Siberia).

In the Other Asia Scenario, more favourable conditions on external markets allow the Russian Federation to increase its production compared to the Baseline Scenario after 2025 (Figure 3.23).

Figure 3.23 – Oil and gas condensate production in the Russian Federation by key producing region, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

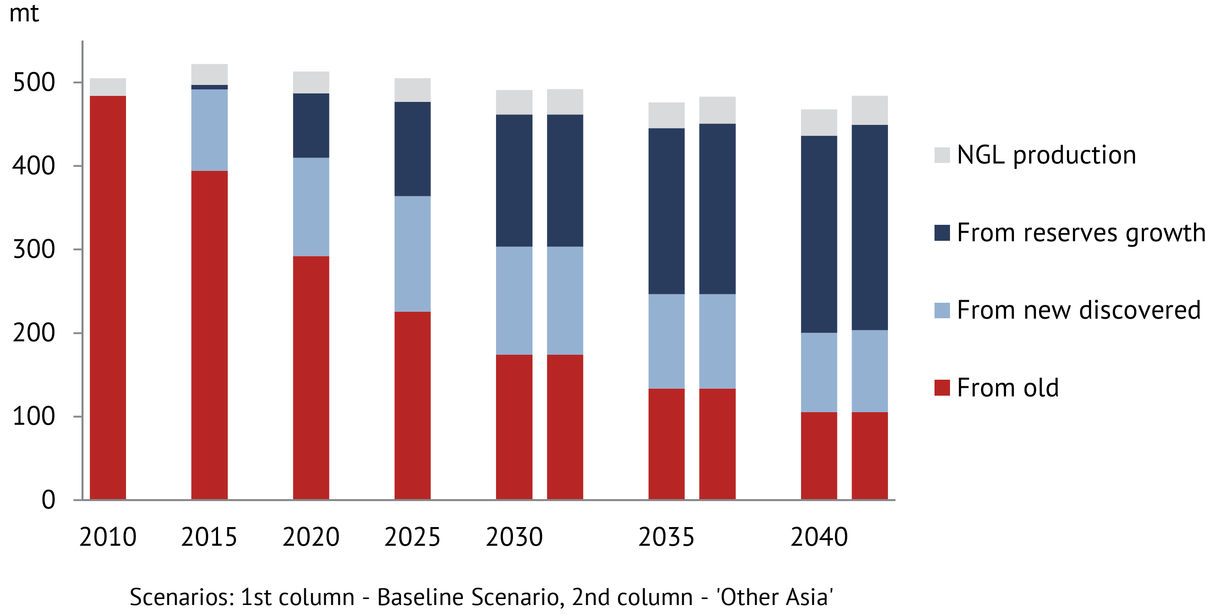
Despite the fall in production in the Baseline Scenario, even at the end of the forecast period the key production capacities of the country will continue to be concentrated in the Tyumen region, with its share accounting for 51 per cent of all crude oil and gas condensate production by 2040 (compared with 61 per cent in 2010). The drop in production is partially offset by the commissioning of fields in Eastern Siberia and the Far East (for example, production in Eastern Siberia increases from 19 million tonnes in 2010 to 92–102 million tonnes in 2040, while production in the Far East increases from 15 million tonnes to 23 million tonnes by 2025, though it does then fall to 18 million tonnes by 2040). The commissioning of fields in the Vankorskoye block, in particular, eases the fall in production, as does increased production from the Sakhalin projects.

One should point out the significant role that will need to be played by geological exploration during the forecast period, since by 2040 more than 50 per cent of production in all scenarios will need to come from growth in reserves, and final reconnaissance of fields resulting in category C2 reserves becoming category C1.

One other factor that will soften the fall in production will occur in the gas sector, with the development of wet natural gas fields (see 'NGL production', Figure 3.24).

3 Central Dispatching Department of the Fuel and Energy Complex.

Figure 3.24 – Oil and NGL production in the Russian Federation by reserve type, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

In the Other Asia Scenario increased domestic demand allows a less sharp fall in production after 2025 than is seen in the Baseline Scenario. Production can be raised, compared with the Baseline Scenario, by the large-scale utilization of enhanced oil recovery methods (EOR) and the introduction of domestic shale oil extraction technologies in the fields of the Bazhenov Formation, but this will not succeed in reversing the decline in production.

Russia will not be able to keep oil production at current levels; even the implementation of the scenarios presented will require large-scale investment in exploration and the development of new technologies.

The increasing proportion of reserves that are difficult to extract (their share is more than 60 per cent of domestic reserves[4]) , together with the high degree of depletion of currently operational oil fields, have severely reduced the sector's average producible oil index in Russia: if in the mid-1980s the average coefficient of oil recovery in the country was more than 40 per cent, by 2010 it had fallen to 30 per cent[5].

The adoption of enhanced oil recovery methods (EOR) will significantly increase the resource base of the oil industry, due to the increased coefficient of oil recovery. If in the Baseline Scenario there is an expected 10 per cent increase in oil recovery compared to the 2010 level, then with the large-scale implementation of EOR in existing Russian fields, the coefficient of oil recovery may increase by another 10 per cent. This would represent an increase in production of nearly 20 million tonnes by as early as 2035. But methods to increase oil recovery seriously increase the costs of production. According to the company Ernst & Young[6], current specific costs (excluding taxes) for Russian oil fields where EOR is implemented could increase from the current 15 $2010/barrel to 50 $2010/barrel[7] and tax cuts would be required for projects using EOR to become attractive for companies in the light of predicted oil prices.

4 'Enhanced oil recovery (EOR) methods in Russia: time is of the essence', Ernst & Young, 2013, http://www.ey.com/Publication/vwLUAssets/EY_-_Enhanced_oil_recovery_(EOR)_methods_in_Russia:_time_is_of_the_essence/$FILE/EY-Enhanced-Oil-Recovery.pdf.

5 According to Ministry of Energy data.

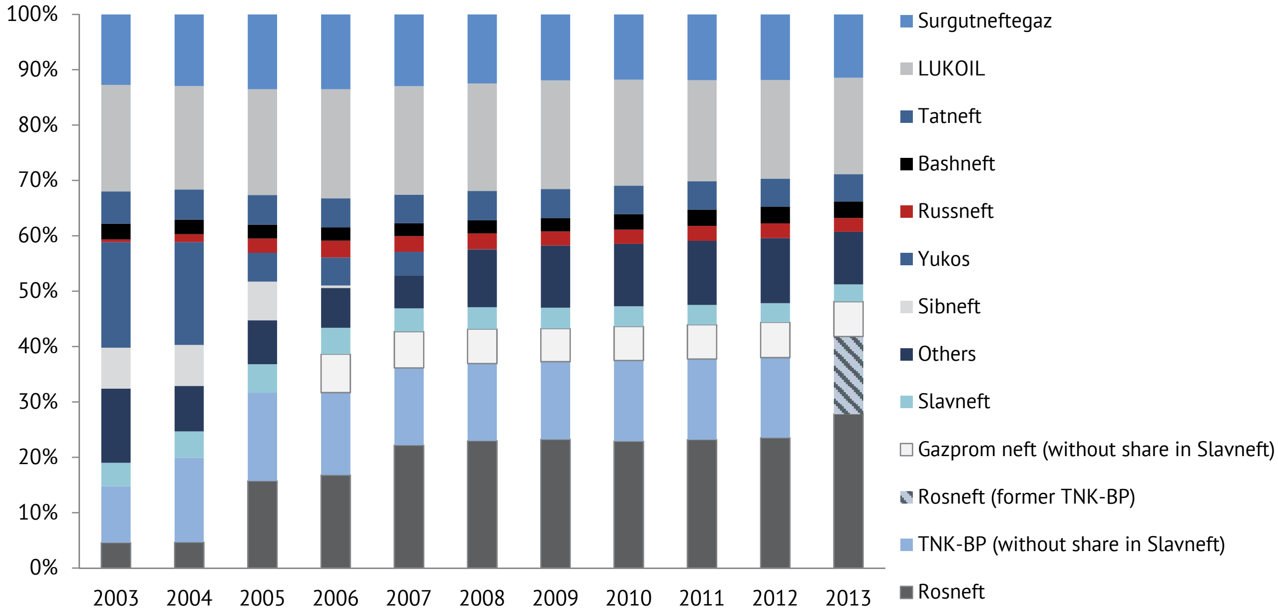
6 'Enhanced oil recovery (EOR) methods in Russia: time is of the essence', Ernst and Young, 2013, op. cit.

7 'Half a billion tons of hydrocarbons from the bowels of the State Duma extract Ugra tax benefits', Pravda, 27 March 2013, http://pravdaurfo.ru/articles/polmilliarda-tonn-uglevodorodov-gosduma-izvlechet-iz-nedr-yugry-nalogovymi-lgotami.

A significant increase in production can be achieved through another technological innovation – the start of oil shale production in Russia at the **Bazhenov Formation**, which has estimated reserves of 500 million tonnes. At the present stage, significant tax incentives have already been introduced – in particular, reductions in the mineral extraction tax for fields that have been worked out less than 3 per cent. However, given the complex structure of unconventional deposits, most of the deposits still remain unviable given the oil prices in the Baseline Scenario. With extended tax breaks for deposits at the Bazhenov Formation, shale oil production in Russia could exceed 20 million tonnes by 2025.

Another feasible way of increasing oil production in Russia is to **develop bituminous oil and high-viscosity oil**, in particular in Tatarstan. According to our estimates, the development of oil bitumen may increase oil production compared with the Baseline Scenario by 10 million tons by 2040.

Figure 3.25 – Oil production in Russia by company



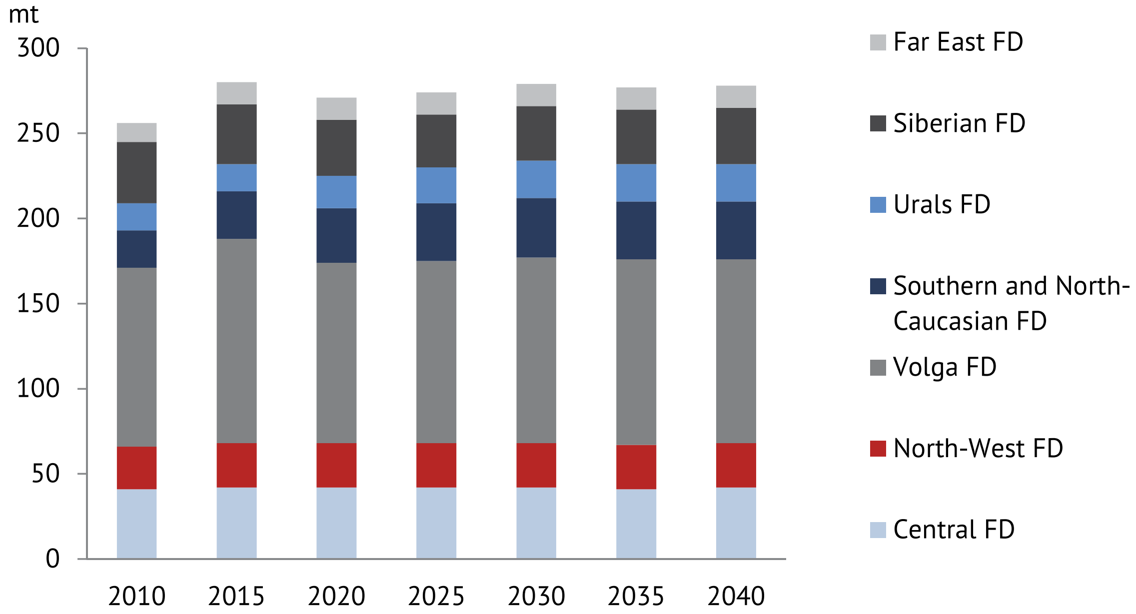
Source: ERI RAS

A peculiarity of the development of Russian oil production from the standpoint of corporate structure is the increasing concentration of assets in the hands of state-controlled companies (Figure 3.25). At the beginning of the 2000s, all the key production assets were concentrated in the hands of private corporations, and state-controlled Rosneft accounted for less than 5 per cent of the country's production. Over the past 10 years the proportion of state-controlled production (Rosneft, Gazprom Neft, and Slavneft) has increased to 50 per cent, and in absolute volume, by more than 13 times.

Oil refining

In the Baseline Scenario, oil refining volumes in Russia will decline after 2015. The projected decline in utilization is due primarily to a glut of oil products on the European market: with falling demand for petroleum products in 2015–20 suppliers of refined products in Russia, the Middle East, Asia, and Europe itself, will compete for European consumers, while maintaining deliveries of diesel fuel from the USA. After 2020, there is expected to be a gradual recovery of primary oil refining in Russia, with up to 280 million tonnes by 2040 (Figure 3.26), along with a systematic growth in the production of petroleum motor fuels and feedstock for the petrochemicals industry due to an increase of refining depth from 71.1 per cent in 2010 to 85 per cent in 2040, and an increase in the yield of light oil products from 55 per cent to 73 per cent (Figure 3.27).

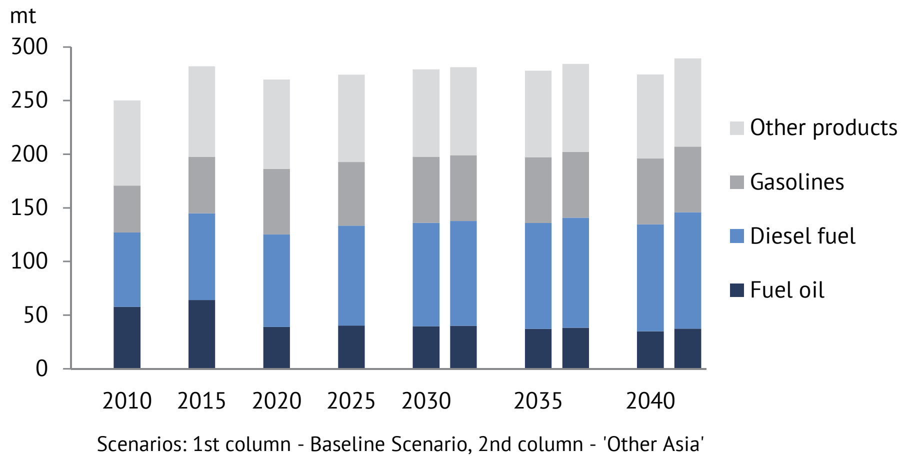
Figure 3.26 – Oil refining volumes by federal district, Baseline Scenario



Source: ERI RAS

Given the current operational structure and state of the country's refineries, domestic oil processing requires modernization and expansion of capacity both in primary processing and in deepening processes to increase the yield of light oil products and to improve the quality of motor fuels, in order to meet the country's needs for motor fuels and petroleum products. Forecast commissioning of new facilities is presented in Table 3.3.

Figure 3.27 – Oil refining and production of main products, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

Table 3.3 – Growth in capacity of key oil refining processes in Russia by 2040, Baseline Scenario

Process name	Purpose of process	Existing capacity according to 2010 data, million tonnes/year	Total capacity by 2040, million tonnes/year
Primary processing	Atmospheric and vacuum distillation.	305	326
Catalytic cracking	Deepening processing, integration of vacuum distillation in processing, obtaining high-octane gasoline, raw material for diesel hydrofining, and valuable raw petrochemicals (unsaturated hydrocarbon gases).	22	34
Catalytic reforming	Production of high-octane gasoline component (reformate) from low-octane straight-run gasoline fractions and individual aromatic compounds (benzene, toluene, xylenes).	31	38
Diesel hydrofining	Improving the performance characteristics of straight-run and secondary diesel fractions to European standards.	55	100
Gasoline hydrofining – catalytic cracking	Improving the performance characteristics of high octane gasoline – catalytic cracking.	1	10
Hydrocracking	Integration of vacuum distillation in processing and residues obtaining high quality motor fuels and intermediates.	8	49
MTBE production	Production of efficient oxygenated octane-increasing additives from catalytic cracking gases and their derivatives (isobutylene, methanol).	0.2	0.7
Isomerization	Production of high-octane gasoline component (isomerate) from light straight-run petroleum fractions (naphtha) and factory gasoline distillates.	6	13
Alkylation	Production of high-octane gasoline component (alkylate) from gas from destructive processes (BBF, isobutane).	1	3
Coking	Production of pure solid carbon (coke) from sludge, used in metallurgy, high-tech industry, and as fuel. As a by-product gives a high yield of liquid hydrocarbons.	8	28

Sources: ERI RAS, KORTES, 4 – party agreement

Exports of crude oil and oil products

Russian exports of crude oil in the Baseline Scenario decline from 245 million tonnes in 2010 to 185 million tonnes in 2040, due to both a reduction in Russian oil production and an increase in refining volumes, and also to a significant change in the structure of oil exports in terms of their destinations. Europe's share will decline from 73 per cent in 2010 to less than 50 per cent by 2040, while the importance of the 'eastern vector' of Russian oil exports greatly increases: in the Baseline Scenario deliveries to the Asia–Pacific countries exceed supplies to Europe by 2040, reaching 85–90 million tonnes (Table 3.4).

Table 3.4 – Crude oil exports from the Russian Federation, Baseline Scenario, million tonnes

	2010	2015	2020	2025	2030	2035	2040
CIS	26	27	27	24	21	20	18
Europe	182	160	152	124	108	90	83
Asia–Pacific	40	53	65	79	80	85	86

Source: ERI RAS

Reduced crude oil supplies to Europe will exacerbate the competition between pipeline and maritime transport in the western direction. While 55 million tonnes was delivered via the Druzhba pipeline in 2010, by 2040 it will carry only 45 million tonnes, and no increase of exports through the ports to the west is expected, indeed their current load (more than 125 million tonnes of oil in 2010) will fall by more than three times (35–40 million tons per year) by 2040.

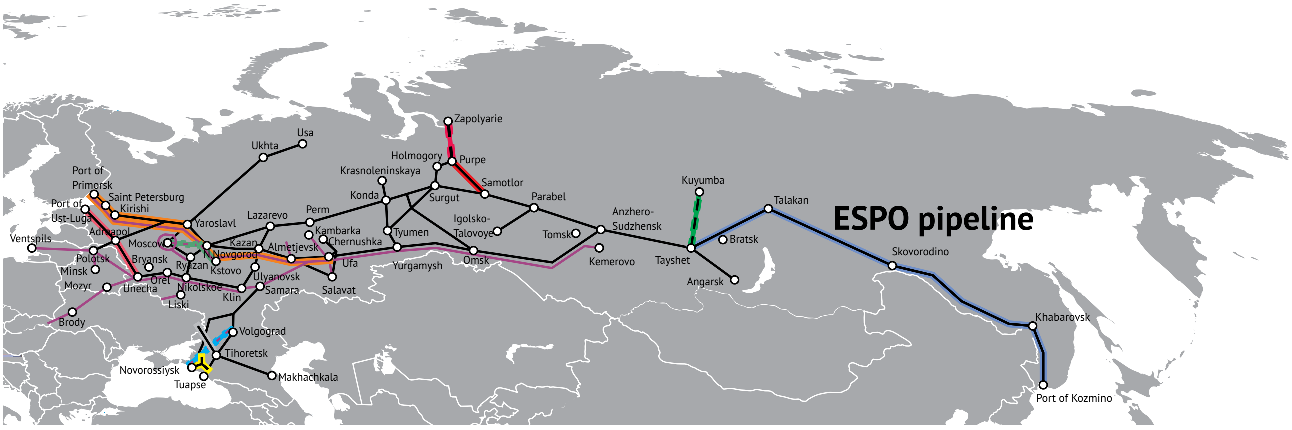
Among the CIS countries, Belarus, which took almost half of all Russian deliveries to the region in 2010, will remain a key consumer of Russian oil in 2014. By 2040 Belarus will take 12 million tonnes, with a further 6 million tonnes of deliveries to the CIS going to Ukraine.

Despite the decline in its own oil exports to the West, Russia will increase its significance as a transit country, with up to 65 million tonnes of Caspian oil (mainly from fields in Kazakhstan) passing through the Caspian Pipeline Consortium's system.

Russia's reorientation to the East is key in the development of its exports. Kazakhstan will become a crucial partner for Russia, with its capacity for oil transit to China and Russia's capacity for deliveries to Europe.

Deliveries of oil to domestic refineries and reorienting its exports will require the reconstruction of existing pipelines and an increase in their capacity by 1.5–1.7 times in the eastern regions of the country. The country's most important pipeline route in the future will remain the East Siberia–Pacific Ocean pipeline, via which 65–70 million tonnes will be delivered by 2020 to markets in China, South Korea, and Japan (Figure 3.28).

Figure 3.28 – Russian pipeline system



Source: ERI RAS, Transneft

The Western direction does retain its significance for the Russian oil industry: by 2040 up to 90 per cent of total Russian oil product exports will go to Europe (Table 3.5), though with an unavoidable fall in absolute volumes from the present 110 million tonnes to 65 million

Table 3.5 – Oil product exports from the Russian Federation by direction, Baseline Scenario, million tonnes

	2010	2015	2020	2025	2030	2035	2040
CIS	6	6	6	5	5	3	4
Europe	110	105	84	74	73	71	64
Asia–Pacific	11	8	4	3	2	2	2

Source: ERI RAS

European market for Russia: oil or oil products exports?

It is important to point out that a decrease in the volumes of oil products delivered to European markets can be caused by various factors from time to time. From 2015 through 2020 Russian oil products will be driven from the European market by cheaper supplies from the Middle East and Asia (produced in India), which will lead to a sudden drop in Russian oil product exports of 20 million tonnes for five years. Interestingly this period also sees costly European products being driven from the European market.

After 2020, the rate of decline in oil exports to Europe is slowed down considerably, as growing demand for such products in the Middle East and Asia compels producers in those regions to refocus on meeting the needs of their domestic markets, thus freeing up space for deliveries of Russian oil products and allowing a slight growth in Europe's own processing. Nevertheless, even after 2020, no additional niche opens on the European market for supplies of Russian oil products; this is primarily due to the downward dynamic of demand for oil products in Europe.

The reduction in deliveries of oil products to European countries and the absence of growth in deliveries elsewhere can be explained economically. Contemporary price relations on world oil and oil product markets, Russian customs and duties, as well as the structure of production of most of Russia's refineries are such that the price of oil products sold abroad is 1–3 per cent less than the price of a tonne of the Western Siberian oil. Practically, this implies that refining has a negative added-value, meaning that it is more profitable for domestic companies to export crude oil than petroleum.

For the state, reduced customs duty on petroleum products (compared to oil) results in loss of budget revenues from exports. It is estimated that in 2014 the budget will receive 15 per cent less export revenues from each exported tonne of oil products than from an exported tonne of crude oil. Receipts of excise duties on oil products partially compensate for these losses, but in the current regulatory environment crude oil exports remain preferable to exports of refined products for both the state and for the companies.

Deliveries of oil products to the markets of the CIS countries in 2040 remain virtually unchanged, with the main focus of supply being Ukraine. It would be dangerous to regard the Asian market as a key direction for supplies of domestic oil products, due to the unprecedented growth of refining capacity in China, which will reach 820 million tonnes by 2020, and which will satisfy Chinese demand for oil products until 2040. The other two potential target markets – South Korea and Japan – are predicted to have reducing levels of demand and, moreover, the refining capacities of these countries are sufficient to meet domestic demand for oil products.

So during the forecast period there is expected to be a reduction in the interdependence of Russia and Europe in the liquid fuels market, with a simultaneous reorientation of exports of crude oil to the East. In these circumstances, a reasonable question arises in relation to the gradual withdrawal of Russian participants from trading on western exchanges and their entry into Asian marketplaces, as this process could eventually lead to Russia's own oil marker in the Asian direction and reduce the influence of Brent prices on Urals prices.

The gas sector

Production

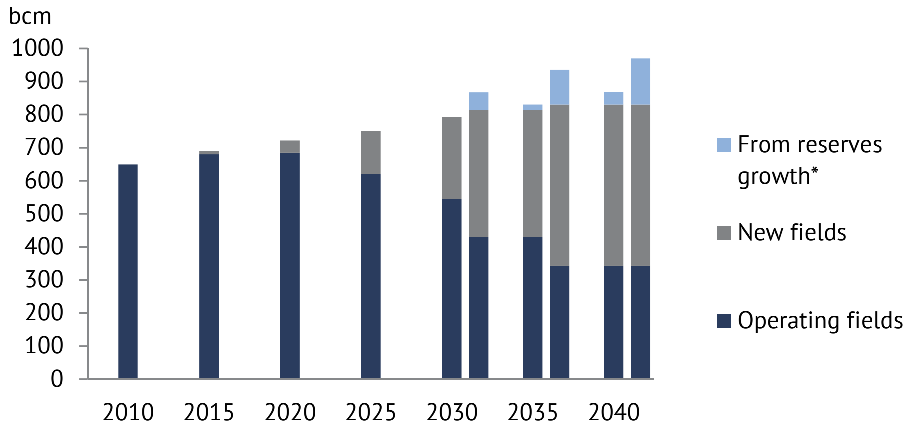
The Russian gas industry needs to perform four difficult but vital tasks: to increase gas production by 35–50%, to expand the unified gas supply system eastwards for pipeline gas exports, to create an LNG production and transportation industry, and to expand its wet gas and helium processing capacity several times over.

In the gas sector, during the global financial crisis there was a decline in production of 12 per cent from 2008 levels due to lower domestic and external demand, which was exacerbated by the slow recovery of prices in foreign markets and the inhibition of domestic gas price increases. This was in turn compounded by the ongoing implementation of excessively expensive investment projects that had uncertain prospects for payback.

The structure of gas reserves in Russia as a whole is favourable, but problems concerning their exploitation result from the falling off of highly productive and shallow reserves that are currently operational, and also from the difficult climatic conditions and remoteness of new areas of gas production from the centres of consumption. Reserves at the producing fields of the Tyumen region – the country's major gas producing region – such as Medvezhe and Yamburgskoe, have been 76–79 per cent worked out, and are now in the stage of falling production, as is the Urengoiskoe field (54 per cent). There is a need to develop significant reserves of low-pressure gas and to increase the share of wet, condensate, and helium-rich gases that require the creation of a gas-processing industry.

In principle, the state of the gas industry's resource base allows for a substantial increase in production, but this will require the involvement of reserves with increased extraction costs. Looking ahead to 2040, production of natural and associated gas will increase from 649 billion cubic meters in 2010 to 870–970 bcm by 2040 (an increase of 33–49 per cent) depending on the scenario (Figure 3.30) and this will mainly be provided by reserves; only in the 'high' Other Asia Scenario will additional new discoveries be required.

Figure 3.29 – Structure of gas production by field, Baseline Scenario



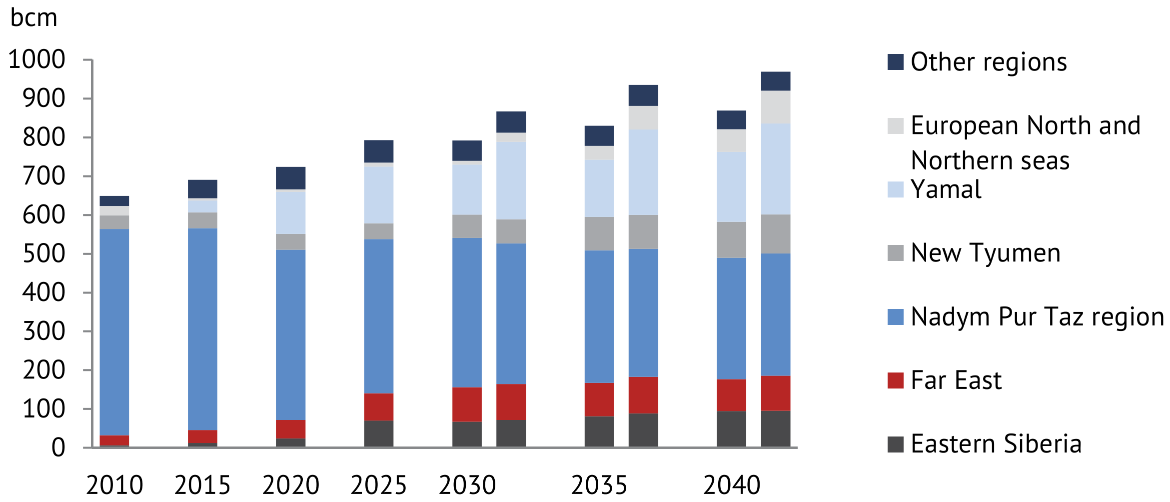
Scenarios: 1st column - Baseline Scenario, 2nd column - 'Other Asia'

* production of associated gas from undiscovered fields

Source: ERI RAS

Gas production will be developed in both the traditional gas-producing areas – in Western Siberia (the main one) and in northern European Russia – and in the new oil and gas provinces of Eastern Siberia and the Far East, as well as in the Caspian region (Figure 3.30). Against the backdrop of the fall in production in the Nadym–Pur–Taz region (from 531 bcm in 2010 to 313–315 bcm in 2040) production will increase in the Ob–Taz bay and the Bolshekhetsk Depression (by 1.7–1.8 times for the period 2010–40). Production will increase on the Yamal Peninsula (up to 180–235 bcm in 2040), Eastern Siberia (95 bcm), and the Far East (about 80–90 bcm).

Figure 3.30 – Natural and associated gas production in oil and gas producing provinces in Russia, Baseline Scenario and Other Asia Scenario



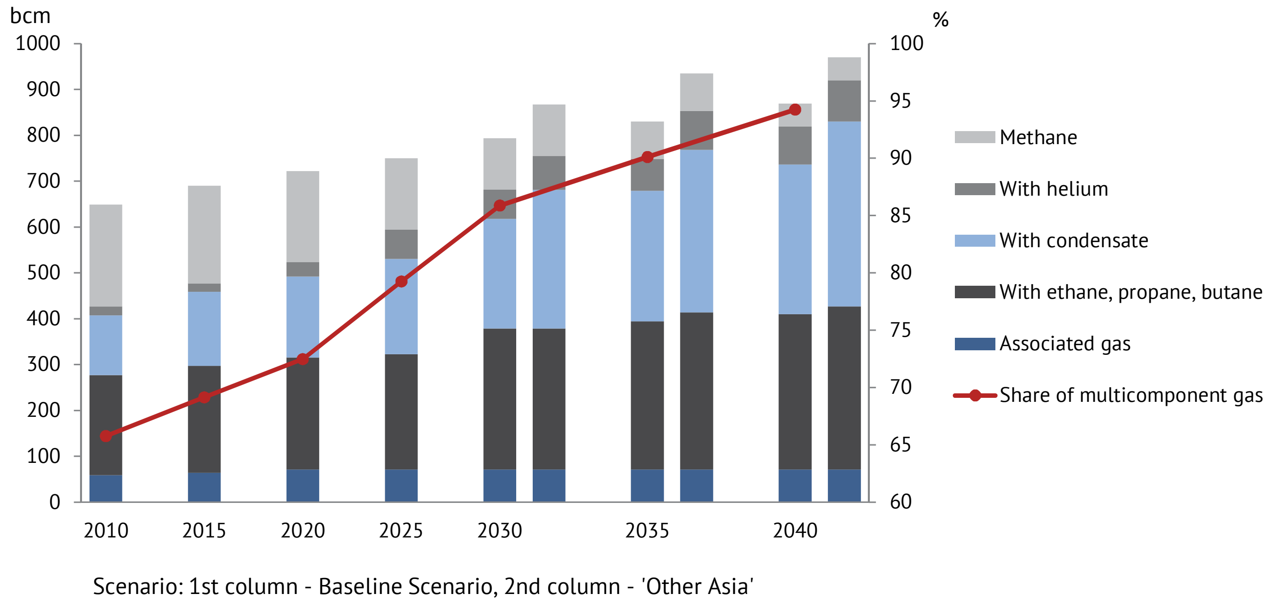
Scenario: 1st column - Baseline Scenario, 2nd column - 'Other Asia'

Source: ERI RAS

With the development of gas fields in Eastern Siberia, which are characterized by a high helium content (from 0.15 to 1 per cent), there is a need to develop the helium industry, which would include the construction of several large gas processing plants and underground storage for helium concentrate. There are plans to establish gas production centres in Irkutsk (based on the Kovyktinsk field with the prospect of developing the Yuzhno – Kovyktinskoe licence area and fields in the north of Irkutsk region) and Krasnoyarsk (based on the Sobinsk–Paiginskoe and Yurubcheno–Tokhomskoe deposits with the prospect of developing the Omorinskoe, Kuyumbinskoe, Agaleevskoe, and other deposits). The significance of the Yakutia gas production centre (based on the Chayandinskoe field, with the prospect of developing the neighbouring Srednebotuobinskoe, Taas–Yuryakhskoe, and Verkhnevilyuchanskoe deposits, among others) is dramatically increasing, while production is stabilizing at Sakhalin (Sakhalin-1 and Sakhalin-2 are already operational, and Sakhalin-3 and Sakhalin-6 appear promising) at a level of around 40 billion cubic meters, and development of the West Kamchatka sector of the Pacific Ocean is beginning.

Production will increase in the north-west of Russia (to 60–85 bcm in 2040). Development of the Shtokman field is planned for no earlier than 2030–5 and will depend on the situation on the world oil and gas market. The development of the shallow shelf of the Kara Sea will begin with the development of the Ob and Taz offshore areas. Targets for development in the region will be the already discovered fields (Kamennomysskoe, North Kamennomysskoe, the Ob and Chugoryakhinskoe), the development of which is planned alongside the infrastructure development of onshore fields (Parusovoe, Semakovskoe etc.).

Figure 3.31 – Composition of produced gases



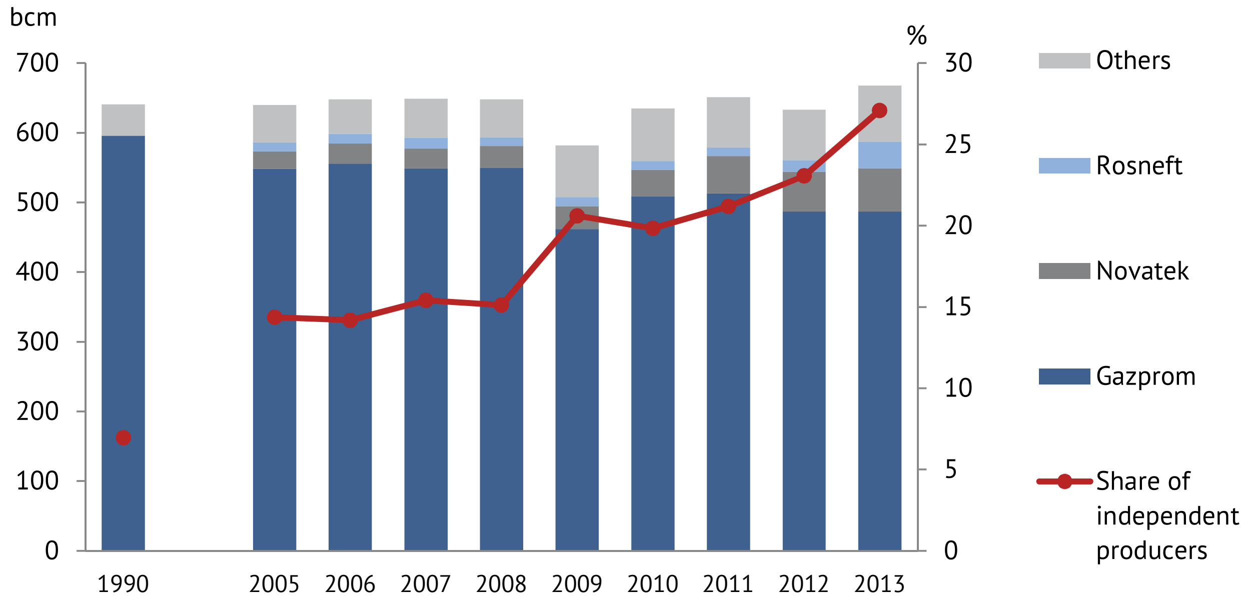
Source: ERI RAS

Looking ahead to 2040, the composition of gas changes markedly (Figure 3.31): the proportion of gas with a complex composition requiring additional processing will increase from 66 per cent in 2010 to 94–95 per cent by 2040. This is primarily due to the increase in the proportion of wet gas, especially in the Tyumen region. Helium, which has a high concentration in eastern Siberian gas fields, presents a problem of its own, as its separation and

storage requires the creation of costly additional infrastructure. In any case, such changes in the quality of the resource base make a significant increase in the volume of gas processing and gas chemistry inevitable. By 2040, 30–35 bcm will require advanced refining, and the development programme for gas chemistry and construction of LNG plants will be the main strategic innovation in the gas industry.

Since 2008, Russian gas companies have been forced to limit production volumes due to the low volumes of domestic and external demand. Gazprom has had to fundamentally dampen down its activities as it gradually loses ground to independent suppliers (Novatek and vertically integrated oil companies, primarily Rosneft), which have increased their share in Russian production from 15 per cent to 27 per cent (Figure 3.32). It is assumed that there will be further growth on the part of the independent producers, but if by 2025 they have reserves at their disposal, they will need new licences in order to increase production going forward, which means that the fate of these independent producers will depend on the government's subsurface management policies.

Figure 3.32 – Gas production by company

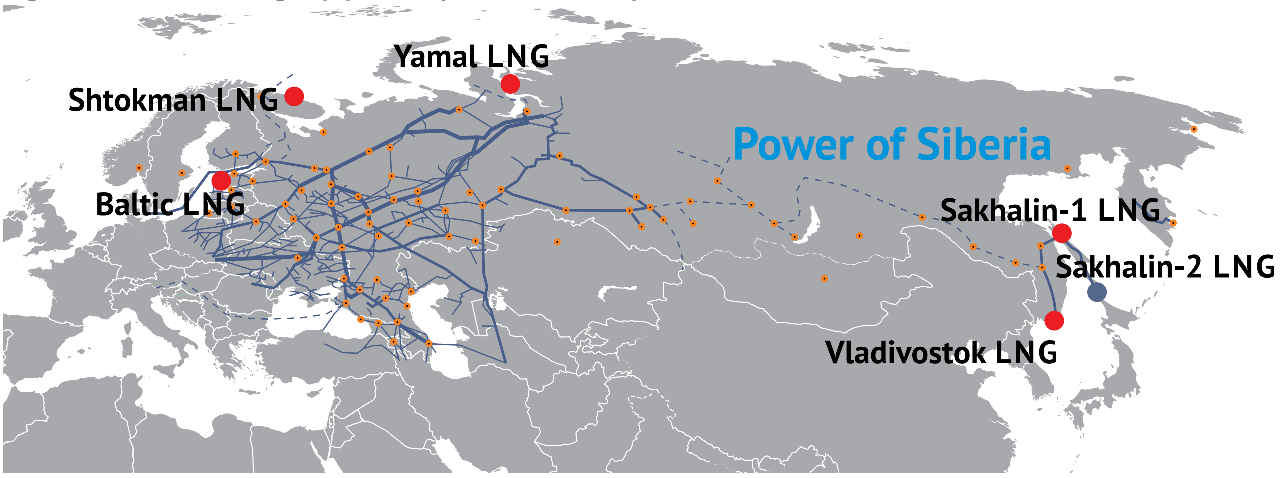


Source: ERI RAS

Gas exports

In the field of gas transport, the Unified Gas Supply System (UGSS) will be developed further by being connected to new facilities and expanded in an economically viable manner to the east of Russia (Figure 3.33). The length of main trunk pipelines will increase by 25,000–27,000 km; this will also include pipelines to new export destinations. As part of the programme for the gas supply system in Eastern Siberia and the Far East, a gas pipeline system will gradually be established in these regions for Russian gas supplies to the Asia–Pacific region, above all to China which, given the appropriate external conditions, and if it is economically viable, can be connected to the UGSS.

Figure 3.33 – Russian gas pipeline system and LNG plants

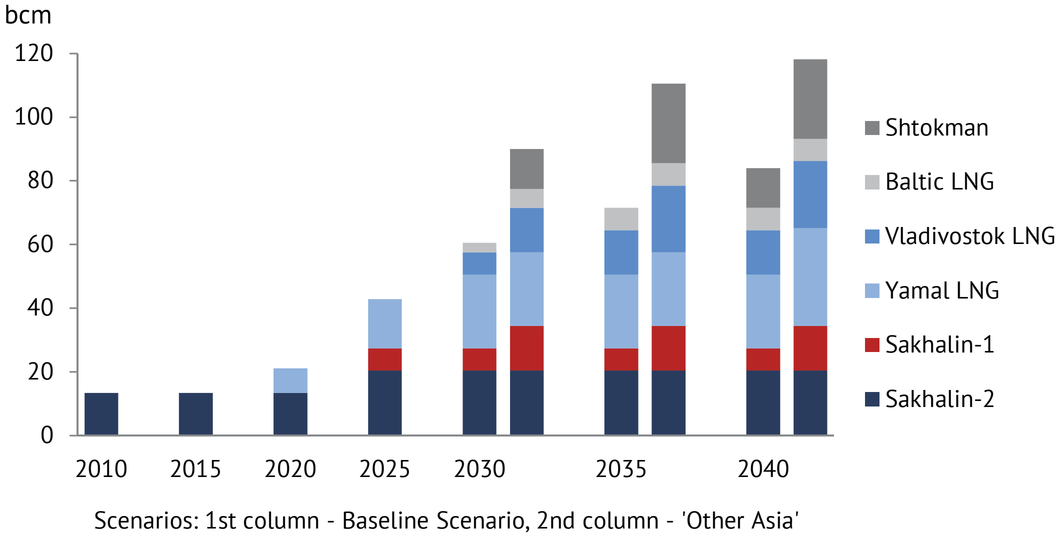


Source: ERI RAS

Alongside gas pipelines, Russia will also be actively developing LNG production and transportation projects, the main purpose of which will be to strengthen the country's position in the external market. In total, Russian LNG exports could increase from the present level of 14 bcm to 80–120 bcm in 2040 (Figure 3.34).

It is also necessary to mention that the weak point of the Russian LNG industry will be the high production costs in the main regions (Yamal, the Barents Sea shelf, Sakhalin, Yakutia), which might significantly exceed production costs in other LNG exporting countries. In addition, transportation costs from Yamal will be higher, as the depth of the sea restricts the size of methane tankers.

Figure 3.34 – LNG production in the Russian Federation, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

Gas exports carried both on the basis of long-term contracts and spot trading will mean that Russia can increase the necessary volumes to the European market while expanding supplies to the East (China, Japan, Korea etc.) many times over.

Total exports of natural gas will increase from 223 bcm in 2010 to 310 bcm by 2040 in the Baseline Scenario and to 388 bcm in the Other Asia Scenario, while overall the share of eastward gas exports will grow from 6 per cent

to 30 per cent in the Baseline Scenario and 40 per cent in the Other Asia Scenario. In other words, there is expected to be a significant diversification of supplies in terms of markets and methods of transportation, while at the same time the European market for pipeline gas will continue to account for around 50 per cent of Russian exports in 2040 in the Baseline Scenario and 40 per cent in the Other Asia Scenario.

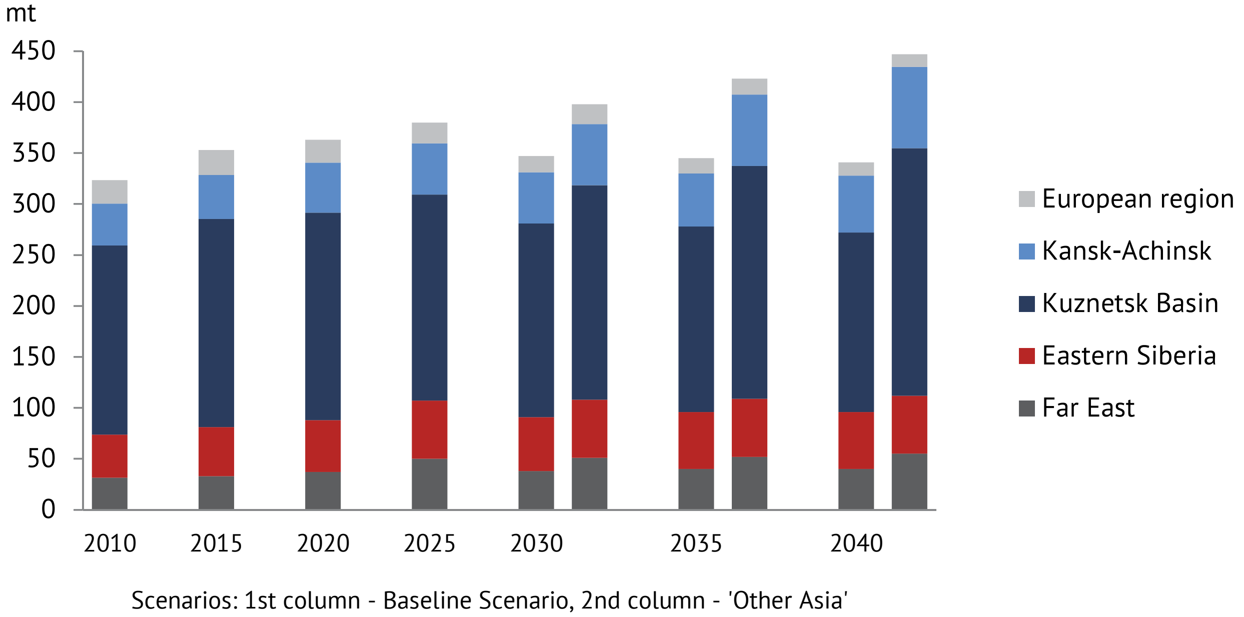
Depending on conditions in external gas markets and the state of Russia's energy balance, there will be imports of gas from Central Asia, though these will fall to half their present level over the forecast period.

Artificial constraints on gas prices are leading the Russian coal industry to stagnation on the domestic market, while competing coal exporters are crowding the external markets. In the Other Asia Scenario, these barriers weaken and the industry has new opportunities for growth

The coal sector

Between now and 2040 coal production is expected to grow to 340–445 million tonnes (Figure 3.35). Kuznetsk will remain the main basin while production of coal from Kansk-Achinsk, Irkutsk, and the Far East will increase.

Figure 3.35 – Coal production in Russia by region, Baseline Scenario and Other Asia Scenario

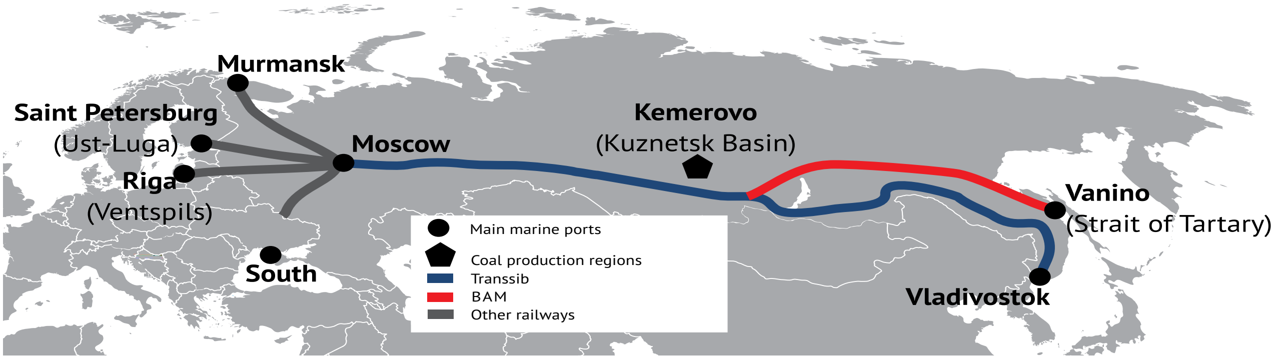


Source: ERI RAS

The probable stagnation in domestic demand makes exporting the main driver of development in the coal industry. As in the gas sector, the main limitation to further production growth is the capacity of the external market rather than the limitations of coal reserves or production capacities. The main problem for Russian coal (which undermines its competitiveness in foreign markets) is the considerable distance of suppliers from ports (Figure 3.36) and the distances involved in transporting coal by rail (Trans Siberian, BAM, etc.). Exports to Europe are mainly routed via the northern ports of Russia (Murmansk, Ust-Luga) and the Latvian port of Ventspils, among others.

Russian coal is supplied to Japan, South Korea, and China through the Far East ports (Vladivostok, Busan, Nakhodka, etc.). Extensive expansion of rail and port infrastructure for coal exports to the Asia–Pacific market is crucial to the development of the industry.

Figure 3.36 – Coal transportation in Russia



Source: ERI RAS

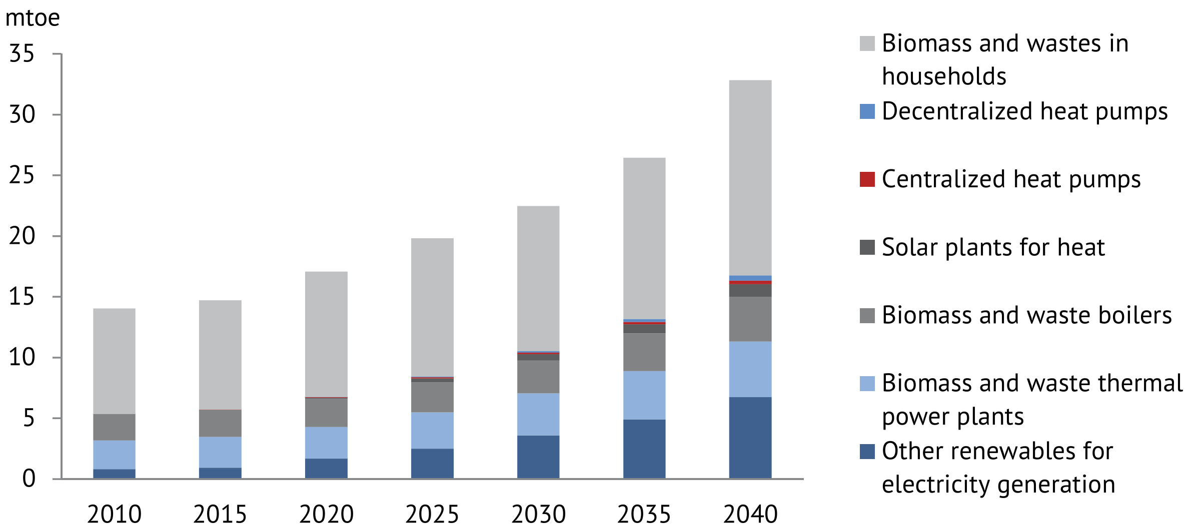
The Baseline scenario proposes relatively moderate growth in coal exports. In 2013 they amounted to 140 million tonnes (with a total production of 350 million tonnes), while by 2040 the figure will increase to 170–205 million tonnes, due to the expansion of supplies to the east. In the Other Asia Scenario both domestic demand (because coal will be fuelling all growth in electricity generation in the east of Russia) and exports are higher.

Unconventional renewable energy resources

The exploitation of unconventional renewable energy resources in Russia will double, mainly due to biomass and waste, but their role in the energy sector will remain localized.

The use of all types of unconventional renewable energy will increase by 1.9–2.6 times by 2040 (Figure 3.37), and their share in total energy consumption will grow from 1.1 per cent in 2010 to 4,2 per cent in 2040. They will, however, play only a localized role in Russia's energy sector.

Figure 3.37 – Use of unconventional renewable energy sources, Baseline Scenario



Source: ERI RAS

Impact of the fuel and energy complex on the economy

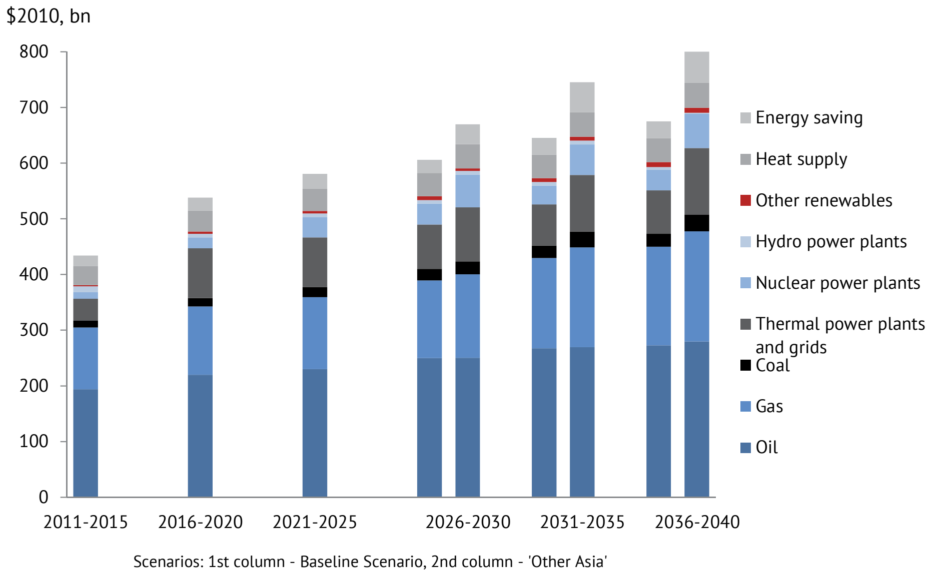
Investment

A two- to three-fold reduction of the energy sector's contribution to Russia's GDP will be fully offset by a decrease in the energy intensity of the economy and the reduction of energy costs.

In the period to 2040 investment in the development of the fuel and energy sector, energy saving, and decentralized energy supply will grow from an expected $435 billion in 2011–15 to $675–815 billion in 2036–40 (Figure 3.38). This is a big burden on the country's economy, although the GDP share of investment in energy supply will decrease from 6 per cent in 2011–15 (which is almost five times higher than the global average) to 4 per cent in 2031–40 (2.5–3 times more than the predicted global figure).

Russia will slow the growth of investment per unit of primary energy produced, but will reduce the share of investment in the energy sector in the country's GDP by 1.4–1.55 times.

Figure 3.38 – Investment in the fuel and energy sector, billion dollars 2010, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

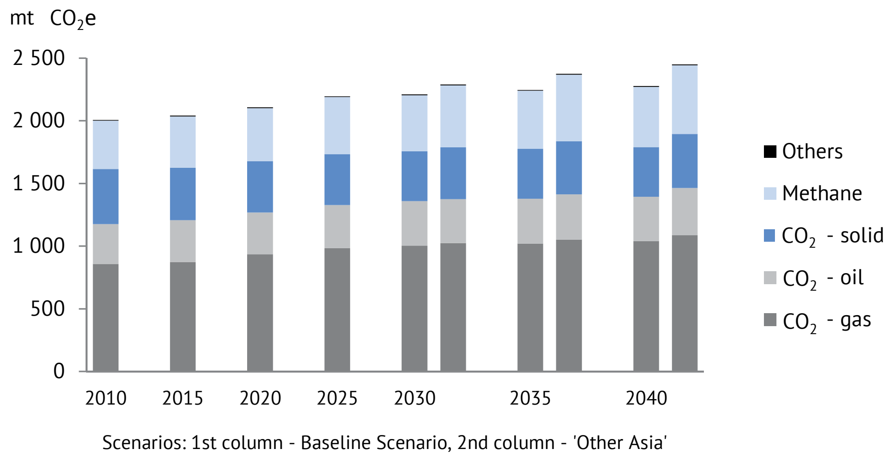
CO_2 Emissions

Russia is ambivalent about the issue of global warming and related measures to diversify energy, but the projected increase in the economy's energy efficiency, and the restructuring of energy production in favour of gas, will lead to a modest growth and stabilization of energy-related greenhouse gas emissions at the end of the period.

Russia is quite non-committal with respect to climate warming (and may even have something to gain from it) and therefore regards this issue and the special measures for energy diversification and energy efficiency of the economy ambivalently.

Slow growth in greenhouse gases emitted from burning fossil fuels will be seen in Russia to the end of the 2030s, and this only varies by 2–3 per cent in the different scenarios. Without taking special measures emissions will increase, compared to 1990, from 74.8 per cent in 2010 to 85–91 per cent by 2040 (Figure 3.39).

Figure 3.39 – Emissions of main greenhouse gases, Baseline Scenario and Other Asia Scenario



Source: ERI RAS

According to the President of the Russian Federation's decree 'On Reducing Emissions of Greenhouse Gases' of 30 September 2013, N 752, Greenhouse gas emissions (all six mentioned in the Kyoto Protocol) should be 25 per cent lower than the 1990 level by 2020. According to the forecast, this requirement will not be met in respect of greenhouse gases emitted from burning fossil fuels: by 2020 emissions will be only 21.5 per cent lower than the 1990 level. However the decree will be fulfilled as far as increased absorption of greenhouse gases in the 'Land Use, Land Use Change and Forestry' (LULUCF) section of the Protocol.

The situation with methane emissions is the worst. This is the only greenhouse gas whose emissions (associated with the burning of fossil fuels) will exceed the 1990 level by 2040 (to 16 per cent in the Other Asia Scenario).

Greenhouse gas emissions associated with transport will grow fastest of all due to continued growth in the number of vehicles. It is the only sector where emissions by 2040 will approach (95 per cent) or exceed (by 10 per cent) the level in 1990. The lowest rates of growth in emissions from fuel combustion are in industry and construction – in 2040 they amount to only 63–65 per cent of the 1990 level. Emissions in the domestic sector even decrease in comparison to current levels, due to the upgrading of housing stock and the equipment used in doing it, as well as efforts to improve energy efficiency.

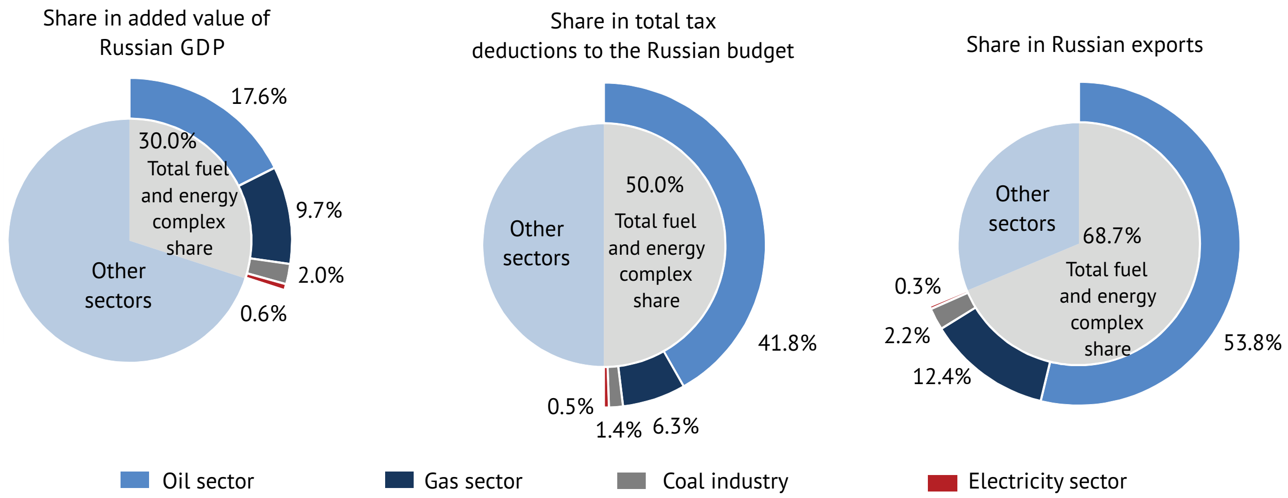
Russia will remain fourth in the world for greenhouse gas emissions after China, the USA, and India, while the gap between Russia and these countries will grow considerably.

The role of the fuel and energy sector in the economy

Outlook 2014 concludes that the Russian energy sector's diminished ability to remain a large-scale contributor to the economy will lead to the appearance of new drivers of the country's economic growth.

In post-reform Russia the fuel and energy sector quickly took on a key role in the economy, being responsible for more than a quarter of GDP and almost 30 per cent of the country's consolidated budget, two-thirds of foreign exchange earnings from exports, and a quarter of total investment in the national economy. More than 45 per cent of primary energy resources produced in Russia are exported, providing 70 per cent of total export earnings (Figure 3.40), and having a significant impact on Russia's balance of payments and state budget. By 2012, customs duties and the mineral extraction tax on oil and natural gas amounted to half of federal budgetary income, while only a decade ago, they accounted for around 15 per cent.

Figure 3.40 – Shares of energy sector in Russian GDP, exports and budget



Source: Ministry of Energy

However, in the coming period the role of energy in the economy will fundamentally change. With the solving of one of the most important economic policy issues facing Russia – reducing the excessive dependence of the economy and the state budget on oil and gas revenues – the energy sector will change its current role as the locomotive of the economy to the function of enabling its infrastructure and move towards balanced development that prioritizes the internal energy market. In this, the figures showing the role of energy in the economy (Table 3.6) suggest that reducing the Russian economy's dependence on the energy sector will not decrease its absolute contribution, but will occur due to the more rapid development of other sectors of the economy.

Table 3.6 – The role of the fuel and energy sector in the economy: key figures (1 – Baseline Scenario, 2 – Other Asia Scenario)

		2010	2015	2020	2025	2030	2035	2040
The fuel and energy complex and the economy								
The fuel and energy complex's contribution to	1		25.3	22.2	19.4	16.5	16	14
	2	26.2	25.2	21.9	20	18.1	13.8	11.2
Same, % by 2010	1		96.6	84.7	73.9	63	61.1	53.3
	2	100	96.2	83.6	76.3	69.1	52.7	42.7
Share of energy of total exports, %	1		67.9	56.5	47.6	38.7	28.3	23.9
	2	65.6	67.3	57.2	51.2	45.1	37	31.3
Same, % by 2010	1		103.5	86.1	72.6	59	43.1	36.4
	2	100	102.6	87.2	78	68.8	56.4	47.8
The fuel and energy complex's contribution to the consolidated budget %	1		27.2	23.6	20.5	17.4	14.3	11.9
	2	28.6	27.5	25	23.1	21.2	19.5	17.7
Same, % by 2010	1		95.1	82.5	71.7	60.8	50	41.5
	2	100	96.2	87.4	80.8	74.1	68.2	61.8
Contribution of energy exports to GDP, %	1		14.6	12.3	10.4	8.4	6.3	4.9
	2	18.6	14.9	12.8	11.6	10.3	8.7	7.2
Same, % by 2010	1		78.5	66.1	55.6	45.2	33.9	26.3
	2	100	80.1	68.8	62.1	55.4	46.8	38.7
Energy efficiency of the economy, $1,000/tce.	1		1.6	1.8	2	2.2	2.4	2.7
	2	1.48	1.6	1.8	2	2.3	2.6	3.1
Same, % by 2010	1		109	123	138	151	165	181
	2	100	109	123	136	154	178	209
Energy efficiency of the economy, dollar/kWh	1		1.55	1.67	1.8	1.91	2.03	2.16
	2	1.44	1.55	1.67	1.79	1.96	2.21	2.5
Same, % by 2010	1		108	116	125	133	141	150
	2	100	108	116	125	136	153	174
The fuel and energy complex and business								
Share of investment in the fuel and energy sector from GDP*, %	1		6.8	5.5	5.5	5	4.7	4.4
	2	5.2	6.4	5.6	5.6	5.4	5.1	4.5
Same, % by 2010	1		131	107	106	97	91	85
	2	100	105	108	109	105	98	88
Investment in the fuel and energy sector's share of total investment*, %	1		20.9	19.2	17.5	16.6	16	15.3
	2	25.3	20.4	17.4	15	14.8	14.5	13.8
Same, % by 2010	1		83	76	69	66	63	60
	2	100	81	69	59	58	57	54
Capital intensity of the fuel and energy sector*, dollar 2010/tce	1		40	49	52	53	56	57
	2	41.5	40	49	52	56	58	60
Same, % by 2010	1		97	117	124	128	134	138
	2	100	97	118	126	134	140	145
Average gas price, dollar 2010/ thousand cubic metres	1		109	123	134	149	161	171
	2	83	119	127	142	163	178	189
Same, % by 2010	1		132	149	162	181	195	207
	2	100	144	154	172	197	216	229
Share of energy of costs to energy intense industry sectors, %	1		21.9	21	20.4	19.7	19.3	18.6
	2	20.9	22.2	21.7	21.3	20.8	20.3	19.8
Same, % by 2010	1		105	100	97	94	92	89
	2	100	106	104	102	100	97	95

Table 3.6 continued

		2010	2015	2020	2025	2030	2035	2040
The fuel and energy complex and the population								
Per capita consumption of energy resources, tce/person	1		7.1	7.5	7.8	8.1	8.4	8.7
	2	6.9	7.1	7.5	7.9	8.2	8.6	9.1
Same, % by 2010	1		103	107	112	117	121	126
	2	100	103	107	113	119	124	131
Per capita consumption of electricity, MWh/person	1		7.4	8.1	8.8	9.4	10	10.6
	2	7.1	7.4	8.1	8.8	9.5	10.2	11
Same, % by 2010	1		104	114	123	132	140	149
	2	100	104	114	123	133	143	154
Energy costs in population's income, %	1		5	4.9	4.8	4.7	4.6	4.4
	2	5	5.1	5	4.9	4.8	4.7	4.5
Same, % by 2010	1		100	98	96	94	92	87
	2	100	102	100	98	96	94	89

*For the last five years

Baseline Scenario indicated by '1' in second column, Other Asia Scenario by '2' in second column

Source: Rosstat, calculations by ERI RAS

The new, different, role of the energy sector in the Russian economy is illustrated by a reduction in:

- energy sector contribution to GDP – by 1.9–2.3 times in 2010–40;
- share of energy resources in export revenues – by 4 and 5 times respectively in two scenarios;
- share of energy resource exports in GDP – by 3.7–2.7 times;
- share of investment in the energy sector in GDP – by 16 and 12 per cent respectively, and the share in total volumes of investment – by 1.7–1.8 times;
- GDP specific energy intensity – by 1.8–2.1 times and electrical intensity – by 1.5–1.7 times.

At the same time, the Russian energy sector will retain its decisive significance in addressing the major strategic development objectives of the country. Above all, this concerns the construction of new energy infrastructure that will ensure the accelerated socio-economic development of Eastern Siberia and the Far East, help improve the infrastructural integration of a host of regions of the Russian Federation, and form new industrial clusters based on the development of energy and processing.

The reduction of economic dependence on the energy sector will be accompanied by a change in the role of the fuel and energy sector as a customer for the products and services of many related branches of the economy – engineering, metallurgy, the chemical industry, construction, transport, etc. The energy sector will boost the competitiveness of all sectors of the economy, but especially the energy-intensive sectors, by reducing their energy costs by 5–10 per cent by 2040.

* * *

Even with the clear incremental progress and significant positive drive shown in the scenarios we have considered in relation to the development of Russia's energy sector (especially in the Other Asia Scenario) we cannot, unfortunately, assume a timely success in resolving the urgent and, at the same time, complex challenges facing the country. These include: increasing the energy efficiency of the national economy, diversifying energy supplies, ensuring the affordability of energy supply to consumers, reducing fuel and energy costs to industries and projects, and particularly, ensuring the rational management of natural resources and protection of the environment.

The challenging task of formulating and, even more importantly, carrying out a truly effective energy policy for Russia as part of a new social and economic strategy for the country still needs to be performed.

APPENDIX

Countries and regions

Table A1 – List of countries and regions

Region	Countries of region
Africa	***North Africa:*** Algeria, Egypt, Libya, Morocco, Tunisia ***Central and Southern Africa:*** Angola, Benin, Botswana, Burkina Faso, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Djibouti, DR Congo, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Saint Helena, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Swaziland, Tanzania, Togo, Uganda, Western Sahara, Zambia, Zimbabwe
Middle East	Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen
Europe	Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark (including Greenland), Estonia, Finland, France (including Monaco), Germany, Gibraltar, Great Britain, Greece, Hungary, Iceland, Ireland, Ireland, Italy (including San Marino and Vatican City), Kosovo, Latvia, Lithuania, Luxembourg, Macedonia, Malta, Montenegro, Netherlands, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Sweden, Switzerland (including Liechtenstein), Turkey
Developing Asia	Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia, China, East Timor, India, Indonesia, Laos, Malaysia, Maldives, Mongolia, Myanmar, Nepal, North Korea, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Vietnam ***Countries of Oceania:*** American Samoa, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Samoa, the Federated States of Micronesia, the Marshall Islands, the Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna Islands
Developed Asia	Australia, Japan, Korea, New Zealand
North America	Canada, Mexico, USA
CIS	Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan
South and Central America	Anguilla, Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bolivia, Brazil, British Virgin Islands, Caribbean Netherlands, Cayman Islands, Colombia, Costa Rica, Cuba, Curacao, Dominica, Dominican Republic, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Martinique, Montserrat, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Saint Kitts and Nevis, Saint Vincent and the Grenadines, US Virgin Islands, Venezuela Chile, Ecuador, El Salvador, Falkland Islands, French Guiana, Jamaica, St. Lucia, St. Maarten, Suriname, Trinidad and Tobago, Turks and Caicos Islands, Uruguay

Source: ERI RAS

Energy balances

World

Figure A1 – Global primary energy consumption by fuel type

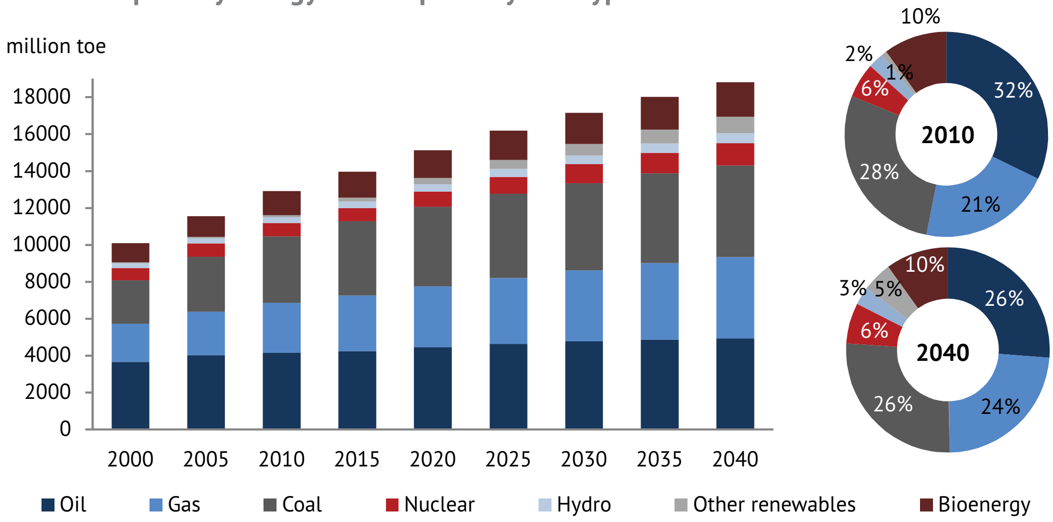


Table A2 – Basic figures, global development

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	75090	88700	108048	129674	153749	180511	209884	3.5%
Population, million	6915	7326	7721	8090	8433	8754	9051	0.9%
Per capita GDP, dollars/person.	10858	12107	13995	16030	18232	20621	23190	2.6%
GDP energy intensity toe/$1,000	0.17	0.16	0.14	0.12	0.11	0.10	0.09	–2.1%
Per capita energy consumption toe/person	1.87	1.91	1.96	2.00	2.03	2.06	2.08	0.4%
CO_2 emissions, million tonnes	30841	33396	35644	37529	38972	40226	41347	1.0%

Table A3 – Global primary energy resource consumption, mtoe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	12911	13971	15130	16194	17150	18024	18815	1.3%
Oil	4146	4233	4445	4638	4772	4858	4931	0.6%
Gas	2715	3018	3303	3572	3850	4157	4418	1.6%
Coal	3604	4032	4314	4557	4726	4860	4952	1.1%
Nuclear	713	705	822	917	1031	1111	1210	1.8%
Hydro	323	361	396	433	469	506	542	1.7%
Other renewables	112	215	350	485	619	755	890	7.1%
Bioenergy	1297	1406	1499	1592	1683	1778	1873	1.2%

Table A4 – Global electricity generation, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	21395	24332	28354	32446	36626	40892	45167	2.5%
Oil	989	908	880	851	820	786	751	–0.9%
Gas	4768	5576	6592	7757	8941	10236	11516	3.0%
Coal	8663	9923	11314	12587	13710	14721	15373	1.9%
Nuclear	2756	2732	3196	3578	4030	4352	4742	1.8%
Hydro	3437	3857	4287	4722	5154	5586	6010	1.9%
Other renewables	450	924	1579	2309	3131	4065	5137	8.5%
Bioenergy	332	412	508	643	841	1146	1639	5.5%

Source: ERI RAS

North America

Figure A2 – Primary energy consumption by fuel type in North America

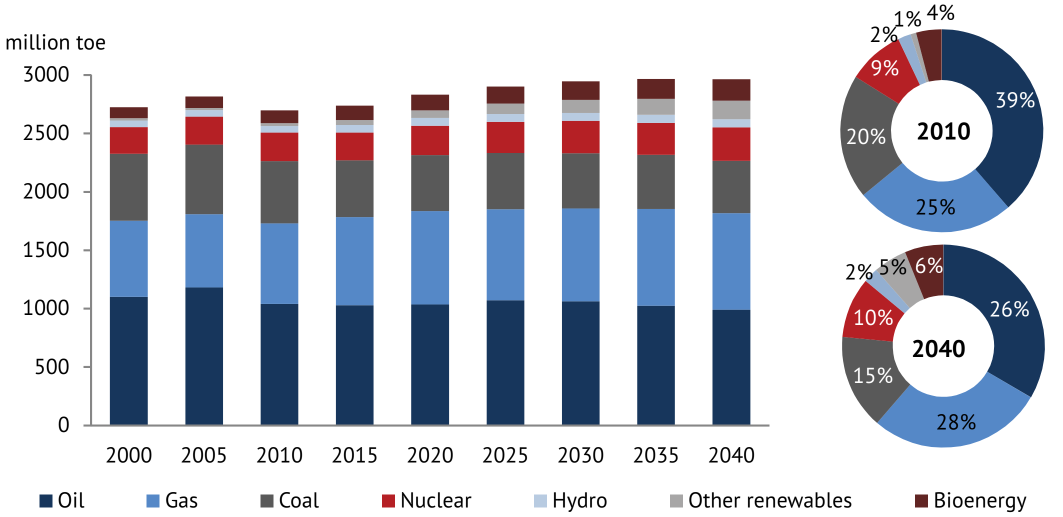


Table A5 – Basic figures, development in North America

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	17930	20241	23619	26884	30017	32933	35600	2.3%
Population, million	464	486	508	528	547	564	578	0.7%
Per capita GDP, dollars/person.	38620	41628	46536	50917	54885	58435	61589	1.6%
GDP energy intensity toe/$1,000	0.15	0.14	0.12	0.11	0.10	0.09	0.08	–2.0%
Per capita energy consumption toe/person	5.81	5.63	5.58	5.50	5.39	5.26	5.13	–0.4%
CO_2 emissions, million tonnes	6359	6293	6390	6433	6397	6327	6177	–0.1%

Table A6 – Primary energy resource consumption in North America, million toe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	2699	2738	2832	2901	2947	2966	2964	0.3%
Oil	1042	1029	1037	1072	1064	1025	990	–0.2%
Gas	688	755	798	779	794	828	826	0.6%
Coal	534	485	480	482	472	463	449	–0.6%
Nuclear	244	239	251	266	278	275	286	0.5%
Hydro	56	64	65	66	68	69	70	0.7%
Other renewables	25	43	66	89	112	135	158	6.3%
Bioenergy	110	122	134	146	159	171	183	1.7%

Table A7 – Electricity generation in North America, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	5233	5631	6262	6799	7249	7604	7867	1.4%
Oil	99	85	76	67	59	51	44	–2.7%
Gas	1211	1424	1720	2000	2263	2519	2711	2.7%
Coal	2115	2132	2266	2303	2275	2204	2039	–0.1%
Nuclear	935	916	964	1021	1066	1056	1099	0.5%
Hydro	651	745	759	773	786	800	814	0.7%
Other renewables	135	223	350	482	618	757	900	6.5%
Bioenergy	87	107	128	152	182	217	259	3.7%

Source: ERI RAS

Europe

Figure A3 – Primary energy consumption by fuel type in Europe

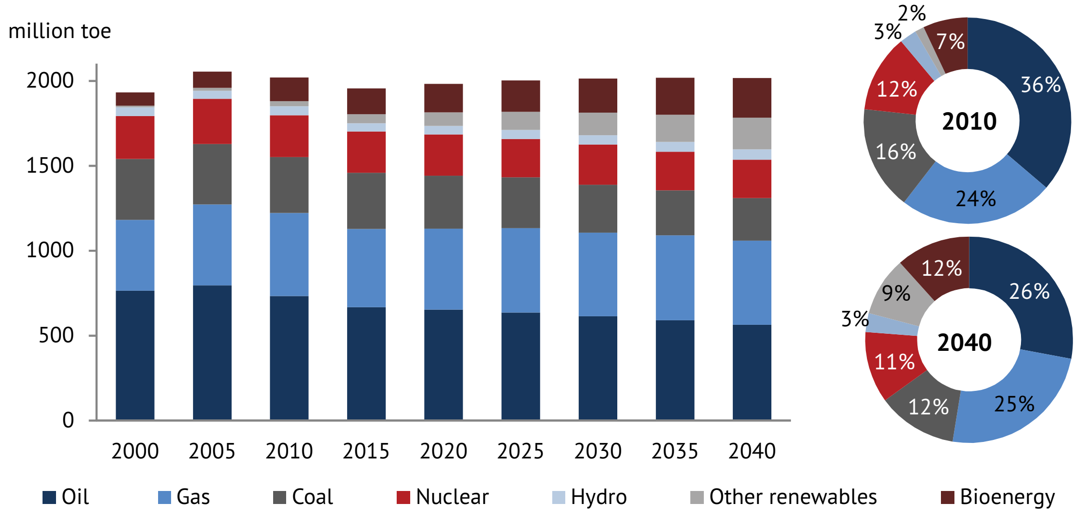


Table A8 – Basic figures, development in Europe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	16945	17899	19811	21807	23819	25841	27883	1.7%
Population, million	611	622	630	636	640	642	643	0.2%
Per capita GDP, dollars/person.	27736	28792	31462	34308	37236	40251	43370	1.5%
GDP energy intensity toe/$1,000	0.12	0.11	0.10	0.09	0.08	0.08	0.07	–1.7%
Per capita energy consumption toe/person	3.31	3.15	3.15	3.15	3.15	3.14	3.14	–0.2%
CO_2 emissions, million tonnes	4308	4079	4001	3947	3804	3688	3558	–0.6%

Table A9 – Primary energy resource consumption in Europe, million toe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	2020	1956	1983	2003	2014	2018	2016	0.0%
Oil	733	667	653	637	615	590	564	–0.9%
Gas	489	460	477	496	492	501	495	0.0%
Coal	329	332	311	300	282	264	251	–0.9%
Nuclear	246	242	242	226	236	228	225	–0.3%
Hydro	54	49	51	53	56	58	60	0.4%
Other renewables	29	53	80	106	133	160	186	6.4%
Bioenergy	140	152	168	184	201	217	234	1.7%

Table A10 – Electricity generation in Europe, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	3827	3887	4118	4337	4530	4700	4851	0.8%
Oil	90	60	47	37	30	25	21	–4.7%
Gas	865	873	923	1001	1015	1063	1067	0.7%
Coal	965	935	911	894	804	713	608	–1.5%
Nuclear	944	930	929	867	906	875	865	–0.3%
Hydro	625	573	598	624	649	674	699	0.4%
Other renewables	192	351	528	709	898	1096	1306	6.6%
Bioenergy	146	164	183	204	228	255	285	2.3%

Source: ERI RAS

EU-28

Figure A4 – Primary energy consumption by fuel type in EU-28

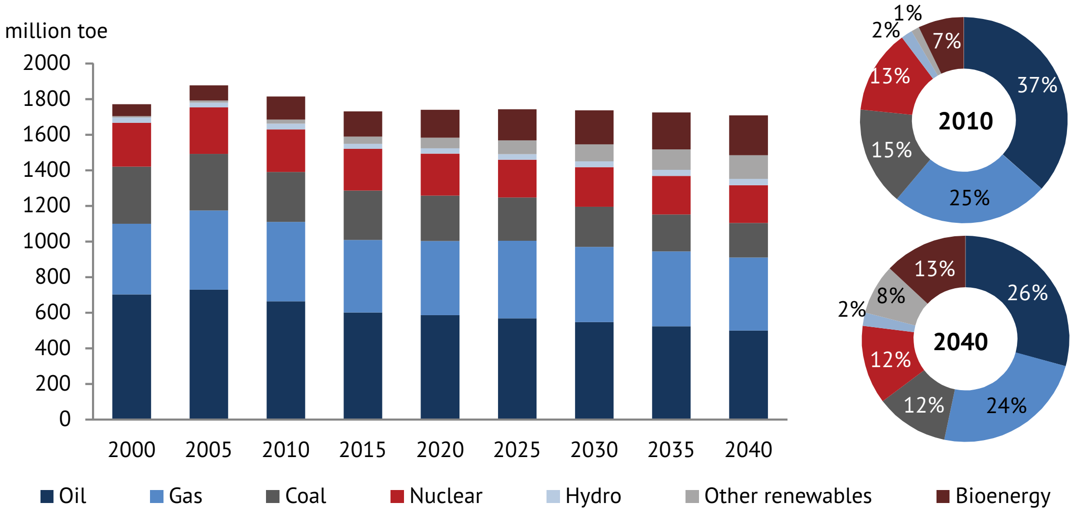


Table A11 – Basic figures, development in EU-28

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	15212	15857	17380	18943	20493	22034	23587	1.5%
Population, million	506	511	515	518	518	518	516	0.1%
Per capita GDP, dollars/person.	30077	31006	33722	36602	39546	42564	45681	1.4%
GDP energy intensity toe/$1,000	0.12	0.11	0.10	0.09	0.08	0.08	0.07	–1.6%
Per capita energy consumption toe/person	3.59	3.39	3.38	3.37	3.35	3.33	3.31	–0.3%
CO_2 emissions, million tonnes	3844	3574	3474	3419	3259	3124	2985	–0.8%

Table A12 – Primary energy resource consumption in EU-28, million toe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	1814	1731	1741	1743	1737	1725	1708	–0.2%
Oil	663	601	586	569	548	524	500	–0.9%
Gas	446	409	417	435	423	420	410	–0.3%
Coal	281	276	256	244	225	208	195	–1.2%
Nuclear	239	235	236	212	222	216	211	–0.4%
Hydro	32	28	30	31	33	34	36	0.3%
Other renewables	23	40	59	78	97	115	134	6.1%
Bioenergy	130	142	158	174	190	207	223	1.8%

Table A13 – Electricity generation in EU-28, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	3329	3334	3494	3637	3757	3856	3941	0.6%
Oil	87	58	45	36	30	25	21	–4.6%
Gas	761	740	752	817	799	813	810	0.2%
Coal	865	817	781	764	668	573	471	–2.0%
Nuclear	917	903	905	812	851	830	812	–0.4%
Hydro	375	325	343	360	378	396	414	0.3%
Other renewables	183	332	489	649	809	971	1135	6.3%
Bioenergy	142	160	179	199	222	249	278	2.3%

Source: ERI RAS

Developed Asia

Figure A5 – Primary energy consumption in developed Asia

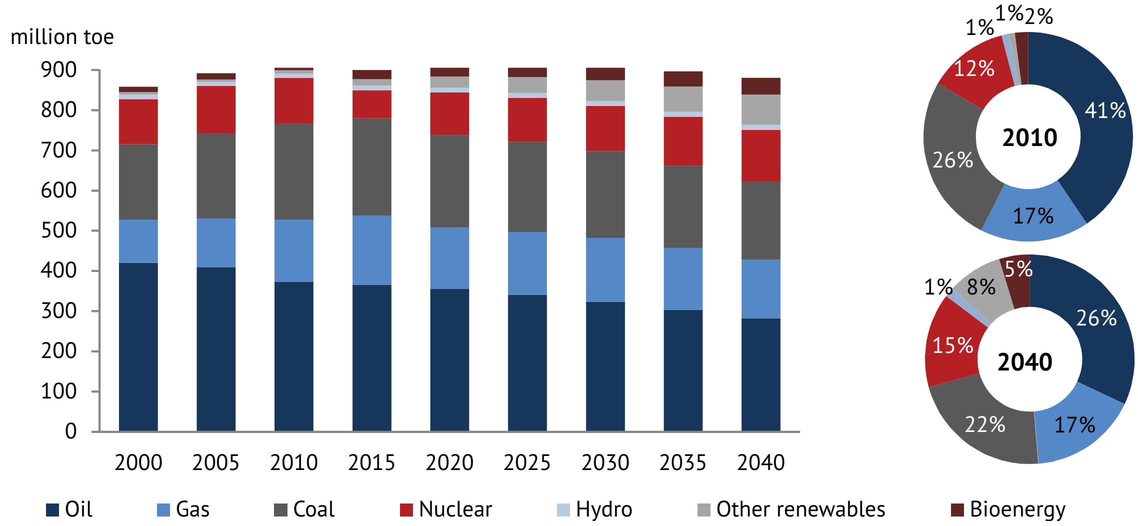


Table A14 – Basic figures, development in developed Asia

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	6800	7452	8243	8979	9629	10185	10652	1.5%
Population, million	203	205	206	207	206	205	203	0.0%
Per capita GDP, dollars/person.	33568	36335	39938	43421	46662	49646	52382	1.5%
GDP energy intensity toe/$1,000	0.14	0.12	0.11	0.10	0.09	0.09	0.08	-1.6%
Per capita energy consumption toe/person	4.53	4.39	4.41	4.41	4.40	4.37	4.33	-0.2%
CO_2 emissions, million tonnes	2250	2281	2162	2104	2023	1912	1799	-0.7%

Table A15 – Primary energy resource consumption in developed Asia, million toe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	918	900	910	913	908	897	880	-0.1%
Oil	372	365	355	340	323	304	282	-0.9%
Gas	155	173	153	157	160	154	147	-0.2%
Coal	240	242	230	224	215	204	194	-0.7%
Nuclear	114	70	106	110	113	122	129	0.4%
Hydro	11	11	12	12	12	13	13	0.6%
Other renewables	8	16	28	40	51	63	75	7.6%
Bioenergy	19	23	26	30	34	38	42	2.7%

Table A16 – Electricity generation in developed Asia, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	1894	2027	2194	2333	2437	2509	2550	1.0%
Oil	120	91	70	53	40	30	23	-5.4%
Gas	454	614	614	668	709	729	734	1.6%
Coal	707	830	817	841	836	788	727	0.1%
Nuclear	437	269	407	421	433	468	494	0.4%
Hydro	123	131	134	137	141	144	147	0.6%
Other renewables	25	57	107	160	215	273	334	9.1%
Bioenergy	29	35	43	52	63	76	91	3.9%

Source: ERI RAS

CIS

Figure A6 – Primary energy consumption by fuel type in CIS

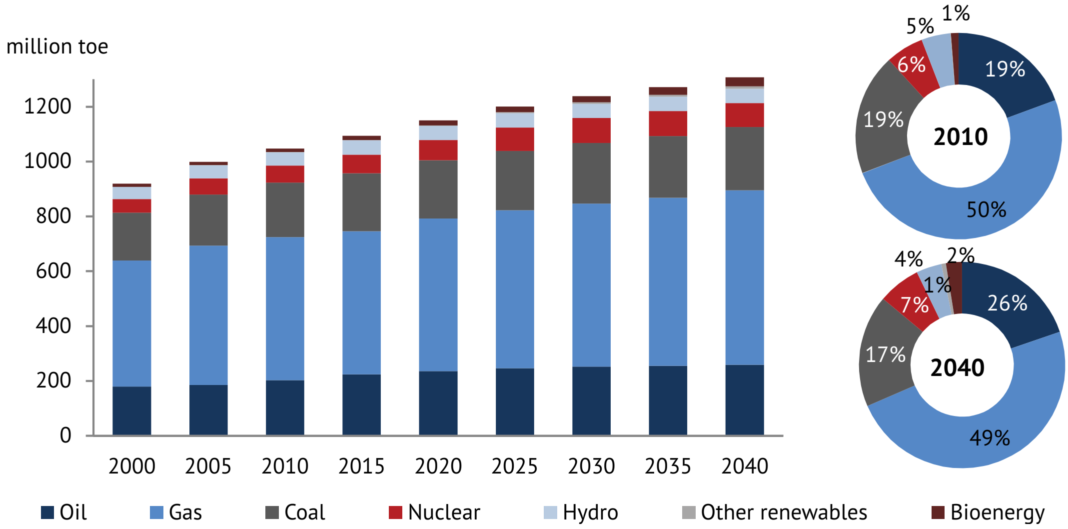


Table A17 – Basic figures, development in CIS

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	3140	3646	4349	5134	5910	6742	7635	3.0%
Population, million	280	284	287	288	288	287	286	0.1%
Per capita GDP, dollars/person.	11211	12830	15151	17819	20543	23516	26738	2.9%
GDP energy intensity toe/$1,000	0.33	0.30	0.26	0.23	0.21	0.19	0.17	–2.2%
Per capita energy consumption toe/person	3.74	3.85	4.01	4.17	4.31	4.43	4.58	0.7%
CO_2 emissions, million tonnes	2477	2581	2694	2771	2837	2892	2977	0.6%

Table A18 – Energy resource consumption in CIS, million toe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	1047	1094	1150	1201	1239	1271	1308	0.7%
Oil	202	224	236	247	252	255	259	0.8%
Gas	522	522	556	576	596	613	637	0.7%
Coal	199	212	213	216	221	225	230	0.5%
Nuclear	62	68	73	86	91	92	87	1.1%
Hydro	48	52	52	52	52	52	52	0.3%
Other renewables	1	1	2	3	5	7	9	8.3%
Bioenergy	13	15	18	21	23	27	33	3.2%

Table A19 – Electricity generation in CIS, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	1479	1596	1765	1934	2092	2244	2388	1.6%
Oil	12	8	7	6	5	4	2	–5.5%
Gas	654	713	805	871	953	1030	1120	1.8%
Coal	305	313	341	359	385	423	468	1.4%
Nuclear	263	288	323	389	423	440	433	1.7%
Hydro	240	268	279	294	306	318	323	1.0%
Other renewables	1	2	4	6	10	14	20	12.3%
Bioenergy	3	5	6	9	12	16	23	6.7%

Source: ERI RAS

Developing Asia

Figure A7 – Primary energy consumption by fuel type in developing Asia

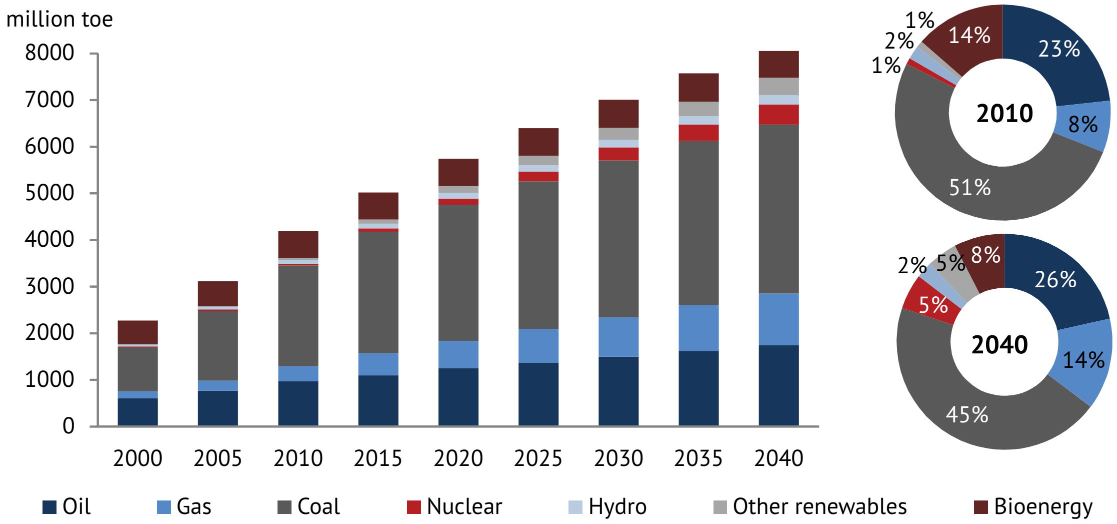


Table A20 – Basic figures, development in developing Asia

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	19459	26526	36149	47608	61319	77518	96116	5.5%
Population, million	3632	3819	3987	4129	4246	4338	4404	0.6%
Per capita GDP, dollars/person.	5358	6946	9067	11529	14441	17870	21823	4.8%
GDP energy intensity toe/$1,000	0.22	0.19	0.16	0.13	0.11	0.10	0.08	–3.1%
Per capita energy consumption toe/person	1.15	1.31	1.44	1.55	1.65	1.75	1.84	1.6%
CO_2 emissions, million tonnes	11483	13872	15694	17130	18346	19422	20432	1.9%

Table A21 – Primary energy resource consumption in developing Asia, million toe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	4188	5021	5744	6402	7008	7577	8094	2.2%
Oil	972	1100	1252	1368	1495	1621	1746	2.0%
Gas	324	475	587	723	852	986	1107	4.2%
Coal	2157	2604	2918	3165	3360	3515	3625	1.7%
Nuclear	39	74	135	209	282	352	430	8.4%
Hydro	84	100	120	140	160	180	200	2.9%
Other renewables	43	86	143	200	258	315	372	7.5%
Bioenergy	569	583	589	595	601	607	613	0.3%

Table A22 – Electricity generation in developing Asia, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	6290	8072	10277	12620	15162	17901	20753	4.1%
Oil	158	143	133	121	109	97	84	–2.1%
Gas	658	847	1097	1408	1793	2265	2786	4.9%
Coal	4238	5344	6555	7712	8885	10020	10938	3.2%
Nuclear	149	283	516	803	1083	1349	1652	8.4%
Hydro	981	1162	1397	1633	1868	2104	2340	2.9%
Other renewables	86	252	503	812	1190	1653	2219	11.4%
Bioenergy	23	42	74	131	233	414	734	12.2%

Source: ERI RAS

South and Central America

Figure A8 – Primary energy consumption by fuel type in South and Central America

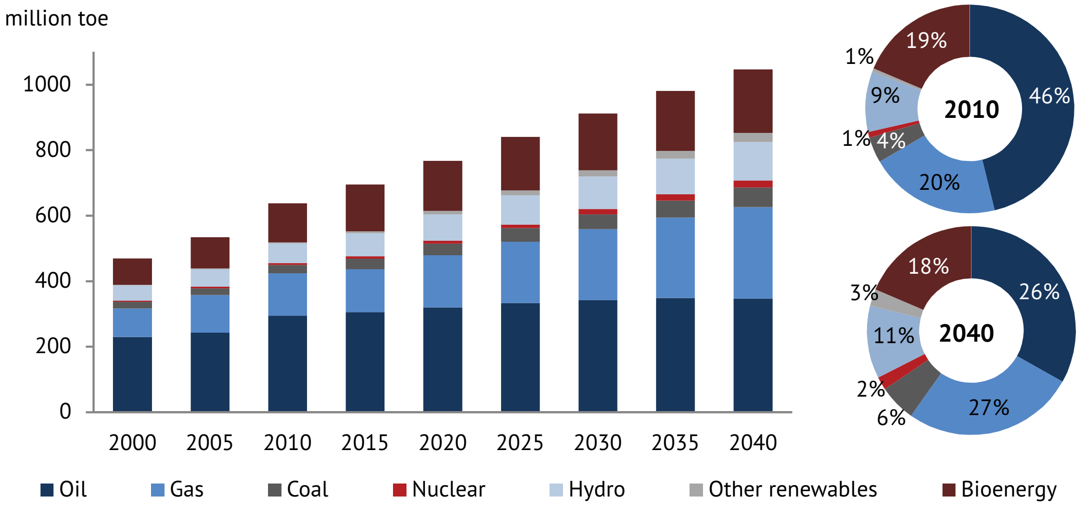


Table A23 – Basic figures, development in South and Central America

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	4845	5738	6867	8114	9441	10825	12244	3.1%
Population, million	478	505	530	553	573	591	605	0.8%
Per capita GDP, dollars/person.	10130	11365	12962	14682	16476	18331	20232	2.3%
GDP energy intensity toe/$1,000	0.13	0.12	0.11	0.10	0.10	0.09	0.09	–1.4%
Per capita energy consumption toe/person	1.33	1.38	1.45	1.52	1.59	1.66	1.73	0.9%
CO_2 emissions, million tonnes	1176	1258	1347	1472	1575	1684	1786	1.4%

Table A24 – Primary energy resource consumption in South and Central America, million toe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	637	695	767	840	912	981	1047	1.7%
Oil	294	305	320	333	342	349	347	0.6%
Gas	130	131	159	188	217	246	279	2.6%
Coal	25	32	35	42	45	51	60	2.9%
Nuclear	6	7	10	11	17	20	21	4.5%
Hydro	60	71	80	90	99	108	118	2.3%
Other renewables	3	6	11	15	19	23	28	7.2%
Bioenergy	119	142	153	163	173	184	194	1.6%

Table A25 – Electricity generation in South and Central America, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	1129	1286	1482	1686	1889	2087	2276	2.4%
Oil	144	141	136	129	122	112	103	–1.1%
Gas	181	186	235	296	337	379	411	2.8%
Coal	39	34	37	40	36	32	26	–1.4%
Nuclear	22	27	37	41	65	77	82	4.5%
Hydro	694	824	934	1043	1153	1262	1372	2.3%
Other renewables	7	16	32	51	74	101	135	10.6%
Bioenergy	43	58	70	85	102	123	148	4.2%

Source: ERI RAS

Middle East

Figure A9 – Primary energy consumption by fuel type in the Middle East

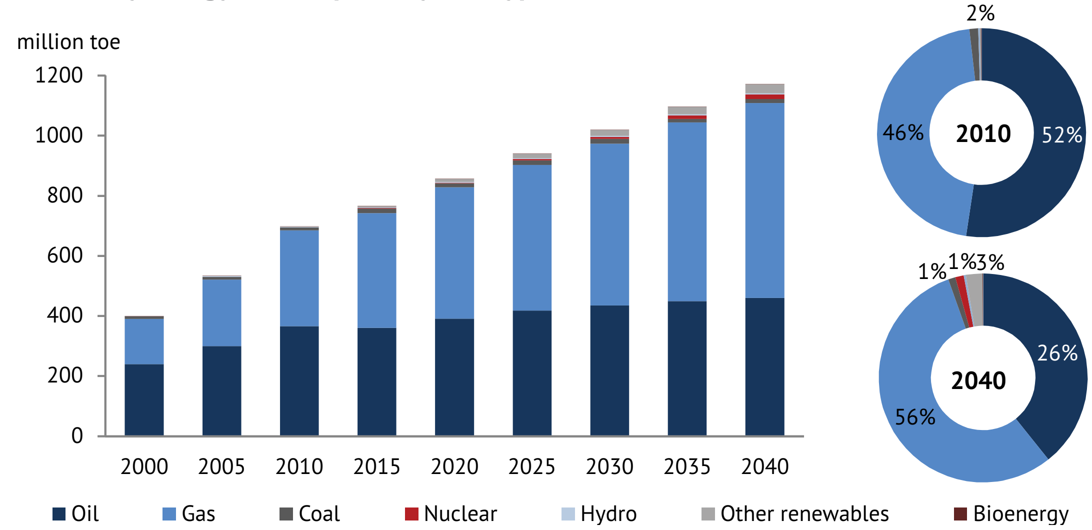


Table A26 – Basic figures, development in the Middle East

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	2991	3495	4246	5071	5945	6875	7861	3.3%
Population, million	216	239	261	281	299	316	332	1.4%
Per capita GDP, dollars/person.	13818	14610	16263	18057	19887	21753	23658	1.8%
GDP energy intensity toe/$1,000	0.23	0.22	0.20	0.19	0.17	0.16	0.15	–1.5%
Per capita energy consumption toe/person	3.23	3.20	3.28	3.35	3.41	3.47	3.53	0.3%
CO_2 emissions, million tonnes	1736	1876	2081	2265	2438	2598	2751	1.5%

Table A27 – Primary energy resource consumption in the Middle East, million toe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	698	766	856	941	1020	1097	1172	1.7%
Oil	366	361	391	418	436	450	460	0.8%
Gas	319	382	437	485	538	594	649	2.4%
Coal	10	15	14	15	16	12	13	1.1%
Nuclear	0	2	2	4	6	11	15	-
Hydro	2	2	2	3	3	4	4	3.2%
Other renewables	1	4	10	15	20	25	30	11.1%
Bioenergy	1	1	1	1	1	1	1	1.4%

Table A28 – Electricity generation in the Middle East, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	882	1055	1317	1609	1929	2280	2665	3.8%
Oil	285	300	326	348	365	376	383	1.0%
Gas	544	674	879	1108	1368	1650	1965	4.4%
Coal	35	37	39	41	42	40	40	0.5%
Nuclear	0	7	7	17	25	44	58	-
Hydro	18	24	28	33	37	42	46	3.2%
Other renewables	0	12	37	62	92	129	173	23.9%
Bioenergy	0	0	0	0	0	0	1	8.6%

Source: ERI RAS

Africa

Figure A10 – Primary energy consumption by fuel type in Africa

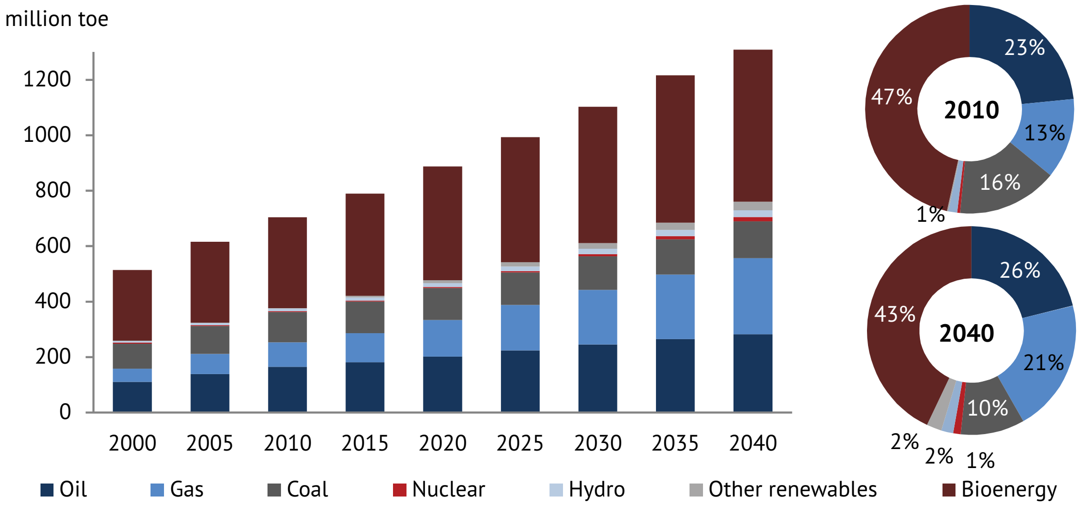


Table A29 – Basic figures, development in Africa

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	2979	3703	4762	6076	7670	9592	11893	4.7%
Population, million	1031	1166	1312	1468	1634	1812	1999	2.2%
Per capita GDP, dollars/person.	2889	3175	3629	4139	4693	5295	5950	2.4%
GDP energy intensity toe/$1,000	0.24	0.21	0.19	0.16	0.14	0.13	0.11	–2.5%
Per capita energy consumption toe/person	0.68	0.68	0.68	0.68	0.67	0.67	0.67	–0.1%
CO_2 emissions, million tonnes	1053	1155	1275	1407	1551	1704	1866	1.9%

Table A30 – Primary energy resource consumption in Africa, million toe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	704	789	887	993	1103	1217	1334	2.2%
Oil	165	181	201	224	245	265	282	1.8%
Gas	88	105	132	164	198	233	274	3.9%
Coal	109	115	116	117	121	127	133	0.6%
Nuclear	3	3	3	5	8	11	16	5.5%
Hydro	9	12	14	17	19	22	24	3.2%
Other renewables	2	5	10	16	21	26	32	10.5%
Bioenergy	327	369	410	451	492	533	573	1.9%

Table A31 – Electricity generation in Africa, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	664	776	940	1128	1337	1567	1816	3.4%
Oil	81	81	85	88	90	91	91	0.4%
Gas	201	245	318	405	502	601	722	4.4%
Coal	260	298	346	396	446	502	526	2.4%
Nuclear	12	12	13	18	30	44	60	5.5%
Hydro	105	129	157	185	213	241	270	3.2%
Other renewables	4	10	17	25	33	41	50	8.8%
Bioenergy	1	2	4	9	21	45	98	17.2%

Source: ERI RAS

OECD

Figure A11 – Primary energy consumption in OECD

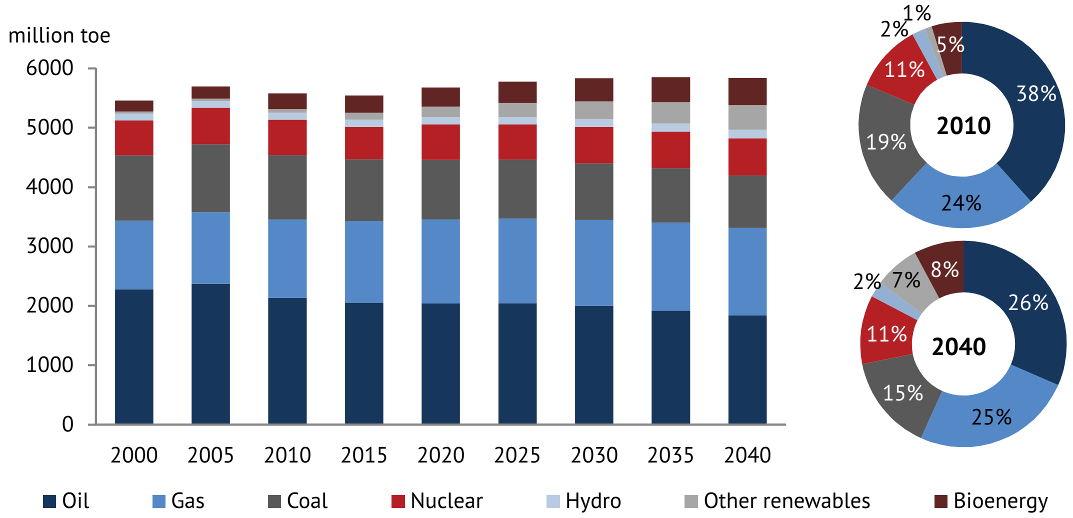


Table A32 – Basic figures, development in OECD

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	41462	45435	51525	57541	63368	68908	74140	2.0%
Population, million	1242	1279	1312	1342	1367	1387	1403	0.4%
Per capita GDP, dollars/person.	33381	35511	39260	42890	46370	49685	52845	1.5%
GDP energy intensity toe/$1,000	0.13	0.12	0.11	0.10	0.09	0.08	0.08	–1.8%
Per capita energy consumption toe/person	4.49	4.33	4.33	4.31	4.27	4.22	4.16	–0.3%
CO_2 emissions, million tonnes	12792	12534	12448	12402	12166	11884	11511	–0.4%

Table A33 – Primary energy resource consumption in OECD, million toe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	5581	5542	5679	5776	5833	5852	5837	0.2%
Oil	2137	2057	2042	2047	2002	1920	1840	–0.5%
Gas	1319	1374	1415	1424	1443	1483	1473	0.4%
Coal	1085	1039	1004	990	954	918	882	–0.7%
Nuclear	596	544	592	591	614	613	628	0.2%
Hydro	116	122	126	129	133	137	140	0.6%
Other renewables	63	113	175	236	297	359	420	6.5%
Bioenergy	264	293	325	357	390	422	454	1.8%

Table A34 – Electricity generation in OECD, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	10854	11450	12476	13369	14119	14719	15179	1.1%
Oil	309	237	192	156	127	104	84	–4.2%
Gas	2544	2919	3268	3685	4015	4340	4546	2.0%
Coal	3746	3845	3937	3986	3863	3651	3324	–0.4%
Nuclear	2289	2089	2273	2269	2356	2352	2411	0.2%
Hydro	1351	1421	1463	1504	1546	1588	1630	0.6%
Other renewables	351	632	987	1354	1735	2130	2544	6.8%
Bioenergy	264	308	356	412	477	553	641	3.0%

Source: ERI RAS

Non-OECD countries

Figure A12 – Primary energy consumption by fuel type in non-OECD countries

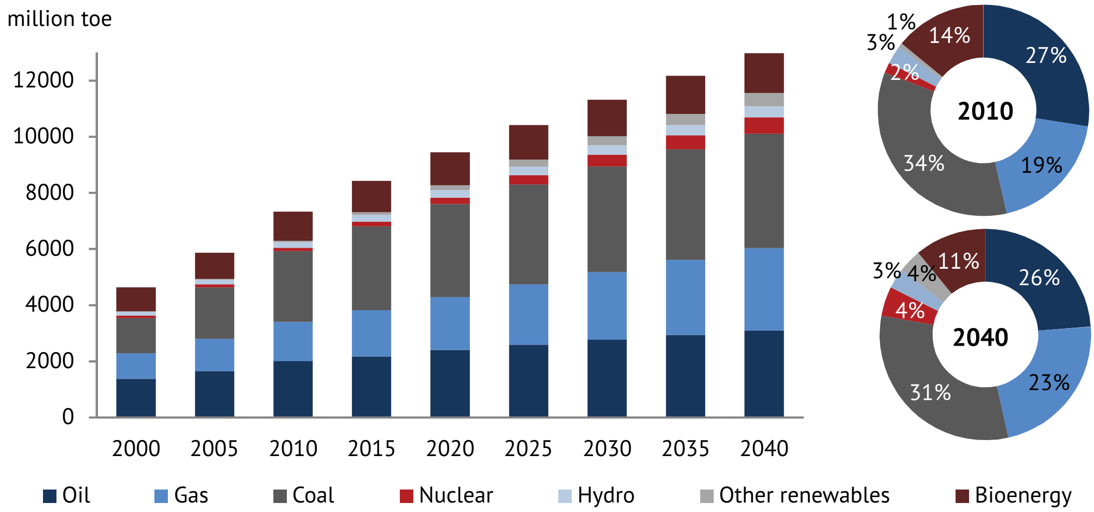


Table A35 – Basic figures, development in non-OECD

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	33628	43265	56522	72134	90381	111604	135744	4.8%
Population, million	5673	6047	6408	6748	7067	7367	7648	1.0%
Per capita GDP, dollars/person.	5927	7155	8820	10690	12790	15150	17750	3.7%
GDP energy intensity toe/$1,000	0.22	0.19	0.17	0.14	0.13	0.11	0.10	–2.7%
Per capita energy consumption toe/person	1.29	1.39	1.47	1.54	1.60	1.65	1.70	0.9%
CO_2 emissions, million tonnes	18050	20862	23196	25127	26806	28342	29836	1.7%

Table A36 – Primary energy resource consumption in non OECD, million toe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	7331	8428	9451	10418	11317	12172	12978	1.9%
Oil	2010	2176	2403	2591	2770	2938	3091	1.4%
Gas	1396	1644	1888	2148	2407	2674	2945	2.5%
Coal	2519	2993	3310	3567	3771	3941	4070	1.6%
Nuclear	117	161	230	326	417	498	582	5.5%
Hydro	207	239	271	303	336	369	401	2.2%
Other renewables	49	102	175	248	322	396	470	7.8%
Bioenergy	1033	1114	1174	1234	1294	1356	1419	1.1%

Table A37 – Electricity generation in non-OECD, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	10541	12881	15879	19078	22507	26174	29988	3.5%
Oil	680	672	687	695	692	683	666	–0.1%
Gas	2224	2657	3324	4071	4926	5895	6970	3.9%
Coal	4916	6078	7377	8600	9847	11070	12049	3.0%
Nuclear	467	644	923	1308	1674	2000	2331	5.5%
Hydro	2086	2436	2824	3217	3607	3998	4380	2.5%
Other renewables	99	292	592	955	1396	1935	2593	11.5%
Bioenergy	68	104	152	231	364	594	998	9.4%

Source: ERI RAS

BRICS countries

Figure A13 – Primary energy consumption by fuel type in the BRICS countries

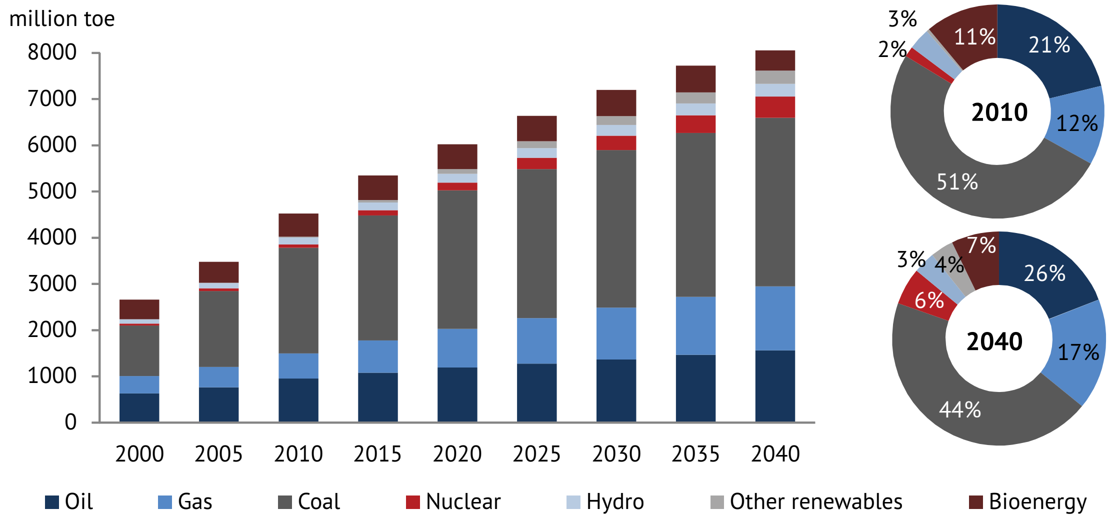


Table A38 – Basic figures, development in the BRICS countries

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	20242	26846	35817	46516	59285	74471	92043	5.2%
Population, million	2963	3093	3204	3293	3361	3409	3439	0.5%
Per capita GDP, dollars/person.	6833	8680	11177	14124	17640	21844	26765	4.7%
GDP energy intensity toe/$1,000	0.22	0.20	0.17	0.14	0.12	0.10	0.09	–3.0%
Per capita energy consumption toe/person	1.53	1.73	1.88	2.02	2.14	2.27	2.39	1.5%
CO_2 emissions, million tonnes	12428	14709	16402	17706	18790	19735	20663	1.7%

Table A39 – Primary energy resource consumption in the BRICS countries, million toe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	4526	5351	6025	6641	7200	7725	8212	2.0%
Oil	957	1077	1193	1276	1369	1468	1565	1.7%
Gas	542	701	833	986	1122	1251	1381	3.2%
Coal	2287	2706	2999	3226	3406	3551	3653	1.6%
Nuclear	71	110	166	240	312	383	459	6.4%
Hydro	149	171	191	211	232	252	272	2.0%
Other renewables	20	55	101	147	193	240	287	9.4%
Bioenergy	500	531	543	555	566	580	594	0.6%

Table A40 – Electricity generation in the BRICS countries, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	6873	8548	10672	12918	15363	18022	20818	3.8%
Oil	101	98	99	98	96	93	88	–0.5%
Gas	863	948	1180	1450	1811	2256	2833	4.0%
Coal	4080	5098	6238	7310	8405	9468	10365	3.2%
Nuclear	285	439	664	961	1246	1559	1862	6.5%
Hydro	1425	1659	1905	2157	2405	2654	2895	2.4%
Other renewables	71	236	487	799	1185	1661	2249	12.2%
Bioenergy	48	71	100	144	215	331	525	8.3%

Source: ERI RAS

OPEC

Figure A14 – Primary energy consumption by fuel type in OPEC

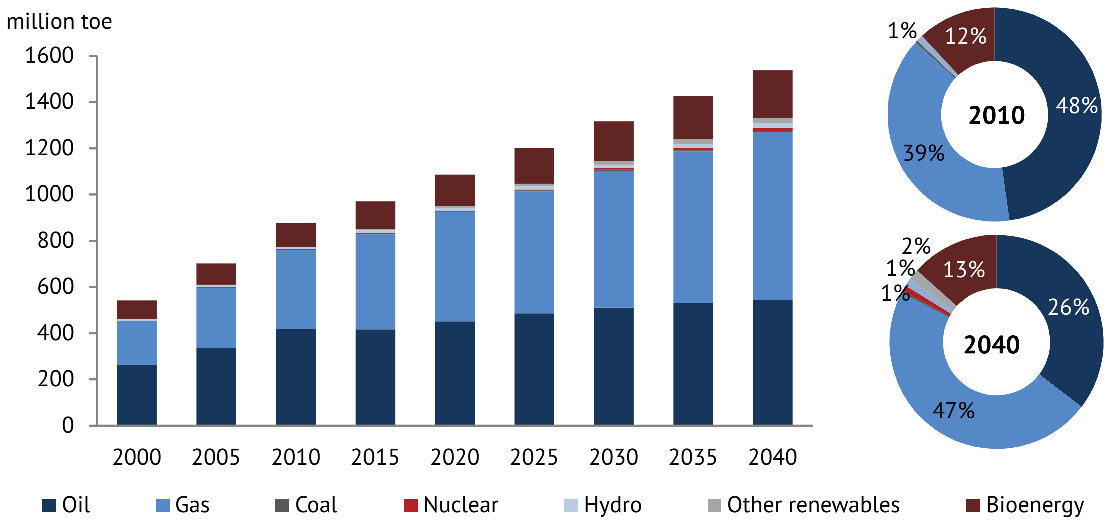


Table A41 – Basic figures, development in OPEC

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
GDP (PPP) dollars, 2010	3689	4462	5530	6768	8152	9708	11456	3.8%
Population, million	412	461	512	565	619	675	735	1.9%
Per capita GDP, dollars/person.	8947	9668	10791	11987	13178	14372	15580	1.9%
GDP energy intensity toe/$1,000	0.24	0.22	0.20	0.18	0.16	0.15	0.13	–1.9%
Per capita energy consumption toe/person	2.13	2.10	2.12	2.13	2.13	2.11	2.09	–0.1%
CO_2 emissions, million tonnes	1904	2063	2291	2513	2727	2932	3129	1.7%

Table A42 – Primary energy resource consumption in OPEC, million toe

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	878	970	1087	1204	1316	1428	1538	1.9%
Oil	419	416	451	486	511	530	544	0.9%
Gas	342	411	473	528	592	657	726	2.5%
Coal	3	6	4	4	5	5	5	2.2%
Nuclear	0	2	2	4	6	10	14	-
Hydro	9	12	13	14	16	17	19	2.3%
Other renewables	0	3	7	11	16	20	25	27.5%
Bioenergy	104	121	137	154	171	188	205	2.3%

Table A43 – Electricity generation in OPEC, TWh

	2010	2015	2020	2025	2030	2035	2040	Growth rate 2010–40
All	951	1127	1365	1628	1906	2203	2518	3.3%
Oil	285	311	346	379	408	434	459	1.6%
Gas	555	691	889	1108	1353	1612	1890	4.2%
Coal	0	0	0	0	1	1	1	1.7%
Nuclear	0	7	7	13	13	20	26	-
Hydro	8737	9655	9708	9761	9814	9867	9921	0.4%
Other renewables	0	9	31	54	82	115	157	25.7%
Bioenergy	0	0	0	0	0	0	0	10.7%

Source: ERI RAS

Russia's energy balance, Baseline Scenario

	2010	2015	2020	2025	2030	2035	2040
Domestic consumption, million toe	695	718	751	782	808	828	849
average annual growth, %	6	1	0	1	1	0	1
same in % to 2010	100	103	108	113	116	119	122
of total consumption							
- gas	358	365	392	408	422	430	439
- liquid	123	135	141	149	155	158	155
- coal etc.	124	119	118	118	119	121	126
- non-hydrocarbon	90	99	100	108	112	119	128
Same in %%:							
- gas	52	51	52	52	52	52	52
- oil products	18	19	19	19	19	19	18
- solid fuel	18	17	16	15	15	15	15
- non-hydrocarbon	13	14	13	14	14	14	15
Exports, toe	623	656	642	632	627	624	632
including:							
- CIS	89	85	85	74	64	55	54
of which gas	50	47	45	37	31	26	28
- non-CIS	534	571	557	557	563	569	578
of which gas	129	141	140	154	177	203	222
Growth of reserves, million toe	1	2	2	2	2	2	2
TOTAL CONSUMPTION, million toe	1319	1376	1395	1416	1437	1454	1483
RESOURCES, million toe	1319	1376	1395	1416	1437	1454	1483
of which:							
Imports	43	27	22	22	20	15	14
of which gas	29	16	18	18	16	13	12
Production - total	1276	1348	1373	1394	1416	1439	1469
average annual growth, %	5,95	0,21	0,11	0,31	0,31	0,32	0,41
Same in %% to 2010	100	106	108	109	111	113	115
including:							
- oil and condensate, million tonnes	505	522	513	505	491	476	468
- natural and associated gas, billion cubic metres	649	690	722	750	792	830	869
- coal, million tonnes	323	353	363	352	347	345	341
million toe.	156	170	175	171	168	162	156
- hydro, billion KWh	170	193	198	208	215	222	222
- nuclear, billion KWh	170	192	205	245	268	293	318
- renewable energy resources, million toe	13	14	16	19	21	26	33
Same in %%:							
- gas	41	41	42	44	45	47	48
- oil and condensate	39	39	37	36	35	33	32
- coal, other solids	12	13	13	12	12	12	11
- hydro	3	3	3	3	3	3	3
- nuclear	3	3	3	4	4	4	4
- renewable energy resources	1	1	1	1	2	2	2

Source: ERI RAS

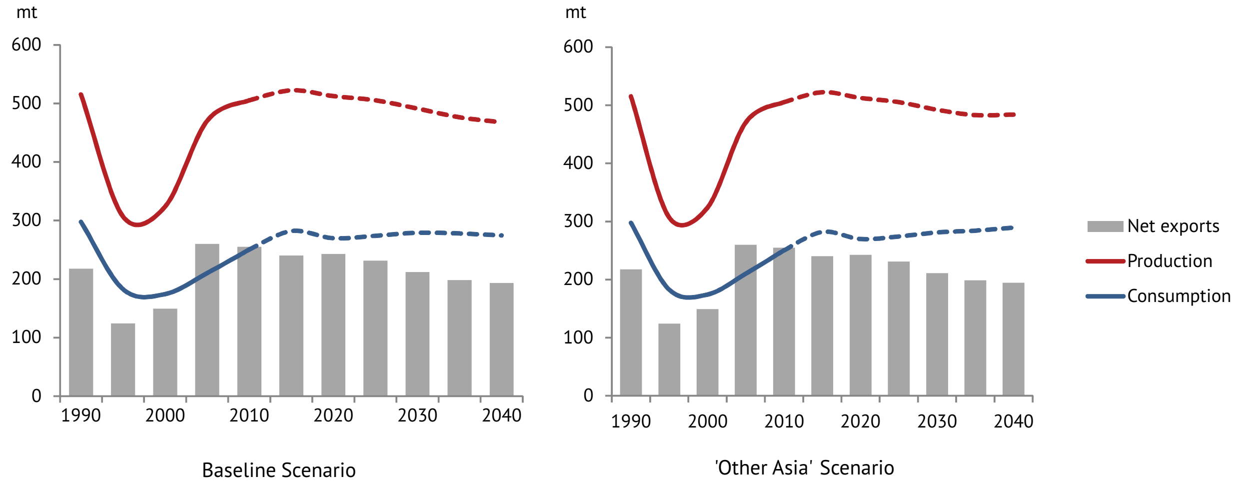
Russia's energy balance, Other Asia Scenario

	2010	2015	2020	2025	2030	2035	2040
Domestic consumption, million toe	695	718	751	789	822	856	891
average annual growth, %	6	1	0	1	1	1	1
same in % to 2010	100	103	108	114	118	123	128
of total consumption							
- gas	358	365	392	411	428	441	456
- liquid	123	135	141	150	158	165	169
- coal etc.	124	119	118	120	123	128	135
- non-hydrocarbon	90	99	100	108	113	122	131
Same in %%:							
- gas	52	51	52	52	52	52	51
- oil products	18	19	19	19	19	19	19
- solid fuel	18	17	16	15	15	15	15
- non-hydrocarbon	13	14	13	14	14	14	15
Exports, toe	623	656	644	674	703	733	747
including:							
- CIS	89	85	85	74	64	55	54
of which gas	50	47	45	37	31	26	28
- non-CIS	534	572	559	600	639	678	693
of which gas	129	141	142	184	230	274	285
Growth of reserves, million toe	1	2	2	2	2	2	2
TOTAL CONSUMPTION, million toe	1319	1377	1397	1465	1527	1591	1640
RESOURCES, million toe	1319	1376	1397	1465	1527	1591	1640
of which:							
Imports	43	27	22	22	20	15	14
of which gas	29	16	18	18	16	13	12
Production - total	1276	1349	1375	1443	1507	1576	1626
average annual growth, %	5,95	1,12	0,12	0,98	0,87	0,89	0,64
Same in %% to 2010	100	106	108	113	118	123	127
including:							
- oil and condensate, million tonnes	505	522	513	505	492	483	484
- natural and associated gas, billion cubic metres	649	691	724	793	867	935	970
- coal, million tonnes	323	353	363	380	398	423	447
million toe.	156	170	175	184	192	199	205
- hydro, billion KWh	170	193	198	208	215	222	222
- nuclear, billion KWh	170	192	205	245	286	330	375
- renewable energy resources, million toe	13	14	16	19	21	26	33
Same in %%:							
- gas	41	41	43	45	47	48	48
- oil and condensate	39	39	37	35	33	31	30
- coal, other solids	12	13	13	13	13	13	13
- hydro	3	3	3	3	3	3	3
- nuclear	3	3	3	3	4	4	4
- возобновляемые ЭР	1	1	1	1	1	2	2

Source: ERI RAS

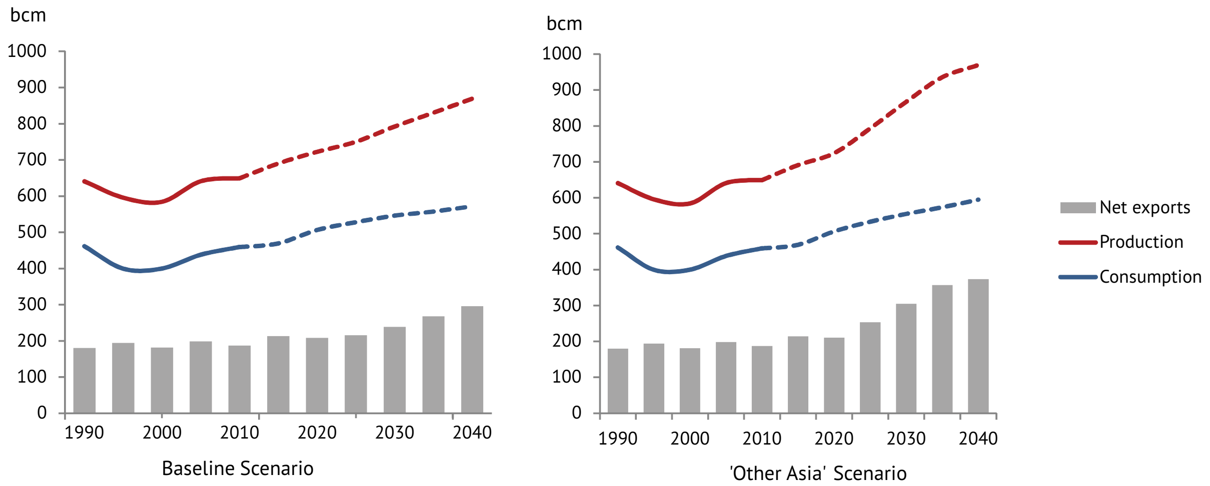
Russian energy balance scenarios

Oil



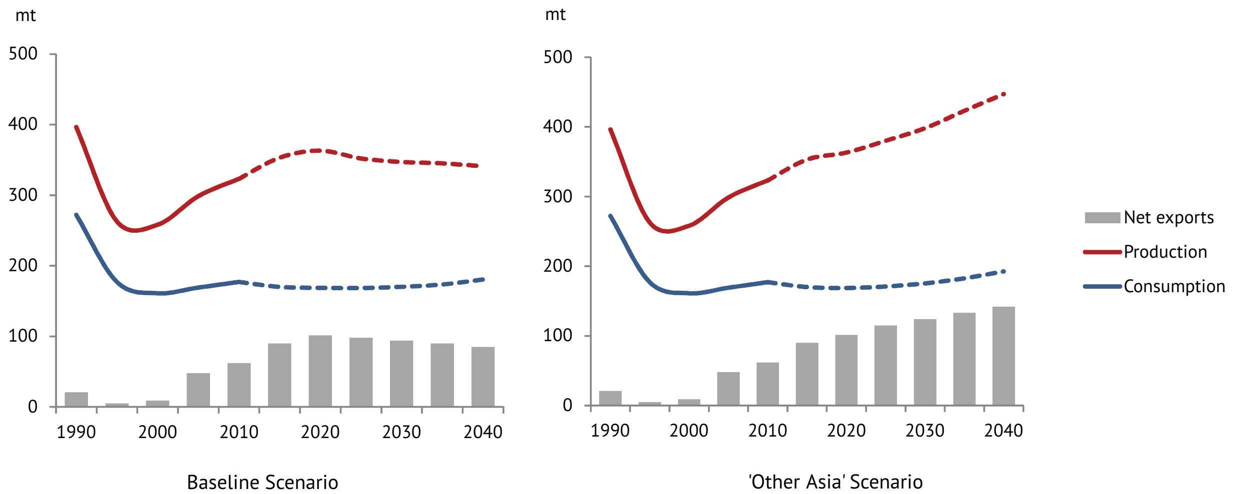
Source: ERI RAS

Gas



Source: ERI RAS

Coal



Source: ERI RAS

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The institute was established in 1985 for the provision of fundamental research within the framework of the development and implementation of the country's energy policy. The Institute combines the advantages of academic science – in-depth study of tasks and rigorous methodological apparatus – with a dynamic and customer-oriented approach.

During more than 25 years of operation, the Institute has obtained extensive practical experience, developed powerful mathematical tools, and has accumulated unique databases on world energy, the energy industries of the world, CIS countries, Russia, and its regions.

The main scientific objective of the Institute is the development of the theory and methodology of systems research and energy development forecasting. The main objectives of applied research are: the fuel and energy industries of the world, countries and regions; Russia's Unified Gas Supply System and power grid (including the nuclear sector); the country's oil and coal industries; scientific and technical progress of its energy sector; and the energy industry in CIS countries.

The Analytical Center for the Government of the Russian Federation – is a multifunctional expert and analytical agency working in the field of operational analysis and advanced research, organizing training using management by objectives (MBO).

The Centre was established in accordance with a Resolution of the Government of the Russian Federation of 20 December 2005. The purpose of its activity is to provide reliable and timely information that provides anticipatory warnings to the Government of the Russian Federation relating to material circumstances that help or hinder the achievement of final results – identified as being the primary focus of government programmes under development or implementation, and projects for the country's social and economic development.

The task of the Analytical Centre is the improvement of data quality used for analysis and forecasting of socioeconomic phenomena and processes, the management of government projects and programmes, as well as the expansion and deepening of cooperation with think tanks, expert groups, and individuals for the development of an external expertise base. Special attention is given to cooperation with Russian regions, international organizations, and research centres, with the goal of achieving best practice in operational and strategic monitoring of socioeconomic development.

The results of the work on Outlook 2013 received awards from the World Energy Council and the Global Energy Non-Profit Partnership.

Further research in energy forecasting is being carried out with the support of the Global Energy Non-Profit Partnership.

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