Center for Energy Efficiency (CENEf)

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DRIVING INDUSTRIAL ENERGY EFFICIENCY IN RUSSIA

Moscow, March 2013

CONTENTS

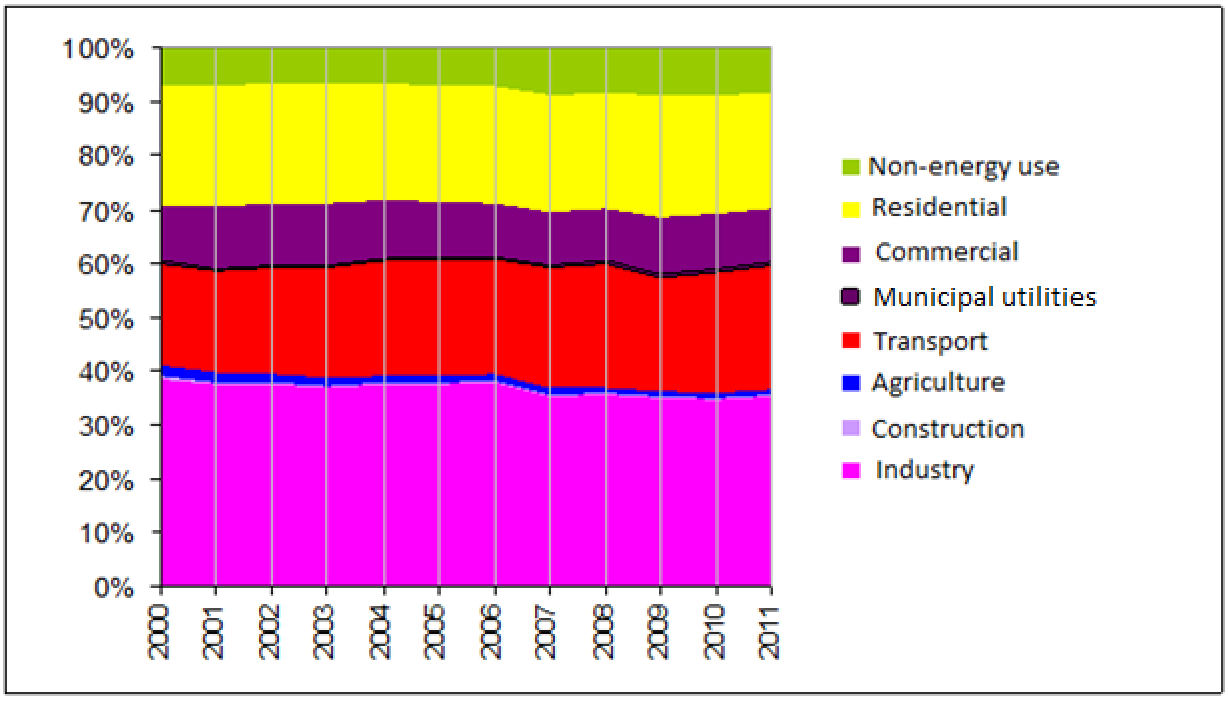
1 Major findings: what needs to be done?

1.1 Energy consumption and energy efficiency structure and trends in Russian industry: 2000-2011

Russia's energy consumption structure is dominated by industry

- Industry was responsible for 26% of primary energy consumption in 2011, or for 32% with an account of fuel use for non-energy purposes;
- The share of industry in end-use energy consumption is still quite substantial: 35.3% in 2011 (43.6% with an account of non-energy needs), but is declining (3% decline in 2000-2011, Fig. 1.1);

Figure 1.1 **Evolution of end-use energy consumption structure by sectors: 2000-2010**



Source: CENEf

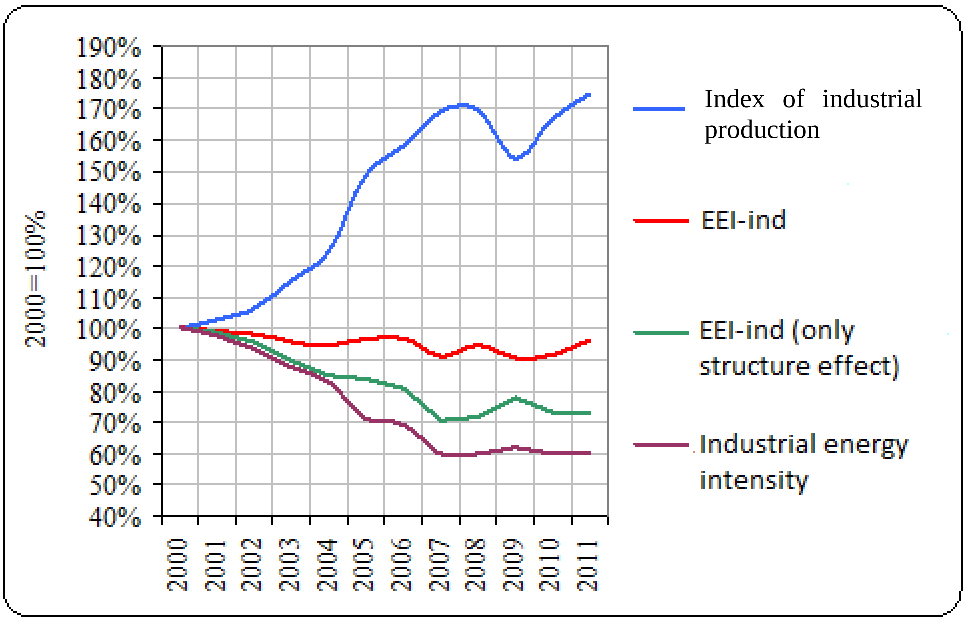
In 2000-2011, growth of industrial output in Russia was practically decoupled from energy consumption dynamics

- In 2002-2006, industrial energy consumption was growing, then started to decline, and in 2010 it was below the 2001 level;
- However, in 2011, industrial energy consumption showed 12.3 mln tce growth, which was most substantial in “other industries” (8.7 mln tce), oil production and cement production.

Industrial energy intensity dropped by 40% in 2000-2011, but technology improvement was responsible for just a small part of this drop

- Industrial energy intensity was annually declining by 4.5% in 2000-2011, while energy efficiency index by only 2.9% per annum;
- The difference between these two dynamics reflects the impact of the structural factor, which was responsible for 38% of energy intensity reduction;
- The impact of specific energy consumption reduction was 62%, which is close to the relevant data for the U.S. (65% industrial energy intensity reduction);
- However, with other factors included in the analysis, energy efficiency index in industry (EEI-ind) dropped by only 4%, or was annually dropping by 0.3% on average. Therefore, technology improvement factor was responsible for only a small part of industrial energy intensity reduction;
- Major drivers of this reduction included structural shifts, capacity load fluctuations, evolution of energy prices, and weather.

Figure 1.2 Evolution of GDP energy intensity and energy efficiency index (EEI) in industry: 2000-2011



EEI-ind – energy efficiency index in the industrial sector with 24 types of industrial products, as well as capacity load, energy prices, and weather factors

Source: CENEf

Actual values of 18 of 33 indicators of the “Energy conservation and energy efficiency in the industrial sector” Subprogramme were below the target values set in the Federal Programme. The most important reasons that determined inability to achieve the target values in industry included:

- much slower, than anticipated, implementation of measures related to the replacement and retrofits of energy intense industrial equipment determined by shrinkage of investments during the economic crisis (2008-2009) and slow restoration in 2010-2011;
- post-crisis structure of the industrial sector became more energy intense. Slow restoration of non-energy intense industries after the economic crisis slows down industrial energy intensity reduction after 2010;
- reduced capacity load in some energy-intense industries and relevant growth of specific energy consumption driven by the growing share of semi-fixed costs in the crisis years (2008-2009) and further slow restoration of capacity load;
- worse conditions for the production and processing of some mineral resources;
- reduced energy prices compared to product prices in some energy intense industries (lack of incentives for energy efficiency improvements);
- comparatively low rating of energy efficiency improvements in the strategic plans of industrial companies. Half of industrial companies did not do any innovative energy efficiency projects;
- no spurring energy efficiency improvements in the industrial sector by the federal government. The incentives in place mostly relate to energy audits, oil refinery retrofits, and utilization of associated gas.

1.2 Risks pertaining to continued existence of industrial energy inefficiency in Russia

The road to the future is only along the descending curve of GDP and industrial energy intensity

- Russia is much above this curve. There is little chance of economic progress with such high energy intensity;
- before the 2009 economic crisis, Russia was one of the world leaders in terms of GDP energy intensity reduction rates, and the gap between Russia and developed countries was narrowing dynamically;
- 40% reduction of GDP energy intensity within 10 years was already achieved once (in 1998-2008) in Russia;
- however, despite the impressive progress achieved in the recent years, very much needs to be done to bridge the significant original gap between energy intensity levels in Russia and in the developed countries.

Of 132 countries, Russia comes 108th in the industrial energy efficiency rating

- After 2000, during transition to the restoration growth, industrial energy efficiency showed substantial (33%) reduction;
- however, in pre-crisis 2008 it was still 12 times industrial energy efficiency in Great Britain, 11 times that in the U.S., 5 times that in Canada, and 2.4 times that in China.

Practically in all industrial technologies, there is a substantial energy efficiency gap with not only best available technologies (BAT), but with "actual consumption abroad", too

- In 2000-2011, technology gaps with BAT somewhat narrowed;
- however, they are still high: 1.4 times in coke, 1.9 times in cast iron and electric steel, 3.7 times in rolled steel, 1.5 times in fertilizers, 1.6 times in pulp, 1.5 times in paper, and 2 times in clinker (Fig. 1.5-1.8);
- even with comparatively low fuel and energy prices, the share of fuel and energy costs in the overall production costs in Russia is higher, than in the developed and many developing countries (Table 1.1).

Table 1.1 Share of fuel and energy costs in the overall production costs (%)

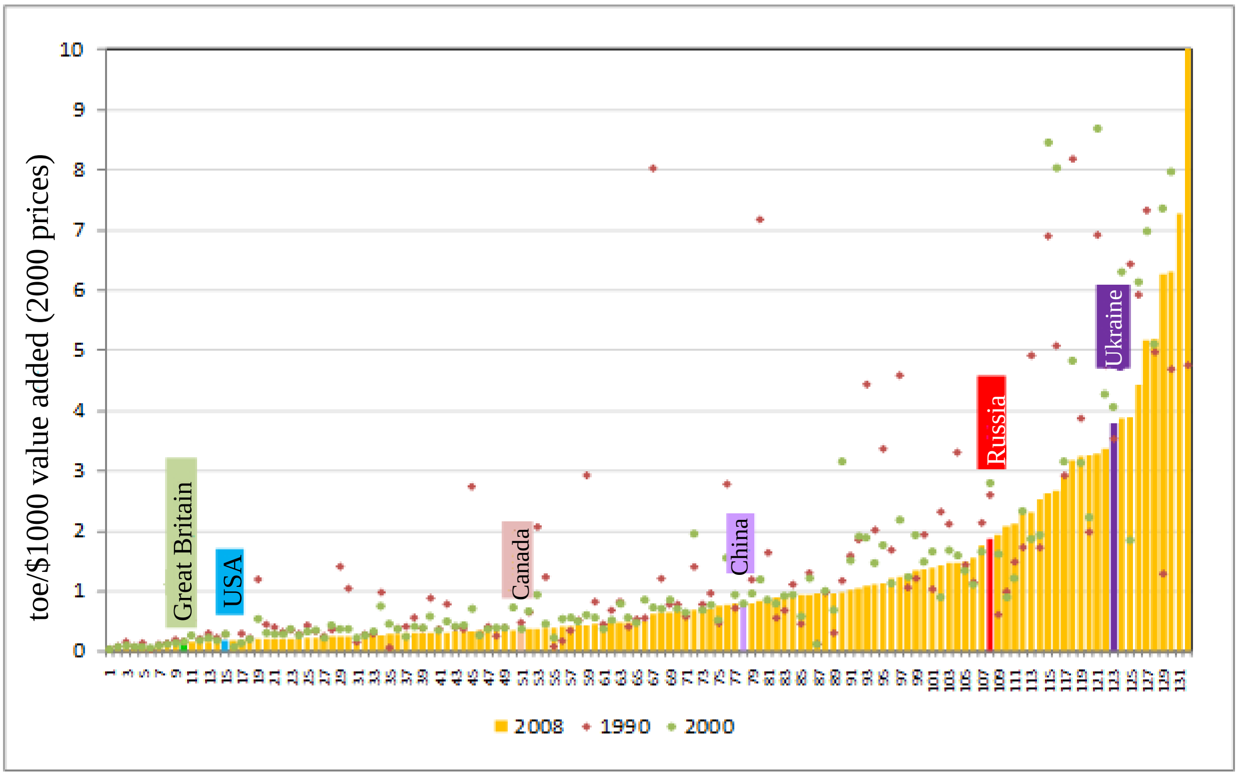
Sector	All countries[1]	Developed countries	Developing countries	BRICS	Russia
Oil refinery	61.6	59.4	70.6	68.4	54.7
Building materials	11.8	7.2	12.7	6.5	13.2
Metallurgy	7.3	5.8	8.3	9.9	11.7
Chemistry and petrochemistry	3.9	4.9	3.5	10.0	9.9[2]
Pulp and paper	3.2	3.6	2.9	4.0	9.6
Rubber and plastics	5.3	3.4	6.8	7.8	4.1[2]
Transport machinery	3.2	1.3	5.6	2.4	2.9
Machine building	2.0	1.4	2.7	4.0	3.7
Electronic equipment	1.5	1.7	1.4	2.2	2.9
Textile	3.0	2.3	3.3	2.5	5.1
Food	2.3	1.7	2.5	1.9	3.1

[1] By 50 countries. The data include costs related to the use of energy resources as raw materials

[2] Excl. costs related to the use of energy resources as raw materials

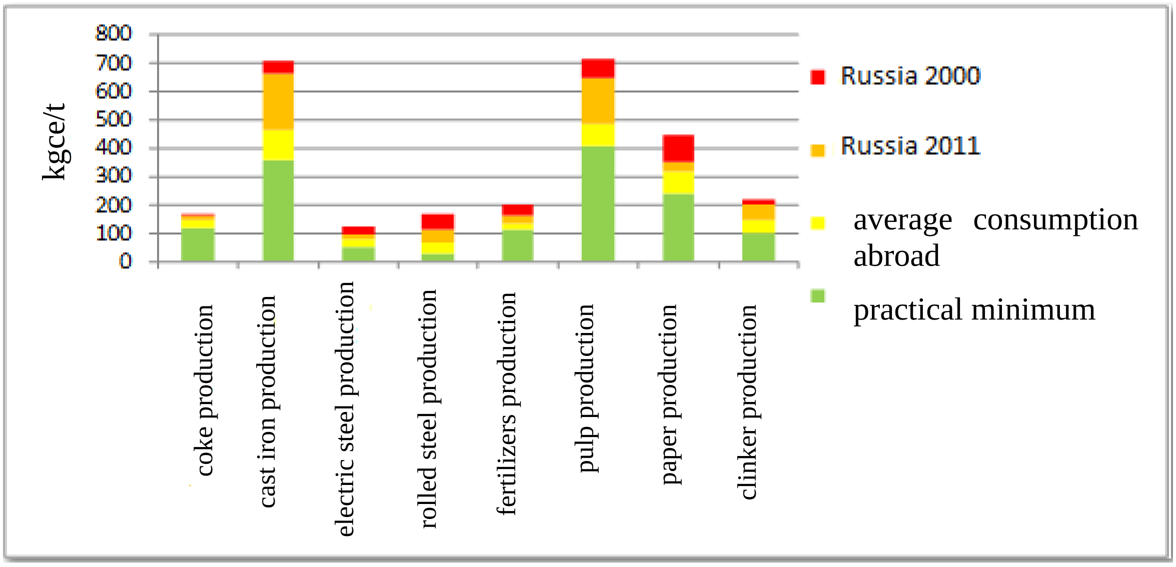
Sources: data for Russia – Russia's Industry. 2012. Rosstat. 2012; data for other countries – UNIDO. 2011. Industrial Development Report 2011. Industrial energy efficiency for sustainable wealth creation. Capturing environmental, economic and social dividends.

Figure 1.3 Russia's rating by energy intensity of manufacturing



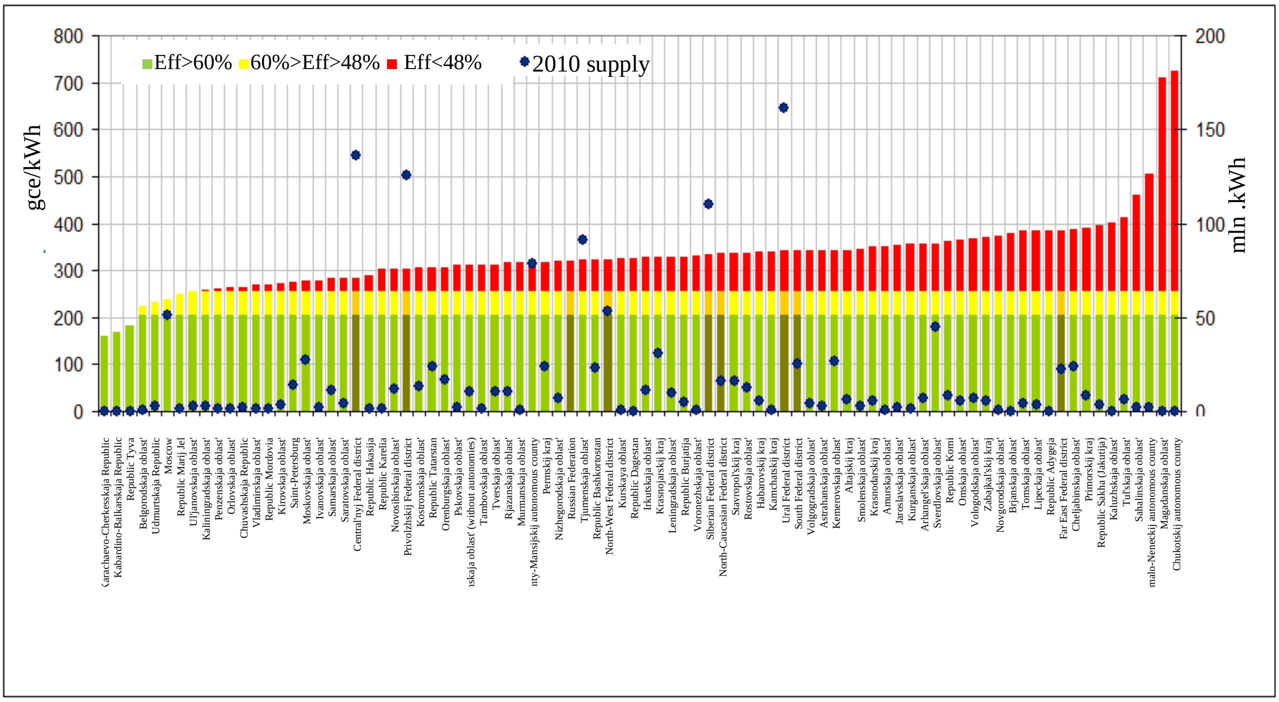
Source: CENEf based on UNIDO's data from UNIDO. 2011. Industrial Development Report 2011. Industrial energy efficiency for sustainable wealth creation. Capturing environmental, economic and social dividends.

Figure 1.4 Gap in specific energy consumption for the production of some goods between Russian and best/average foreign values



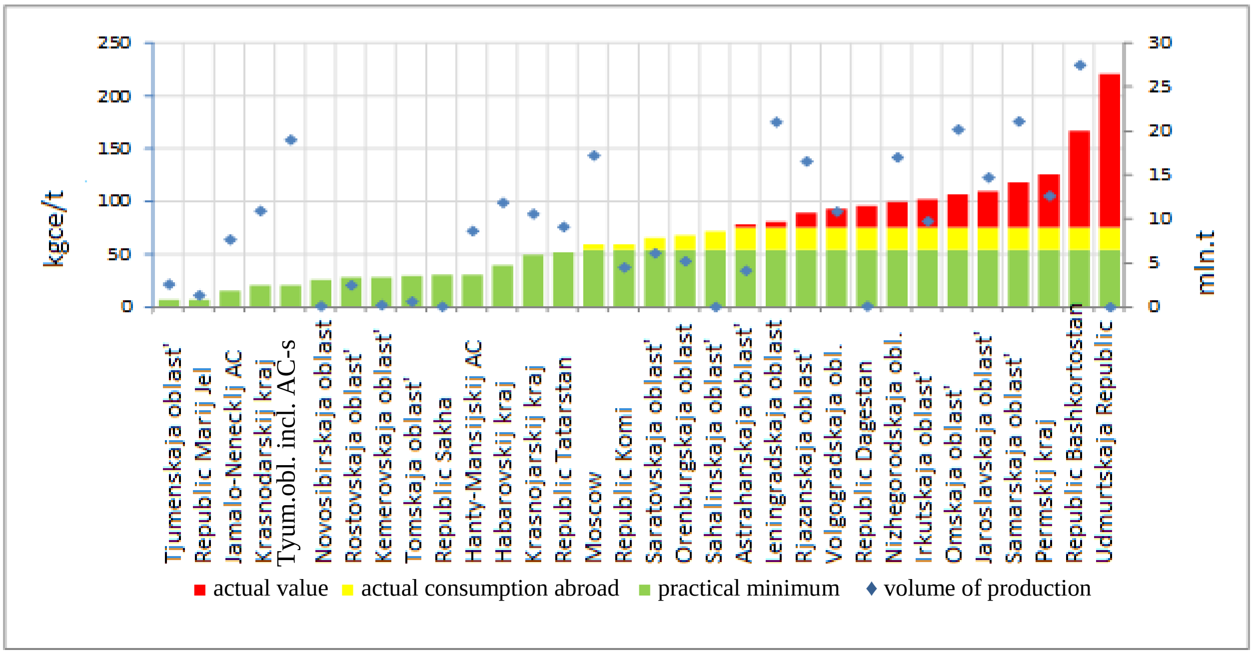
Source: CENEf

Figure 1.5 Rating Russian regions by specific fuel consumption of power plants for electricity supply (data for 2010)



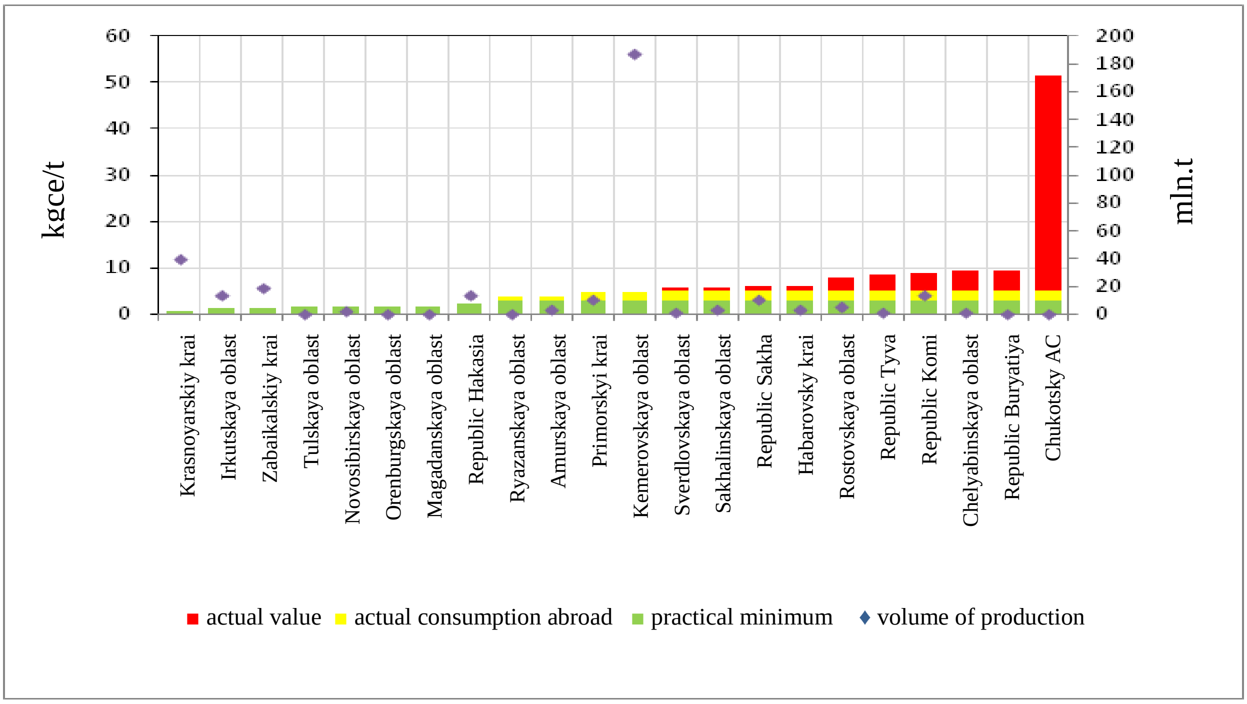
Source: CENEf

Figure 1.6 **Rating Russian regions by specific fuel consumption for oil refinery and natural gas liquids processing (data for 2011)**



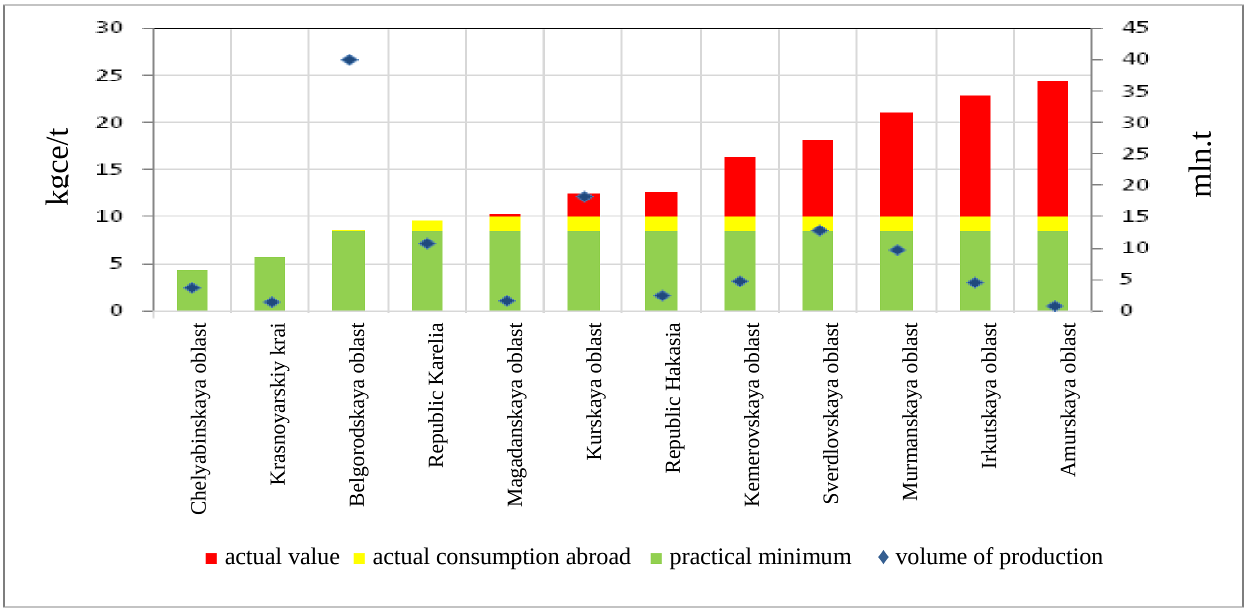
Source: CENEf

Figure 1.7 **Rating Russian regions by specific fuel consumption for coal production (data for 2011)**



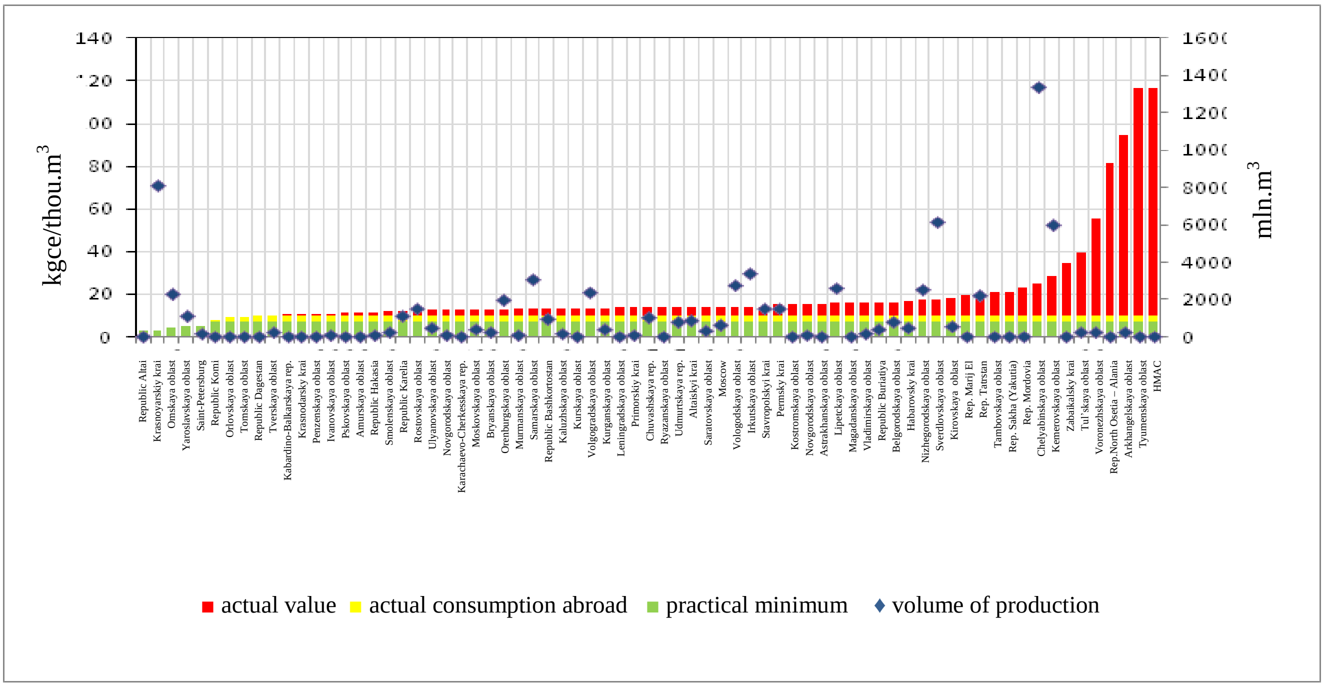
Source: CENEf

Figure 1.8 Rating Russian regions by specific fuel consumption for iron ore production (data for 2011)



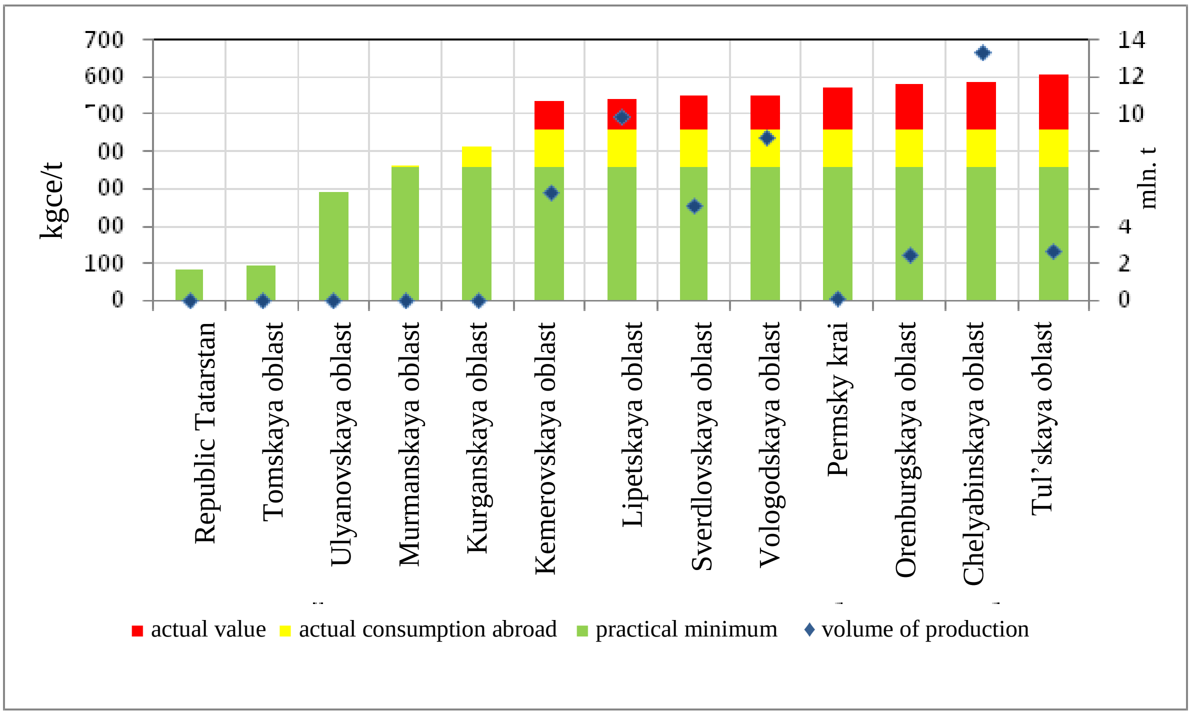
Source: CENEf

Figure 1.9 Rating Russian regions by specific fuel consumption for compressed air production (data for 2011)



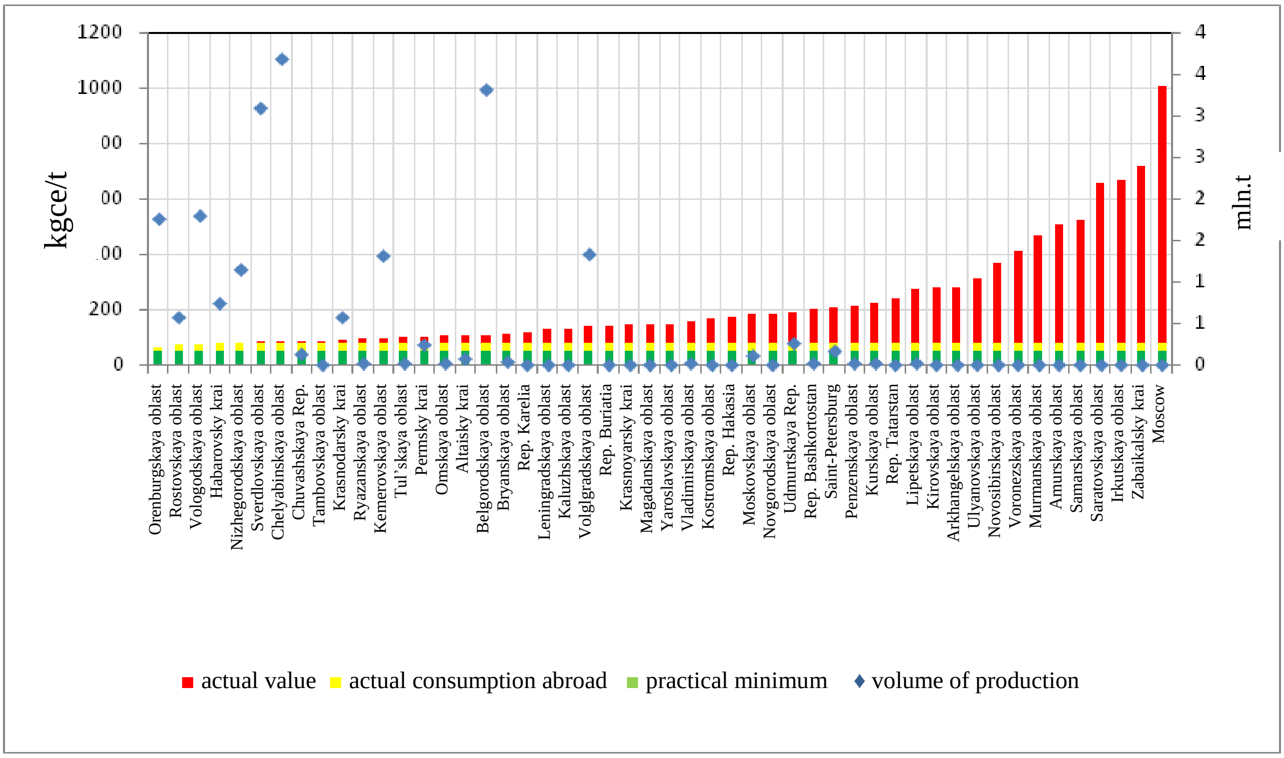
Source: CENEf

Figure 1.10 Rating Russian regions by specific fuel consumption for cast iron production (data for 2011)



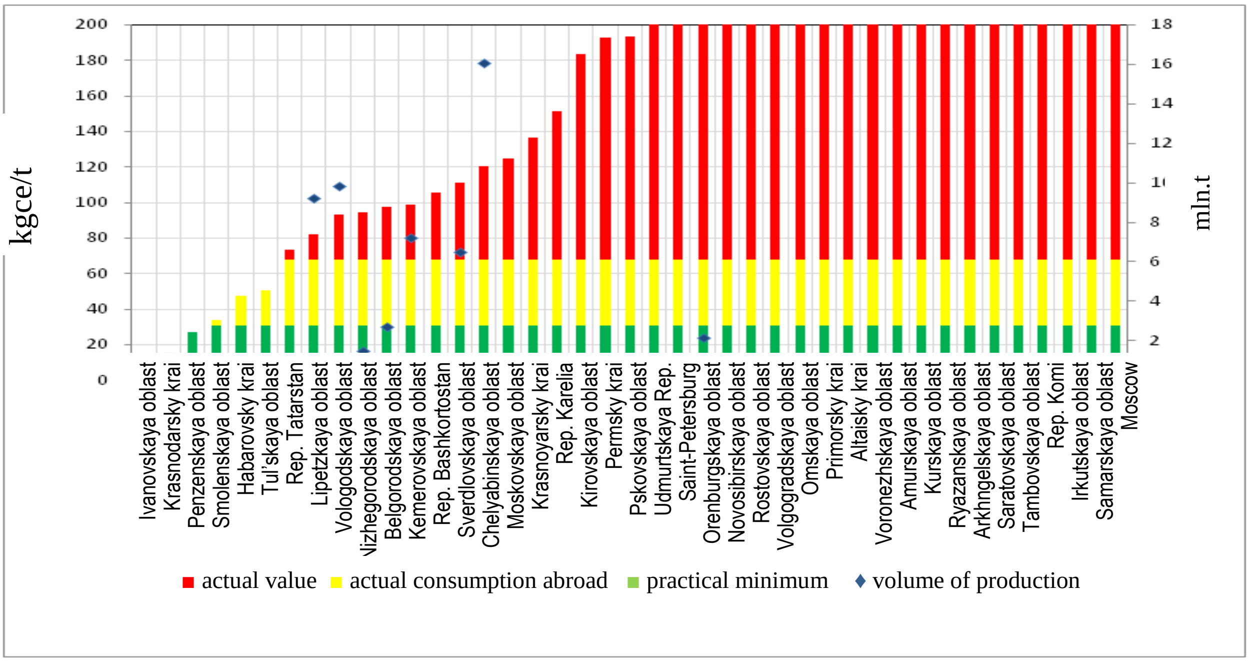
Source: CENEf

Figure 1.11 Rating Russian regions by specific fuel consumption for electric steel production (data for 2011)



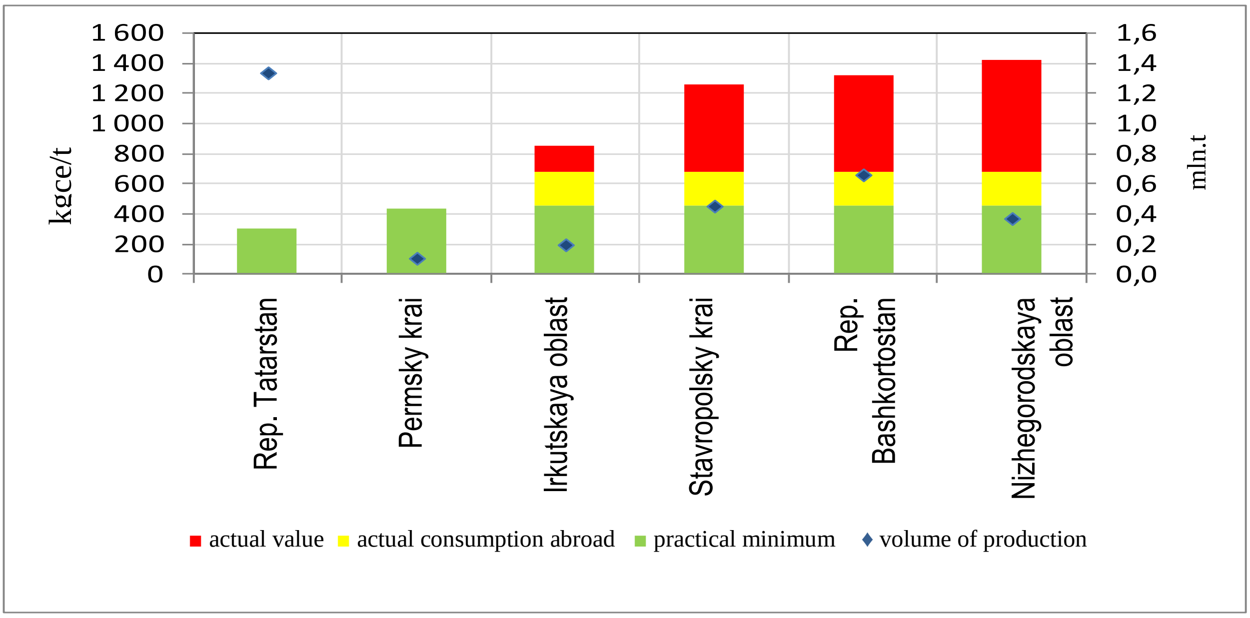
Source: CENEf

Figure 1.12 Rating Russian regions by specific fuel consumption for rolled ferrous metals production (data for 2011)



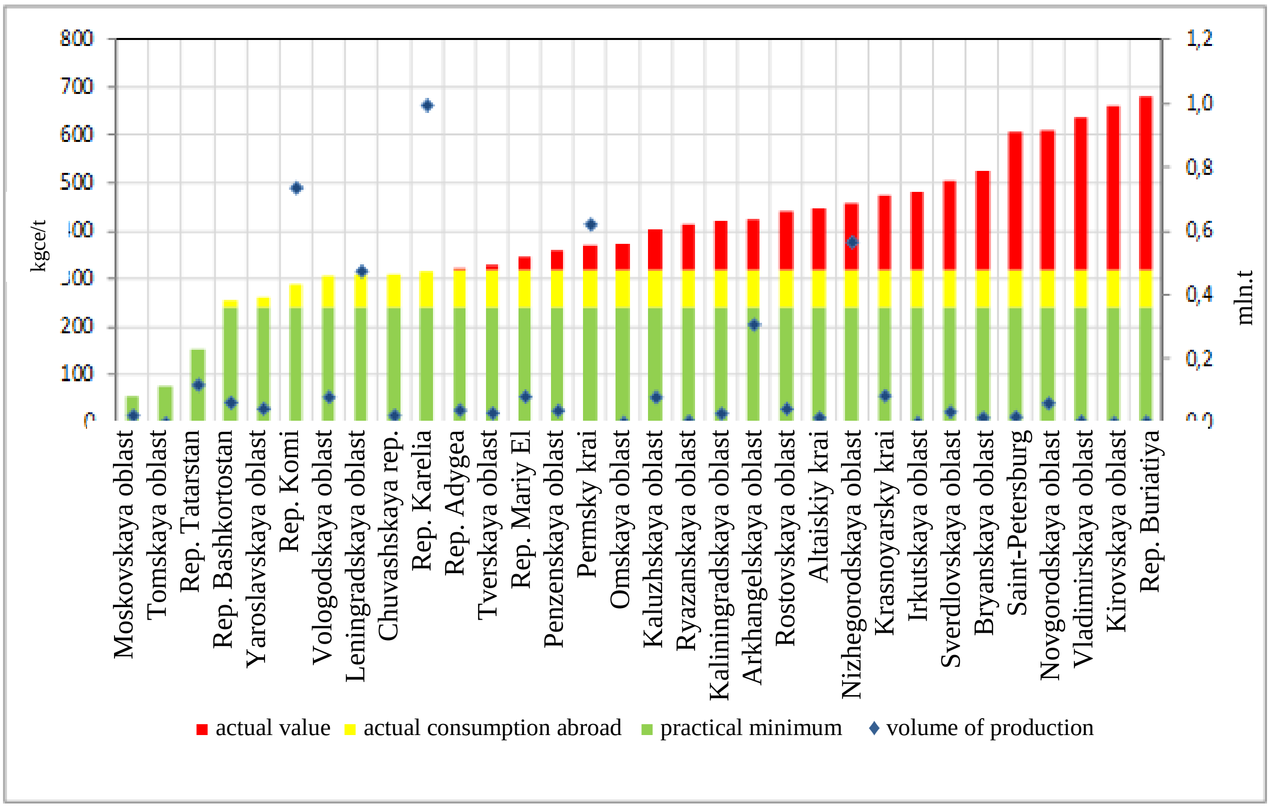
Source: CENEf

Figure 1.13 Rating Russian regions by specific fuel consumption for ethylene production (data for 2011)



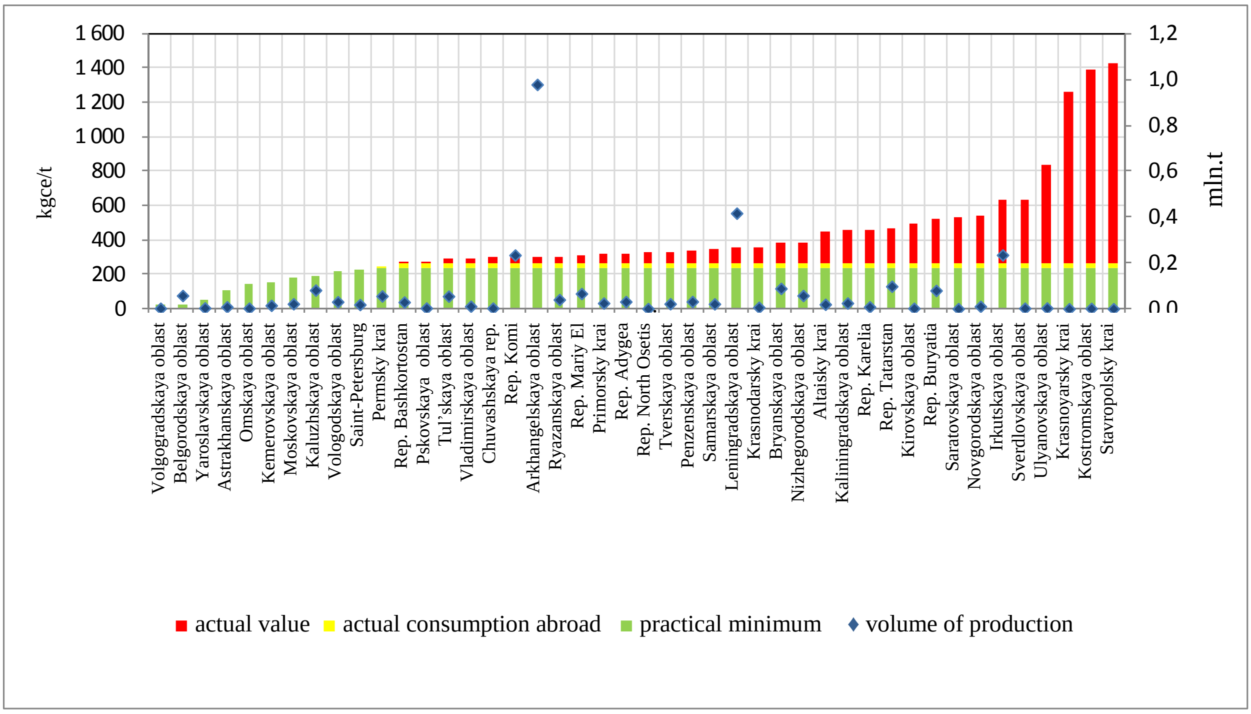
Source: CENEf

Figure 1.14 Rating Russian regions by specific fuel consumption for paper production (data for 2011)



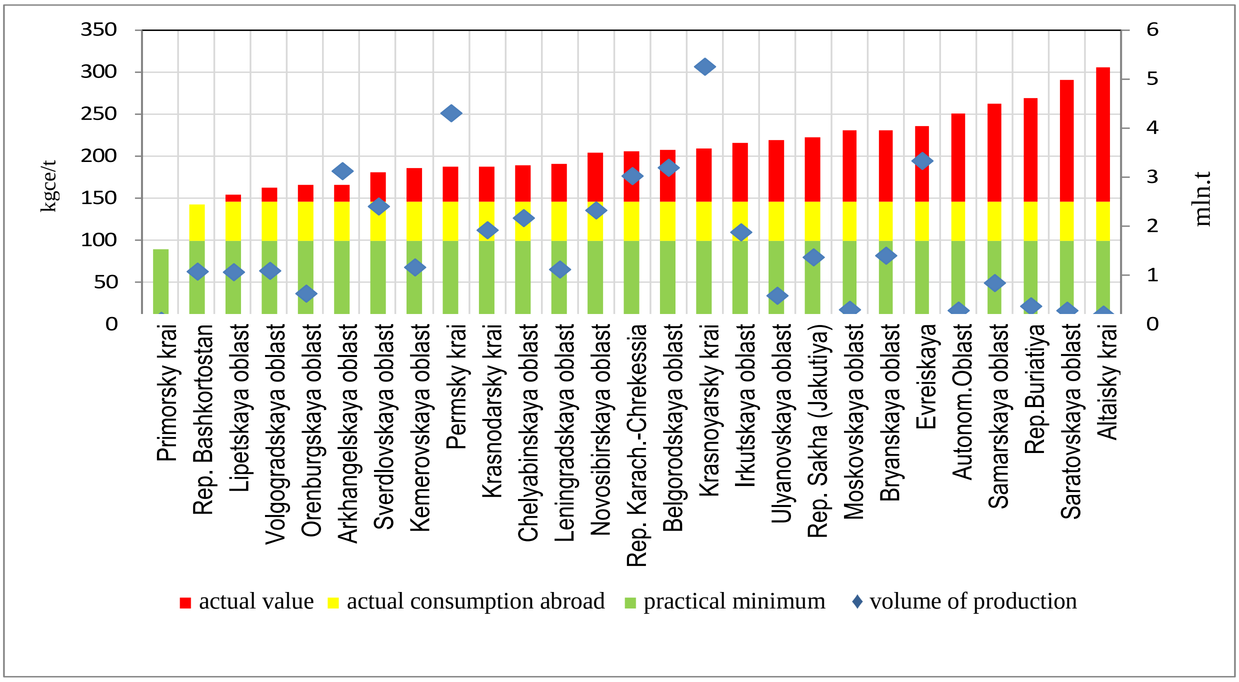
Source: CENEf

Figure 1.15 Rating Russian regions by specific fuel consumption for cardboard production (data for 2011)



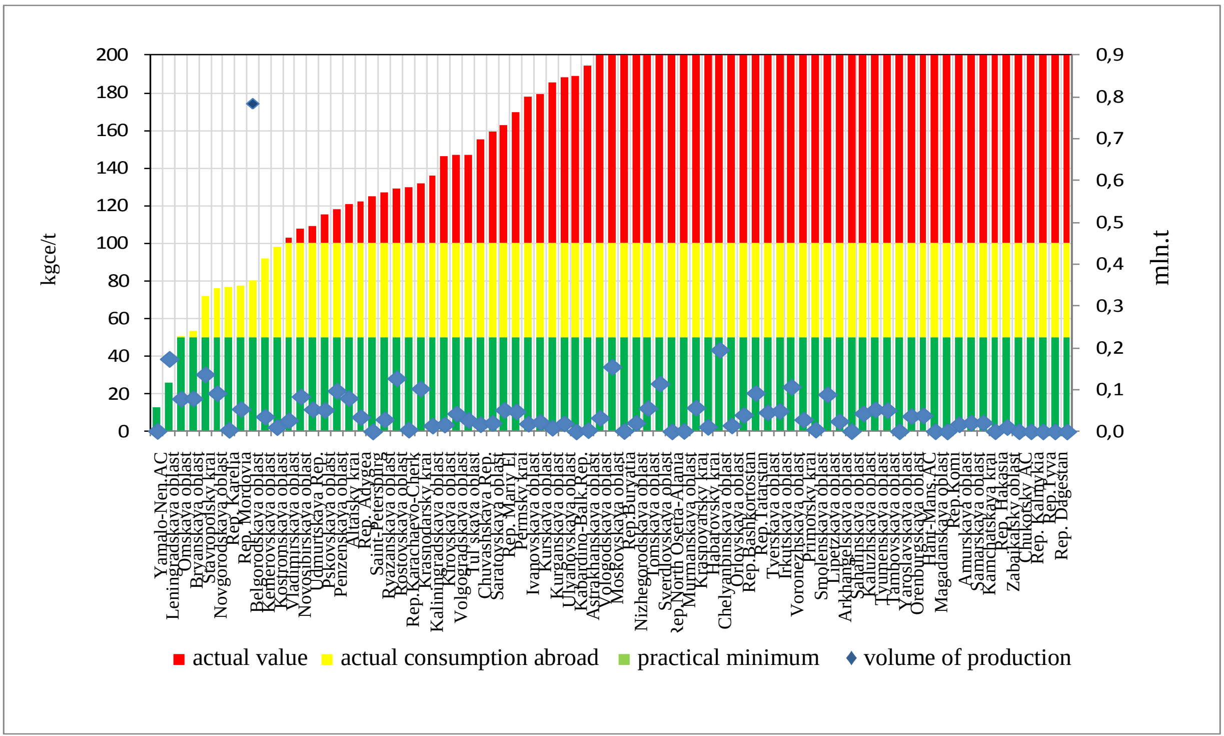
Source: CENEf

Figure 1.16 Rating Russian regions by specific fuel consumption for clinker production (data for 2011)



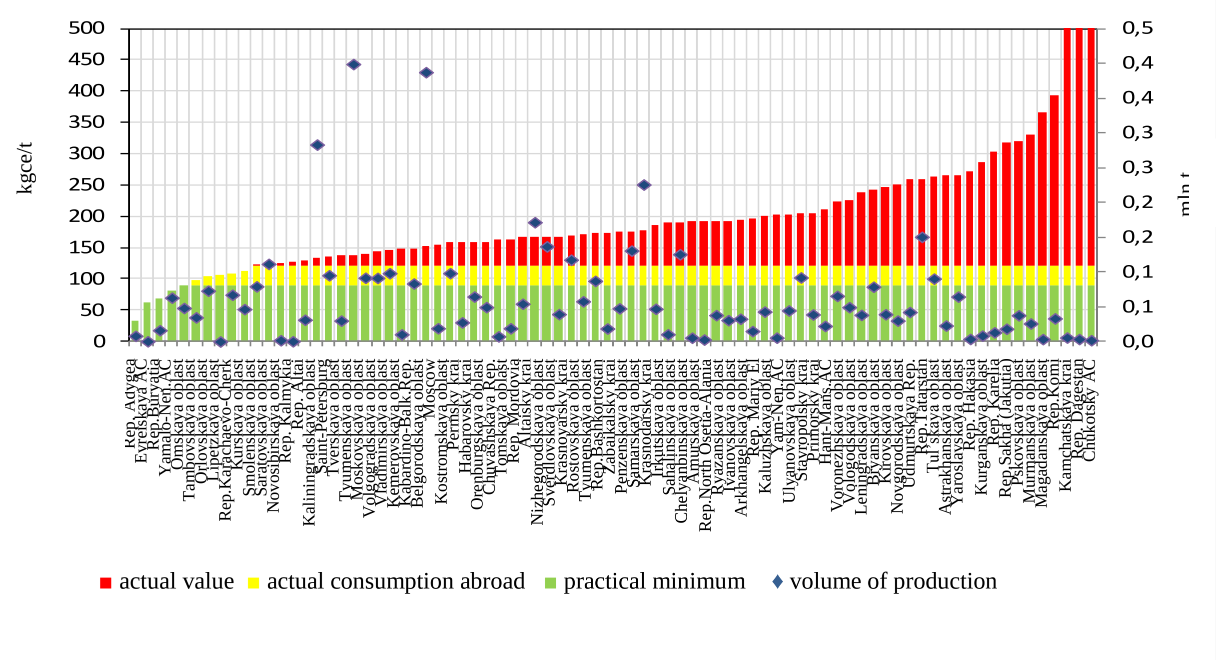
Source: CENEf

Figure 1.17 Rating Russian regions by specific fuel consumption for meat production (including 1st category by-products, data for 2011)



Source: CENEf

Figure 1.18 Rating Russian regions by specific fuel consumption for bread and bakery products (data for 2011)



Source: CENEf

"Conservative energy" scenario suggests energy price growth

- in 2015-2030, wholesale gas prices will grow 4.3-4.4-fold on average for all consumer groups and by 2030 will reach fantastic from today's point of view USD 350-360;
- in 2015-2030, electricity price will grow 2.4-2.5-fold. Average retail electricity prices for all consumer groups will grow 2.6-2.65-fold on average during 2015-2030 and by 2030 will be 16.5-17 cents per kWh;
- heat tariffs in 2015-2020 will double, and in 2015-2030 will grow 3.7-fold.

It was not incidentally that the RF Ministry of Economic Development included GDP energy intensity in the set of indicators of Russia's innovative economic development. If energy prices grow up to the EU level, Russian industry is no longer competitive

- Cement industry: profitability drops from current 40% to -17%;
- pulp and paper: profitability drops from current 23% to -14%;
- mineral fertilizers: profitability drops from current 33% to 2%;
- iron and steel: prices of rolled products become 30-36% higher, than in West Europe[1];
- therefore, reduction of energy intensity of Russia's economy and industry is one of the essential conditions for Russia to move up the competitiveness index scale.

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[1] According to SBS company.

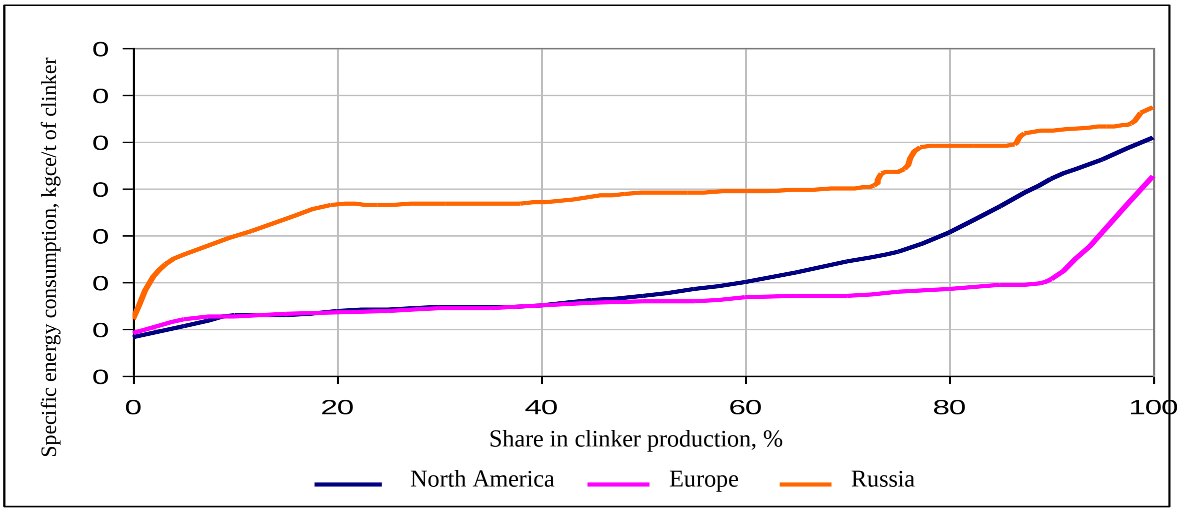
Outdated technologies determine a substantial part of the energy efficiency gap

- In Russia, the distribution curve of clinker production by specific energy consumption goes above those of West Europe or North America (Fig. 1.19);
- for this reason, in terms of average specific energy consumption for clinker production Russia exceeds the European Union by 62%, China by 46%, and North America by 33%.

Comparison of new industrial technologies application in China and Russia in the last 10 years (Table 1.2) shows, that:

- Russia is much behind in new technologies application;
- Russia’s energy intense industries modernization rates are far slower, than in China;
- in China, about half of the new technologies were introduced during industrial retrofits, and the other half during new construction.

Figure 1.19 Distribution of clinker production by specific energy consumption in Russia, North America, and West Europe



Source: I. Bashmakov. Energy efficiency policies and developments in Russia. Prepared for OECD under Contract No. JA00069287. Estimated based on IEA’s data from 2010 Key World Energy Statistics. OECD/IEA. 2010.

Table 1.2 Examples of energy efficiency BAT application dynamics in China and Russia (%)

Sector and technology	2000	2006	2007	2008	2009	Energy savings
Iron and steel						
Continuous steel casting	83	99	99	99	99	Savings of 200 kgce/t of steel
Russia	***50***	***68***	***71***	***71***	***82***	
Dry coke quenching			45	50	>70	Savings of 100 kgce/t of coke
Russia					***70***	
Aluminum						
Pre-baked anode cells	52	82	83	86	90	Up to 9% energy savings compared to Soderberg cells
Russia					***75***	
Cement						
Transition to multi-stage “dry” clinker production	12	50	55	63	73	Up to 40% energy savings compared to vertical furnace
Russia	***14***	***15***	***16***	***16***	***16***	

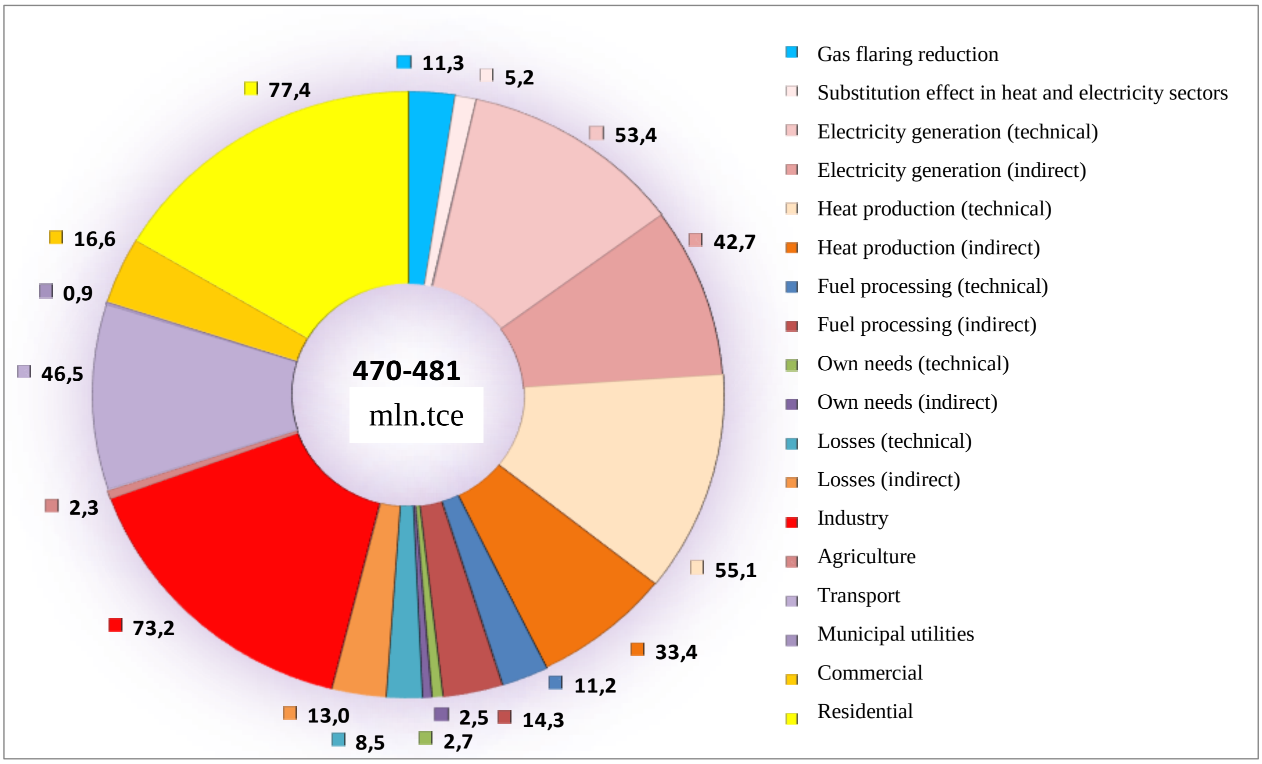
Sources: Data for Russia – CENEf. Data for China – UNIDO. 2011. Industrial Development Report 2011. Industrial energy efficiency for sustainable wealth creation. Capturing environmental, economic and social dividends.

1.3 Energy savings potential in Russia’s industry

With independent implementation of energy saving measures in the industrial sector and fuel-and-energy complex energy savings potential equals 231 mln. tce

- Energy saving potential in the industrial sector is the sum of the potentials in fuel processing industry and fuel end-use industry, and of the potential determined by gas flaring reduction;
- with an account of overlapped effects, energy saving potential equals 114 mln. tce, or 25% of the overall energy saving potential and 43% of industrial energy consumption. This is more than energy consumption by such countries as Poland, the Netherlands, or Turkey;
- part of this energy saving potential in electricity and heat generation (242 mln. tce) can be attributed to industrial power plants and boilers. If this part is one third, then overall technical energy saving potential in the Russian industry is 194 mln. tce, or 41% of the overall Russia’s technical energy saving potential;
- industrial (excl. fuel-and-energy complex) end-use energy saving potential is 73 mln. tce.

Figure 1.20 Integrated assessment of Russia's technical energy saving potential in 2011 (mln. tce)



Source: Transformed for 2011 based on I.A. Bashmakov and A.D. Myshak. Factors determining Russian energy-related GHG emission dynamics. Analysis based on the data from the National Inventory Report. FGBU "Institute of the Global Climate and Ecology of Roshydromet and the Russian Academy of Science". 2012.

Indirect effects are the reason why the government and the society should subsidize energy efficiency efforts: they get these indirect effects for free

- If the end-use (industrial) consumer saves 1 tce of petroleum products, overall energy demand in the fuel and energy complex goes down by another 0.12 tce, or by 0.2 tce, if transportation costs are accounted;
- electricity and heat bring the largest indirect effects. With an account of all indirect effects, if a Russian end-user saves 1 tce of electricity, not 2.5-3 tce, but 4.7 tce (4.9 tce with an account of fuel transportation) are saved along the whole energy chain.

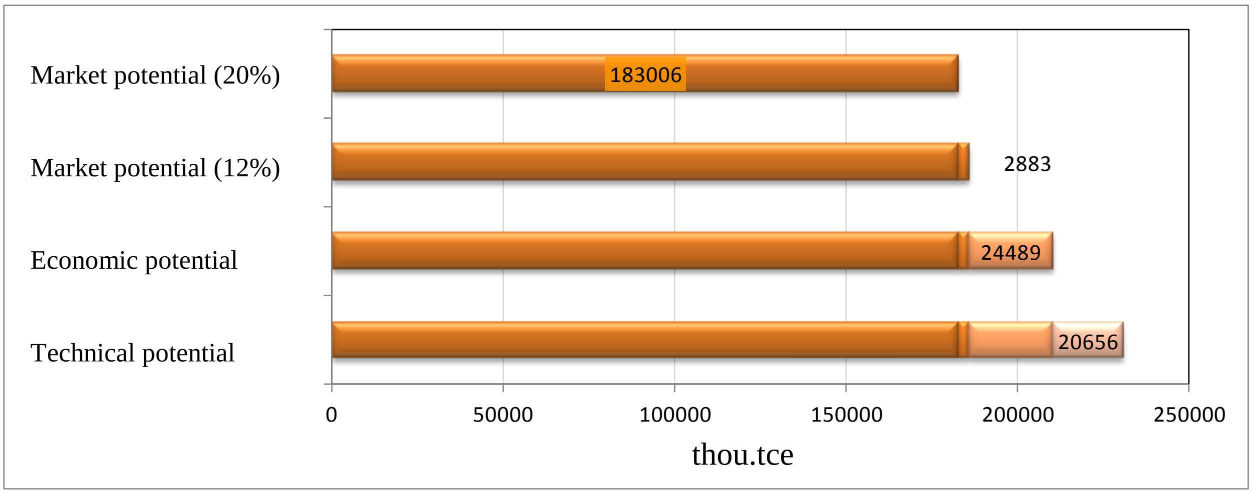
Comparison of relative values of the technical energy saving potential in some Russian industries with other countries shows, that:

- in Russia, this value is larger, than in the developed countries, and often larger, than in developing countries;
- the latter is no surprise, because in the developing countries the share of new equipment built in the recent years on a new technology basis is quite large;
- as to the absolute volume of savings, in some industries Russian potential is comparable to the global one.

Market energy saving potential equals 183-186 thou. tce, or nearly 80% of the technical potential, and 89% of the economic potential

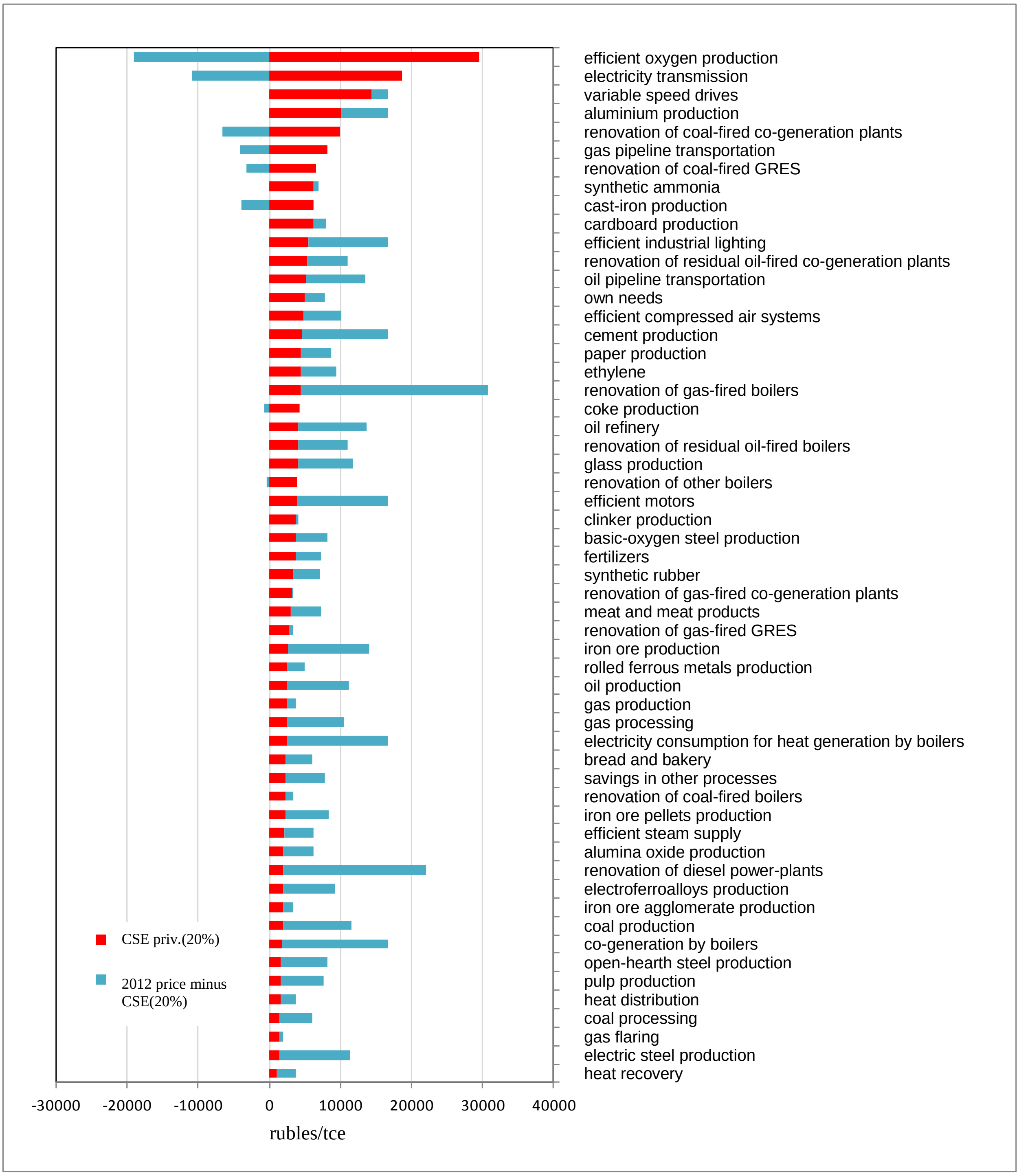
- Economic energy saving potential in the industrial sector (including fuel-and-energy complex) is 210 mln. tce (91% of the technical potential), which is 21 mln. tce below the technical potential (Fig. 1.21);
- average paybacks of industrial energy efficiency measures in OECD are less than 5 years, 1.5-2 years in other countries, and 4 years in Russia;
- for most energy efficiency measures, energy saving costs are lower, than the costs of energy purchase or generation (Fig. 1.22 and 1.23).

Figure 1.21 Comparison of technical, economic and market energy saving potentials in Russia as of 2012



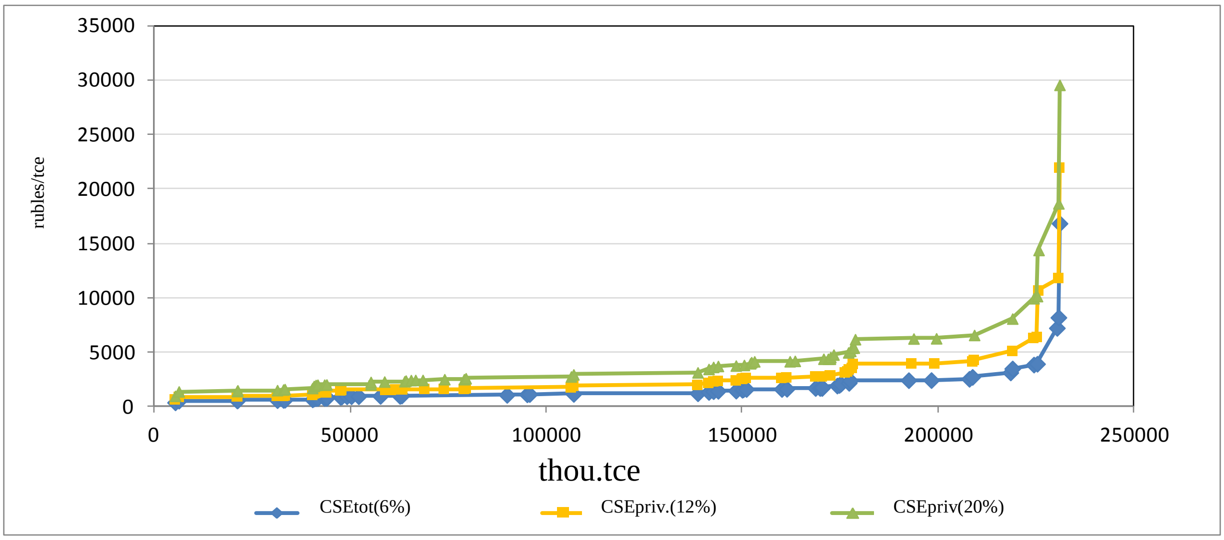
Source: CENEf

Figure 1.22 Assessment of energy saving costs (with 20% discount rate)



Source: CENEf. Red – reduced energy saving cost with a 20% discount rate. Blue – the difference between average Russian energy carrier price in 2012 in this industry and energy saving cost.

Figure 1.23 Energy saving cost curves for Russia's industry (with different discount rates)

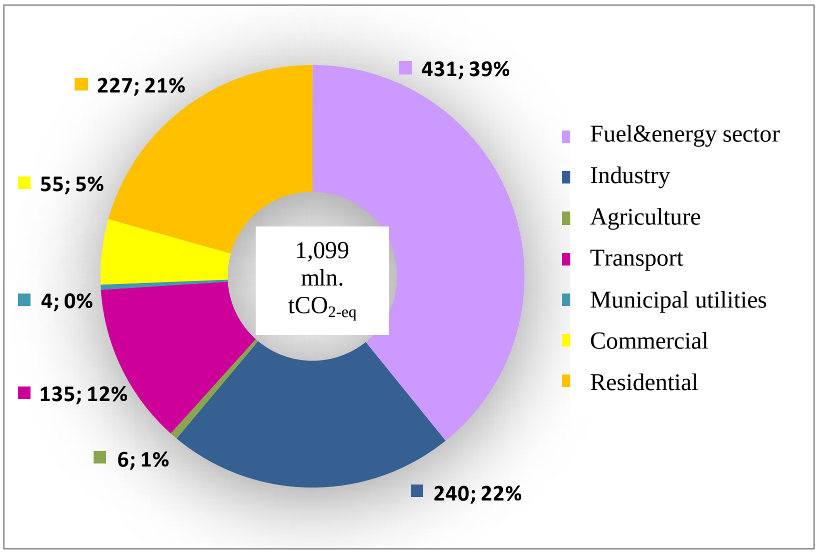


Source: CENEf

The share of industry (including fuel-and-energy complex) in Russia's GHG emission reduction potential is 61%

- If fuel-and-energy complex is not included, the share of industry in GHG emission reduction potential is 22% (Fig. 1.24);
- the major part of the potential is in electricity and heat generation, on condition that all indirect savings are attributed to this sector. In this case about 90 mln. t $CO_{2eq.}$ are attributed to industry, plus 24 mln. t $CO_{2\text{-}eq.}$ of gas flaring reduction, or almost 11% of GHG emission reduction potential;
- however, a substantial part of indirect savings result from end-use energy efficiency measures, so these savings are attributed to these sectors by four effects: electricity savings; heat savings; fuel processing; and reduced emission and leakage in fuel production. In this case, the share of industry grows up to 240 mln. t $CO_{2\text{-}eq.}$ (22%), and together with fuel-and-energy industries it equals 61%.

Figure 1.24 **Direct and indirect contributions of sectors to Russia's energy-related GHG emissions reduction potential in 2010 (mln. t $CO_{2\text{-eq.}}$)**



Source: CENEf. Transformed for 2011 based on I.A. Bashmakov and A.D. Myshak. Factors determining Russian energy-related GHG emission dynamics. Analysis based on the data from the National Inventory Report. FGBU "Institute of the Global Climate and Ecology of Roshydromet and the Russian Academy of Science". 2012.

The cost of saved energy. Prize: 1210 bln. rubles per annum

- overall energy cost savings from all considered measures, including fuel-and-energy industries, is 1,210 bln. rubles, or nearly USD 40 bln., per annum;

  this is equivalent to 42% of all industrial energy supply costs in 2012;

- with fuel-and-energy industries excluded, the savings equal 509 bln. rubles per annum;

  this is equivalent to 27% of overall industrial energy supply costs in Russia (excl. fuel-and-energy complex) in 2012;

- overall energy cost savings with the implementation of:

  economic energy saving potential equals 1,020 bln. rubles;
  market energy saving potential equals 959 bln. rubles.

1.4 Possibilities for “mining” energy saving potential in Russia’s industry

Key parameters that determine the effectiveness of energy efficiency measures in the industrial sector include:

- estimates of output volumes;
- estimates of equipment retirement;
- estimates of equipment retrofits;
- commissioning of new equipment;
- technology parameters of equipment retrofits (tuning to the average parameters of foreign equipment);
- technology parameters of new equipment. Two options were considered: tuning to the average and to the best parameters of foreign equipment (practical minimum).

Two scenarios were considered:

- Inertial: technology modernization will take place, but the rates will be close to those in 2000-2011. In some industries, large-scale projects have been, or are about to be, launched in the recent years to introduce new, energy efficient capacities. These effects of “autonomous” technical progress were integrated in the inertial scenario estimates;
- Innovative: industrial modernization process will be substantially accelerated through ***additional industrial energy efficiency policies***, allowing for a more dynamic reduction of specific energy consumption;
- the difference between energy consumption values in these two scenarios equals savings generated by additional energy efficiency policies (see example in Table 1.3);
- calculations were made using CENEf’s model Mod-Prom.

In the inertial scenario:

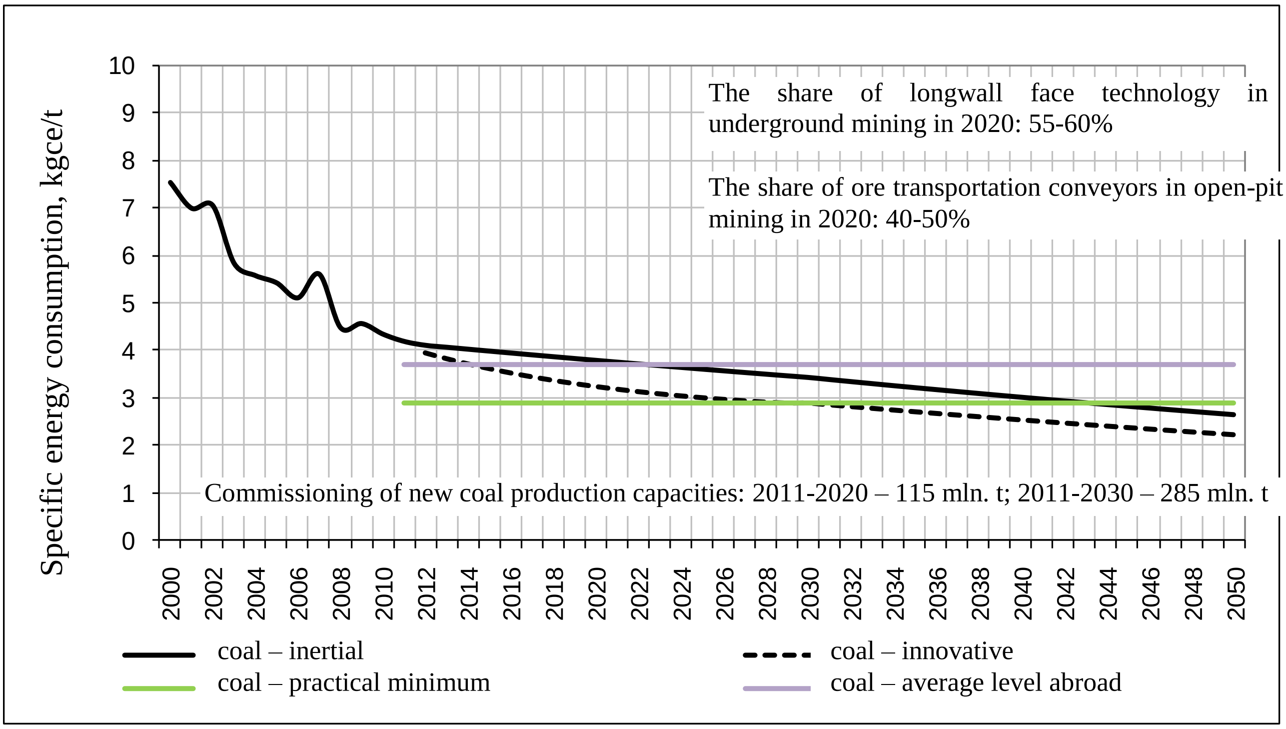
- by 2020, GDP energy intensity goes down by only 22% of the 2007 level;
- industrial energy intensity also goes down by 2020 by 22% of the 2007 level;
- energy efficiency improves much more slowly, than in the innovative scenario (Fig. 1.25-1.30);
- with growing energy prices, risks related to high energy intensity stay high.

Table 1.3 Energy efficiency benefits in cement industry

Sector	Cement industry
Anticipated savings	1,388 thou. tce in 2020, 2,445 thou. tce in 2030. Cumulative savings equal 8.37 mln. tce in 2013-2020, and 26.53 mln. tce in 2013-2030
Description of measures and application scale	Transition to a “dry” method of clinker production (multi-stage, from three to six stages), cyclone heat exchangers and pre-calcination kilns. Application of fluidized-bed kilns. Clinker production by low-temperature salt technology; installation of efficient heat exchangers and burners in cement kilns for intense clinker burning; automated combustion systems; timely decommissioning/retrofits of worn-out and/or obsolete equipment, insulation improvement. Flue gas heat recovery. More waste used as fuel in clinker burning kilns. Improving the efficiency of ball mills. Automation of process management. Introduction of efficient motors and variable speed drives. Increasing the share of agents, including smelter slug and thermal power plant ash in cement production.
Measures	Long-term agreements between the government and cement holding companies to improve energy efficiency (under the “500 energy intense plants” programme). Incentives: • investment subsidies per tce of energy saved (1,000 rubles/tce – Chinese experience); • federal guarantees and benefits for loans taken to implement investment projects; • zero VAT for imported process equipment, which has no counterparts in Russia; • profit tax exemption (up to 0.2% of the cost of energy resources used) for one year after the plant energy management system is certified; • incentives for production round up at small and obsolete plants Development of a database and benchmarking for specific energy consumption during natural gas transportation Development (translation and tailoring) of energy efficiency guidelines for energy managers in the cement industry
Assumptions made to assess the effect, and effect assessment	
2011 situation	Specific energy consumption for cement and clinker production – 196 kgce/t; specific energy consumption for clinker production – 200 kgce/t; specific electricity consumption for cement production – 106 kWh/t
Extrapolation of trends in 2020	Specific energy consumption for cement and clinker production – 172 kgce/t; specific energy consumption for clinker production – 185 kgce/t; specific electricity consumption for cement production – 101 kWh/t
Implementation of the programme measures in 2020	Specific energy consumption for cement and clinker production – 153 kgce/t; specific energy consumption for clinker production – 163 kgce/t; specific electricity consumption for cement production – 97 kWh/t
Emission reduction	Overall reduction of 8.4 mln. t $CO_{2\text{-eq.}}$ in 2013-2020 and 26.6 mln. t $CO_{2\text{-eq.}}$ in 2013-2030.
Capital cost of implementing the measures	27.8 bln. rubles in 2012 prices in 2013-2020. 45.6 bln. rubles in 2012 prices in 2013-2030.
Costs of saved energy	34 bln. rubles in 2013-2020 in 2012 prices. 109 bln. rubles in 2013-2030 in 2012 prices.

Source: CENEf’s estimates

Figure 1.25 Perspective reduction of specific energy consumption in coal production



The share of longwall face technology in underground mining in 2020: 55-60%

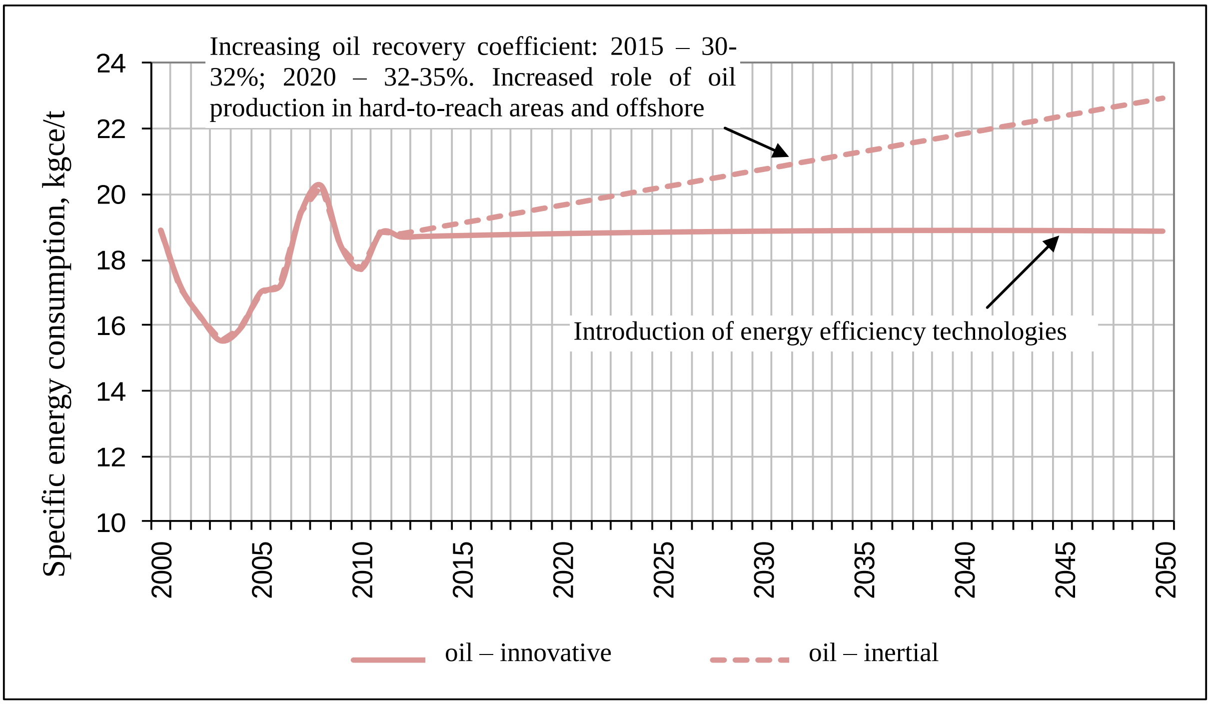
The share of ore transportation conveyors in open-pit mining in 2020: 40-50%

Commissioning of new coal production capacities: 2011-2020 – 115 mln. t; 2011-2030 – 285 mln. t

Before 2011 – reported data, 2012-2050 – projection.

Source: CENEf’s estimates.

Figure 1.26 Perspective evolution of specific energy consumption in oil production



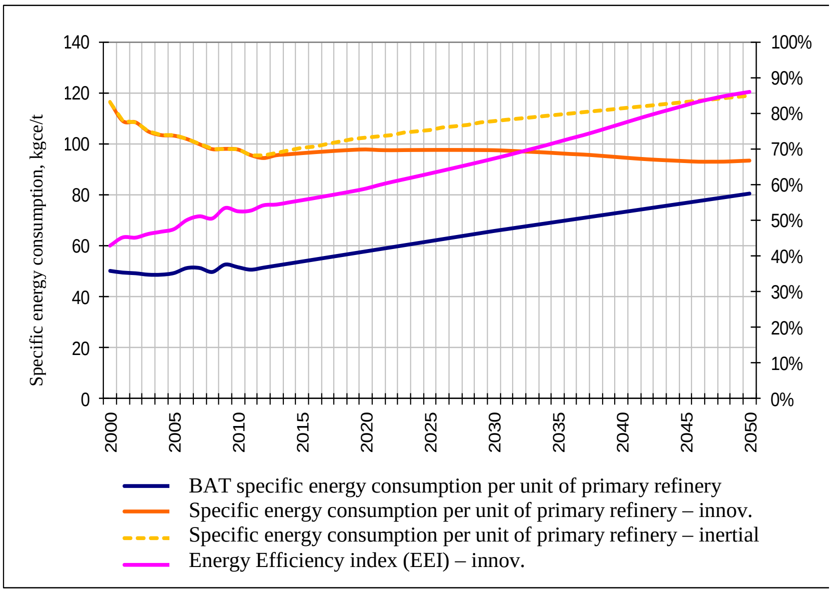
Increasing oil recovery coefficient: 2015 – 30-32%; 2020 – 32-35%. Increased role of oil production in hard-to-reach areas and offshore

Introduction of energy efficiency technologies

Before 2011 – reported data, 2012-2050 – projection.

Source: CENEf’s estimates.

Figure 1.27 Perspective evolution of specific energy consumption in oil refinery



2013-2020

Primary oil refinery: commissioned capacity – 9 mln. t; decommissioned obsolete capacity – 23 mln.t;

retrofits – 45 mln. t

Deep oil refinery: commissioned capacity – 14 mln. t; decommissioned capacity – 14 mln. t;

retrofits – 25 mln. t

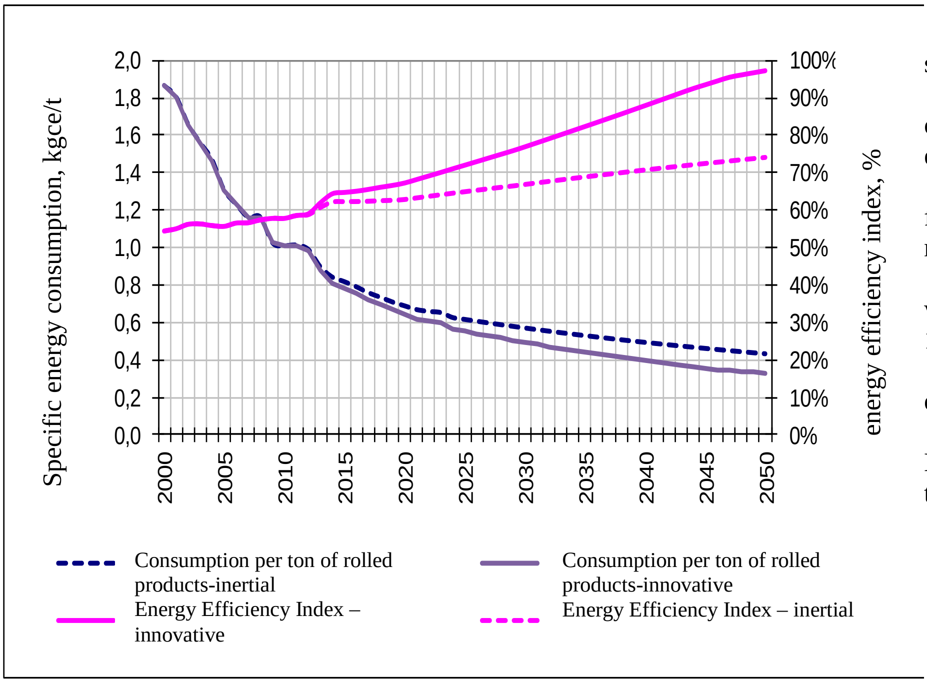
Commissioned BAT capacity. Capacity retrofits to reach current average foreign level.

Increased oil refinery level (to 81-83% in 2020).

Before 2011 – reported data, 2012-2050 – projection.

Source: CENEf's estimates.

Figure 1.28 Perspective evolution of integrated energy efficiency parameters in iron and steel industry



Elimination of open-hearth steel production by 2020.

Increased share of basic-oxygen steel to 61%, and electric steel to 39% in 2020.

Share of steel production from continuous casting machines in 2020: 99%.

Share of cast iron produced with pulverized coal injection: 15-20%.

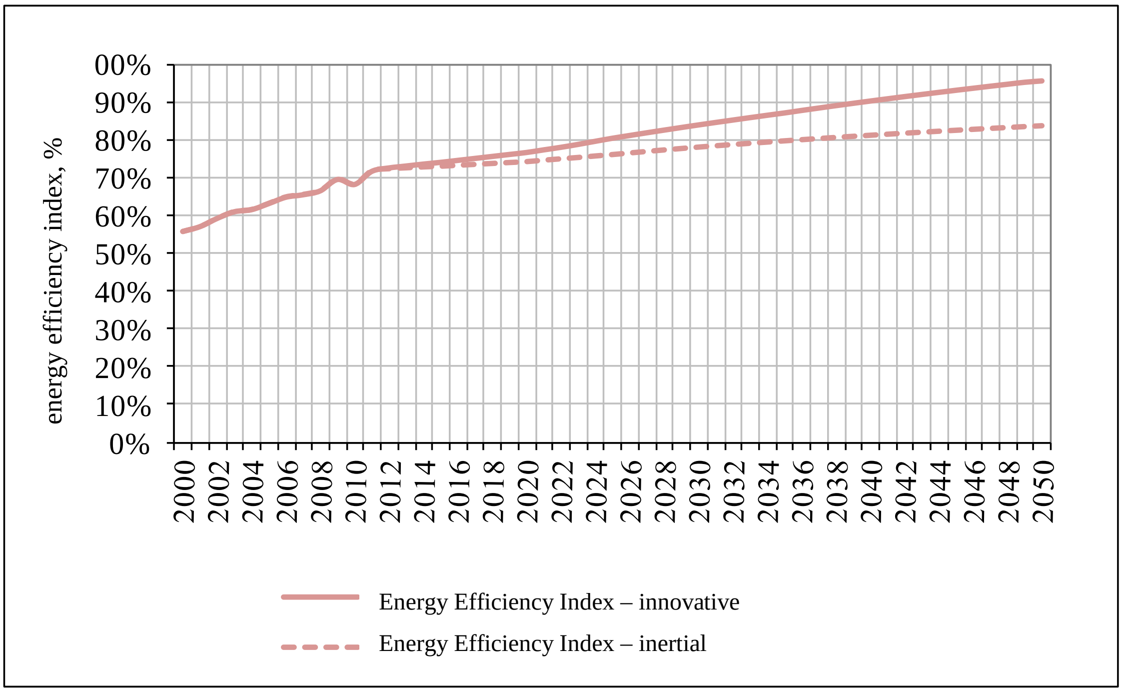
Commissioning of heavy-duty electric furnaces.

Increased application of Direct Reduction Iron technology

Before 2011 – reported data, 2012-2050 – projection.

Source: CENEf's estimates.

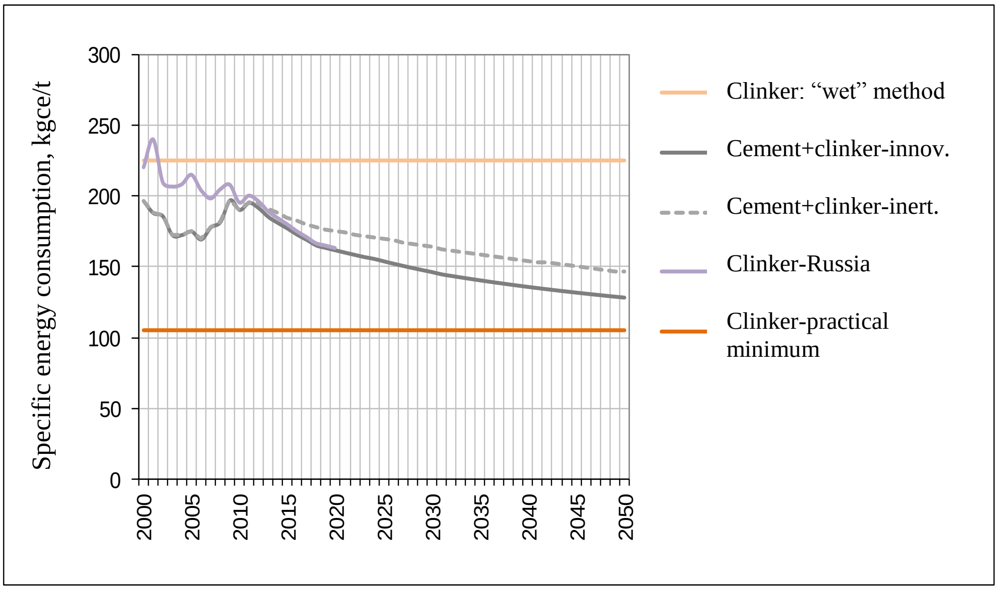
Figure 1.29 Perspective evolution of integrated energy efficiency characteristics in pulp and paper



Before 2011 – reported data, 2012-2050 – projection.

Source: CENEf's estimates.

Figure 1.30 Perspective evolution of specific energy consumption in cement production



Increased share of cement produced by the "dry" method: 57% in 2020.

Decommissioning of 8 mln. t old capacity in 2013-2020, commissioning of 29-31 mln. t new capacity with BAT specific energy consumption; 8 mln. t capacity retrofits.

Increased share of agents added to cement (to 25%).

Before 2011 – reported data, 2012-2050 – projection.

Source: CENEf's estimates.

In non-energy-intense industries, 60-90% of energy are consumed by cross-industry equipment

- industrial co-generation units and other sources and intrafactory power distribution lines;
- motors;
- heat- and steam supply systems;
- compressed air systems;
- lighting;
- oxygen and cold production, etc.

Cross-industry equipment projects bring the following advantages:

- development and use of wide-access databases and information portals (for consumers from different industries and sectors of economy);
- application of standardization and certification procedures;
- development of a special business focusing on the systems retrofits, with a large market formed by a variety of industries, possibilities for outsourcing, i.e. maintenance of industrial equipment by special energy service companies;
- development of standard bank products aiming at energy efficiency improvement of cross-industry equipment;
- simplified procedures of introducing tax incentives for purchases of energy efficient equipment, as it is cross-industry and certified;
- replication of successful programs and demo projects.

Efficient motors promotion policies require, that at least 20% of incremental capital costs be reimbursed through subsidies or tax benefits. This policy would bring 8 mln. tce in savings in 2013-2030 (Table 1.6)

- Chinese experts estimate average capacity savings generated by efficient motors at 670 USD/kW. It is 2-4 times less, than specific costs of new power plants construction in Russia;
- international experience shows, that installation of efficient motors normally pays back within 1-3 years;
- ESCO in cooperation with banks can tune the mechanisms to attract relatively short-term financing to projects dealing with motor and electric drive systems retrofits;
- for such financial schemes, banks with state participation can be attracted in the first place to test and further disseminate bank products to the whole bank system;
- South Korea provides subsidies for both production and installation of efficient motors (240 USD/kW, i.e. around 7,200 rubles/kW, of saved capacity) (Table 1.4), on condition that more than 0.5 kW is saved through improved capacity coefficient (cos φ). Subsidies are also provided for industrial lighting retrofits (Table 1.5).

Table 1.4 Incentives for the application of efficient industrial motors in South Korea

Equipment		Consumers	Equipment suppliers
Efficient motors and pumps	Benefit	7,200 rubles/kW of saved capacity	1,200 rubles/kW of saved capacity
	Beneficiaries	Consumers, who install new, or replace old, motors	ESCO or retail (final) sellers of motors
Variable speed drives	Benefit	5,700 rubles/kW of saved capacity	
	Beneficiaries	Those who buy variable speed drives	

Source: KEMCO Annual Report. 2007.

Table 1.5 Incentives for the application of efficient industrial lighting systems in South Korea (on condition that more than 1 kW is saved)

Efficient lighting	Type of lamp	Capacity (W)	Discount for a new lamp purchase (USD)	Discount for the old lamp replacement (USD/lamp)
Electronic control gear for efficient lighting	FLR 32W one tube	18		4.2
	F3L T-5 one tube	18	2.8	
	FLR 32W two tubes	36		6.3
	FPL T-5 two tubes	36	4.2	
Lamps with in-built electronic control gear		45	2.1	2.1

Source: KEMCO Annual Report. 2007.

Table 1.6 Assessing the effects of motor efficiency improvement

Sector	Industrial electricity supply systems
Anticipated savings	422 thou. tce in 2020, 802 thou. tce in 2030. Cumulative savings: 2.0 mln. tce in 2013-2020 and 8.05 mln. tce in 2013-2030.
Description of measures and application scale	Optimization of motor capacity; installation of highly efficient motors, which are part of the process equipment (pumps, compressors, industrial refrigerators, ventilation and air conditioning systems, conveyors, etc.). No rewinding. Replacement of 50% of obsolete motors with highly efficient models.
Measures	• Standardization and certification of motors by energy efficiency classes; • introduction of the “white certificates” scheme; • development of domestic manufacture of efficient motors; • development of standard bank products by banks with state participation to finance motor efficiency programmes; • development of tax incentives: accelerated depreciation of efficient motors; tax benefits; subsidized interest rate for old motors replacement projects; • development of a system to provide express estimates of motors efficiency (like Motor Rater); • development of a database and an information portal, guidelines to help industrial energy managers develop motors replacement plans; • support to ESCO specializing in motor replacement programmes.
Assumptions made to assess the effect, and effect assessment	
2011 situation	Number of motors: nearly 12 mln. Installed motor capacity: around 80 GW. Electricity consumption by motors: 120 bln. kWh. Share of efficient motors: 17%. Share of highly efficient motors: 3%
Extrapolation of trends in 2020	Share of efficient motors: 11% Share of highly efficient motors: 26%
Implementation of the programme measures in 2020	Increasing the share of efficient motors to 27% by 2020, and of highly efficient motors to 33%. Increasing the share of efficient motors to 43% by 2030, and of highly efficient motors to 57%.
Emission reduction	Cumulative reduction by 9.6 mln. t $CO_{2\text{-eq.}}$ in 2013-2020 and 38.4 mln. t $CO_{2\text{-eq.}}$ in 2013-2030
Capital cost of implementing the measures	6.7 bln. rubles in 2012 prices in 2013-2020. 12.8 bln. rubles in 2012 prices in 2013-2030.
Costs of saved energy	34 bln. rubles in 2013-2020 in 2012 prices. 135 bln. rubles in 2013-2030 in 2012 prices.

Source: CENEf’s estimates

1.5 Integrated cost/benefit analysis of energy efficiency measures in Russia

Development under the "conservative energy" scenario will increase industrial energy supply costs from 2.7 trillion rubles in 2011 to 6.9 trillion rubles in 2020 and to 15.3 trillion rubles in 2030. In other words, they will grow at least 5-6-fold!

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- While the share of energy costs in the overall costs of shipped Russian products in 2011 was 7%, and for manufacturing 8.7%, in the U.S. it was only 3%;
- energy tariffs, if not compensated by substantial energy efficiency improvement, will lead to further decline of competitiveness of the Russian industry;
- the large gap in industrial energy efficiency between Russia and other countries (to say nothing of BAT) will not be bridged;
- transition to the innovative scenario and intensification of Russian industrial retrofits will allow it to use an additional resource of energy efficiency (which is at least 64 mln. tce in 2030) (Fig. 1.31);
- this will reduce industrial energy intensity by 42% by 2030;
- it will also reduce industrial GHG emission by 85 mln. t $CO_{2\text{-eq}}$. by 2020 and by 152 mln. t $CO_{2\text{-eq}}$. by 2030 (Fig. 1.32). The latter figure equals 10% of Russian energy-related GHG emission in 2010. Let us add here, that this emission reduction will be additional compared to the inertial scenario.

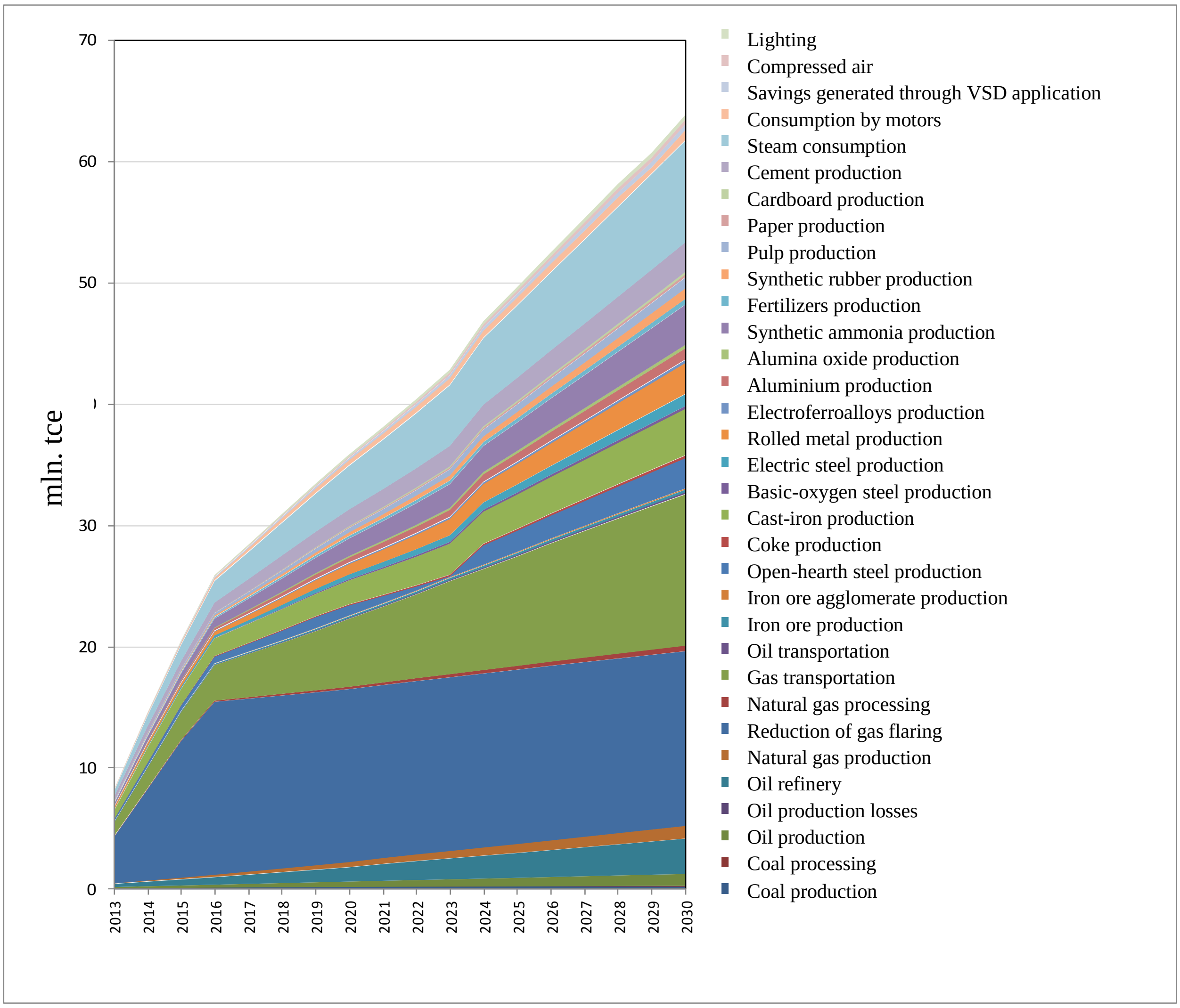
Substantial financial resources are needed to implement these measures within 18 years: 1,330 bln. rubles

- This is nearly USD 44 bln., or around 74 bln. rubles on average per annum (Fig. 1.33), including 500 bln. rubles for the modernization of the gas transportation system. Excluding this latter component, the cost would be 830 bln. rubles (around USD 26 bln., or 46 bln. rubles per annum).

According to the IEA, in 2011 Russia spent USD 5,700 mln., or nearly 174 bln. rubles, for energy efficiency

- CENEf's estimates are close: USD 5,200-5,900 mln. Of these, around USD 1,000-1,200 mln., or 30-36 bln. rubles, were spent on industrial energy efficiency;
- therefore, the goal is to practically double average annual energy efficiency investment until 2030.

Figure 1.31 Reduction of energy consumption through additional energy efficiency measures in industry



Source: CENEf.

What difference will this investment make? It will bring 170 bln. rubles in 2020 and 360 bln. rubles in 2030 in 2012 prices in annual energy cost savings (Fig. 1.34)

- Overall savings in 2013-2020 will account for 857 bln. rubles, and in 2013-2030 for 3,570 bln. rubles, or USD 117 bln. This is as much as:

✓ 1.3 years overall energy supply costs of the whole industrial sector;

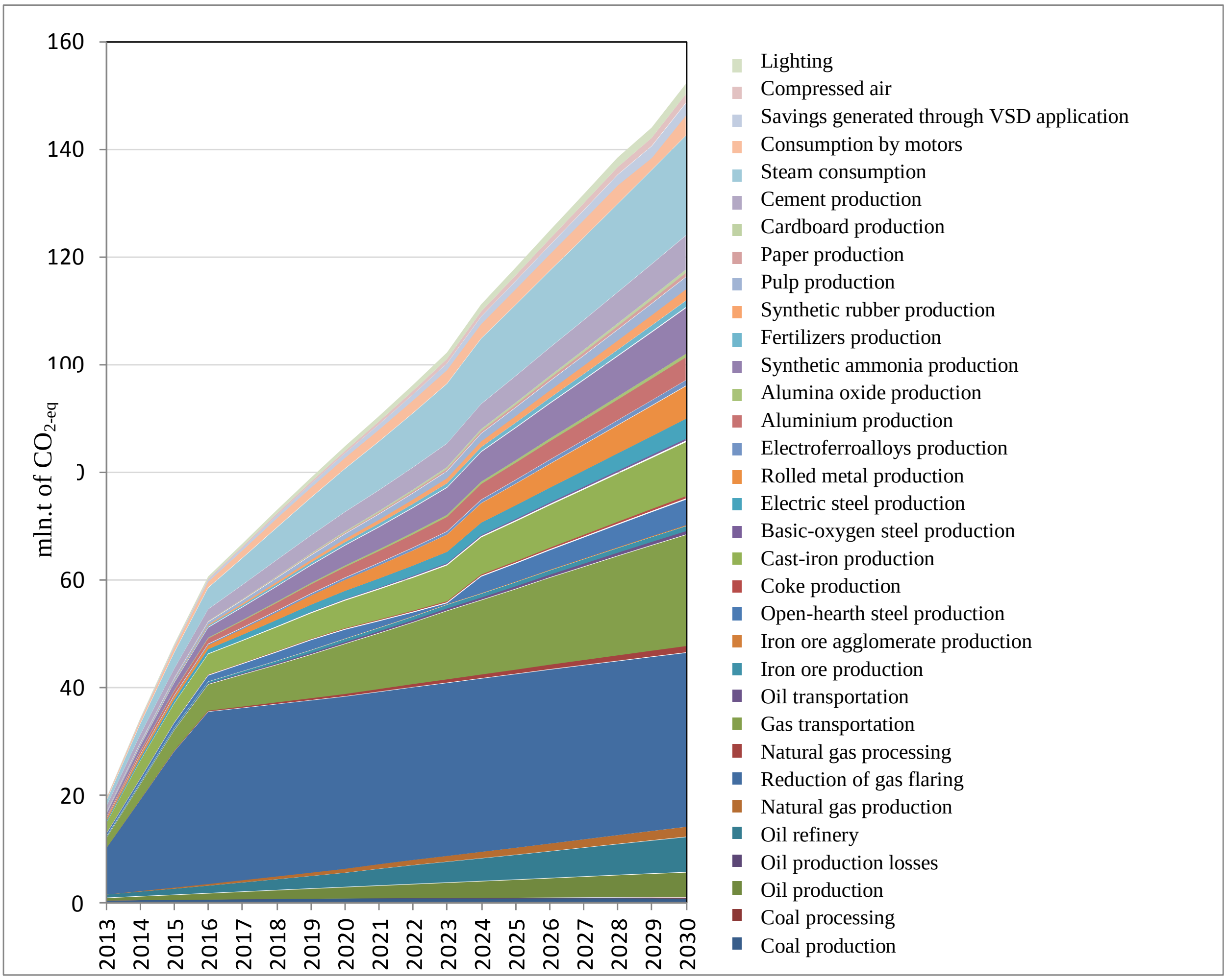
✓ 67% of oil export revenues in 2011;

✓ 183% of gas export revenues in 2011;

✓ 10 times fertilizers export revenues in 2011;

✓ more than 5 times iron and steel export revenues in 2011.

Figure 1.32 **GHG emission reduction through additional energy efficiency measures in industry**

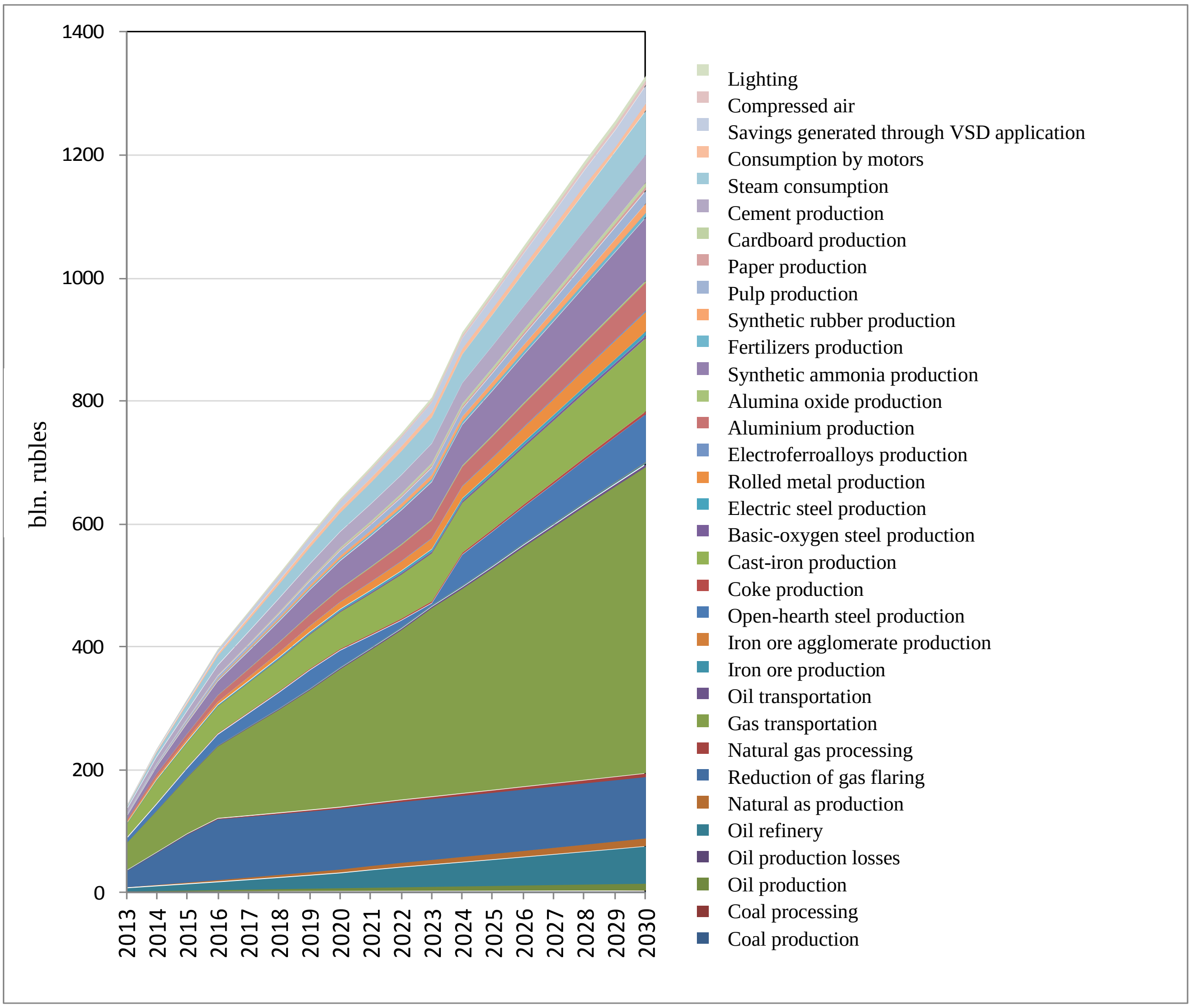


Source: CENEf

With energy tariffs growth over 2013-2030 in mind, energy savings in the industrial sector in then-year rubles will be substantially larger

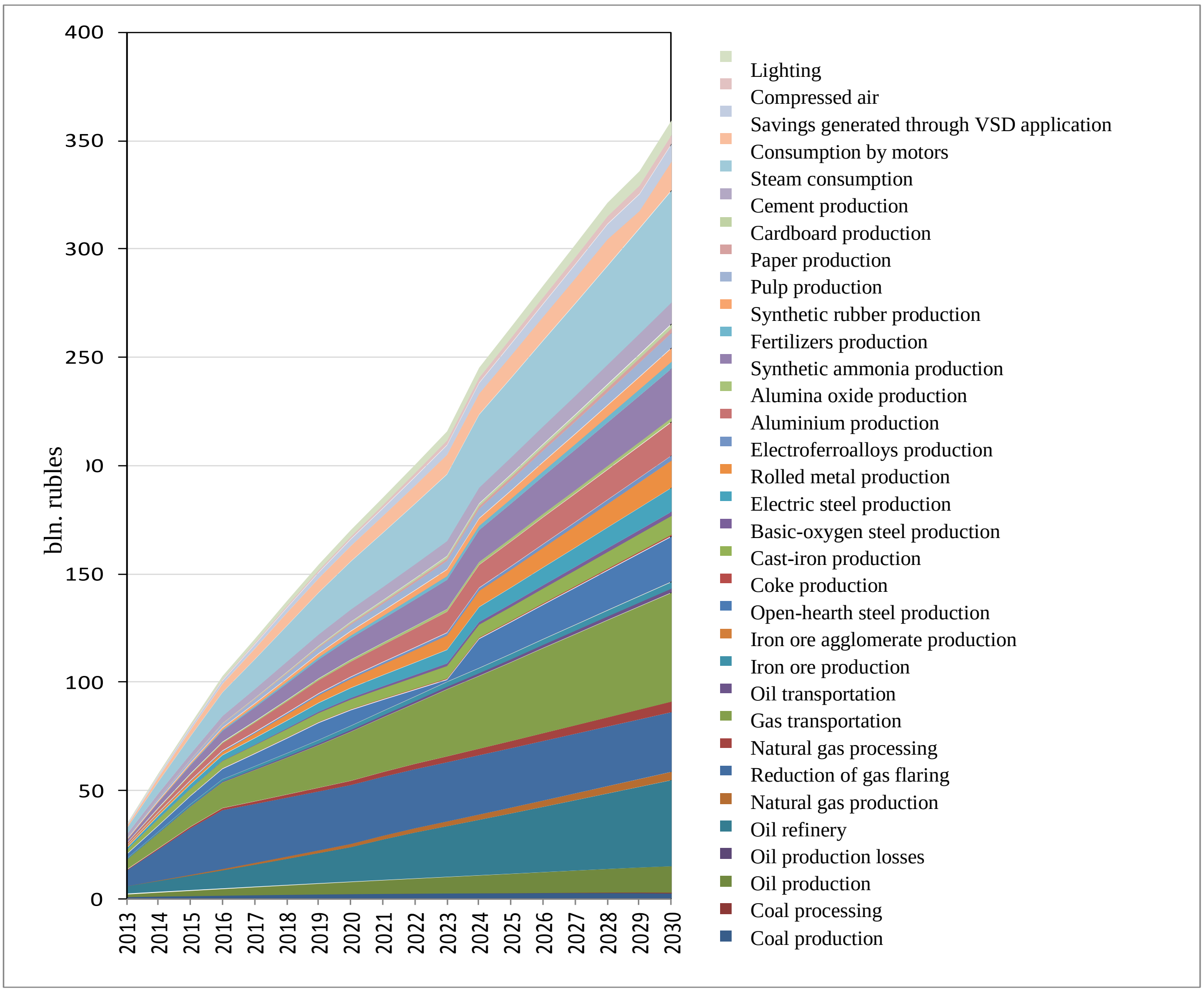
- In all, over 2013-2020:
  - ✓ for industry they will be 1,090 bln. rubles;
  - ✓ for the electricity sector nearly 800 bln. rubles;
  - ✓ for the heat sector another 280 bln. rubles;
  - ✓ for pipeline transportation 470 bln. rubles;
- total: 2,640 bln. rubles.
- Otherwise industrial energy supply costs in 2020 would be 40% higher.

Figure 1.33 Implementation costs of additional energy efficiency measures in industry



Source: CENEf

Figure 1.34 Energy cost savings from additional energy efficiency measures in industry



Source: CENEf

Summing up, let us point out that implementation of additional energy efficiency measures in industry in 2013-2030 would help:

- reduce industrial energy consumption by 64 mln. tce in 2030 and by 706 mln. tce in 2013-2030;
- reduce GHG emission by 85 mln. t $CO_{2\text{-eq.}}$ in 2030 and by 1,673 mln. t $CO_{2\text{-eq.}}$ in 2013-2030;
- over 17 years cumulatively reduce the costs of energy supply to Russian industry by USD 117 bln. and limit their growth by 2030 to 40% compared to the conservative scenario.

In order to achieve this, it is important to at least double average annual investment in industrial energy efficiency projects in the coming 17 years and for this purpose develop an effective private-public partnership in industrial energy efficiency improvement.

1.6 What's interfering? Barriers to energy efficiency improvement in industry

Energy efficiency potential, like oil deposits, can be large, but it will stay "in situ" until a "well" is drilled. Deposit development should start from going through the dense rock of barriers to energy efficiency

- These barriers are very diverse: pricing and financial; those related to the structure and organization of the economy and market; institutional barriers; social, cultural, behavioral, etc;
- practically all of them are removable through targeted energy efficiency policies;
- so that these policies were effective, it is important to clearly realize the main barriers to the introduction of energy efficiency technologies and behavioral patterns.

Lack of motivation

- Limited competition and a possibility to shift increased costs to consumers (until their solvency thresholds are reached), cross subsidies, lack of consumption control and metering – all this brings energy efficiency motivation down;
- economic mechanisms are such that it is not always clear, who benefits from energy savings, and the beneficiary is not institutionally defined. Today, it is not always possible to get an answer to a simple question: who in person is interested in energy efficiency improvement?
- consumer reactions are provoked by the growing share of energy costs in the income. If consumers can compensate tariff growth by improved energy efficiency, then energy price hikes do not hamper economic growth, or accelerate inflation, or reduce payment discipline;
- confiscation of savings in the business-to-business, budgetary, and tariff processes is the major problem;
- under such circumstances, energy price growth provides incentives for the justification of further tariff growth or for additional financing demand, rather than for energy efficiency improvement;
- energy efficiency ought to be included in the set of indicators used for performance budgeting and is to be used by the governance bodies to assess the performance of industrial energy systems operators.

Lack of information	• Borne by the market price information alone cannot spur energy efficiency improvement; • market signals should be put on prepared soil, pass through unclogged channels, if they are to be picked up, providing there is a technical opportunity to react to the market signals; • introduction of energy efficiency standards is a barrier to inefficient technologies and equipment, and so is quite effective in the sectors where information barrier is most important; • information and motivation are often ignored while developing and implementing solutions; • not many people spend time and money looking for information, the majority act by stereotypes. Behavioral stereotypes ("Do as everybody does!") are so popular exactly because they relieve from having to look for information and from decision-making.
Lack of financial resources and "long" money	• Insufficient financing of the maintenance of energy supply systems is another factor determining insufficient financing of energy efficiency activities; • large companies and banks have much stricter payback and cost reduction requirements to energy efficiency projects, than to new construction projects; • those who have financial difficulties and no own capital, who cannot attract loan capital, are most vulnerable in terms of energy inefficiency.
Lack of organization and coordination	• Takes place at all decision-making levels; • in Russia, so far there are few federal authorities responsible for the coordination of energy efficiency activities in industry (a sector with thousands of jobs).

Some 20 years ago, a list of 16 barriers to energy efficiency improvement in industry was developed, which is still viable[2]:

1. Lack of detailed and comprehensive information on energy consumption by industrial processes by plant divisions;
2. Lack of information on energy efficiency technologies;
3. Lack of energy efficient equipment, meters and controls in the market;
4. Competing responsibilities of the management;
5. Unwillingness to be a pioneer in the implementation of new ideas and introduction of new technologies;
6. Lack of benefits (or unawareness of any benefits) provided by the state or energy utilities for the implementation of energy efficiency projects;
7. Restraining influence of threshold paybacks at the project initiation stage;
8. Project implementation delayed until previously installed equipment is completely depreciated;
9. Low rank of cost reduction projects in companies' strategic plans;
10. Unlikelihood of obtaining financing for projects which rank low in the strategic plan;
11. Growing share of obligatory projects in the overall investment programme;
12. Limited financing for small cost reduction projects;
13. Inertial process of capital distribution by types of projects;
14. Inefficient combination of segments of the energy efficient equipment market;
15. High threshold requirements to investment performance during investment distribution by projects;
16. Higher requirements to the profitability of small projects compared to large ones.

These barriers are universal, and little do they depend on the business location

- For example, Johnson Controls has identified the following major barriers to energy efficiency in Chinese industry based on energy managers' opinions:
  - ✓ large paybacks (21% of respondents);
  - ✓ insufficient expertise (18%);
  - ✓ lack of financing (17%);
  - ✓ uncertainty in terms of energy savings volume and sustainability (17%); and
  - ✓ little attention paid to energy efficiency issues (13%).
- In Europe, barriers rank practically in the same order.

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[2] I. Bashmakov. Financial and economic analysis of energy efficiency projects. Moscow, CENEf. 1993.

1.7 Energy efficiency policies in Russian industry and policy experience in other countries

Industry is a sector, where energy efficiency policies are very limited

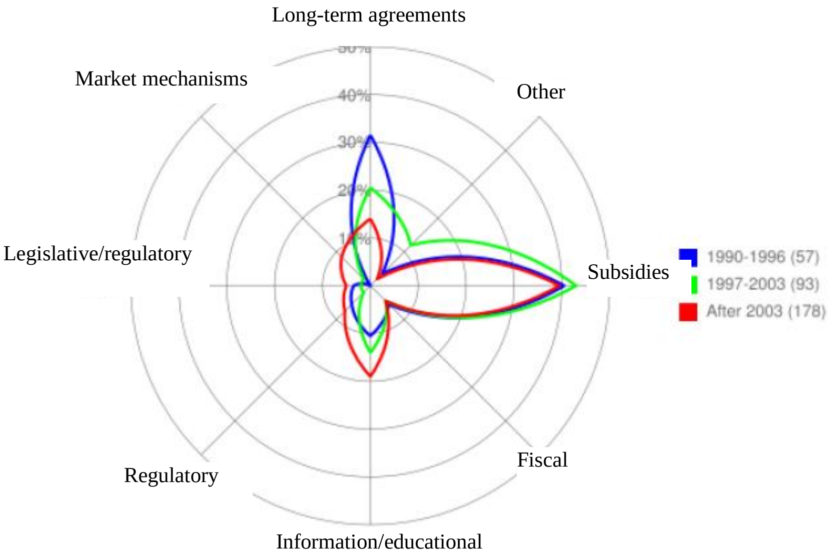
- They primarily deal with energy audits and do not meet IEA’s recommendations (Table 1.7);
- U.S., European, and Chinese legislature pay much more attention to industrial energy efficiency;
- investigation of the number of policies applied in the EU industry showed, that 30 policies are applied in Germany, 14 in France, 13 in Great Britain, 9 in the Netherlands. On average, nearly 10 policies are applied in each EU country;
- they form sort of a “shamrock” of industrial energy efficiency policies (Fig. 1.35);
- countries that meet with more difficulties in industrial energy efficiency improvement apply more policies;
- most popular policies deal with co-generation units, motor systems, compressed air, and lighting.

Table 1.7 IEA policy recommendations and Russian energy efficiency regulation on industry

IEA EE policy recommendations	Russian regulatory acts enacting corresponding policies
Governments should support the IEA energy efficiency indicator work that underpins critical policy analysis by ensuring that accurate energy intensity time series data for industrial sectors is reported regularly to the IEA. Governments should consider adopting mandatory minimum energy performance standards for electric motors in line with international best practice. Governments should examine barriers to the optimization of energy efficiency in electric motor-driven systems and design and implement comprehensive policy portfolios aimed at overcoming such barriers Governments should consider providing effective assistance in the development of energy management (EM) capability through the development and maintenance of EM tools, training, certification and quality assurance. Governments should consider developing and implementing a package of policies and measures to promote energy efficiency in small and medium-sized enterprises (SMEs).	*RF Government Resolution No. 2446-r dated December 27, 2010 "On adopting the Federal program «Energy conservation and energy efficiency until 2020»"* Sets several indicators for energy intense industries and a system of program monitoring to track energy efficiency indicators in industries. *Federal program "Energy efficiency and energy development"* contains no energy efficiency indicators for the industrial sector. *Federal law No. 261-FZ "On energy saving and improving energy efficiency and on amending some legislative acts of the Russian Federation"* Mandates energy audits for organizations with federal or municipal involvement; organizations involved in regulated activities; organizations involved in the production and/or transportation of water, natural gas, heat, electricity, production of natural gas, oil, coal, petroleum, transformation of natural gas and oil, transportation of oil and petroleum products; organizations with overall annual natural gas, diesel and other fuels, residual oil, heat, coal, electricity bills exceeding 10 million rubles. *RF Government Decree No. 391 dated June 1, 2010 "On the procedure for developing a federal energy conservation and energy efficiency information system and on the conditions for its operation"* Specifies that the RF Ministry of regional development is to present to the operator of the federal information system data on the availability of information on energy efficiency classes in the technical documentation attached to industrial goods, as well as on labels and stickers. *RF Government Decree No. 19 of 25 January, 2011 "On approving the requirements for the collection, processing, systematization, analysis, and use of the data of energy passports, based on mandatory and voluntary energy audits"* *Order of the RF Ministry of energy No. 182 dated April 19, 2010 "On approving the requirements for energy passports based on mandatory energy audits and for energy passports based on design documentation, and on the rules of forwarding a copy of the energy passport developed based on a mandatory energy audit"* Provides a format for energy passport, but does not set mechanisms for further processing of energy passports, or further analysis and decision-making. Energy efficiency performance standards for motors are missing. A package of measures to promote energy efficiency at SME is missing. Certification of energy managers is missing.

Source: CENEf

Figure 1.35 Distribution of energy efficiency measures in EU industry by types and compliance dates



Source: Energy Efficiency Policies in Industry. Lessons Learned from the ODYSSEE-MURE Project. ADEME. Draft September 2012.

RF Government Decree No. 562 dated August 12, 2011 "On approving the list of top energy efficient facilities and technologies, investing in which makes eligible for investment tax credits" specifies, that:

- An organization which invests in the production of highly energy efficient facilities or technologies is eligible for an investment tax credit;
- the list of such facilities and technologies was revised and includes 56 items (used to be 4);
- for example, it includes facilities and technologies related to the production of high temperature superconductor, light-duty vehicles, cardboard, paper, pulp, synthetic rubber, fertilizers, electroferroalloys, LED lights;
- it is not clear, if this benefit works.

Federal regulation of industrial energy efficiency may look at two basic groups of industrial enterprises:

- **Large, energy intense plants** (fuel&energy complex, iron and steel, non-ferrous metals, chemistry and petrochemistry, pulp and paper, cement production). Agreements to reach target energy efficiency indicators are the major tool for energy intense industries. Modernization of basic technologies in energy-intense economic activities is an important method of reaching the target values.
- **Small- and medium-size enterprises.** Large-scale implementation of typical technical projects, i.e. projects which include a set of cross-industry measures, is the basic tool for non-energy intense industries. Modernization of cross-industry equipment is an important direction of energy efficiency improvements in these industries.

In Russia, there is no history of public-private partnerships in energy efficiency. The following 10 steps are needed for energy efficiency agreements:

1. Specify industrial energy intensity reduction target to be achieved by 2020;
2. For some industries, the RF Ministry of energy, RF Ministry of economic development and/or RF Ministry of industry and trade should develop “Guidance to specify industrial energy efficiency indicators”, like it has been done in many countries. Targets may be formulated as absolute savings, reduction of specific energy consumption, or evolution of energy efficiency indices;
3. Identify industrial groups and holding companies, and possibly, unions and associations, which can become parties to energy efficiency agreements. Determine the energy consumption threshold for a company to become a party to the agreement;
4. Decompose industrial energy efficiency target into a system of low-level energy efficiency targets for separate industries (as average weighted by major products) and/or for industrial products;
5. Develop a benchmarking system for enterprises, so they can compare their specific energy consumption to average values across the industry and to the world “best practices” for similar conditions. In addition, the benchmarking system shall provide energy efficiency recommendations and display energy efficiency rating of the enterprise after it implements energy efficiency recommendations;
6. Industrial groups, companies, unions, or associations, which are to become parties to such agreements, make energy audits and develop plans to meet their energy efficiency commitments. “Energy efficiency plan development guides” are to be developed. Companies make commitments to implement projects with up to 5 years paybacks and to introduce energy management standards;
7. Representatives of the federal government and of industrial associations coordinate energy efficiency targets and plans; the targets and plans shall be revised at least once every five years;
8. Coordinate formats for annual reports on the plan implementation and energy efficiency targets achievement, and develop a monitoring system. Develop a system to verify monitoring results and assign a federal agency with monitoring and verification responsibilities;
9. Specify financial incentives for parties to the agreements, who successfully implement their plans and reach their energy efficiency targets, and specify penalties for those who fail to comply with their commitments;
10. An analytical center authorized by the government estimates the effectiveness of the energy efficiency agreements at least once every three years. The estimates focus on the development of recommendations on how to improve the program and assess its direct and indirect effects.

In addition to long-term agreements, a considerable experience in industrial energy efficiency policies has been accumulated globally. The following measures should be taken to launch and successfully operate these mechanisms:

- development of statistical monitoring of industrial energy efficiency and of the shape of energy equipment;
- setting energy efficiency targets, a benchmarking system, and monitoring the achievement of energy efficiency targets and the effectiveness of typical projects implementation;
- enforcement of new standards and technical regulations for industrial equipment;
- energy audits, including specialized audits by types of industrial process equipment and development of energy efficiency plans;
- enforcement of energy management standards, personnel training and providing informational support;
- support to the energy service business to maintain, and improve the efficiency of, cross-industry equipment;
- introduction of subsidies and tax benefits;
- encouraging utilities to support energy efficiency activities in the industrial sector;
- energy tariff regulation;
- support to R&D in industrial energy efficiency.

Energy efficiency benchmarking system for plants producing similar products can operate in two modes:

- ***Mandatory and depersonalized***, which provides data on specific energy consumption by plants for product manufacturing, without mentioning the plants' names. This system shall be based on, but not limited to, annually published data of 11-TER statistical form and the federal energy register. It will also use foreign data, including data from special benchmarking information systems and world best energy efficiency practices[3];
- ***Voluntary, which shall provide the names of companies.*** In this case, the company rating system builds on the work of industry associations and is supported by industrial scientific and information centers[4]. The system operation includes annual workshops, an Internet website and columns is specialized periodicals.

For the optimization of industrial energy systems, it is important to:

- develop:
  - ✓ plant energy balance[5], and
  - ✓ general outline of a plant's energy supply development,

  so that basic technical solutions could be developed in the framework of these two documents;
- energy supply contracts are an important factor for effective energy management.

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[3] This is the way many systems operate in Canada.

[4] This is the way the system operates in South Korea.

[5] See Guidelines to improve energy efficiency in the food industry. Dena and CENEf. Moscow, 2002.

In 2012, the United States launched a certification program titled Superior Energy Performance (SEP)

- It will provide plants with roadmaps for continuous improvement in energy efficiency while maintaining competitiveness;
- the program will provide a transparent, globally accepted system for verifying energy performance improvements and management practices;
- the focus of the program is implementation of the global energy management standard, ISO 50001, with additional requirements to achieve and document energy performance improvements;
- experts estimate, that the SEP and ISO 50001 can improve industrial energy efficiency by 10-30%.

China. Long-term agreements. Success of the "Top-1000" programme. While the target for 2006-2010 was 100 mln. tce in savings, the actual savings were 150 mln. tce. In the 12th 5-year plan the program was expanded, and now it is "Top-10000". The target of this programme is 250 mln. tce in savings over 5 years

- China is the global leader in energy efficiency financing. According to CENEf, in 2011 China spent USD 57 bln. on energy efficiency;
- these 1,000 plants (1,008 to be more exact) are responsible for 33% of the country's total energy consumption and for 47% of China's industrial energy consumption;
- energy consumption reduction targets were set for each of the plants for 2010, and each plant was to establish an energy saving unit, outline energy efficiency measures, develop energy consumption reporting, make energy audits and training, develop energy efficiency plan, invest in energy efficiency;
- the plants must report their energy consumption to the National Statistics Bureau on a quarterly basis;
- the industries included in the Top-1000 program are large-scale enterprises in nine major energy-consuming industries (250 iron and steel, 100 petroleum and petrochemicals, 240 chemicals, nearly 140 electric power generation, around 70 non-ferrous metals, 55 coal mining, 95 construction materials, nearly 20 textiles, and 20 pulp and paper)[6].

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[6] L. Price, X. Wang and J. Yun. The Challenge of Reducing Energy Consumption of the Top-1000 Largest Industrial Enterprises in China. Energy Policy, Volume 38: Issue 11. November 2010.

To provide incentives for industrial companies, they were awarded at a rate of USD 24-30 per every tce saved per year. The initial subsidy (60%) was around 5-10% of the project costs. The share of energy efficiency costs in the new equipment cost is normally 15-20%. In other words, the Chinese government financed nearly half of incremental energy efficiency costs

The rewards and tax rebates are paid to enterprises on condition that:

- ❖ they have energy metering to document proven energy savings;
- ❖ proven savings of at least 10,000 tce from "energy saving technical transformation" projects, which are to be confirmed by the regional commission for economics and trade;
- ❖ the project should fall into one of the five categories: modernization of coal-fired boilers or furnaces; heat or excess pressure recovery; oil or petroleum products savings; motor energy efficiency improvement; optimization of energy supply;
- ❖ the company is to be at least 3 years in the market;
- ❖ the company has to consume at least 20000 tce per year (this condition was only included in the 12th 5-year plan).

The awarding process is structured as follows:

- ❖ the enterprise sends an application to the provincial government;
- ❖ after the application is approved, it is forwarded to the Commission for national development and reform and to the Ministry of Finance for further consideration;
- ❖ after final approval the enterprise gets 60% of the award for the declared savings as an advance payment to finance the programme implementation;
- ❖ the rest of the amount is paid after the project is completed based on the verification report submitted to the Ministry of Finance.

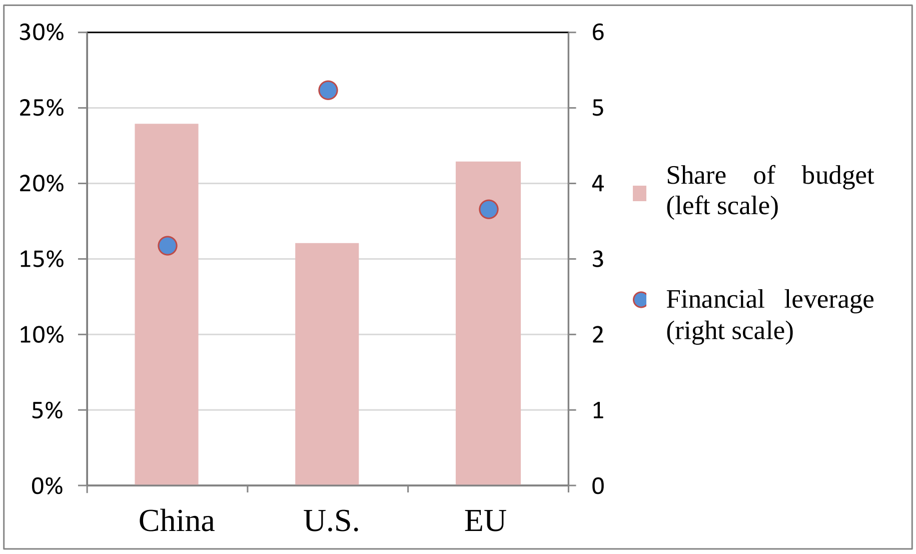
The share of public funds in these costs varies between 15% in the U.S. to 24% in China (Fig. 1.36 and 1.37)

- In industry, the financial leverage, i.e. ability to attract private financing per 1 dollar of public funds, is 5.7 in the EU, 5.2 in the U.S., and 3.2 in China. In other words, USD 3-6 can be attracted from various sources per every dollar invested by the government;
- Russia is trying to make this leverage infinite;
- industry is dominated by non-budgetary energy efficiency financing sources. These primarily include loans, lease, own capital, energy efficiency funds, and energy utility programmes.

Factors that determine the success of energy efficiency measures in industry

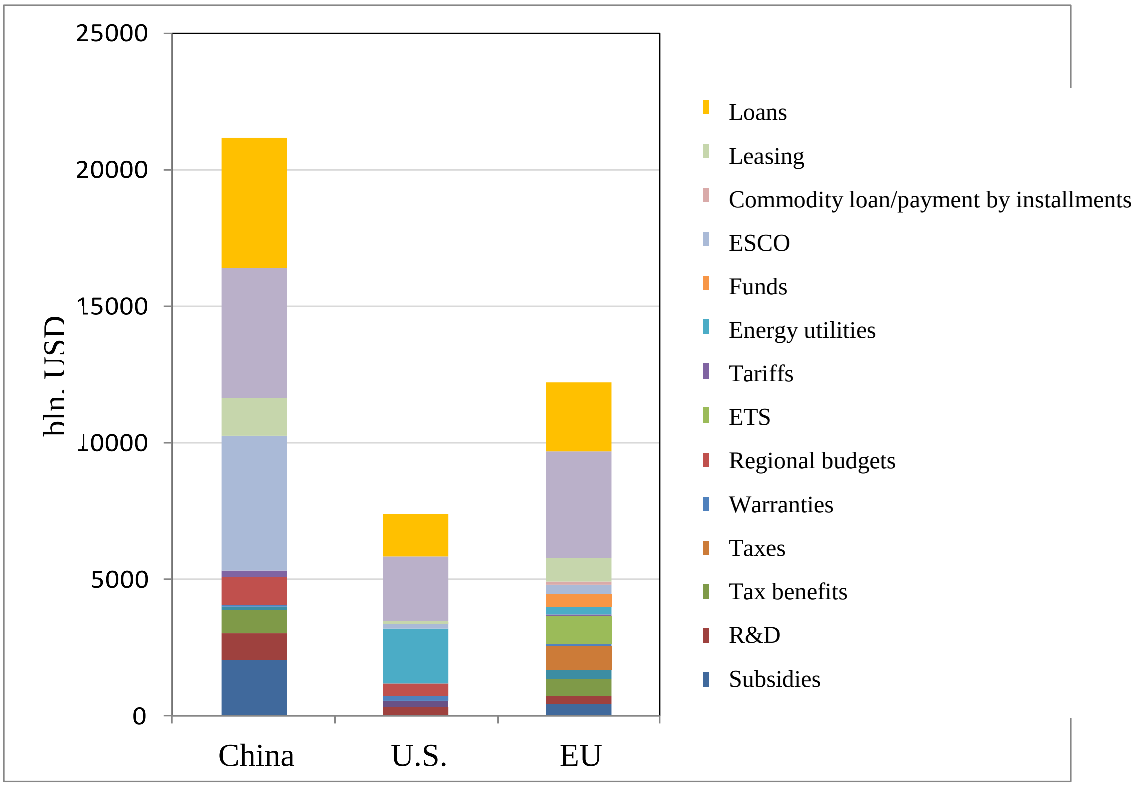
- The level and rates of economic development;
- phase of the business cycle (combination of the investment and restoration growth, capacity load evolution, price dynamics);
- energy efficiency potential and potential implementation costs;
- set of measures complementing one another;
- development of a viable public-private partnership in energy efficiency;
- economic incentives for energy efficiency measures provided by the government.

Figure 1.36 The role of public funds in leveraging non-budgetary financing in the industrial sectors of China, U.S., and EU



Source: CENEf's estimates

Figure 1.37 Financing industrial energy efficiency in China, U.S., and EU in 2011: volumes and sources (mln. USD)



Source: CENEf's estimates.

2 Risks pertaining to continued existence of industrial energy inefficiency in Russia

2.1 Risks pertaining to continued existence of high energy intensity of Russian industry

The following risks pertaining to industrial energy inefficiency can be pointed out:

- reduced competitiveness as fixed assets increasingly wear out;
- reduced profitability of production as energy prices grow up, and so less financing available for innovations;
- slowly going retrofits of fixed assets and slow market expansion for innovative domestic equipment, which means slow development of machine building and continued existence of low productivity;
- continued high load on the environment; GHG emission; waste disposal; and specific harmful emissions into the atmosphere and water along with limited access to the "green" bank products;
- possible discrimination of Russian goods for having a large "carbon footprint";
- exhausted resource base along with little use of secondary energy resources;
- weakened position in the global market (products do not meet international standards and accreditation systems).

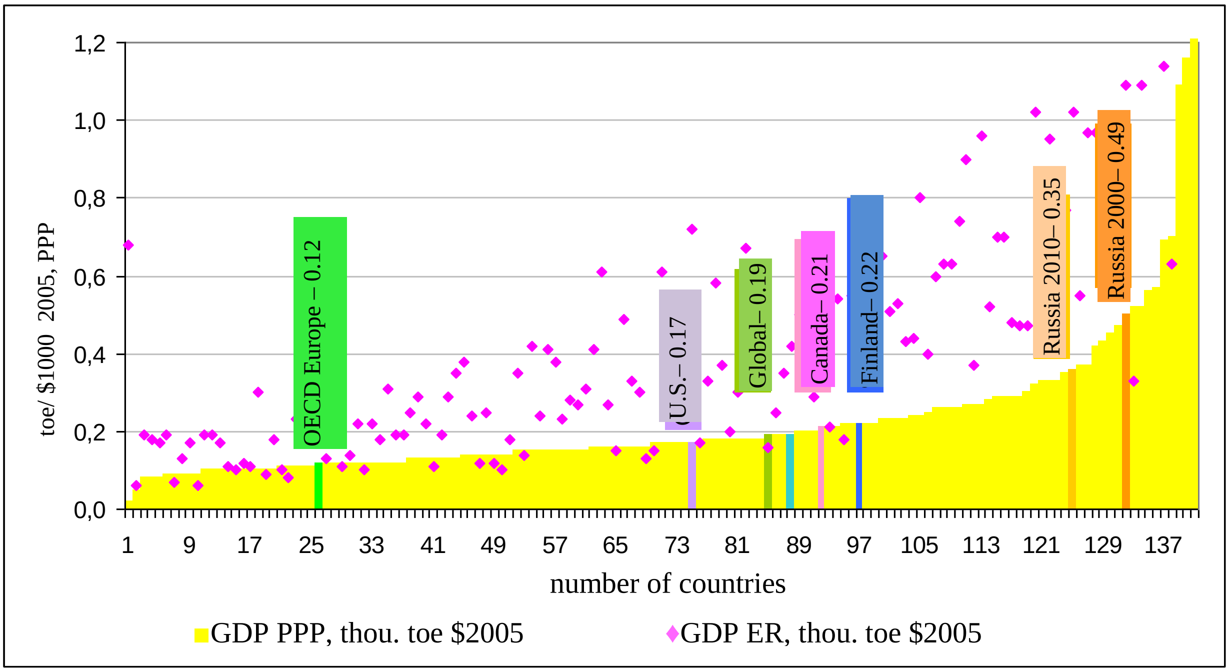
2.2 Russia's GDP energy intensity ranking

Specific energy consumption per unit of product, work, or services has been increasingly used in the recent years for cross-country comparisons. However, this indicator is no good for aggregated assessments, so for this purpose GDP energy intensity continues to be used. Correct comparisons by this indicator require a consistent methodology of assessing primary energy consumption (IEA's methodology) and development of comparable GDP indicators (by purchasing power parity in 2000 prices).

Despite substantial progress in energy efficiency improvement made in the recent years, in 2010 Russia still ranked 124th of 141 countries for which IEA provides GDP energy intensity data for 2010 (Fig. 2.1). By this indicator Russia was 1.8 times above the average global, 2 times above the U.S., and 3 times above the European level. It was also above the other BRICS countries: 35% above China, 94% above India, 2.5-fold above Brazil, and 21% above South Africa.

The difference in energy intensity levels are partially determined by differences in the structure of economies, climate, levels of technology used. Canada's GDP energy intensity is 60% of Russia's level. This is exactly where the goal of 40% reduction of Russia's GDP energy intensity by 2020 comes from. Cross-country comparisons with Finland and Canada, countries with similar climate, shows, that Russia's energy saving potential assessed using this extremely simple method is at least 280 mln. toe, or 400 mln. tce.

Figure 2.1 Russia's GDP energy intensity ranking (2010)



PPP – purchasing power parity; ER – exchange rate.

Source: I. Bashmakov. Energy efficiency policies and developments in Russia. Prepared for OECD under Contract No. JA00069287. Estimates based on the IEA's data from 2012 Key World Energy Statistics. OECD/IEA. 2012.

Using the exchange rate to identify GDP in USD substantially enlarges the energy intensity gap between developing countries and transition economies (Fig. 2.1). The reason is, that GDP measured by PPP is much higher for these countries, than GDP measured by the exchange rate, because a large part of these countries' economies is very faintly, if at all, incorporated in the international trade, so part of goods and services is excluded from the stream of commerce (subsistence sector), and for the other part domestic prices are decoupled with international prices. The share of these sectors in the developed countries is small, so energy intensity measuring by PPP and by the exchange rate is just the same for them. However, in transition economies the share of these sectors is higher, and even more substantial in the developing countries. Therefore, for them GDP estimates by PPP are much higher, than by the exchange rate.

If measured by the exchange rate, Russia's GDP energy intensity is 3 times higher, than the average global, 4.5 times higher, than in the U.S., 3.7 times higher, than in Canada, 7 times higher, than in Germany. It is also higher, than energy intensities of the BRICS countries: 22% above China, 38% above India, 3 times above Brazil, and 64% above South Africa.

The road to the future is only along the descending curve of GDP energy intensity. Russia is much above this curve. There is little chance of economic progress with such high energy intensity.

The accomplished analysis allows for the following findings:

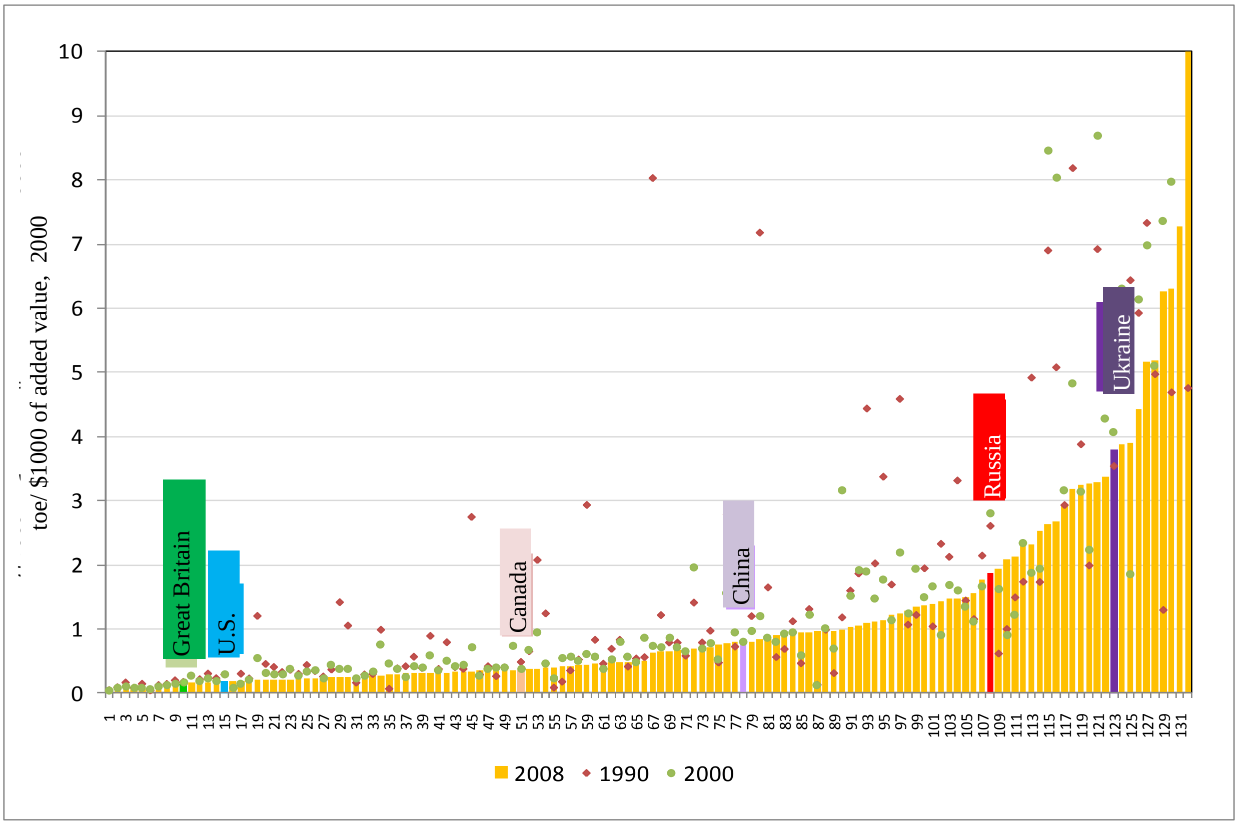
- before the 2009 economic crisis, Russia was one of the global leaders in terms of GDP energy intensity reduction rates, and the gap between Russia and developed countries was narrowing dynamically;
- 40% reduction of GDP energy intensity within 10 years was already achieved once (in 1998-2008) in Russia;

- however, despite the impressive progress achieved in the recent years, very much needs to be done to bridge the significant original gap between energy intensity levels in Russia and in the developed countries.

2.3 Russia's industrial energy intensity rating

UNIDO has accomplished a cross-country comparison of energy intensity of manufacturing in 1990, 2000, and 2008 (exchange rate-adjusted in 2000 prices). According to this research, of 132 countries included in the analysis, Russia comes 108th (Fig. 2.2).

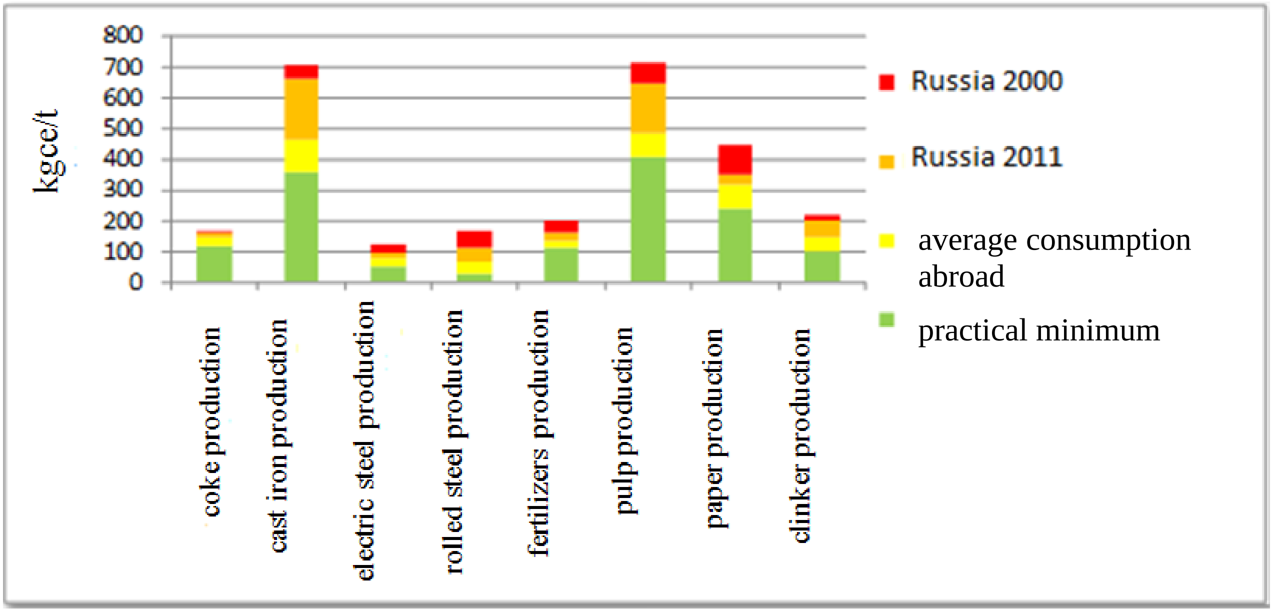
Figure 2.2 Russia's energy intensity rating: manufacturing sector



Source: CENEf based on UNIDO's data from UNIDO. 2011. Industrial Development Report 2011. Industrial energy efficiency for sustainable wealth creation. Capturing environmental, economic and social dividends.

In 1990-2000, industrial energy intensity in Russia was growing. After 2000, during transition to the restoration growth, it showed substantial (33%) reduction. However, in pre-crisis 2008 it was still 12 times industrial energy efficiency in Great Britain, 11 times that in the U.S., 5 times that in Canada, and 2.4 times that in China, albeit 43% lower, than in Ukraine, and 45% lower, than in Kazakhstan. If the analysis were based on PPP, the gap would be narrower, but still substantial, as proved by the gap in specific energy consumption for the manufacture of some industrial products (Fig. 2.3).

Figure 2.3 The gap in specific energy consumption for the manufacture of some products between Russia and "the best available (BAT)" and "average" foreign values

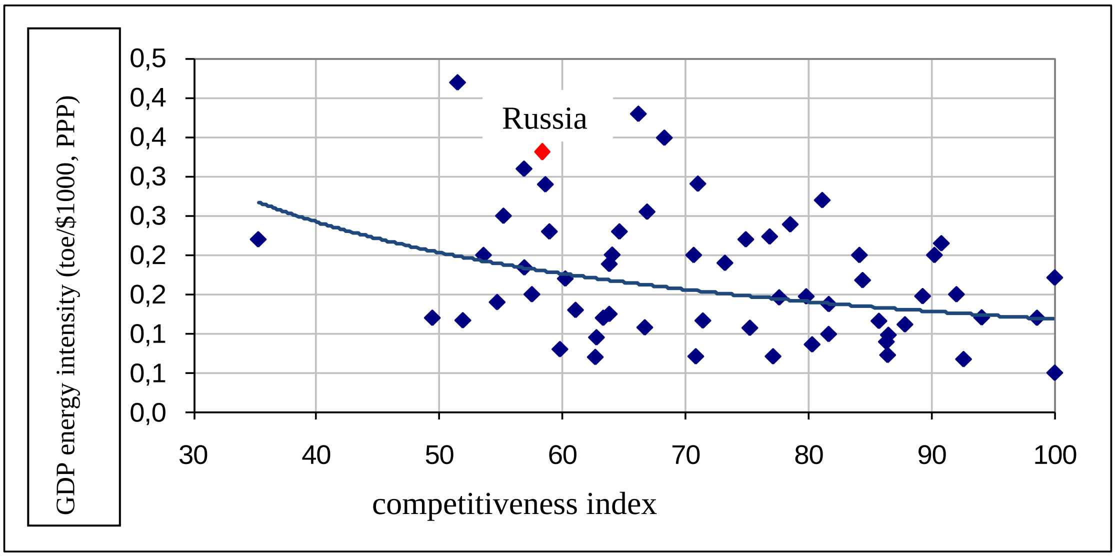


Source: CENEf

In 2000-2011, technology gaps with BAT somewhat narrowed, but are still high: 1.4 times in coke, 1.9 times in cast iron and electric steel, 3.7 times in rolled steel, 1.5 times in fertilizers, 1.6 times in pulp, 1.5 times in paper, and 2 times in clinker.

It is not incidental, that, according to UNIDO, Russia ranks only 66th of 118 countries by the index of industry competitiveness, while the U.S. ranks 2nd, China 5th, Great Britain 19th, and Canada 28th. The relationship between the competitiveness and energy intensity of industry is obvious (although not rigid). There is also a relationship between the competitiveness index of economy and GDP energy intensity (Fig. 2.4).

Figure 2.4 Relationship between the competitiveness index and GDP energy intensity in 2009

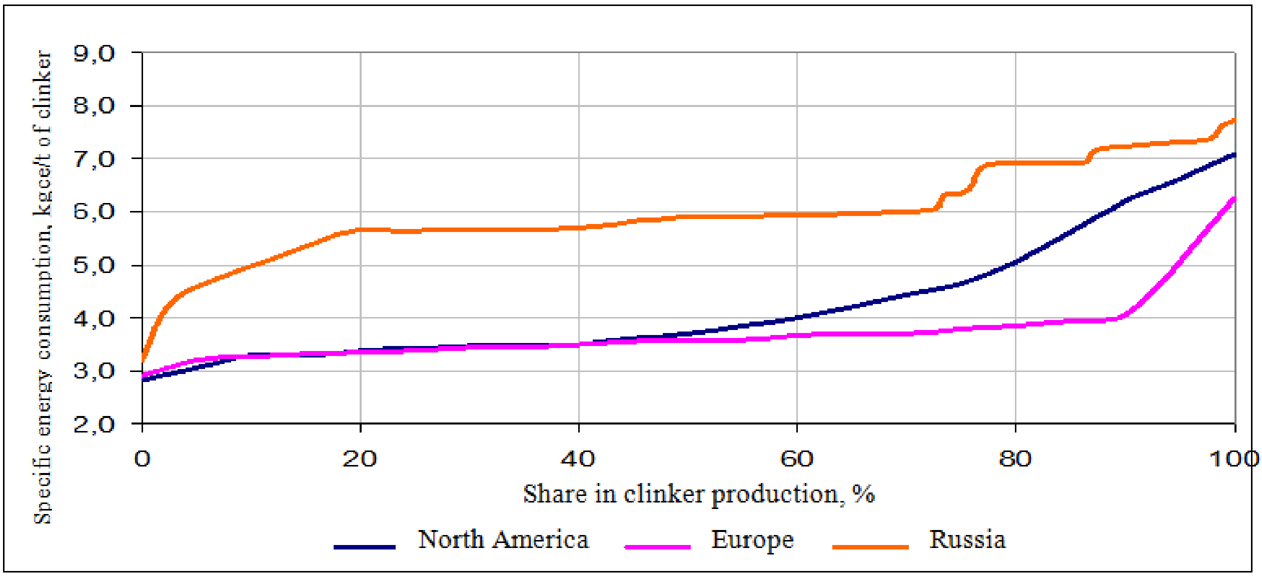


Source: I. Bashmakov. Energy efficiency policies and developments in Russia. Prepared for OECD under Contract No. JA00069287. Estimates based on the IEA's data from 2012 Key World Energy Statistics. OECD/IEA. 2012.

2.4 Introduction of innovations is going slowly

The energy efficiency gap is to a large degree determined by obsolete technologies. This can be illustrated by clinker production. In Russia, “wet” production dominates. In the European Union and North America, nearly 50% of cement is produced by new technologies, and so specific energy consumption values in these regions are practically the same (Fig. 2.5).

Figure 2.5 Distribution of clinker production volumes by specific energy consumption in Russia, North America, and West Europe



Source: I. Bashmakov. Energy efficiency policies and developments in Russia. Prepared for OECD under Contract No. JA00069287. Estimates based on the IEA’s data from 2012 Key World Energy Statistics. OECD/IEA. 2012.

In North America, the share of old plants with higher specific energy consumption is larger. In Russia, the curve of clinker production distribution by specific energy consumption goes higher, than in West Europe or North America. Therefore, by average specific energy consumption for clinker production Russia is 62% above the European Union, 46% above China, and 33% above North America.

Comparison of new industrial technologies introduction rates in China and Russia over the last decade (Table 2.1) shows, that:

- Russia is substantially behind;
- energy intense industries renovation rates in Russia are much slower, than in China.

In China, around 50% of all new technologies were introduced in the course of existing plants retrofits, and the other half during new construction.

Table 2.1 Examples of energy efficiency BAT application dynamics in China and Russia (%)

Sector and technology	2000	2006	2007	2008	2009	Energy savings
			Iron and steel			
Continuous steel casting	83	99	99	99	99	Savings of 200 kgce/t of steel
Russia	***50***	***68***	***71***	***71***	***82***	
Dry coke quenching			45	50	>70	Savings of 100 kgce/t of coke
Russia					***70***	
Using blast furnace gas to for electricity generation in top pressure recovery turbine	50	95	96	99	100	Production of 30 kWh of electricity per ton of cast iron
			Coke			
Mechanical coke production	72	88	91	96	99	Reduced consumption of coking coal per ton of mechanical coke
			Aluminum			
Pre-baked anode cells	52	82	83	86	90	Up to 9% energy savings compared to Soderberg cells
Russia					***75***	
			Chemicals			
Caustic soda production by membrane technology	25	*3'*	38	50	55	Electricity savings of 123 kWh/t (compared to the diaphragm process)
			Cement			
Large-scale processing	28	39	45	46	46	Net savings of 24 kgce/t of cement through 4.5% loss reduction and reduced utilization of paper bags
Transition to multi-stage "dry" clinker production	12	50	55	63	73	Up to 40% energy savings compared to vertical furnace
Russia	***14***	***15***	***16***	***16***	***16***	
			Flat glass			
Floatation	57	82	83	83	83	16% energy savings
			Construction			
Shift from bricks to new construction materials	28	46	48	50	52	Up to 40% energy savings

Sources: Data for Russia – CENEf. Data for China – UNIDO. 2011. Industrial Development Report 2011. Industrial energy efficiency for sustainable wealth creation. Capturing environmental, economic and social dividends.

Even with relatively cheap fuel and energy, the share of these costs in production costs in Russia is not only higher than in the developed countries, but even higher than in many developing economies (Table 2.2). In some Russian enterprises, the share of fuel and energy costs in production costs is substantially higher: in Rosneft, Gasprom, SIBUR (12-66%); MMK, NLMK, EVRAZ (20-31%); in Eurochim, FOSAGRO, Uralkaliy (12-40%); in ILIM, Archangelsk Pulp and Paper plant (21-41%)[7].

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[7] Estimated by SBS.

Table 2.2 Share of fuel and energy costs in the overall production costs (%)

Sector	All countries[1]	Developed countries	Developing countries	BRICS	Russia
Oil refinery	61.6	59.4	70.6	68.4	54.7
Building materials	11.8	7.2	12.7	6.5	13.2
Metallurgy	7.3	5.8	8.3	9.9	11.7
Chemistry and petrochemistry	3.9	4.9	3.5	10.0	9.9[2]
Pulp and paper	3.2	3.6	2.9	4.0	9.6
Rubber and plastics	5.3	3.4	6.8	7.8	4.1[2]
Transport machinery	3.2	1.3	5.6	2.4	2.9
Machine building	2.0	1.4	2.7	4.0	3.7
Electronic equipment	1.5	1.7	1.4	2.2	2.9
Textile	3.0	2.3	3.3	2.5	5.1
Food	2.3	1.7	2.5	1.9	3.1

[1] By 50 countries. The data include costs related to the use of energy resources as raw materials.

[2] Excl. Costs related to the use of energy resources as raw materials.

Sources: data for Russia – Russia’s Industry. 2012. Rosstat. 2012. Data for other countries – UNIDO. 2011. Industrial Development Report 2011. Industrial energy efficiency for sustainable wealth creation. Capturing environmental, economic and social dividends.

If energy prices grow up to the EU level, Russian industry is no longer competitive:

- cement industry: profitability drops from current 40% to -17%;
- pulp and paper: profitability drops from current 23% to -14%;
- mineral fertilizers: profitability drops from current 33% to 2%;
- iron and steel: prices of rolled products become 30-36% higher, than in West Europe[8];

Therefore, reduction of energy intensity of Russia’s economy and industry is one of the essential conditions for Russia to move up the competitiveness index scale. So it was not incidentally that the RF Ministry of Economic Development included GDP energy intensity in the set of indicators of Russia’s innovative economic development.

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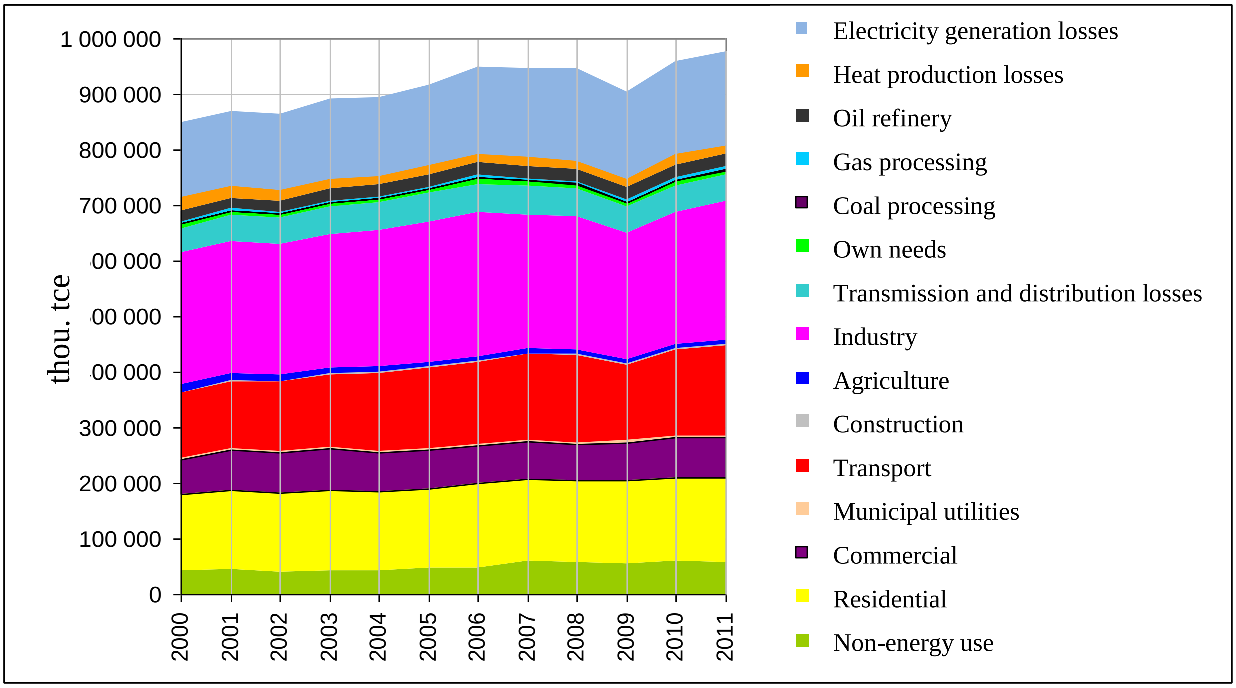
[8] According to SBS company.

3 The structure and trends of energy consumption and evolution of energy efficiency in Russian industry in 2000-2011

3.1 Energy consumption evolution and structure

Primary energy consumption in Russia declined in the crisis year 2009. Commercial and residential sectors were least vulnerable to the crisis-determined reduction of energy consumption in 2009, while industry, transport, and electricity sector were most vulnerable (Fig. 3.1). In 2010, primary energy consumption nearly reached the pre-crisis maximum of 2008, and in 2011 was 2.1% above the 2008 level.

Figure 3.1 Energy consumption evolution by major sectors of economy

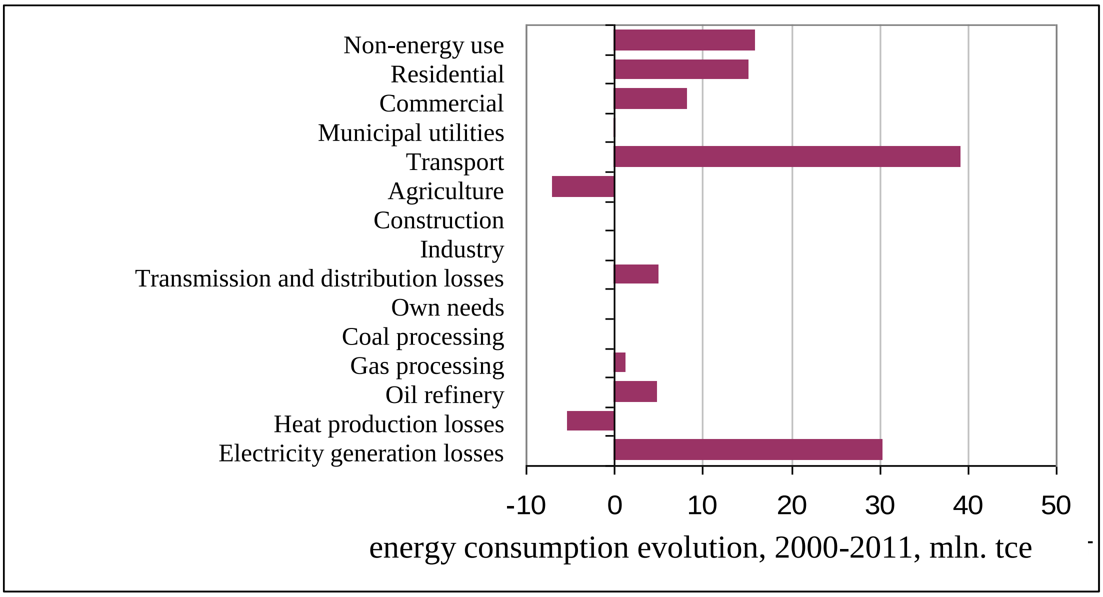


Source: CENEf

In 2000-2011, energy consumption showed most dynamic growth in transport (46% of the whole energy consumption increase), followed by thermodynamic losses in electricity generation (determined by fast increasing electricity consumption), consumption for non-energy needs, in the residential and commercial sectors. At the same time, in some sectors energy consumption during these years was either not growing (for example, in industry), or declining (in agriculture, Fig. 3.2). The structure of primary energy consumption is dominated by industry (26%, or, with account of fuel use for non-energy needs, 32%), followed by transport and energy losses in electricity generation; residential energy use; commercial; and other sectors.

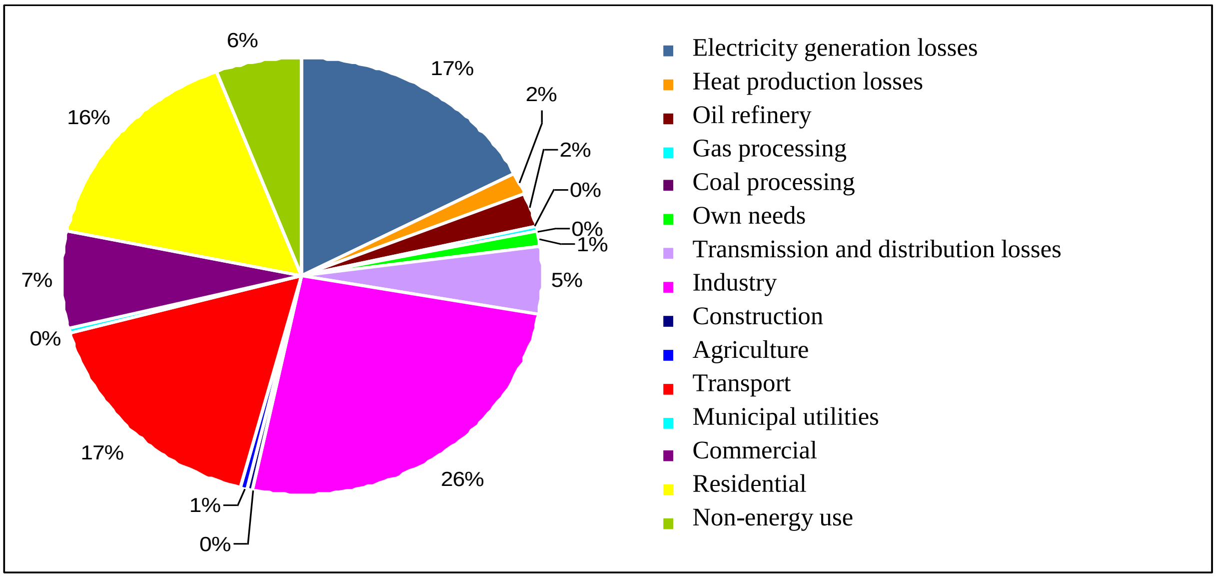
In 2010, the share of final energy consumption (the difference between primary consumption and energy transformation, transportation, transmission, and distribution losses) was 71.3% of primary energy consumption. In other words, nearly 29% of entire primary energy use is lost in fuel and energy processing and transformation (Fig. 3.3). This share is quite stable during the whole period of 2000-2010.

Figure 3.2 Energy consumption increase by major sectors in 2000-2011



Source: CENEf

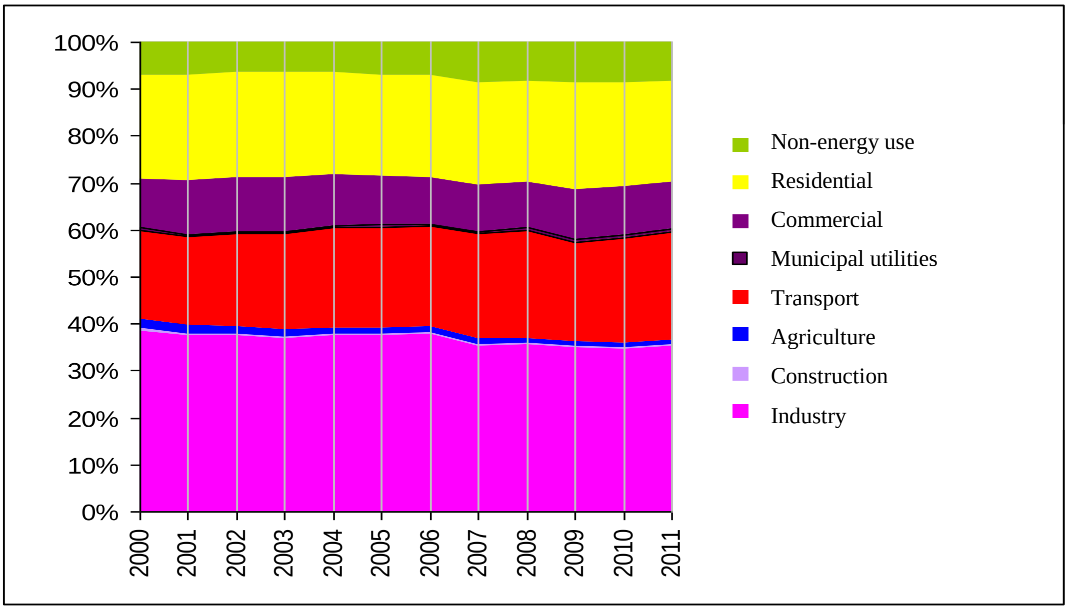
Figure 3.3 Structure of primary energy consumption in 2011



Source: CENEf

The share of transport in the final energy consumption is growing (more than 4% growth in 2000-2011), and so does fuel use for non-energy needs, while the share of industry is declining (3% decline in 2000-2011). However, this latter is still quite substantial (Fig. 3.4). The share of industry in final energy use in 2011 was 35.3%, (43.6%, if non-energy use is accounted for), construction was responsible for 0.3%, agriculture for 0.9%, transport for 23.1% (including motor vehicles for 12.5%), municipal utilities (water supply and street lighting) for 0.4%, commercial for 10.0%, residential for 21.6%, non-energy use for 8.2%. All buildings, including residential, commercial, and industrial, accounted for nearly 40% of final energy use.

Figure 3.4 **Evolution of end-use energy structure by sectors in 2000-2010**



Source: CENEf

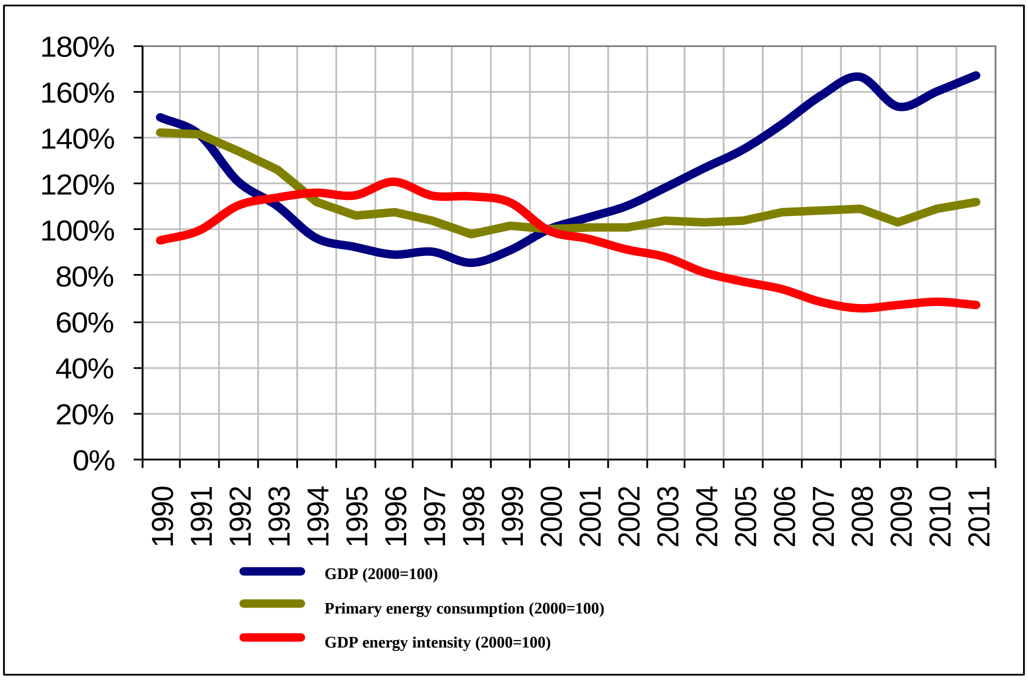
3.2 Evolution of Russia's GDP energy intensity

Energy efficiency improvements are accompanied by GDP energy intensity reduction. GDP energy intensity dynamics in 1990-2011 mirrors GDP evolution (Fig. 3.5). Economic recession of early 90's was accompanied by energy intensity growth. This was naturally determined by the growing share of energy intense resource industries due to the loss of competitiveness by machine building and light industries, reduced capacity load, growing energy use in the residential and commercial sectors.

Russia's economic recovery and transition to the market economy substantially bridged the energy intensity gap with the developed countries. After the 1998 crisis, Russia practically managed to decouple GDP growth and energy consumption evolution. With 94% GDP growth in 1998-2008, primary energy consumption only showed 12% increase. For 1998-2011, corresponding figures were 95% for GDP and 14% for primary energy use.

In 1998-2008, after long lagging behind, Russia became a global leader in GDP energy intensity reduction rates: this indicator dropped by 42% and was annually declining by more than 5% on average, which is much faster, than in many countries (Fig. 3.6). GDP energy intensity reduction to a large extent neutralized energy consumption growth and became the largest energy resource for economic growth. If it hadn't been for the progress in energy intensity reduction, energy consumption in Russia in 2008 would have been 73% above the real level, and net energy export would have dropped by 90%.

Figure 3.5 **Dynamics of Russian GDP, primary energy consumption and GDP energy intensity in 1990-2010**

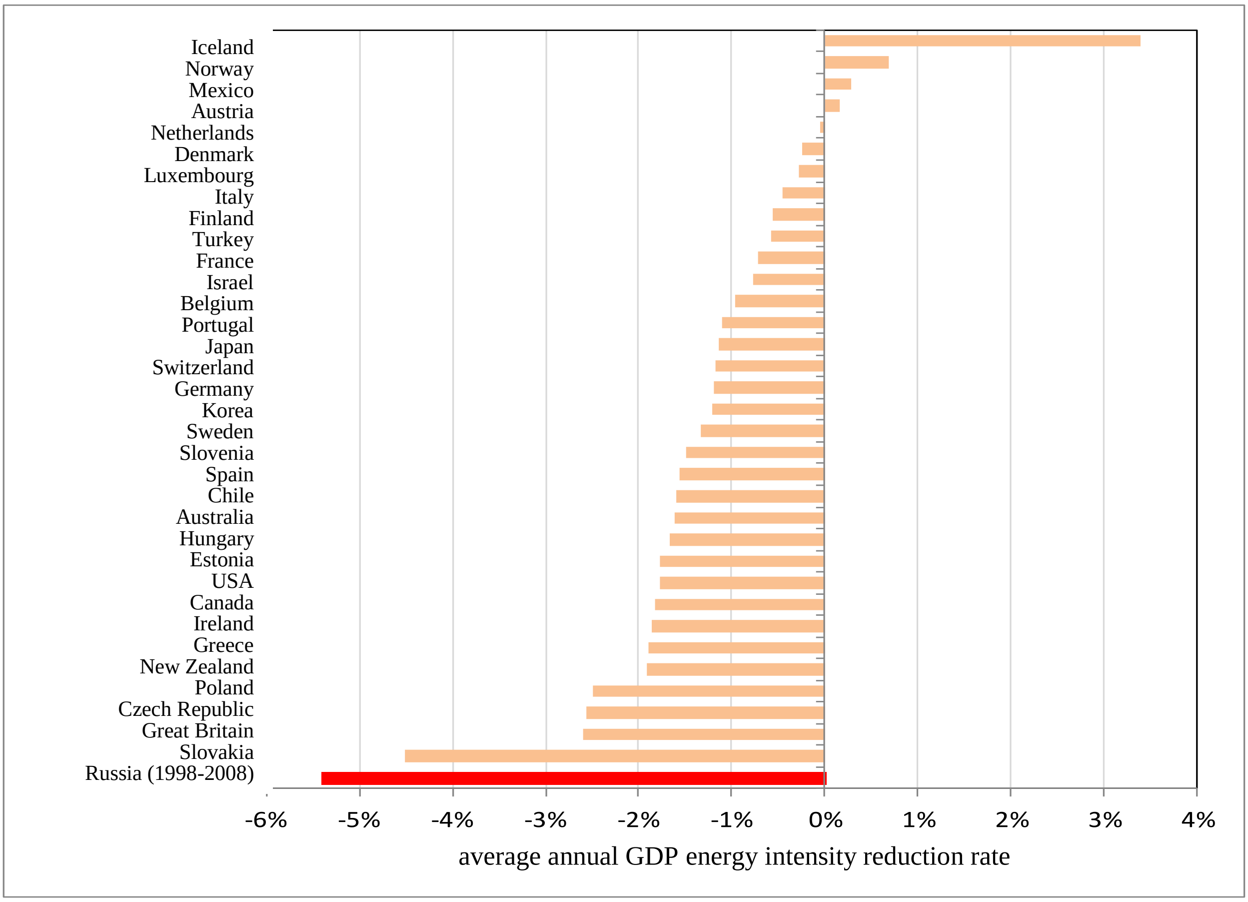


Source: CENEf

New deep economic crisis of 2009 broke up this impressive dynamics. In 2009, GDP energy intensity grew up by 2.1%, and by another 1.7% in 2010 (Fig. 3.5). As a result, ironically, after the RF Presidential Decree No. 889 of June 4, 2008 “On some measures to improve energy and environmental efficiency of Russian economy” was issued and Federal Law No. 261 “On energy conservation and energy efficiency improvement” was enacted, Russian GDP energy intensity not only showed no decline, but on the contrary, grew up by 3.9% in 2008-2010. This is a paradox of Russian energy efficiency policy: while there was no federal policy, energy intensity was fast declining, and when the federal policy was launched, it immediately stopped descending. During the economic crisis much time was wasted that could be used to achieve 40% GDP energy intensity reduction by 2020. This time will be very hard to catch up.

However, in 2011 Federal programme “Energy conservation and energy efficiency improvement until 2020” was launched breaking the last two years’ trend for GDP energy intensity growth. In 2011, GDP energy intensity declined by 2.2% due to the impacts of all factors, including structural shifts in the economy. According to CENEf’s preliminary estimates, in 2012 GDP energy intensity declined by 3.5-3.8%.

Figure 3.6 **Comparison of average annual GDP energy intensity reduction rates in Russia and OECD member states (2000-2010)**



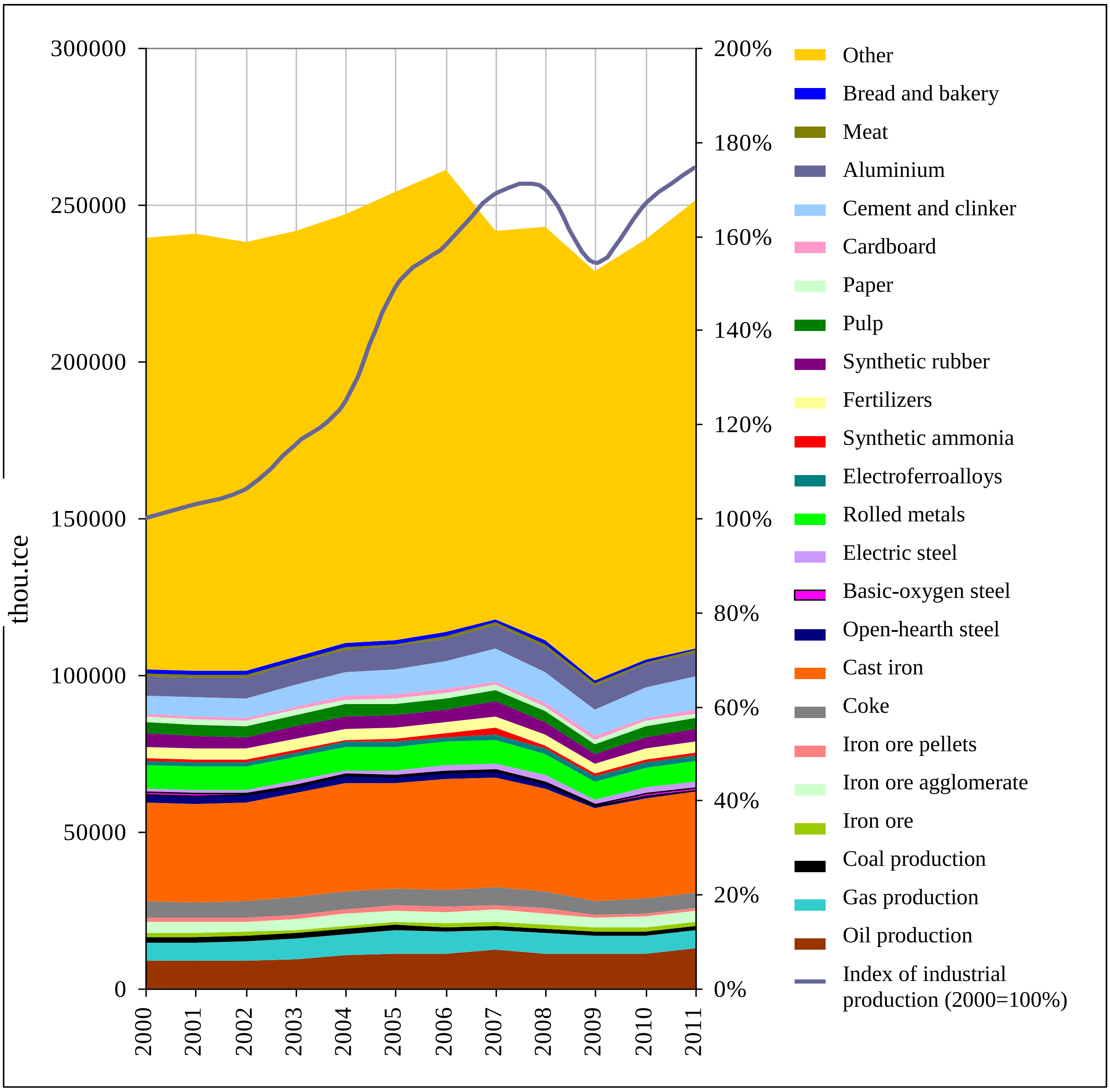
Source: CENEf

3.3 Factors that determined evolution of industrial energy consumption in 2000-2010

Russian statistics on industrial energy consumption provides data on the evolution of energy consumption for a large variety of industrial products. The list of these products has been expanding in the recent years. However, sustained data series for a decomposition analysis are unavailable for many products that have been statistically monitored for only a short period. Unfortunately, data are available only on energy consumption by large- and medium-size enterprises. Small-size enterprises that may be responsible for a large share of industrial output, are not covered by monitoring.

Selection of industrial products for the decomposition analysis was determined by the following considerations: significant amount of energy used and minimization of the distorting role of small-size enterprises in the industrial output and inclusion of these industrial products in the Federal program “Energy conservation and energy efficiency until 2010”. After all, 23 industrial products were identified plus “other industry” as an additional product. Russian statistics does not provide detail on energy consumption in machinery, so “other industry” is hard to further break down. In other words, the decomposition analysis includes 24 industrial products, of which energy consumption dynamics is shown in Fig. 3.7. It is important to mention, that industry does not include energy transformation (electricity and heat production by public utilities or by customers’ plants and boilers) or oil, gas, and coal processing, refinery, and enrichment. However, fuel production is part of industry.

Figure 3.7 Evolution of energy consumption in industry



Source: CENEf

In 2000, "other industry" was responsible for 56.6% of total final energy consumption in the industrial sector, and in 2011 for 56.8%. Then came pig iron production (13.5% in 2000 and 14.3% in 2011), oil production (4.8% in 2011), cement and clinker (4.3%), aluminum and rolled steel (2.7%), gas production (2.3%), coke (2.1%), agglomerate, fertilizers, synthetic rubber, pulp (1.4-1.5% each). Each one of the remaining products was responsible for less than 1% of the total final energy consumption by industry.

In 2000-2008, Russia made a huge progress in decoupling industrial output growth and energy consumption dynamics. In 2002-2006, industrial energy consumption was growing, then started to decline, and in 2010 it was below the 2001 level. However, in 2011 energy consumption by industry showed 12.3 mln. tce growth, which was most substantial in other industries (8.7 mln. tce), oil production and cement production. District heating dominates in the structure of industrial energy consumption, although its share dropped from 39% in 2000 to 31.7% in 2011. The share of coal also dropped from 17.1% to 14.6%. The share of natural gas grew up from 21.9% to 24.4%, and the share of electricity from 17.0% to 22%.

Uneven dynamics of industrial energy consumption is determined both by uneven output evolution and uneven decline of specific energy consumption. The first aspect is reflected by structural shifts in the industry. Apart from these, the decomposition analysis includes the following factors: evolution of technology energy intensity, capacity load, energy prices (related to product prices), and climate (weather). The results of the analysis displaying contributions of these factors are shown in Table 3.1 and in Fig. 3.8.

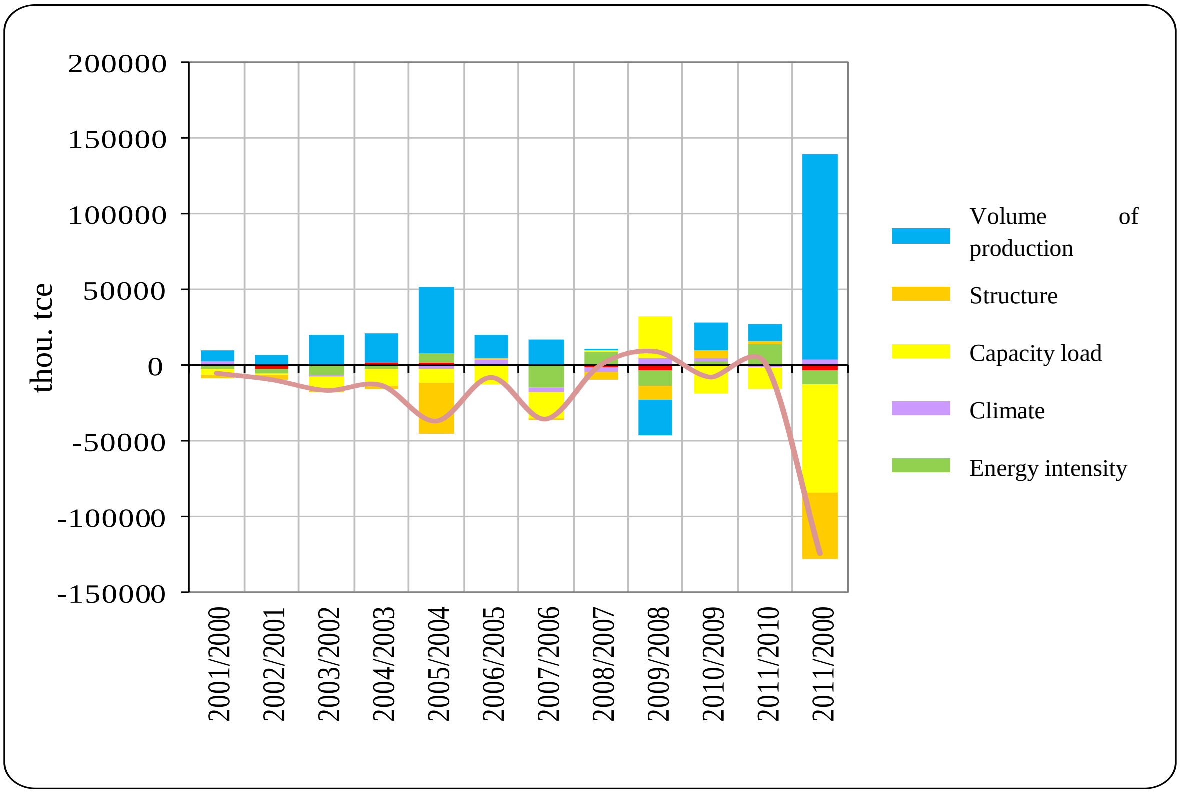
Table 3.1 Decomposition of factors that determined evolution of industrial energy consumption in 2000-2011 (thou. tce)

Years	Structure of industrial output	Energy intensity of equipment	Industrial production index	Climate	Capacity load	Prices	Total
2001/2000	-2333	-1953	6860	2996	-3713	-626	1232
2002/2001	-3109	-3035	7306	-457	-1216	-2053	-2564
2003/2002	-60	-6300	20442	-217	-9821	-537	3507
2004/2003	-1533	-2534	18789	-190	-11309	2009	5233
2005/2004	-33552	5608	44198	-1944	-9420	2134	7024
2006/2005	1012	-105	15727	3257	-12719	143	7315
2007/2006	-995	-15035	16511	-2686	-17227	105	-19327
2008/2007	-4934	9331	1449	-3156	100	-1511	1279
2009/2008	-9561	-10208	-23006	4817	27126	-3475	-14307
2010/2009	5169	2777	18427	2229	-17932	-442	10228
2011/2010	2825	12409	11255	-1232	-14158	1218	12317
2011/2000	**-44290**	**-9400**	**136461**	**3425**	**-70780**	**-3478**	**11938**

Source: CENEf

Nearly all the time, except in 2006, 2010, and 2011, structural shifts in industry have been making industrial energy consumption go down. In the recession year 2009, they determined substantial energy consumption and industrial energy intensity decline. Output growth in energy intense industries promoted energy consumption increase in 2010 and 2011.

Figure 3.8 Decomposition of factors that determined evolution of energy consumption by industry



* energy savings are estimated as the sum of contributions made by all factors, except the economic activity factor

Source: CENEf

Energy intensity of equipment was another factor that made a visible contribution to the limitation of industrial energy consumption growth. However, this contribution was not as significant, as that of the capacity load factor. In 2005, 2008, 2010, and 2011 (four years of the decade) technologies did not hamper industrial energy demand.

In the recession year 2009, the impact of the technology factor was the most prominent. Plants were no longer willing to use the most outdated technologies and closed down or dismantled corresponding capacities. In 2010-2011 again, the technology factor did not hamper energy consumption growth, which was primarily driven by increasing energy intensity in 2011 in “other industries”. However, this indicator is not disaggregated, so it is impossible to statistically reveal the reasons for such increase. Importantly, the reliability of energy consumption estimates in “other industries” leaves much to be desired. Changes introduced in the statistical reporting system made assessment of this indicator more difficult after 2007. This affected relevant estimates for 2007 and 2008. Besides, in 2007 statistics related to the energy consumption for synthetic ammonia, cement and clinker production was revised.

In 2009, industrial output dropped by 9.3%, and in the manufacturing by 15.2%, so that year industrial output dynamics factor determined a drop in industrial energy demand by almost 23 mln. tce. On the contrary, in 2010 industrial recovery promoted 18.4 mln. tce energy demand increase, and in 2011 energy demand grew up by another 11.3 mln. tce.

The climate factor is not really associated with industry. However, the floor area of industrial buildings accounts for 30-40% of the entire heated floor area. Therefore, in the manufacturing industry the share of heat used for space heating and ventilation of industrial buildings, rather than for process needs, is quite significant. This part of energy consumption is climate sensitive.

2007, 2008, and 2011 were quite warm, and the soft winters hampered energy consumption growth, while the cold winters of 2009 and 2010, on the contrary, promoted energy demand increase.

Industrial recovery of 2000-2008 was driven not so much by investment in technology, as by increased load of earlier built capacities. This facilitated industrial output increase without significant energy consumption growth and helped decouple industrial production index and the growth of industrial energy demand (Fig. 3.8). A similar situation was observed during economic growth revival in 2010-2011. It was this factor, rather than equipment retrofits, that basically determined evolution of specific energy intensity of many industrial products in 2010-2011.

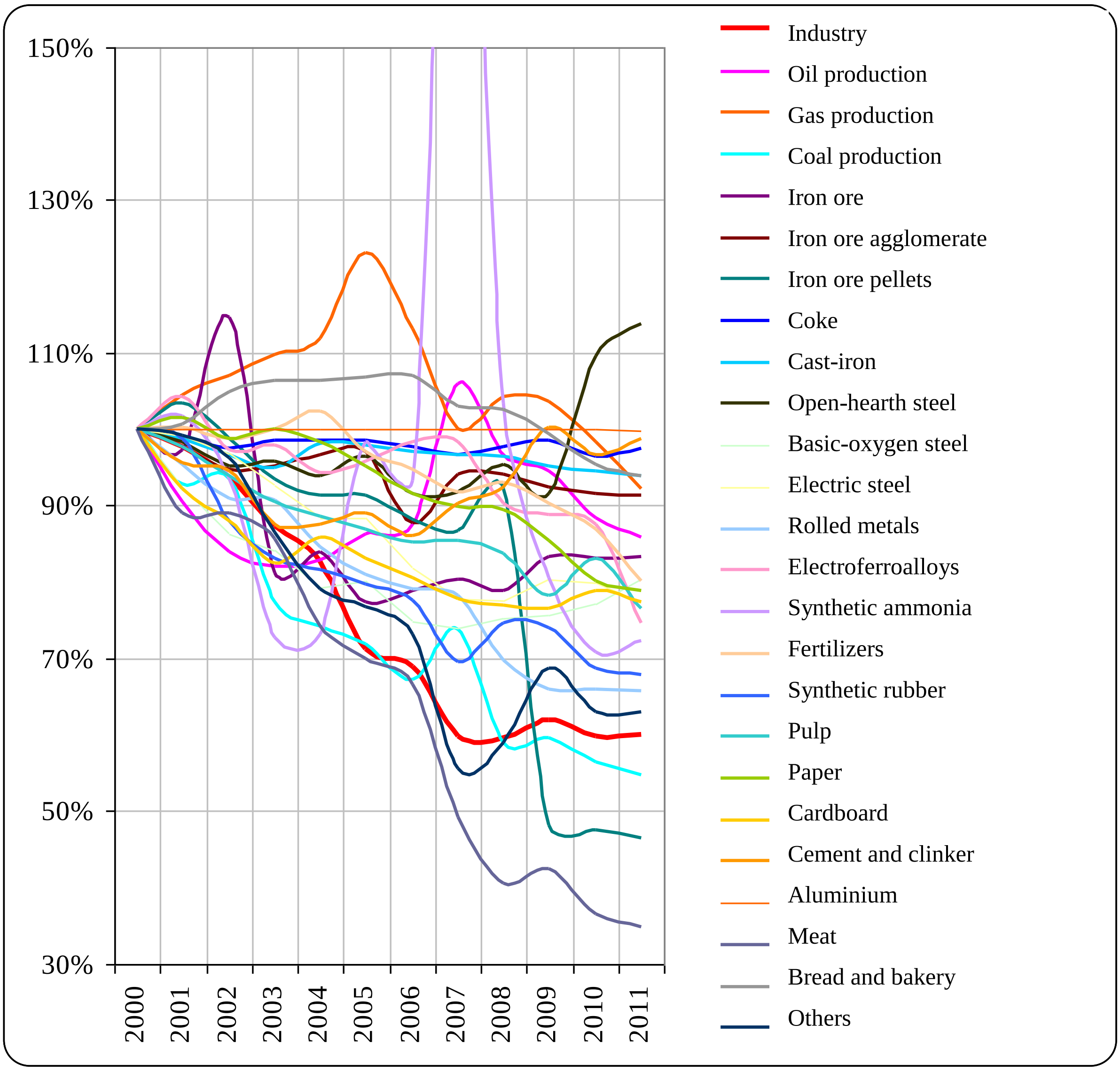
In some periods of time, relative energy price factor was hindering energy demand growth, while in other periods it was not. The industrial boom of 2004-2007 determined fast growing prices of industrial products, which left behind energy prices. A natural consequence was relatively cheap energy and low scoring of energy cost savings on the agenda. In the recession years 2008 and 2009, prices of industrial products dropped, while energy prices kept growing, so industrial energy demand was not increasing very fast. This situation passed over to 2010. A reverse trend was observed in 2011, hampering reduction of industrial energy intensity.

3.4 Evolution of energy efficiency index in industry in 2000-2011

Evolution of energy intensity of different industrial products looks very much like a ball of multicolor yarn (Fig. 3.9). Integral indicators of energy efficiency progress are needed to reveal the order camouflaged by this Brownian motion.

One of the following indicators can be used as an index reflecting the evolution of industrial energy intensity: value added energy intensity (this indicator depends on the ratio of costs and revenues in the industrial sector and is not the best one to reflect the evolution of industrial output in physical units); energy intensity of shipped products (this indicator is shown in the statistics in current prices and cannot be used for the analysis of industrial energy efficiency evolution); the ratio of industrial energy consumption to industrial production index. This latter indicator was used in this research, because it is the dynamics, not the value, that matters most for the analysis.

Figure 3.9 **Evolution of energy intensities of particular industrial products**

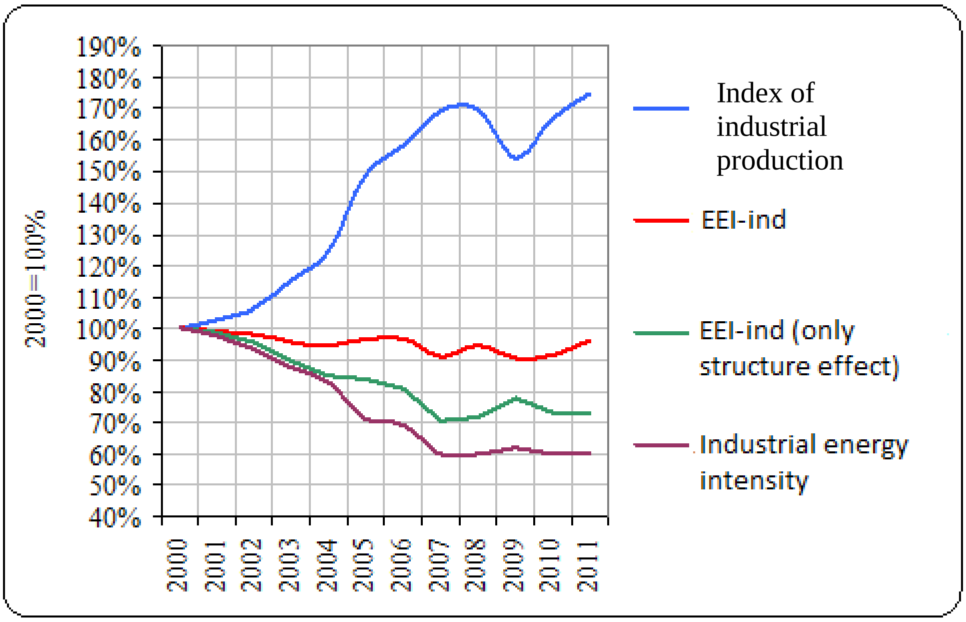


Source: CENEf

Dynamics of any of the above indicators is to a large extent affected by the structural shifts, capacity load, energy prices, and climate. Energy efficiency index for industry (EEI-industry) is evaluated to isolate the contribution of improved technology to the energy intensity evolution. Besides, EEI-industry (structure only) is used to reflect evolution of the structure of industrial production, while such factors as capacity load, weather, prices, etc. are not used. Dynamics of these factors are shown in Fig. 3.10. After the economic crisis reduction of these indicators obviously slowed down.

While industrial energy intensity dropped by 40% in 2000-2011, i.e. was annually declining by 4.5% on average, EEI-industry (structure only) dropped by 28%, or was annually declining by 2.9%. The difference between these two reflects the impact of the structural shifts, which were responsible for 38% of energy intensity reduction. Reduction of specific energy consumption contributed 62%, which is close to the data for the U.S., where this factor was responsible for 65% of industrial energy intensity reduction.

Figure 3.10 **Evolution of GDP energy intensity and of the energy efficiency index (EEI) of industry in 2000-2011**



EEI-industry – energy efficiency index in industry with 25 industrial products and the following factors: capacity load, energy prices, and weather.

Source: CENEf

However, if other factors are included in the analysis, it turns out that the energy efficiency index in industry (EEI-industry) only dropped by 4%, i.e. was annually declining by 0.3% on average. Therefore, improved industrial technologies contributed just a little bit to the energy intensity reduction in industry, while the largest impact was provided by the evolution of the structure of industrial production, capacity load fluctuations, dynamics of energy prices and weather.

4 Slow progress amid total lack of federal policy. Industrial energy efficiency: targets and actual levels

4.1 Targets set for 2011

Russia has formulated an ambitious target of 40% GDP energy intensity reduction in 2007-2020. Obviously, an energy efficiency and energy savings accounting system is to be developed to monitor how close this target is. Such accounting systems have been developed and are used in different countries and groups of countries. They allow for quantitative estimates of the impacts provided by various factors on the energy consumption and energy intensity dynamics in various sectors. For Russia, such analysis is especially important, because after a long and dynamic reduction GDP energy intensity grew up in 2009 and in 2010 was practically at the same level and started to decline again only in 2011.

There is a hierarchy of energy efficiency indices.

- integrated GDP energy intensity, or integrated energy efficiency index, is on the upper tier;
- then energy efficiency indices can be estimated for major energy consumption sectors: energy intensity of industry, transport, housing, etc.;
- on the third tier, energy efficiency indices are estimated for various types of goods, work, and services, often as special physical values: specific energy consumption to produce a unit of electricity, 1 ton of metal; 1 ton of cement; for heating of 1 m^2 of living space; per unit of truck transport work; etc.;
- finally, the last tier includes energy efficiency indices for particular technologies and types of equipment: power plants efficiency; daily electricity consumption by a refrigerator; fuel consumption per unit of a car mileage; or the ratio of a lamp capacity to the luminous flux.

Integrated energy efficiency indices allow it to unite all energy efficiency indicators in a single system, such as, for example, a set of 89 energy efficiency indicators of the RF Federal programme “Energy conservation and energy efficiency improvement until 2020” (Appendix 13). This set includes indicators from all four groups.

This section contains the results of the analysis of indicators from Appendix 13 to the RF Federal programme “Energy conservation and energy efficiency improvement until 2020”, primarily for industry.

Basic findings of the assessment of the target indicators:

- after the RF Federal programme “Energy conservation and energy efficiency improvement until 2020” was launched, in 2011 the last two years’ (2009-2010) trend for GDP energy intensity growth was broken;
- in 2011, GDP energy intensity declined by 2.2%. During the economic crisis much time was wasted that could be used to achieve 40% GDP energy intensity reduction by 2020. This time will be very hard to catch up;
- 1.5% GDP energy intensity drop (versus the Federal programme target of 2%) was determined by the reduction of specific energy consumption for the manufacture of goods, work and services;

- reduction of GDP energy intensity in 2011 beyond 1.5% was determined by other factors, including structural shifts in the economy;
- in 2011, the measures of the Federal programme brought 14.4 mln. tce in primary energy savings. It is less than was required by the Federal programme in 2011 (33 mln. tce). The basic reason why the target was not met is 9 mln. tce increase in natural gas consumption versus 11 mln. tce savings required by the programme. This difference of 20 mln. tce did not allow it to meet the Federal programme energy savings target;
- the saving targets set in the Federal Programme:
    - for electricity were met;
    - for heat were met by 98% (with the verification for climate by 84%);
    - for oil and liquid fuels were met by 74%;
    - for GHG emission reduction were met only by 10%, basically for increased natural gas consumption;
- substantial progress in improving energy efficiency of federal (municipal) organizations was achieved:
    - in 2007-2011, specific energy consumption by public buildings (for comparable climate conditions) dropped by 14%, and specific heat consumption by 11%;
    - the share of organizations equipped with heat meters grew up by nearly 40%;
- the analysis shows, that:
    - substantial energy savings were obtained in sectors where energy efficiency policies and measures of the Federal programme were implemented most aggressively (public and residential sectors);
    - the Programme measures practically ignored industry and transport. The result was the limited or negative (transport) impacts of these sectors to the energy savings obtained;
    - pipeline, motor, and other transport was responsible for 5 mln. tce energy consumption increase instead of expected energy savings. Gas pipeline transport alone was responsible for nearly 9 mln. tce natural gas consumption increase;
- in some instances, actual values of the target indicators were worse, than the Federal programme targets. There were 47 such indicators of the total number of 89. Interestingly, the values of 15 indicators (primarily in industry and transport) in 2011 were even worse, than in 2007.

An indicator was regarded as achieved, if the difference with the target set in the Federal programme was 1% or less (the accuracy of measuring many target indicators). The values of indicators, for which the 2011 targets were not met, are coloured pale-gray in Table 4.1. The indicators whose 2011 values were worse, than in 2007, are coloured darker gray. If different statistical forms provide different values, making it impossible to unambiguously judge, whether the target was met, such indicators are coloured lavender (actually, there is only one such indicator: fuel consumption by boilers). If statistical reporting system has changed in a way that this change has a noticeable impact on specific energy consumption indicators, and they have become incomparable to the target values, such indicators were coloured pale-yellow (there are 4 of them).

Table 4.1 Values of some energy efficiency indicators of the Federal Programme “Energy Conservation and Energy Efficiency Improvement until 2020” for 2000-2010*

No.	Energy efficiency indicators	Units	Actual values					Target values
			2007	2008	2009	2010	2011	2011
1	GDP energy intensity reduction through the Program measures	%					1,5	2
1a	GDP energy intensity reduction compared to the 2007 level	%		4,1	2,0	0,3	2,2	
9	Specific fuel consumption for electricity generation by thermal power plants	gce/kWh	335,6	338,3	335,7	337,9	334,3	326,4
10	Fuel use efficiency coefficient	%	58,2	57	58,4	57,4	57,3	56
11	Efficiency of new gas-fired power plants	%	50	47,8	41,7	51	53,4	At least 55
12	Efficiency of new coal-fired power plants	%	41	30	35,6	No new plants commissioned	30	At least 43
16	Share of energy consumption for power plants’ own needs	%	6,9	6,5	6,4	6,3	6,3	6,6
17	Specific fuel consumption for heat supply by boilers	kgce/Gcal	173,2	173,6	173,7	178,0	177,0	172,2
	Same, 11-TER statistical form		171,2	170,2	170,4	170,1	170,2	172,2
18	Specific electricity consumption for heat supply by boilers	kWh/Gcal	26	27,2	41,1	36,6	40,1	24,0
20	Share of heat distribution losses	%	9,0	9,6	10,1	10,6	10,7	13,8
21	Share of heat recovery	%	65,4	61,8	63,1	60,7	61,3	63,0
25	Primary energy intensity of industrial production compared to the 2007 level	%	100,0	100,0	104,5	101,2	101,0	93,2
26	Electricity intensity of industrial production compared to the 2007 level	%	100,0	104,1	106,8	102,9	101,3	93,4
27	Specific energy consumption for oil production	kgce/t	19,4	20,3	18,4	17,7	18,8	19,0
28	Share of technology oil losses	%	1,0	1,0	1,0	0,9	0,9	0,8
29	Energy efficiency index for oil refinery	%	51,2	50,6	53,6	52,6	52,8	53,6
30	Specific energy consumption for oil refinery per unit of crude utilization	kgce/t	100,0	98,1	98,2	97,9	95,7	98,5
31	Specific energy consumption for natural gas production	kgce/ 1000 m^3	9,5	9,9	9,8	9,3	8,7	9,7
32	Specific energy consumption for natural gas processing	kgce/ 1000 m^3	48,8	45,9	49,6	59,0	62,1	48,0
33	Share of associated petroleum gas flaring	%	27,0	23,0	21,0	23,0	24,0	5,0
34	Specific energy consumption for coal production	kgce/t	5,6	4,5	4,5	4,3	4,2	3,9
35	Specific energy consumption for coal processing	kgce/t	5,0	6,3	5,1	6,6	6,3	4,5
36	Energy efficiency index for ferrous metals	%	56,4	56,8	57,0	57,3	58,4	56,5
37	Specific energy consumption for iron ore production	kgce/t	12,1	11,8	12,5	12,4	12,5	11,0
38	Specific energy consumption for iron ore agglomerate	kgce/t	60,8	60,8	59,6	59,1	59,0	56,5
39	Specific energy consumption for iron ore pellets production	kgce/t	41,4	44,0	23,0	22,7	22,2	41,9
40	Specific energy consumption for	kgce/t	159,9	162,0	163,1	159,8	161,5	161,2

No.	Energy efficiency indicators	Units	Actual values					Target values
			2007	2008	2009	2010	2011	2011
	coke production							
41	Specific energy consumption for cast iron production	kgce/t	683,8	681,5	672,7	669,3	664,5	661,6
42	Specific energy consumption for open-hearth steel production	kgce/t	162,7	169,1	162,2	194,1	201,6	162,0
43	Share of open-hearth steel in total steel production	%	16,1	14,3	8,8	7,0	5,9	7,3
44	Specific energy consumption for basic oxygen steel production	kgce/t	11,9	12,1	12,2	12,5	13,0	11,9
45	Specific energy consumption for electric steel production	kgce/t	95,3	95,1	98,3	97,7	94,8	83,6
46	Share of steel produced at continuous casting machines	%	71,2	71,0	81,6	81,4	82,0	88,6
47	Specific energy consumption for rolled ferrous metals production	kgce/t	132,1	117,8	111,6	111,5	111,3	105,4
48	Specific energy consumption for electroferroalloys production	kgce/t	1263,5	1158,9	1140,1	1124,2	959,2	1094,0
49	Specific energy consumption for aluminium production	kgce/t	16000	15856	15713	15572	15434	15310
50	Specific energy consumption for synthetic ammonia production	kgce/t	1487,5	1397,5	1378,0	1369,8	1370,9	1438,0
51	Specific energy consumption for fertilizers production	kgce/t	186,6	189,3	183,7	176,7	163,0	166,0
52	Specific energy consumption for synthetic rubber production	kgce/t	3079,5	3304,4	3277,5	3036,8	3001,6	2971,0
53	Energy efficiency index for pulp and paper	%	65,4	66,4	69,7	68,2	71,7	67,8
54	Specific energy consumption for pulp production	kgce/t	608,4	595,8	557,1	591,7	545,9	576,0
55	Specific energy consumption for paper production	kgce/t	400,5	398,4	381,1	356,8	351,2	347,0
56	Specific energy consumption for cardboard production	kgce/t	344,4	340,2	338,4	348,7	342,7	306,0
57	Specific energy consumption for cement production	kgce/t	178,0	181,9	197,4	190,4	194,3	170,0
58	Share of cement produced by energy saving technology	%	15,7	16,3	15,7	16,8	20	17,8

* The indicators numbering is consistent with Attachment 13 to the Federal Programme “Energy Conservation and energy efficiency improvement until 2020”.

Source: CENEf’s estimates.

4.2 Why some of the energy efficiency targets were not met in 2011

For 3 of 8 indicators of the electricity sector subprogramme, actual 2011 values were worse, than the Federal programme targets. And for one indicator (efficiency of new coal-fired power plants) the 2011 value was worse, than in 2007.

The basic reasons why the electricity sector targets were not met are as follows:

- lagging behind the parameters of the General outline of electricity sector facilities location until 2030 by the commissioning of new, renovation of existing, and decommissioning of old generation capacities during the economic crisis;
- commissioning of capacities that are less efficient, than required by the Federal programme.

For the "efficiency of new gas-fired power plants" indicator, in 2011 this lagging behind was substantially reduced, but not completely eliminated.

For 18 of 33 indicators of the industry subprogramme, actual 2011 values were worse, than the Federal programme targets. And for six indicators the values were worse, than in 2007. As a result, industrial energy intensity was above the 2007 level. This was partially determined by the growth of specific energy consumption in some industries, and to some extent by the slowdown of specific energy consumption reduction in non-energy intense industries. During the 2008-2009 recession, this indicator, on the contrary, showed substantial growth. In 2010 it began declining, and kept going down in 2011.

The basic reasons why the industrial sector targets were not met are as follows:

- smaller-scale (compared to the requirements of Appendix 6 to the Federal programme "Energy conservation and energy efficiency improvement until 2020") replacement and renovation of energy intense industrial equipment determined by scaled-back investments during the recession phase of the business cycle (2008-2009) and their slow recovery in 2010-2011;
- post-crisis industry structure became more energy-intense, which is an important factor driving industrial energy intensity in general. Slow post-crisis recovery of non-energy intense industries hampers industrial energy intensity reduction after 2010;
- reduced capacity load in a number of energy intense industries and corresponding growth of specific energy consumption determined by the increased share of semi-fixed costs during the recession of 2008-2009, and further slow capacity load recovery;
- for some resources, degradation of production and processing environment;
- in some energy-intense industries, declining energy tariffs (compared to the output prices) reduced motivation for energy efficiency projects;
- relatively low rank of energy efficiency measures in industrial companies' strategic plans. Half of enterprises were not involved in any energy efficiency innovations;
- the government provided practically no incentives for industrial energy efficiency improvement. The incentives it did provide were basically related to energy audits, oil refinery retrofits, and associated gas recovery;
- insufficient quality of statistics related to industrial energy use.

5 Energy saving potential in industry

5.1 How can specific energy consumption values be compared?

Methods and approaches to the assessment of the energy efficiency potential of the Russian Federation were tuned during the development of a joint report by the World Bank, International Finance Corporation, and CENEf on the evaluation of Russia's energy efficiency potential and in the framework of TACIS project "Promotion of Energy Efficiency Investments in Russia's Regions" for three regions of the Russian Federation (Sverdlovskaya, Tverskaya, and Rostovskaya Oblasts). Assessments of the potential obtained by CENEf using this methodology were used as official estimates in the RF Federal programme "Energy conservation and energy efficiency improvement until 2020", of which CENEf was one of the major developers[9].

Several energy efficiency categories can be defined:

"Theoretical minimum" - specific energy consumption required by thermodynamic laws to perform necessary work or material transformation;

"Practical minimum" – the best practically achieved specific energy consumption worldwide with application of proven technologies;

"Actual use abroad" – the most wide spread specific energy consumption in other countries;

"Average use abroad" – average specific energy consumption in other countries (depends on the regions selected for comparison);

"Russian average" - average specific energy consumption in Russia.

Depending on the goal of research energy efficiency potential can be estimated as compared to the "practical minimum"[10] or to the "average use abroad". The latter approach was used by the IEA in the chapter on Russia of 2011 World Energy Outlook[11]. In this paper, the first approach was used. Selection of the first approach determines requirements to the list of best available technologies (BAT) to compare major technical parameters with the Russian technologies. The basic requirement is for comparability of energy efficiency levels in Russia and other countries. Therefore, while assessing specific energy consumption for BAT and Russian technologies, it is important that:

- energy consumption:
    - be reported in the same energy units, using the same approaches to metering energy resource consumption volumes and mass, adequate calorific equivalents (the higher or the lower), the same conversion factors for various types of energy, and the same primary energy conversion factors;
- production indicators for goods, work, and services:
    - be set for similar quality and similar product mix measured in the same units;

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[9] See Attachment 1 to the RF Federal Programme "Energy Conservation and Energy Efficiency Improvement until 2020".

[10] Energy Efficiency in Russia: Untapped Reserves. World Bank Group and CENEf. Moscow, 2008; Resource of energy efficiency in Russia: scale, costs and benefits, www.cenef.ru; Energy technology perspectives 2010. Scenarios and strategies to 2050. IEA/OECD. Paris. 2010; Energy technology transitions for industry. Strategies for the next industrial revolution. IEA/OECD. Paris. 2009.

[11] World Energy Outlook. 2011. IEA/OECD. Paris. 2011.

- industrial process systems should be clearly identified and comparable:
    - it is important to account for energy purchased and energy generated locally, participation in the division of labour and completeness of the technology cycle at the enterprise or in the industry; energy consumption processes; the degree of resource recovery; share of energy consumption for the manufacture of exported goods, etc.;
- specific energy consumption for the production of goods, work, and services:
    - were identified with an account of resource production conditions, parameters of processed raw materials, energy equipment lifetime and loads, use of energy resources as raw materials, etc.

Ideal comparability of energy efficiency levels of different countries, and even of different enterprises, is hardly feasible. However, with an accurate account of the above factors, it is possible to obtain a quite reliable quantitative comparison of energy efficiency levels.

Russian statistics helps trace specific energy consumption for the manufacture of some energy-intense products. These values and their dynamics are determined by the evolution of loads, technological structure of the industry (increasing share of energy efficiency technologies), substitution of materials (increasing share of metal and paper scrap) or energy (substitution of coke with coal in cast iron production), as well as by the evolution of corresponding ratios of interrelated products within industries (for example, introduction of direct reduction iron (DRI) technology leads to coke demand reduction; increasing share of electric steel leads to relative reduction of cast iron, coke, and iron ore demand); export-import ratio of various products (cast iron production can be affected by the evolution of both domestic and external demand); decommissioning of obsolete equipment, renovation of the remaining equipment, and commissioning of new machinery; technology parameters of renovated and commissioned equipment. All these factors affect the level and dynamics of specific energy consumption and determine, how close average Russian indicators are to best practices.

In order to reveal the effectiveness and application scale of basic technology energy efficiency measures in energy-intense industries, it is important to account for all the above factors. Combinations of these factors also depend on the development parameters of the Russian economy and industry, and on industrial energy efficiency policies. Replacement and renovation of process equipment in energy intense industries is costly. For this reason, the technology base in these industries is renovated gradually, and implementation of the energy efficiency potential takes time.

Energy efficiency index (EEI) is often used as an integrated indicator to assess the energy efficiency potential implementation in energy intense industries with inter-related set of products. It is estimated as the ratio of energy consumption for the manufacture of the actual set of industrial products (assuming that specific energy consumption corresponds to the best practices) to the energy used to manufacture this set of industrial products (with actual specific energy consumption). For complex product segments EEI allows for the elimination of the structural factor and shows, which part of the energy efficiency potential has been implemented to date.

Foreign statistics helps identify specific energy consumption for a list of best available technologies. This list not nearly coincides with data on specific energy consumption reported in the Russian statistics. Therefore, many compared technologies are the intersection of similar data for Russia and other countries.

5.2 How deep is the gap? Best available technologies and Russia's relevant energy efficiency levels

Industrial energy efficiency benchmarking has been increasingly developing in the recent years. Benchmarking results are used to identify the energy efficiency rating of an enterprise among other enterprises in the industry, to specify energy efficiency targets in long-term agreements between governments and industries. Many countries and groups of countries develop benchmarking systems of various range and depth, with varying degree of integration of the factors specified in Section 5.1. Descriptions and results can be found in a pretty long, yet not complete, list of publications, many of which are mentioned in Sections 6 and 7 of this paper.

BAT specific energy consumption values and efficiencies are shown in Table 5.1. Besides, data on "actual consumption abroad" are provided: not average, but most frequent values of specific energy consumption in other countries (corresponds to "mode" in statistics). Also the table provides information on goods and services production in Russia in 2011 and Russian specific energy consumption in 2011.

Table 5.1 Energy efficiency gap between Russian industry and BAT (as of 2011)

Integrated technologies of goods, work, and services production	Units	Volume of economic activity	Units	Specific consumption in 2010	Practical minimum	Actual consumption abroad	Comments
Gas-fired district power plants (GRES) retrofits	mln. kWh	224000	gce/kWh	325	205	262	Combined cycle gas turbines (CCGT), 60% efficiency
Coal-fired GRES retrofits	mln. kWh	104700	gce/kWh	366	273	293	Equipment with 48% efficiency
Gas-fired co-generation plants (TETs) retrofits	mln. kWh	273200	gce/kWh	321	205	262	CCGT with 60% efficiency
Coal-fired TETs retrofits	mln. kWh	72300	gce/kWh	349	273	293	Equipment with 48% efficiency
Residual oil-fired TETs retrofits	mln. kWh	6100	gce/kWh	322	256	293	Equipment with 48% efficiency
Diesel power plants (DPP) retrofits	mln. kWh	14291	gce/kWh	454	332	332	Equipment with 37% efficiency
Own needs consumption	mln. kWh	1054810	%	6,9%	4,0%	5,0%	Global practice – North America
Electricity transmission	mln. kWh	1054810	%	10,8%	6,9%	7,0%	Global practice – Japan
Coal-fired boilers retrofits	thou. Gcal	85935	kgce/Gcal	199	159		Equipment with 90% efficiency

Integrated technologies of goods, work, and services production	Units	Volume of economic activity	Units	Specific consumption in 2010	Practical minimum	Actual consumption abroad	Comments
Residual oil-fired boilers retrofits	thou. Gcal	43087	kgce/Gcal	173	155		Equipment with 92% efficiency
Gas-fired boilers retrofits	thou. Gcal	511989	kgce/Gcal	165	151		Equipment with 95% efficiency
Other boilers retrofits	thou. Gcal	27079	kgce/Gcal	218	159		Equipment with 90% efficiency
Electricity consumption for heat generation by boilers	thou. Gcal	668091	kWh/Gcal	23	7	9	Finland
Heat distribution	thou. Gcal	1361704	%	10,6%	5,4%		Replacement of heat pipes (new technology)
Heat recovery	thou. Gcal	128448	%	61,3%	90,0%		Global practice
Oil refinery	thou. t	276317	kgce/t	87	53,9	75,1	Global practice
Gas processing	bln. m^3	71780	kgce/ 1000 m^3	62	46,3		2000 level
Coal processing	thou. t	106041	kgce/t	6,3	5,0		Global practice
Oil production	thou. t	502623	kWh/t	130	40,0		Global practice
Associated gas flaring	mln. m^3	67800	%	24,0%	5,0%		Federal requirements
Natural gas production	mln. m^3	668900	kgce/ 1000 m^3	8,7	5,9		Expert estimate
Coal production	thou. t	331006	kgce/t	4,2	3,0		Global practice
Iron ore production	thou. t	111940	kgce/t	12,5	8,5	10,0	Global practice
Iron ore agglomerate production	thou. t	58272	kgce/t	59,0	50,9	58,0	Global practice
Iron ore pellets production	thou. t	38699	kgce/t	22,2	21,4	21,4	Kostamuksha mining and concentrating plant
Coke production	thou. t	30487	kgce/t	161,5	119,0	143,0	Global practice
Cast iron production	thou. t	48233	kgce/t	664,5	355,0	461,0	Global practice
Open-hearth steel production	thou. t	4004	kgce/t	201,6	106,5		Vologodskaya Oblast
Basic oxygen steel production	thou. t	43167	kgce/t	13,0	-15,0	34,0	Global practice
Electric steel production	thou. t	20712	kgce/t	94,8	50,0	80,6	Global practice

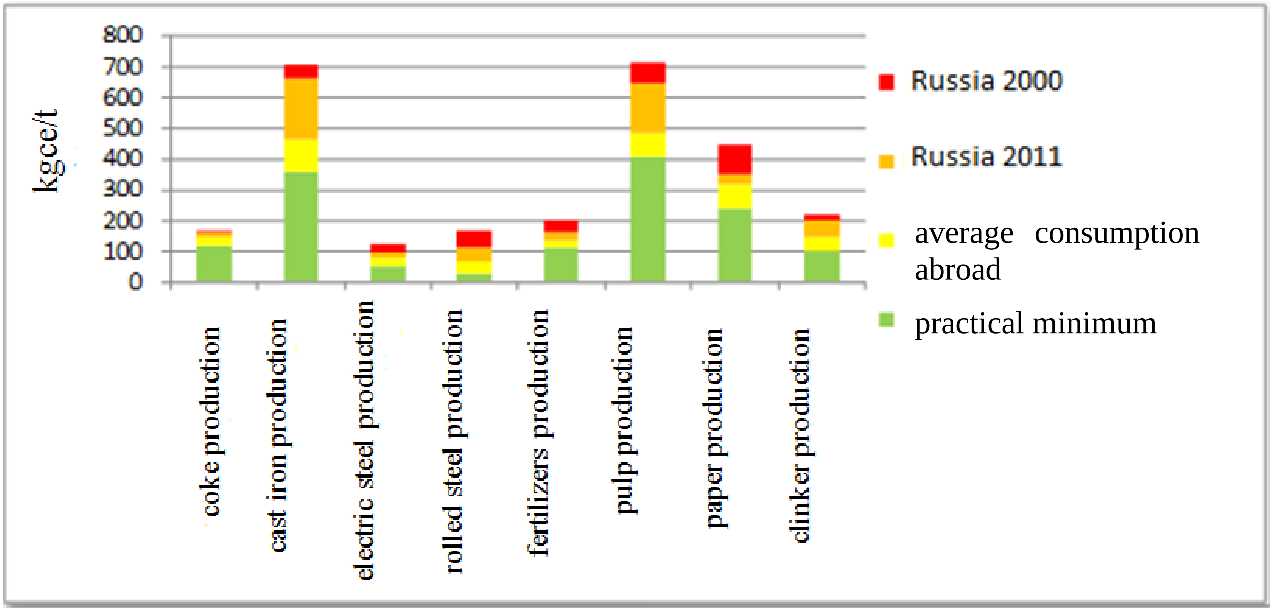
Integrated technologies of goods, work, and services production	Units	Volume of economic activity	Units	Specific consumption in 2010	Practical minimum	Actual consumption abroad	Comments
Rolled ferrous metal products	thou. t	60647	kgce/t	113,1	31	68,0	Global practice
Electroferroalloys production	thou. t	1825	kgce/t	959	700	700	Sverdlovskaya Oblast
Aluminium production	thou. t	3800	kgce/t	1830	1599	1763	Global practice
Alumina production	thou. t	3600	kgce/t	478	324	410	Global practice
Synthetic ammonia	thou. t	13924	kgce/t	1371	956	1120	Global practice
Fertilizers	thou. t	21853	kgce/t	163	109	131	Global practice
Ethylene	thou. t	3129	kgce/t	799	458	683	Global practice
Synthetic rubber	thou. t	1257	kgce/t	3002	765		Global practice
Pulp production	thou. t	6406	kgce/t	646	404	485	Global practice
Paper production	thou. t	4686	kgce/t	351	241	320	Global practice
Cardboard production	thou. t	2908	kgce/t	343	237	266	Global practice
Cement production	thou. t	50379	kgce/t	13	11	13	Global practice
Clinker production	thou. t	44979	kgce/t	200	99	145	Global practice
Glass production	thou. t	2343	kgce/t	250	132		Global practice
Meat and meat products	thou. t	3834	kgce/t	211	50		Chelyabinskaya Oblast
Bread and bakery	thou. t	4844	kgce/t	157	89		Tambovskaya Oblast
Efficiency motors	mln. units	11,7	kWh/motor	9956	8507		Global practice
Variable speed drives	mln. units	5,3	kWh/drive	9956	9356		Global practice
Efficient compressed air systems	mln. m^3	68356	kgce/ 1000 m^3	18	7		Global practice
Efficient oxygen production	mln. m^3	12419	kgce/ 1000 m^3	112	90		Global practice
Efficient industrial lighting	mln. units	47	kWh/ lighting unit	247	160		Global practice
Efficient steam supply	thou. tce	45002	%	75%	100%		Global practice

Source: CENEf

Based on specific energy consumption for the manufacture of goods, work, and services and on the equipment efficiency, Russian average energy efficiency levels and BAT were compared for a list of 52 aggregated technologies, work, and services. For many of these, comparisons were made with “actual consumption abroad”, i.e. most frequent specific energy consumption values in other countries.

Practically by all technologies there is a substantial energy efficiency gap not only between Russian levels and BAT, but also with “actual consumption abroad” (Fig. 5.1). During 2000-2011, technology gaps with the best available technologies somewhat narrowed, but are still quite significant: 1.4 times in coke, 1.9 times in cast iron and electric steel, 3.7 times in rolled steel, 1.5 times in fertilizers, 1.6 times in pulp, 1.5 times in paper, and 2 times in clinker.

Figure 5.1 Gap in specific energy consumption for the manufacture of some goods between Russia and best/average foreign levels



Source: CENEf

5.3 Definitions of technical, economic, and market energy saving potentials

Technical (technological) potential is estimated with an assumption that the whole existing equipment stock is overnight replaced with the best available practically used models. It is equal to the product of Russia’s 2011 goods, services, and work output and the difference between average specific energy consumption in Russia and BAT specific energy consumption. Technical potential shows only hypothetical possibilities, ignoring implementation costs or other limitations. It depends not only on the technology factors, but also on geographical factors, depending on which best practice technologies are considered: domestic or global. What matters here, is the awareness of foreign technologies and limitations related to their effective implementation in Russia. Assessments based on best available technologies are obviously much higher, than any other possible assessments. Only information on already used technologies was used to assess the technical potential.

Implementation of innovations makes the technical potential renewable[12]. For example, since the 60’s, “practical minimum”, i.e. best ever achieved specific energy consumption values for

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[12] The estimate of Russia’s energy saving potential made in 2000 (400 mln. tce) is lower, than the estimate made in 2008 (420 mln. tce), and they both are lower, than the estimate made in 2012 (464 mln. tce). See Bashmakov, I.A. Energy Efficiency: from Rhetoric to Action. CENEf, 2000. 224 p.; I. Bashmakov, K. Borisov, M. Dzedzichek, A. Lunin, I. Gritsevich. Resource of energy efficiency in Russia: scale, costs and benefits, CENEf. 2008, www.cenef.ru; Bashmakov I.A. Will there be economic growth in Russia in mid-XXI century? Institute of Economic Projections of the Russian Academy of Science. No. 3, 2012.

technologies with proved efficiency, dropped more than 2-fold in synthetic ammonia production, nearly 2-fold in steel-making, 1.3-fold in aluminium production, 1.2-fold in cement production[13]. Possibilities for reducing specific energy consumption will exist as long as it approaches the "theoretical minimum", i.e. minimum possible specific energy consumption required by thermodynamic laws to perform necessary work or material transformation. For many technologies, the potential is huge. For example, useful energy used by pumps is only 10% of the energy used by power plants to generate the electricity needed for the pump drives[14].

Economic potential is a part of technical potential, which can be cost-effectively implemented, using public cost-effectiveness criteria: 6% discount rate, opportunity costs (export price of natural gas), environmental and other indirect effects and externalities (for example, carbon price). It takes time to implement the economic potential, which is determined by the time needed to replace basic energy equipment and the growth rate of energy efficiency equipment production.

The structure of economy is a very important factor that affects not only the size, but also the structure of the energy efficiency potential. It is a derivative of the social and political environment in a country and its goals. In planned economies, overemphasis was made on heavy industry and defense machine building. The share of these in the total energy consumption was increasingly growing. Introduction of energy efficiency technologies in these two industries formed the basis for the energy efficiency potential. At the same time, in developed countries with market economies, the major potential was accumulated in private transport and housing.

One limitation is that at each moment of time machine building can produce no more than a certain amount of energy efficiency equipment, as determined by existing production capacities. Construction of new production capacities takes time. At the same time, equipment exporting companies cannot overnight increase their export volumes. Sales increase is limited by production capacity loads of foreign vendors, external trade regulations, customs regulations, time needed to develop an effective dealers and maintenance network.

Another limitation is that energy consumers can use a certain amount of energy efficiency equipment. This limitation is determined by the equipment lifetime and depreciation period: a consumer can incur substantial financial losses, if equipment is replaced before it is completely depreciated. If average equipment lifetime is 10 years, equipment stock will be replaced within 10 years; i.e. only in 10 years' time the whole stock will be replaced with the most efficient models. In fact, in certain instances, with high enough energy prices, replacement of energy intense equipment with more efficient models may be cost-effective even before the equipment is depreciated. However, such replacement is always accompanied by a drop in production. Therefore, assessments are based on standard depreciation time.

None of the economic limitations is absolute or permanent. Successful structural reforms, transition to market economy and decommissioning of uncompetitive energy equipment substantially changes the structure of economy in many countries. Energy efficient equipment manufacture is limited by investment in production capacity increase. Depreciation policies, benefits and subsidies for energy efficient equipment manufacture and/or purchase can ease restrictions related to the equipment replacement. In other words, economic reforms and energy efficiency measures can bring economic and technical potentials closer to each other.

Standards and certification of the energy parameters of equipment and processes for compliance with the federal requirements are very effective federal energy efficiency policies. They are or particular importance, because in the near future Russia will have to replace a large part of worn out assets, and the efficiency of the new assets, which will be operated for decades, will largely

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[13] Industrial Development Report 2011. Industrial energy efficiency for sustainable wealth creation. Capturing environmental, economic and social dividends. UNIDO. 2011

[14] Ibid.

determine energy efficiency levels. Standards require, that only equipment with energy efficiency parameters higher than a certain level be selected, and so oust inefficient models from the market, thus implementing a substantial part of the economic energy saving potential while extending and renewing the equipment stock. They set a barrier to selling equipment or buildings with “mured up” (for 10-50 years) inefficiency. However, standards and SNiP are not the only thing that matters; equally important are application practices and enforcement ability of government agencies.

Liberalization of external trade is another important measure. It has brought a lot of efficient foreign-made equipment to the Russian market. Exchange rate regulation determines the ratio of prices for Russian-made and foreign equipment, and prices, along with the quality and reliability of equipment, affect consumers’ investment decision-making. Approaching best available technologies becomes possible not only in abstract theory, but in practice. Foreign-made equipment that penetrated the Russian market gave a push to domestic production of similar equipment.

Market potential is a part of economic potential, which can be cost-effectively implemented using private cost-effectiveness investment decision-making criteria and under existing market conditions (actual energy and equipment prices, taxes, etc.). Through the level of monopolization, inflation rates, role of the price competition in market expanding or preserving, taxation, loan interest rates, exchange rates, etc. real market situation determines minimal requirements to the effectiveness of private investment or, which is much the same thing, maximum paybacks for private investment. The less sustainable the general economic situation, the less financial resources are available to the consumer, the stricter the payback requirements, and the less the market energy efficiency potential. Energy prices in Russia are already quite high, and so the market potential is approaching the economic potential even with the current tax system and loan costliness. Tax benefits, subsidized loans for energy efficiency projects, spurring competition can bring the market potential substantially closer to the economic potential.

There are three major lines of division between market and economic potential:

- ❖ investment decision-making practices (centrally planned economies always use energy twice or thrice less efficiently compared to market economies, other things equal);
- ❖ investment criteria: discount rates, which reflect risk perception by private investors (12 to 30% for industry, and up to 33-50% for households). Higher alternative cost of capital is determined by a number of factors: unwillingness to take risk related to investment in energy efficiency measures; for any significant investment they have to take loans for high interest rates, and if they have own financing, they also have more important (in their eyes) investment priorities;
- ❖ costs and effects are different: using real, not imputed, prices; taxes, subsidies, and benefits; integration of additional environmental and other costs.

Two more types of the energy efficiency potential can be considered:

- ❖ **information-secured potential** is a part of the market potential existing in the form of feasibility studies or individual decisions based on data collection and estimates;
- ❖ **financial-secured potential** is a part of the information-supported potential for which funding is secured.

Only a small part of the technical potential in the end turns into concrete investment solutions. Federal energy efficiency policies should be targeted to eliminate barriers, which prevent the financial-secured potential in industry to reach the technical potential, or at least to significantly reduce their hampering role.

Evaluation of end-use energy savings for separate measures does not give a complete idea of possibilities to reduce energy consumption. Besides, this evaluation is the sum of savings of energy resources, which differ in their quality, exergy potential and costs, so this is not a correct thing to do. Savings of 1 tce of coal is not the same as savings of 1 tce of electricity.

A unit of end-use energy saved generates additional savings along the entire energy chain: reduction of electricity, heat, and gas distribution losses, energy transportation costs, energy resources enrichment, refinery, and production, fuel consumption for electricity and heat generation, etc. These indirect savings can be quite substantial

Only generation and transmission electricity and heat losses are normally accounted as indirect effects. In this case, for 2010 Russia, 1 tce of end-use energy saved generates 3 tce in savings with an account of effects in the electricity sector (3=1*1.108*338/123), and 1 tce of heat saved generates 1.38 tce (1.38=1.106*178/143). This simplified approach ignores the fact that fuel production and delivery also involves electricity and heat consumption, and again, heat is needed to produce these electricity and heat, and so on.

Back in 1993, in order to present the entire set of indirect effects it was suggested to present the energy efficiency potential in the form of an energy balance and to use a method of estimating indirect effects similar to the one used for the input-output balance[15]. Evaluations are based on the following relationship between primary and end-use energy consumption: $PE=AE*PE+FE$, or $PE=(E-AE)^{-1}*FE$, where PE is the vector of primary energy consumption (production) by energy resources[16], AE – square matrix of coefficients of primary resource i consumption to produce and deliver resource j to the consumer, FE – vector of end-use energy consumption (including net export of energy resources). An estimate of the $(E-AE)^{-1}$ matrix for Russia for 2008 is shown in Table 5.2[17]. Each coefficient a_{ij} shows, how much coal, petroleum products, gas, electricity and heat is needed to provide a consumer with a unit of, say, coal. Any change in technology changes the AE matrix.

Table 5.2 Matrix of full coefficients of energy consumption in the fuel&energy complex per unit of energy delivered to end-user (2010, tce/tce)

	Coal	Crude oil	Oil products	Natural gas	Other solid fuels	Electricity	Heat
Coal	1.01	0.01	0.01	0.00	0.00	0.96	0.24
Crude oil	0.00	1.01	0.00	0.00	0.00	0.00	0.01
Petroleum products	0.00	0.00	1.05	0.00	0.00	0.06	0.07
Natural gas	0.01	0.03	0.03	1.03	0.00	2.22	0.89
Other solid fuels	0.00	0.00	0.00	0.00	1.00	0.01	0.03
Electricity	0.01	0.01	0.01	0.00	0.00	1.33	0.01
Heat	0.00	0.00	0.02	0.00	0.00	0.01	1.10
Total	**1.03**	**1.06**	**1.13**	**1.03**	**1.00**	**4.59**	**2.35**
Total, including pipeline and rail transportation of fuel	**1.04**	**1.07**	**1.21**	**1.10**	**1.00**	**4.76**	**2.41**

Source: CENEf's estimates.

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[15] I. Bashmakov. Costs and benefits of CO2 emission reduction in Russia. In Costs, impacts, and benefits of CO2 mitigation. Y. Kaya, N. Nakichenovich, W. Nordhouse, F. Toth Editors. IIASA. June 1993.

[16] Adjusted for changes in stock and net energy export.

[17] These coefficients have somewhat changed since 2005. See Energy Efficiency in Russia: Untapped Reserves. World Bank Group and CENEf. Moscow, 2008.

If end-user saves 1 tce of petroleum products, overall energy demand across the fuel&energy complex will go down by 0.12 tce (or by 0.2 tce, if transportation is included). The highest indirect effects are for electricity and heat generation. They by far exceed regular multipliers used to evaluate indirect effects: 2.5-3 for electricity (assuming 40% generation efficiency and 6-7% transmission and distribution losses) and 1.25 for heat generation (assuming 85% generation efficiency and 5% transmission and distribution losses[18]). With an account of all indirect effects, 1 tce of electricity saved by a Russian end-user generates not 2.5-3 tce, but 4.6 tce (or 4.9 tce, if transportation is included) along the entire energy supply chain.

These indirect effects provide grounds for subsidizing energy efficiency activities by the government and society, as they obtain these indirect effects free of charge. Accounting for this effect is important while assessing the economic energy efficiency potential. Multipliers in the last two rows in Table 5.2 were used to estimate the values in "primary energy savings-full-1" and "primary energy savings-full-2" columns of Table 5.3.

So the technical potential of primary energy savings was evaluated as the sum of end-use energy savings and primary energy consumption reduction in the energy sector through both improved efficiency of energy transformation and reduced demand for such transformation:

$$\mathrm{TEEP} = \Delta\mathrm{FE} + (\mathrm{AE}-\mathrm{AE}_{\mathrm{nt}})*(\mathrm{PE}-\Delta\mathrm{FE}) \qquad (5.1),$$

with AE_{nt} – matrix AE with new technology multipliers.

While assessing the potential, it is important to remember that baseline values of the primary energy vector (for 2011) are to be verified for the final energy consumption reduction *(*ΔFE*)*. In other words, the more electricity saved by end-users, the lower electricity demand, and so the effect of power plants equipment upgrades will be somewhat lower, than if generation stays at the 2011 level. Therefore, increase in final energy savings brings down energy savings potential in electricity and heat generation and transmission as compared to the baseline levels (Eq. 5.2).

If several energy resources are saved at the same time, multipliers of the full effect of primary energy savings in relation to final energy savings for each sector can be obtained by the following formula:

$$\mathrm{m}_i=\mathrm{dPE}_i=(\mathrm{E}-\mathrm{AE})^{-1}*\mathrm{dFE}_i \qquad (5.2),$$

with: dPE_i – reduction of primary energy consumption with reduced final energy consumption per unit in sector i;

$dFEi$ – vector of shares of particular energy resources consumed in sector i.

Taking account of indirect energy savings makes energy savings and specific costs of saved energy more comparable. Average for Russia coefficients of Table 5.2, obtained from the analysis of Russia's 2010 energy balance, were used to assess indirect effects of energy saving.

Where implemented measures help save a concrete energy resource, corresponding values in the bottom line of Table 5.3 were used as multipliers of the whole primary energy savings. In the most simple case, the following multipliers are used to account for indirect effects: coal – 1.03; crude oil – 1.06; petroleum products – 1.13; natural gas – 1.03; electricity – 3.4; heat – 1.38. These coefficients were used to assess the values in the "Savings of primary energy" column in Table 5.3.

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[18] Worrell, E., Neelis, M., Price, L., Galitsky, C., Zhou, N. World Best Practice Energy Intensity Values for Selected Industrial Sectors, 2007. Berkeley, CA: Lawrence Berkeley National Laboratory. 2007.

5.4 Light at the end of the tunnel. Assessment of technical energy saving potential

Assessment of the technical energy saving potential in provided in Table 5.3. Table 5.4 provides an integrated assessment of the potential, which was obtained by comparing specific energy consumption for the manufacture of goods, work and services in Russia with the best available technologies.

Table 5.3 Scale of energy saving and GHG emission reduction potential of energy efficiency measures in industry

	Savings of final energy	Savings of primary energy	CO_2 emission reduction
	thou. tce	thou. tce	mln. t $CO_{2\text{-eq.}}$
Gas-fired GRES retrofits	**26880**	**27686**	**38413**
Introduction of CCGT	26880	27686	38413
Coal-fired GRES retrofits	**9702**	**9993**	**41845**
Introduction of coal-fired ultra supercritical steam generation units	7762	7995	33478
Steam and gas combined cycle and coal gasification units	1940	1998	8367
Gas-fired co-generation plants retrofits	**31691**	**32642**	**45288**
Introduction of CCGT	31691	32642	45288
Coal-fired co-generation plants retrofits	**5449**	**5612**	**23501**
High pressure heating units	2179	2244	9398
Steam and gas combined cycle and coal gasification units	3270	3368	14103
Residual oil-fired co-generation plants retrofits	**401**	**453**	**575**
Retrofits of residual oil-fired energy units and of fuel handling systems	401	453	575
Diesel power plants retrofits	**1737**	**1963**	**2490**
Construction of new plants and replacement of existing equipment to install new, efficiency machinery	1737	1963	2490
Own needs consumption	**3763**	**17272**	**146039**
Variable speed drives and installation of efficiency motors at induced draft fans, blower fans, network and feed water pumps and for fuel handling. Efficiency lighting	3763	17272	146039
Electricity transmission	**5060**	**23225**	**196375**
Renovation of medium- and high voltage overhead power lines (replacement of A and AC cables with self-supporting insulated wires)	1590	7298	61707
Installation of efficient equipment at high-voltage substations (gas-insulated power transformers; controlled units for reactive power compensation; gas-insulated switch gears and control gears)	904	4149	35084
Renovation of high voltage overhead power lines (replacement of existing A and AC cables with efficient high-temperature cables AERO-Z, TACSR/ACS, (Z)TACSR/HICIN, GTACSR)	710	3259	27555
Introduction of automated information and measuring system of commercial energy metering at high-voltage substations and at consumers	550	2525	21345
Installation of highly accurate electricity meters at consumers (replacement of existing single-phase induction meters of 2.5 accuracy class with new electronic meters of 2.0 or 1.0 accuracy class)	260	1193	10090
Renovation of high-, medium-, and low-voltage power lines (replacement of existing impregnated paper-insulated cables with new cables with cross-linked polyethylene insulation)	250	1148	9702
Renovation of transformer substations (replacement of existing oil transformers with dry transformers with reduced electricity load and no-load losses)	240	1102	9314
Coal-fired boilers retrofits	**3481**	**15978**	**15013**
Replacement of boilers	750	3443	3235

	Savings of final energy	Savings of primary energy	CO$_2$ emission reduction
Application of deaerators	130	597	561
Installation of blowers to clean heated surfaces	50	230	216
Installation of integrated systems for automated control of thermal processes	370	1698	1596
Re-design of chemical water handling systems	60	275	259
Fuel, water, electricity, and heat generation metering	250	1148	1078
Operational optimization of boilers	200	918	863
Residual oil-fired boilers retrofits	**768**	**868**	**1101**
Replacement of boilers	246	278	353
Installation of integrated systems for automated control of thermal processes	123	139	177
Application of deaerators	62	70	88
Fuel, water, electricity, and heat generation metering	62	70	88
Operational optimization of boilers	31	35	44
Re-design of chemical water handling systems	31	35	44
Installation of blowers to clean heated surfaces	18	21	26
Gas-fired boilers retrofits	**7308**	**7527**	**10443**
Replacement of boilers	2196	2262	3139
Installation of integrated systems for automated control of thermal processes	1098	1131	1569
Application of deaerators	732	754	1046
Fuel, water, electricity, and heat generation metering	586	603	837
Operational optimization of boilers	366	377	523
Re-design of chemical water handling systems	300	309	429
Installation of blowers to clean heated surfaces	220	226	314
Other boilers retrofits	**1587**	**1587**	**4952**
Replacement of boilers	513	513	1599
Installation of integrated systems for automated control of thermal processes	220	220	685
Fuel, water, electricity, and heat generation metering	146	146	457
Application of deaerators	124	124	388
Installation of blowers to clean heated surfaces	110	110	343
Re-design of chemical water handling systems	73	73	228
Operational optimization of boilers	73	73	228
Electricity consumption by boilers for heat generation	**1315**	**6036**	**51034**
Renovation of pumps. Introduction of variable speed drives	1315	6036	51034
Heat distribution	**10126**	**23796**	**156243**
Replacement of heat pipes with new pre-insulated pipes	6076	27887	235790
Co-generation at boiler-houses	**7048**	**32350**	**273528**
Heat recovery	**5272**	12389	81346
Pipeline transportation	3110	7726	52065
Steel works	1054	2320	15970
Oil refinery	**9044**	**14665**	**64327**
Improving the efficiency of steam supply	2713	6376	41864
Automated management systems	1809	2933	12865
Improving the efficiency of pumps	904	4151	35099
Application of new catalysts	814	912	1166
Better hydrocarbon gas and hydrogen recovery	543	608	778
Gas processing	**1136**	**2822**	**19015**
Application of more efficient gas separators	454	1129	7606
Energy efficiency GTL technologies	341	846	5704
Coal processing	**134**	**295**	**2030**
Oil production	**5552**	**25484**	**215469**
Optimization of hydraulic layouts and of liquid/water counter-current flows; reduction of water influx	1943	8919	75414
Reduction of process electricity consumption in oil production	1832	8410	71105
Automation of processes	1666	7645	64641
Reduction of associated gas flaring	**14866**	**15312**	**21244**
Gas supply to the grid	13848	14263	19789

	Savings of final energy	Savings of primary energy	CO_2 emission reduction
Electricity generation at oil deposits	3270	3368	4673
Methanol production	2675	2755	3823
LPG production	1783	1836	2548
Stable condensate production	743	765	1062
Production of synthetic liquid hydrocarbons	445	458	636
Gas production	**1862**	2144	5034
Improving the efficiency of boosting compressor stations	1590	1830	4299
Coal production	**381**	1349	10594
Improving ventilation	99	351	2755
Improving mine drainage	91	324	2543
Improving compressed air systems	76	270	2119
Coal-mine methane production	**21000**	**21630**	**30010**
Iron ore production	**448**	**1839**	**15076**
Iron ore agglomerate production	**472**	**652**	**3567**
Retrofits of agglomerate plants to install new, efficient sintering machines with automated process control	453	626	3423
Recovery of secondary energy resources of agglomerate production (agglomerate gas and heat recovery)	15	21	113
Iron ore pellets production	**31**	**63**	**369**
Coke production	**1296**	**1916**	**10689**
Application of dry coke quenching (dry quenching units)	775	1145	6392
Renovation of coke and by-product plants to install new, efficient coke-oven batteries	257	380	2120
Dry coke quenching heat recovery at waste-heat boilers with steam turbines for electricity generation	130	192	1069
Direct reduction iron	**3472**	**5132**	**28635**
Cast iron production	**14928**	**15843**	**60321**
Injection of hot gas and oxygen into blast-furnace and increasing the blast air temperature	6800	7217	27477
Renovation of blast-furnaces to install bell-less tops	5400	5731	21820
Pulverized coal injection in blast-furnaces	1500	1592	6061
Using blast-furnace gas to generate electricity in top-pressure recovery turbines	60	64	242
Plastic waste injection in blast-furnaces	20	21	81
Direct reduction iron	**3472**	**3685**	**14030**
Open-hearth steel production	**381**	**469**	**1234**
Replacement of open-hearth steel production with electric steel production (with the installation of electric arc furnaces)	**3560**	**4385**	**11539**
Basic oxygen steel production	**1209**	**2178**	**11356**
Secondary energy resource (converter gas) recovery in basic oxygen steel production	163	294	1531
Electric steel production	**928**	**3346**	**26439**
Metal scrap pre-heating	200	721	5699
Renovation of electric steel production to install automated process control systems	150	541	4274
Air-operated control	80	289	2279
Oxygen lancing and oxygen injection for carbon monoxide combustion	60	216	1710
Iron and steel rolled products	**4997**	**8103**	**41016**
Continuous steel casting	2807	4552	23040
Renovation of rolled products plants to install automated process control systems	1520	2465	12476
Production of electroferroalloys	**473**	**1443**	**11257**
Aluminium production	**880**	**4039**	**34152**
Alumina oxide production	**553**	**1300**	**8533**
Synthetic ammonia	**5777**	**13217**	**84800**
Renovation of ammonia production equipment to increase productivity and use modern ammonia synthesis processes: AMV, LGA Process, KAAP/KPES and Megammonia	3771	8628	55354

	Savings of final energy	**Savings of primary energy**	**CO_2 emission reduction**
Fertilizers	**1180**	**3008**	**20623**
Renovation of mineral fertilizers (phosphates, potassium) production to use automated process control systems	899	2292	15712
Renovation of carbamide production to increase productivity and use automated process control systems	149	380	2604
Ethylene	**1155**	**2124**	**11582**
Application of the gas phase method of ethylene polymerization in polyethylene production	693	1274	6949
Installation of a gas turbine for gas and electricity production and turbine waste heat recovery	320	588	3209
Synthetic rubber	**474**	**1087**	**7055**
Renovation of synthetic rubber plants for transition to single-stage synthesis of isoprene rubber and hydrocarbon dehydrogenation	427	978	6349
Pulp production	**1550**	**4019**	**27918**
Renovation of pulp plants to use chlorine-free pulp bleaching (TCF bleaching)	874	2267	15747
Automation of processes	280	725	5039
Improving motors and pumps efficiency	72	331	2798
Paper production	**516**	**1565**	**11635**
Renovation of paper plants to use efficient paper-making machines	329	998	7423
Automation of processes	132	399	2969
Improving motors and pumps efficiency	53	241	2037
Cardboard production	**307**	**862**	**6202**
Renovation of cardboard plants to use efficient cardboard-making machines	199	560	4028
Automation of processes	80	224	1611
Improving motors and pumps efficiency	25	116	978
Cement production	**101**	**462**	**3910**
Application of closed-circuit grinding	101	462	3910
Clinker production	**4561**	**6003**	**21402**
Transition to “dry” clinker production – multiphase (from three to six), cyclone heat exchangers and decarbonization furnaces	3877	5102	18192
Furnace flue gas heat recovery	274	360	1284
Increasing the share of waste used as fuel in clinker furnaces	182	240	856
Replacement of clinker with by-products of other plants	**560**	**737**	**2628**
Glass production	**278**	**768**	**5483**
Meat and meat products	**619**	**1640**	**11455**
Bread and bakery	**328**	**650**	**3780**
Efficient motors	**2084**	**9566**	**80879**
Replacement of motors with more efficient models	1715	7872	66558
Replacement of motors with lower capacity models	369	1694	14321
Variable speed drives	**388**	**1781**	**15058**
Efficient compressed air systems	**797**	**2772**	**21959**
Efficient oxygen production	**279**	**1031**	**8225**
Efficient industrial lighting	**495**	**2272**	**19211**
Efficient steam supply	**11250**	**26438**	**173586**
Automation and management of steam production and supply; steam accumulation; condensate collection and return; steam pipes insulation; etc.	9350	21973	144269
Secondary steam recovery to produce electricity in steam turbines	744	1748	11480
Fuel savings in other processes	**5138**	**12686**	**85135**

Source: CENEf’s estimates

It also provides comments on which combination of which technical and technology solutions can generate these savings. BAT parameters can be reached through a combination of many technical solutions. Estimates of contributions made by each of these solutions are conditional, because often savings can only be obtained through the implementation of a set of measures, which, if implemented separately, may generate no, or very little, savings. Tables 5.3 and 5.4 provide estimates of savings by energy resources and of primary energy savings, as well as CO_2 emission reduction assessment. To account for emission reduction through heat and electricity savings, coefficients of average emission per 1 tce from power plants and boilers were used.

With independent implementation of energy saving measures in the industrial sector and fuel&energy complex energy savings the potential equals 231 mln. tce. However, it is important to remember, that electricity and heat savings bring the demand down, and so savings in the fuel&energy complex should be estimated with an account of relevant energy production decline (to avoid double count).

Integrated energy saving potential is estimated by four components:

- reduction of gas flaring;
- direct savings of final and delivered energy;
- indirect energy savings obtained through end-use petroleum products, electricity, and heat savings;
- energy savings obtained through substitution of coal and petroleum products in the electricity and heat sectors with saved natural gas;

Evaluation of the energy efficiency potential determined by improved technology. For each economic activity, potential energy savings are split by energy resources. This is done based on the set of resources, which are saved through the introduction of technologies corresponding to the “practical minimum” specific energy consumption. Such estimates help assess direct fuel and energy savings obtained in each economic activity through the introduction of best available technologies.

Evaluation of indirect energy savings obtained through end-use savings of petroleum products, electricity and heat. End-use electricity and heat savings obtained reduce demand for oil refinery, electricity and heat production, and so fuel demand for these processes. This effect is assessed as indirect savings. Indirect savings are obtained in the electricity and heat sectors and in fuel transformation (primarily in oil refinery), but are formed through energy efficiency measures in energy end-use sectors. Indirect fuel savings were assessed assuming that 2011 volumes of electricity and heat production by non-fuel energy sources (nuclear, hydro, and renewables, as well as heat recovery) will be kept. Indirect savings of some types of fuel were estimated pro rata to fuel consumption.

Evaluation of energy savings generated through fuel substitution in the electricity and heat sectors. Additional reduction of energy consumption can be achieved through the substitution of some fuel types, as the efficiency of electricity and heat production depends on the fuel used: natural gas provides better efficiency. In the assessments of substitution of coal and petroleum products with natural gas, gas consumption was taken equal to the 2011 level.

Evaluation of Russia’s technical energy efficiency potential showed, that it is 48-49% of the 2011 primary energy consumption. In absolute volumes, it is 470-481 mln. tce, including gas flaring reduction (Table 5.5 and Fig. 5.2 and 5.3).

Russia’s potential equals 65% of 2011 oil production, or 61% of 2011 gas production. It is nearly as much as annual primary energy consumption by France, or Great Britain, or Ukraine, and is 2% of global annual primary energy consumption.

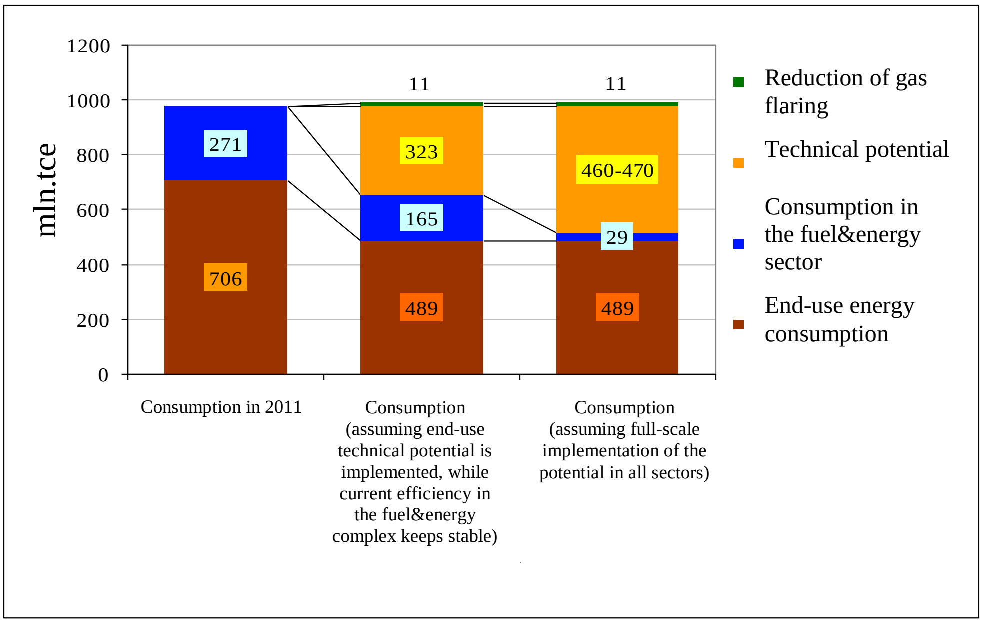
Energy efficiency potential was estimated with an assumption that energy savings obtained in end-use sectors generate indirect savings in fuel transformation sectors and in electricity and heat production through reduced end-use demand for fuel, electricity, and heat.

Table 5.4 Structure of integrated technical energy saving potential in Russia in 2011 (lower estimate, thou. tce)

	Energy savings	Coal	Crude oil	Petroleum products	Natural gas	Other solid fuel	Electricity	Heat
Total, including substitution effect	**470131**	**114255**	**1084**	**70001**	**276866**	**6354**	**0**	**1571**
Total	**464945**	**86731**	**1084**	**68972**	**300233**	**6354**	**0**	**1571**
Associated gas flaring	11283				11283			
Electricity production	100779	60780	54	1938	84179	458	-46631	0
substitution effect	*4679*	*23486*			*-18807*			
Electricity production	96100	37294	54	1938	102986	458	-46631	0
technology savings	*53389*	*17840*	*0*	*719*	*43894*	*97*	*-9161*	*0*
indirect savings	*42711*	*19454*	*54*	*1219*	*59092*	*361*	*-37470*	*0*
Heat production	89050	38491	1030	11096	147213	5537	1238	-115555
substitution effect	*507*	*4038*		*1 030*	*-4561*			
Heat production	88543	34453	1030	10066	151773	5537	1238	-115555
technology savings	*55150*	*11380*	*0*	*2075*	*46036*	*1899*	*568*	*-6809*
indirect savings	*33393*	*23073*	*1030*	*7991*	*105737*	*3638*	*670*	*-108746*
Oil refinery	24133	99	0	19098	882	322	827	2905
technology savings	*10191*	*79*	*0*	*6165*	*705*	*258*	*661*	*2323*
indirect savings	*13943*	*20*	*0*	*12933*	*177*	*65*	*166*	*582*
Gas processing	1114	0	0	27	312	0	265	509
technology savings	*846*	*0*	*0*	*20*	*237*	*0*	*202*	*387*
indirect savings	*268*	*0*	*0*	*6*	*75*	*0*	*64*	*123*
Coal processing	230	91	0	1	0	0	42	97
technology savings	*120*	*58*	*0*	*1*	*0*	*0*	*26*	*35*
indirect savings	*111*	*33*	*0*	*0*	*0*	*0*	*15*	*62*
Own needs	5179	0	0	0	0	0	5021	158
technology savings	*2690*	*0*	*0*	*0*	*0*	*0*	*2679*	*11*
indirect savings	*2489*	*0*	*0*	*0*	*0*	*0*	*2342*	*147*
Losses	21552	0	0	0	0	0	7862	13690
technology savings	*8511*	*0*	*0*	*0*	*0*	*0*	*4457*	*4054*
indirect savings	*13040*	*0*	*0*	*0*	*0*	*0*	*3404*	*9636*
End-use	**216812**	**14794**	**0**	**37841**	**32997**	**36**	**31377**	**99767**
Industry	**73228**	**14794**	**0**	**1239**	**19086**	**19**	**15107**	**22982**
*Share of industry**								
Agriculture	2253	0	0	1547	23	0	32	651
Transport	46463	0	0	34971	9572	17	1818	86
Municipal utilities	864	0	0	0	0	0	864	0
Commercial	16638	0	0	9	2147	0	4457	10026
Residential	77366	0	0	76	2169	0	9099	66023

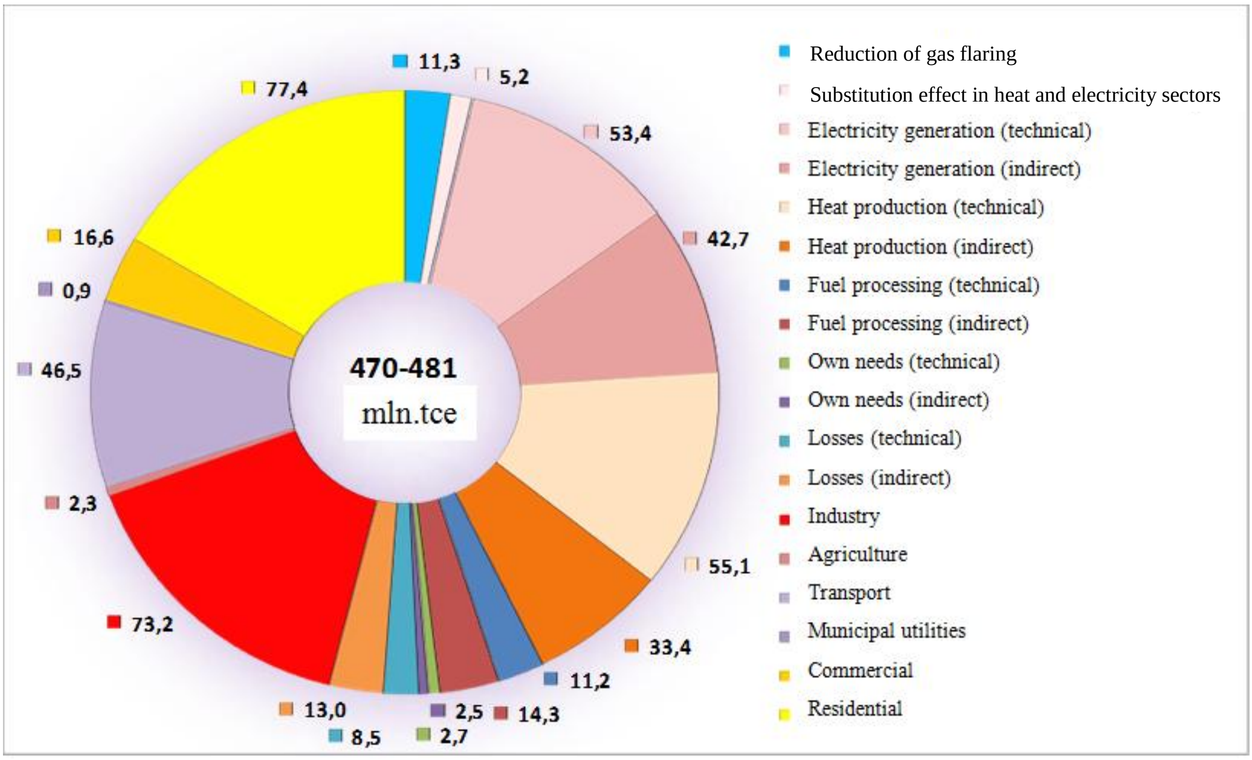
Source: Transformed for 2011 based on I.A. Bashmakov and A.D. Myshak. Factors determining Russian energy-related GHG emission dynamics. Analysis based on the data from the National Inventory Report. FGBU “Institute of the Global Climate and Ecology of Roshydromet and the Russian Academy of Science”. 2012.

Figure 5.2 “Gold stock” of Russian energy efficiency potential (mln. tce)



Source: CENEf’s estimates

Figure 5.3 Integrated assessment of Russia’s technical energy efficiency potential in 2011 (mln. tce)



Source: Transformed for 2011 based on I.A. Bashmakov and A.D. Myshak. Factors determining Russian energy-related GHG emission dynamics. Analysis based on the data from the National Inventory Report. FGBU “Institute of the Global Climate and Ecology of Roshydromet and the Russian Academy of Science”. 2012.

Technological savings in fuel transformation sectors was estimated based on the 2011 production level minus savings of corresponding resources with complete implementation of the end-use potential.

Industrial (excl. fuel-and-energy complex) end-use energy saving potential is 73 mln. tce. However, the energy saving potential in the industrial sector is the sum of the potentials in fuel processing industry and fuel end-use industry, and of the potential determined by gas flaring reduction. This value equals 114 mln. tce, or 25% of the overall energy saving potential and 43% of industrial energy consumption. This is more than annual energy consumption by such countries as Poland, the Netherlands, or Turkey. Part of this energy saving potential in electricity and heat generation (242 mln. tce) can be attributed to industrial power plants and boilers. If this part is one third, then overall technical energy saving potential in the Russian industry is 194 mln. tce, or 41% of the overall Russia's technical energy saving potential;

Comparison of relative values of the technical energy saving potential in some Russian industries with other countries shows, that in Russia, this value is larger, than in the developed countries, and often larger, than in developing countries (Table 5.5). The latter is no surprise, because in the developing countries the share of new equipment built in the recent years on a new technology basis is quite large. As to the absolute volume of savings, in some industries Russian potential is comparable to the global one.

Таблица 5.5 Comparing relative and absolute values for technical energy efficiency potential in some industries in Russia and other countries

Industries and products	Technical potential (%)			Technical potential (mln. tce)		
	Developed countries	Developing countries	Russia	Developed countries	Developing countries	Russia
Oil refinery	10-15	70	38	23,9	157,1	9,0
Ammonia	11,0	25	30	3,4	44,4	5,8
Alumina oxide	35,0	50	32	3,4	17,1	0,6
Aluminium	5-10	5	13	3,4	6,8	0,9
Iron and steel	10	30	41	23,9	184,4	22,6
Cement	20	25	50	13,7	61,5	4,7
Glass	30-35	40	47	13,7	6,8	0,3
Pulp and paper	25	20	28	44,4	10,2	1,8

Sources: data for Russia – CENEf. Data for other countries – UNIDO. 2011. Industrial Development Report 2011. Industrial energy efficiency for sustainable wealth creation. Capturing environmental, economic and social dividends.

Final energy saving potential more than doubles, if indirect effects and the improved efficiency of fuel&energy complex technologies are taken into account (Table 5.4). Reduced end-use demand and full-scale implementation of energy saving potential is supplemented with 31 mln. tce electricity demand reduction, 100-135 mln. tce heat demand reduction, and 38 mln. tce petroleum products demand reduction.

Besides, improved electricity generation technologies bring 53 mln. tce in savings, improved heat generation 55 mln. tce (including through increased heat recovery), improved fuel processing and other fuel&energy technologies 22 mln. tce. Ratios of indirect and technology effects in the fuel&energy complex fluctuate following the progress in end-use energy savings. If there is no progress, energy savings determined by improved technologies will be much larger. For this reason, while final energy savings potential varies in the range of 32 mln. tce, primary energy savings potential varies in the range of only 11 mln. tce. This can be explained by additional reduction of electricity and heat consumption, affecting the potential of technological savings in these sectors.

Full-scale implementation of electricity efficiency potential would reduce electricity consumption by 379 bln. kWh, or by 36% of the 2011 level. The major part of the potential is "hidden" in industry (123 bln. kWh), followed by the buildings sector.

Improving heat efficiency and reduction of heat transmission losses can bring 808-1065 Gcal in savings, or 59-78% of the 2011 heat consumption level. The largest potential is in buildings (532-775 mln. Gcal), followed by the manufacturing sector (161 mln. Gcal).

Natural gas savings potential is 240-249 bln. m^3, or 50-52% of the 2011 gas consumption level, and is substantially above the Russian gas export volume in 2008-2012. End-use consumption is responsible for 28-35 bln. m^3, reduction of gas flaring through increased gas recovery for another 10 bln. m^3; reduction of heat demand and improved heat generation technologies for 128-130 bln. m^3; reduction of electricity demand and improved efficiency of power plants for 89 bln. m^3.

Liquid fuel saving potential accounts for 71 mln. tce, or 38% of the 2011 consumption level. The largest potential (50%) is in transport.

Coal saving potential equals 114 mln. tce, or 83% of coal consumption. Nearly 85% is in the electricity and heat sectors.

5.5 Physical volumes of GHG emission reduction

Energy-related GHG emission reduction potential was estimated for three GHG: CO_2, CH_4, and N_2O by the four above effect components. The estimates are provided both for each gas and as the resulting value for three GHG (Tables 5.6). Technical potential of three energy-related GHG emissions reduction, as of 2011, was estimated at 1,099 mln. t $CO_{2\text{-eq.}}$, or 54% of the 2011 emissions level. Emission reduction potential for CO_2 equals 929 mln. t CO_2 (59%), CH_4 – 7.9 mln. t (37%), N_2O – 11.5 thou. t (48%).

Distribution of the potential by sectors shows, that it is primarily "hidden" in electricity and heat generation (Fig. 5.4), on condition that the entire indirect savings are allocated to this sector. In this case industry is responsible for nearly 90 mln. t $CO_{2\text{-eq.}}$ plus the effect from reduced gas flaring – 24 mln. t $CO_{2\text{-eq.}}$, or around 11% of GHG emission reduction potential.

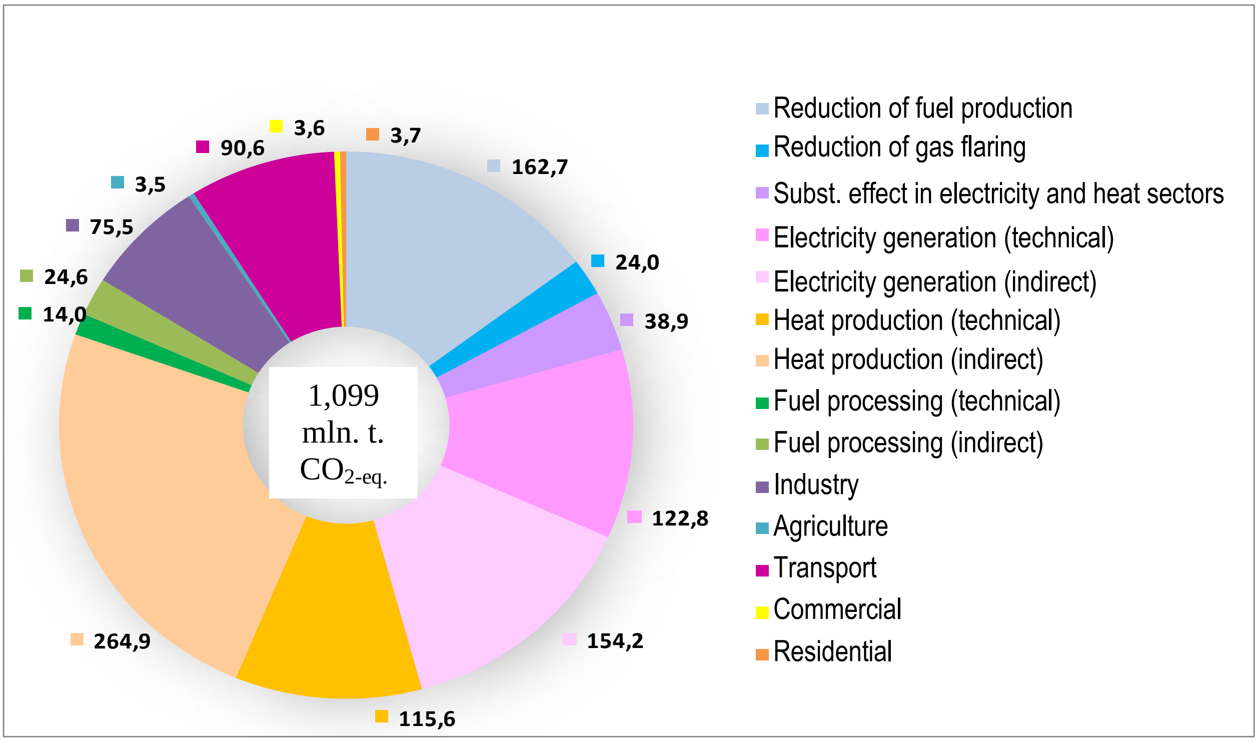
Table 5.6 Technical potential of three GHG emissions reduction in the energy sector in 2011 (thou. t $CO_{2\text{-eq.}}$)

	Total	Coal	Crude oil	Petroleum products	Natural gas	Other solid fuels
Total	**1098568**	**333020**	**2365**	**146870**	**602102**	**14211**
Reduction of coal, oil, and gas production	**162683**	**19496**	**29**	**1818**	**141341**	**0**
Total	**935885**	**313525**	**2336**	**145052**	**460761**	**14211**
Associated petroleum gas flaring	23990	0	0	0	23990	0
Total, with substitution effect	911896	313525	2336	145052	436772	14211
Total	872999	238431	2336	142791	475230	14211
Electricity generation with substitution effect	310017	165635	117	4350	138538	1377
substitution effect	33051	64003	0	0	-30952	0
Electricity generation	276966	101632	117	4350	169490	1377
technological savings	122761	48617	0	1614	72239	292
indirect savings	154205	53016	117	2736	97252	1085
Heat generation with substitution effect	386400	105718	2220	24366	242277	11819
substitution effect	5845	11091	0	2261	-7506	0
Heat generation	380555	94627	2220	22106	249783	11819
technological savings	115633	31257	0	4557	75765	4054
indirect savings	264922	63370	2220	17548	174018	7765
Oil production	37756	141	0	35201	1451	963
technological savings	13406	113	0	11363	1160	770
indirect savings	24350	28	0	23837	291	193
Gas processing	572	0	0	58	514	0
technological savings	435	0	0	44	390	0
indirect savings	138	0	0	14	124	0

	Total	Coal	Crude oil	Petroleum products	Natural gas	Other solid fuels
Coal processing	246	243	0	3	0	0
technological savings	156	155	0	2	0	0
indirect savings	89	89	0	1	0	0
Own needs	0	0	0	0	0	0
technological savings	0	0	0	0	0	0
indirect savings	0	0	0	0	0	0
Losses	0	0	0	0	0	0
technological savings	0	0	0	0	0	0
indirect savings	0	0	0	0	0	0
End-use	**176905**	**41788**	**0**	**81074**	**53991**	**52**
Industry	**75515**	**41788**	**0**	**2610**	**31087**	**30**
Agriculture	**3482**	**0**	**0**	**3444**	**38**	**0**
Transport	**90619**	**0**	**0**	**74845**	**15753**	**21**
Municipal utilities	**0**	**0**	**0**	**0**	**0**	**0**
Commercial	**3557**	**0**	**0**	**19**	**3538**	**0**
Residential	**3732**	**0**	**0**	**156**	**3576**	**0**

Source: Transformed for 2011 based on I.A. Bashmakov and A.D. Myshak. Factors determining Russian energy-related GHG emission dynamics. Analysis based on the data from the National Inventory Report. FGBU "Institute of the Global Climate and Ecology of Roshydromet and the Russian Academy of Science". 2012.

Figure 5.4 Direct contribution of sectors to the emission reduction potential of three energy-related GHG in Russia in 2011 (mln. t $CO_{2\text{-eq}}$.)



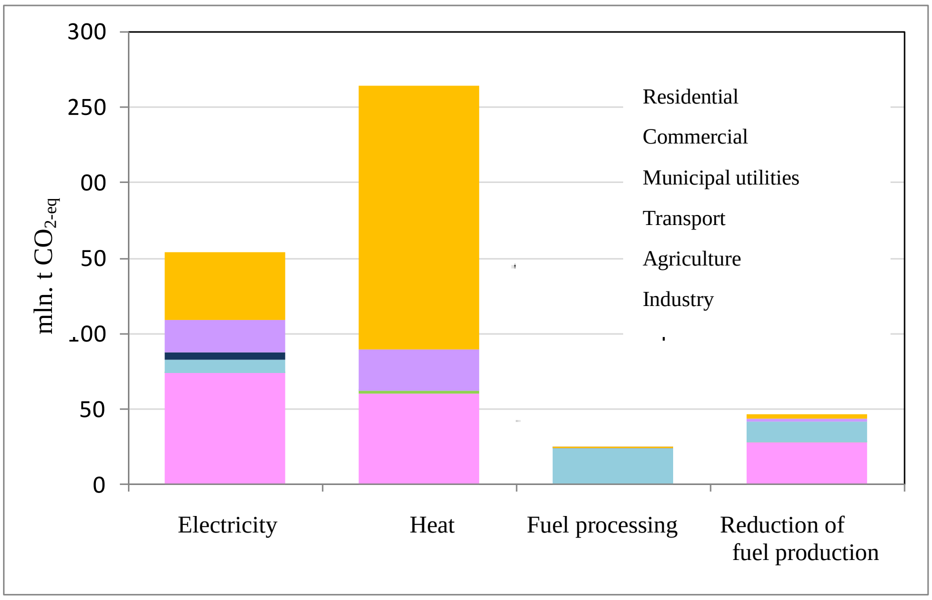
Source: Transformed for 2011 based on I.A. Bashmakov and A.D. Myshak. Factors determining Russian energy-related GHG emission dynamics. Analysis based on the data from the National Inventory Report. FGBU "Institute of the Global Climate and Ecology of Roshydromet and the Russian Academy of Science". 2012.

However, a significant part of indirect savings result from end-use energy efficiency measures, so it should be allocated by these sectors by four effects: electricity savings, heat savings, fuel refinery, and reduced emissions and leakages in fuel production (Fig. 5.5). Obviously, indirect emission reduction determined by measures implemented in industry and in buildings is quite significant.

Modification of the emission reduction structure to account for re-allocation of indirect effects by end-use sectors significantly changes the picture of emission reduction potential (Fig. 5.6). The share of end-use sectors grows up to 63%, including 25% of the potential “hidden” in industry, 12% in transport, and 25% in residential and public buildings. Therefore, emission reduction potential can be implemented through energy efficiency improvements primarily in these sectors. The share of industry grows up to 22%, and together with the energy industries it accounts for 61%.

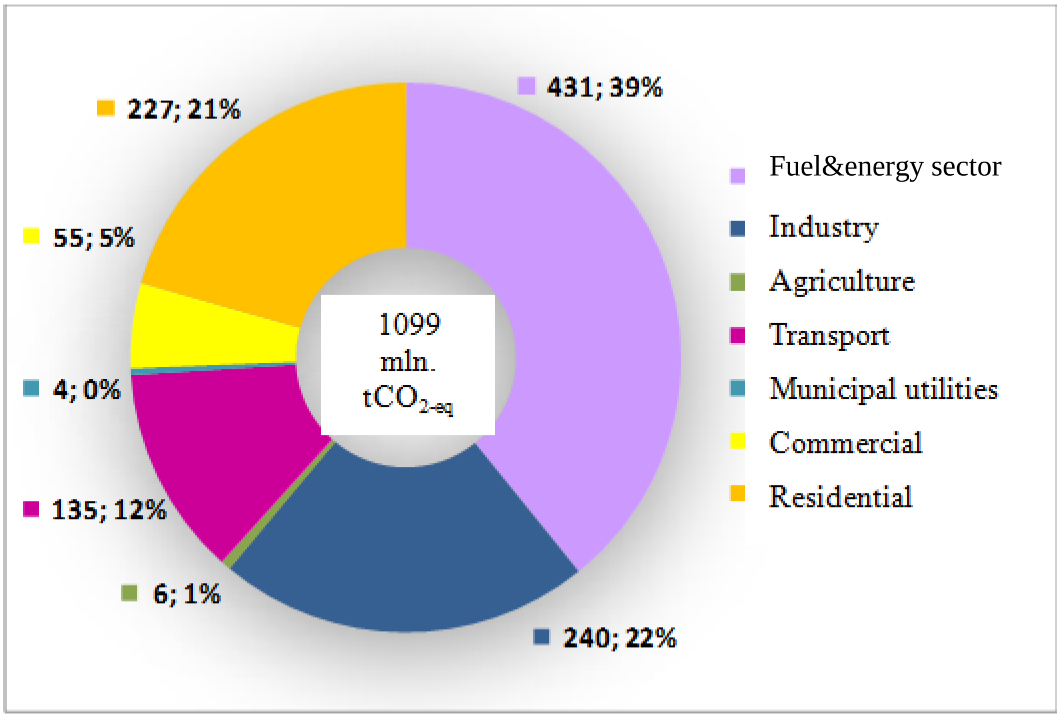
The accomplished analysis did not consider end-use energy substitution. If this is taken into account, emission reduction potential can significantly increase.

Figure 5.5 **Accounting for indirect effects while evaluating contributions of sectors to three energy-related GHG emissions reduction potential in Russia in 2011 (mln t $CO_{2eq.}$)**



Source: Transformed for 2011 based on I.A. Bashmakov and A.D. Myshak. Factors determining Russian energy-related GHG emission dynamics. Analysis based on the data from the National Inventory Report. FGBU “Institute of the Global Climate and Ecology of Roshydromet and the Russian Academy of Science”. 2012.

Figure 5.6 **Direct and indirect contributions of sectors to three energy-related GHG emissions reduction potential in Russia in 2010 (mln t $CO_{2\text{-eq.}}$)**



Source: Transformed for 2011 based on I.A. Bashmakov and A.D. Myshak. Factors determining Russian energy-related GHG emission dynamics. Analysis based on the data from the National Inventory Report. FGBU “Institute of the Global Climate and Ecology of Roshydromet and the Russian Academy of Science”. 2012.

Importantly, emission reduction potential shows hypothetical possibilities, ignoring many limitations. For example, regional unavailability of natural gas is a barrier to fuel switch of many electricity and heat sources from coal to natural gas. Some measures aimed at the potential implementation may turn out too costly or time consuming because of too long life cycles and too slow turnovers of physical elements of fixed capital. Therefore, it is important to understand, how theoretical possibilities for emission reduction can be practically implemented and how they are accounted for in GHG emission dynamics projections for Russia for the coming 40 years.

5.6 Evaluation of the market energy saving potential (in in physical and value terms) by some measures in several economic sectors

5.6.1 Evaluation of paybacks of energy efficiency measures

Costs evaluation is an important component of economic and market potential assessment. Substantial improvement of energy efficiency of Russia's economy is only possible, if a large part of fixed assets are renovated and/or replaced. However, renovation and replacement do not primarily aim at energy efficiency improvement, but at keeping the equipment stock in operation, improving its reliability and overall productivity; additional revenues and cost reduction; as well as reduction of environmental pollution. Improved energy efficiency and reduced energy costs are just one effect of retrofits, therefore, cost estimates are based on the concept of incremental capital costs. The latter are assessed as the difference between the costs of top efficient (BAT) equipment purchased under an energy efficiency project and capital costs of new equipment with medium- or low efficiency (comparable to the equipment currently used in Russia), for example the difference in cost between a highly efficient electric motor and an electric motor with medium efficiency. In some instances, where energy efficiency improvements were the sole investment purpose, for example, with variable speed drives or meters installation, total capital costs were used in calculations.

This approach is widely used to estimate investment demand for energy efficiency projects. It was used by IEA to assess global energy efficiency investments in 2011 (which were USD 180 bln., including USD 20 bln. in the U.S., USD 76.3 bln. in the EU, USD 30.6 bln. in China, USD 9.5 bln. in India, and USD 5.7 bln. in Russia)[19]. CENEf's estimates for Russia are USD 5.2-5.9 bln. in 2011.

Feasibility studies of many projects assess total, rather than incremental, capital costs, since the costs of equipment cannot be split into one part that enables further production or ensures production increase, and the other that helps reduce energy consumption. Therefore, project cost estimates are based on total equipment costs, and not on the part that enables energy efficiency improvements (and so energy efficiency project costs are overestimated 2-10-fold), while the project effect is reduced to improved energy efficiency alone. This often leads to a conclusion on long paybacks of energy efficiency projects. But these estimates are not correct. It is important to either account for additional (sometimes they are primary) effects, or use incremental capital costs in calculations. For example, for a heat pipeline replacement project, primary effects include retaining the heat market position, reduction of repair/emergency costs (for worn out parts of the heat pipeline) and of the emergency service maintenance costs; reduction of leaks, reduction of revenue loss from heat supply breaks during emergencies through improved reliability of heat supply, longer lifetime of the heating network, and only then reduction of heat losses through pipeline insulation. Therefore, while assessing the project cost-effectiveness, only the difference between the cost of traditional insulation (for example, mineral wool) and efficient insulation (for example, foam polyurethane) should be taken into account, and only these incremental costs should be compared to the cost of energy savings obtained through loss reduction.

Capital costs are normally reported per unit of equipment capacity, or per 1 m^2 of buildings floor space, etc. For electric steel, incremental capital costs and the technology effect depend on the burden mix, including the share of scrap; furnace type, brand, and productivity; whether or not

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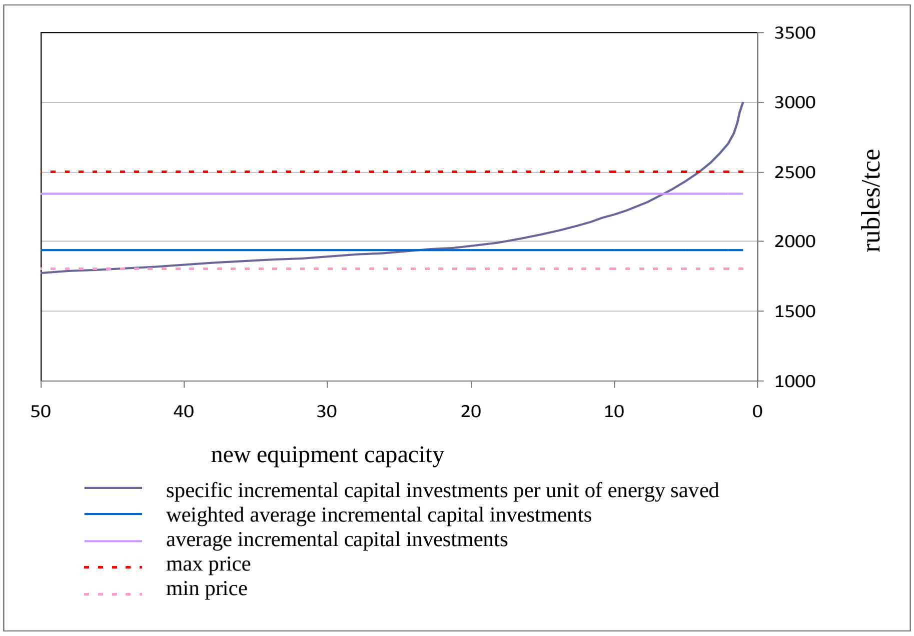
[19] World Energy Outlook 2012. International Energy Agency. 2012. Paris.

the burden is preheated; additional furnace loading procedure; number and type of electrodes, furnace load; and required quality of steel (final product).

For assessments of economic energy saving potential it is important to know the cost of energy savings (per unit). So certain assumptions should be made related to the equipment operation parameters (number of hours in operation, climate, etc.) to obtain incremental capital costs per unit of energy saved (1 tce). This helps operate with an integrated parameter of incremental capital costs for comprehensive typical measures instead of having to deal with a detailed estimation of costs for each small technology improvement. All units, buildings, and equipment differ in capacity or floor area. Specific costs of energy savings normally depend on the capacity, and there is economy of scale. It is impossible to deal with the whole range of cost values, so an average cost should be identified. If an average cost is identified as arithmetic mean, the costs for small and large units have the same weights, substantially increasing the costs (Fig. 5.7). Therefore, average weighted specific capital costs need to be identified. The cost-effectiveness of energy efficiency investments is identified by comparing the cost of energy savings with energy price. However, prices for one and the same energy resource differ for various consumer groups even in the same region. In the Russian Far East prices and tariffs for energy resources (except coal) are the highest. The cheapest electricity is in the North Caucasus, the cheapest heat in the Urals, the cheapest gasoline in the Siberia, the cheapest residual oil on the Volga, the cheapest gas in the Urals. For this reason, measures that have good paybacks in one region, may have very bad paybacks in another, where energy prices are lower. Paybacks can be accurately estimated for a concrete unit, whereas average paybacks for the whole country are estimated with aggregate indicators.

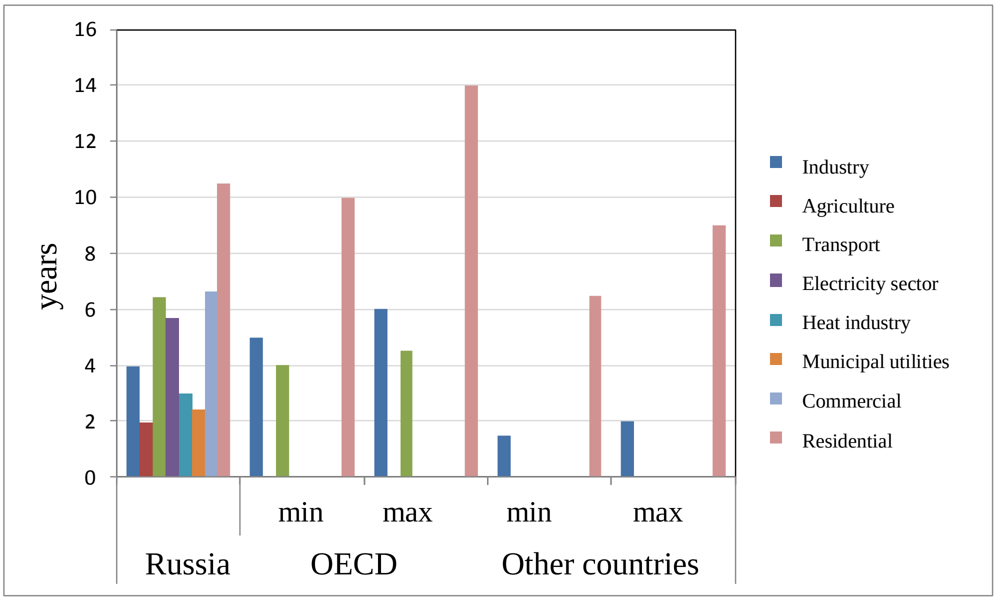
Figure 5.7 **Relationships between specific costs of energy efficiency projects and equipment capacity and between attractiveness of such costs and energy prices**



Source: CENEf

Since incremental capital costs are estimated as the difference between the costs of equipment installed under an energy efficiency project with top energy efficiency parameters corresponding to BAT, and the costs of new equipment with medium or low efficiency, search for such information is a complex and time-taking task. To test the obtained estimates for reliability they are compared with average data for a number of projects. Comparison of paybacks of energy efficiency investments is one of the simplest methods. As Russian energy tariffs and prices are already high enough compared to the international prices, this method of proving the reliability of assessments of specific energy efficiency investments is adequate. The estimates obtained by CENEf (average for measures in various energy consumption sectors) of paybacks of incremental energy efficiency costs are well in line with the IEA estimates (Fig. 5.8). Just like it should be, with an account of Russia's energy efficiency level and energy prices, paybacks for Russia are between the estimates for OECD and for other countries.

Figure 5.8 Comparison of average paybacks of energy efficiency projects in Russia and abroad



Source: CENEf. Data for other countries from World Energy Outlook 2012. International Energy Agency. 2012. Paris.

Energy efficiency measures in industry pay back on average in OECD faster than in 5 years, in other countries in 1.5-2 years, while in Russia in 4 years. UNIDO provides similar estimates based on questionnaires filled in by a large number of companies. According to UNIDO, average payback of energy efficiency investments in the global manufacturing sector is 2 years, in chemistry 3 years, in food and pulp&paper 1 year[20]. Average payback of projects dealing with industrial equipment replacement is nearly 3 years. Three-year energy efficiency programme of OAO "Gasprom" for 2011-2013 is expected to bring 9.8 trillion rubles in savings at the cost of 4.9 trillion rubles. Investments in improving the efficiency of cross-country gas transportation pay back in 1 year, and in natural gas production and processing in less than 1 year. So CENEf's estimates pass the test for compatibility with averaged international payback assessments.

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[20] Industrial Development Report 2011. UNIDO. 2011.

5.6.2 Development of cost of saved energy (CSE) curves to assess the economic and market energy saving potentials

Data on specific incremental capital investments were used for the assessment of economic and market potentials. These data were obtained for various technologies and typical measures from open sources, including data from vendors, energy efficiency projects implementation reports by Russian and foreign companies, analytical papers on energy efficiency policies, including energy savings curves[21]. Both average specific capital costs and the cost range were assessed (Fig. 5.7). The costs were divided by the unit of energy savings in tce.

The cost of saved energy (CSE) was determined by the following formula to identify the economic and market potentials[22]:

$$CSE = \frac{CRF * Cc + Cop}{ASE} \tag{5.3}$$,

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[21] The incomplete list of the sources used includes: World Energy Outlook. 2012. IEA/OECD. Paris. 2012; Energy technology perspectives. 2010. Scenarios & Strategies to 2050. OECD/IEA. 2010; Industrial Development Report 2011 UNIDO. 2011; Energy technology transitions for industry. Strategies for the next industrial revolution. IEA/OECD. Paris. 2009; Transport, energy and CO_2. Moving toward sustainability. OECD/IEA. 2009; Promoting energy efficiency investments. Case studies for residential sector. OECD/IEA. 2008; Tracking industrial energy efficiency and CO_2 emissions. OECD/IEA. 2007; World best practice energy intensity values for selected industrial sectors. Ernest Orlando Lawrence Berkeley Laboratory. Environmental Energy Technologies Division. June. 2007; J. Sathaye, L. Price, S. de la Rue du Can, and D. Fridley. Assessment of energy use and energy savings potential in selected industrial sectors in India. Ernest Orlando Lawrence Berkeley Laboratory. Environmental Energy Technologies Division. February. 2005; Associated petroleum gas utilization strategy in the Russian Federation. Russian gas society. Moscow, 2008 (in Russian); E. Worrell and C. Galitsky. Energy efficiency improvement and cost saving opportunities for petroleum refineries. An ENERGY STAR Guide for energy and plant managers. Ernest Orlando Lawrence Berkeley Laboratory. Environmental Energy Technologies Division. February. 2005; E. Worrell, N. Martin, N. Angliani, D. Einstein, M. Khrushch, L. Price. Opportunities to Improve Energy Efficiency in the U.S. Pulp And Paper Industry, 2001; R. Williams. The Chinese motor system optimization experience: developing a template for a national program. In Energy Efficiency in Motor Driven Systems. 5-8 December. Heidelberg. Germany. 2005; Yu.B. Eisenberg. Today's problems of efficient lighting. Energosberezheniye. No. 1, 2009 (In Russian); Improving compressed air system performance. A sourcebook for industry. LBNL for the U.S. DOE. November 2003; Energy Efficiency Action Plan of the Federal Republic of Germany. Federal ministry of economic affairs. September 2007; J. Jackson. Improving Financial Analysis of Industrial Energy Efficiency Programs. Effective Industrial Energy Efficiency Programs and Tools. September 22, 2008. Expert Working Group Meeting: Advancing Industrial Energy Efficiency in the Post-2012 Framework; Energetics. Industrial Energy Efficiency Improvement Potential; CHARACTERIZING COSTS, SAVINGS AND BENEFITS OF A SELECTION OF ENERGY EFFICIENT EMERGING TECHNOLOGIES IN THE UNITED STATES. Lawrence Berkeley National Laboratory. DECEMBER 2010. BOA-99-205-P; California's Secret Energy Surplus: The Potential For Energy Efficiency. Prepared by XENERGY Inc. Principal Investigators: Michael Rufo and Fred Coito; Oakland, California. Prepared for The Energy Foundation and The Hewlett Foundation. September 23, 2002; Energy efficiency guide for industry in Asia; PNNL. Energy Efficiency Potential in Existing Commercial Buildings: Review of Selected Recent Studies DB Belzer. April 2009. Prepared for the UNITED STATES DEPARTMENT OF ENERGY; Rhode Island Energy Efficiency and Resources Management Council (EERMC): Opportunity Report – Phase I Submitted on July 15, 2008 to the RI Public Utilities Commission, the General Assembly, the RI Office of Energy Resources and National Grid; Pathways to World-Class Energy Efficiency in Belgium. 2009. McKinsey & Company; M. Weiss, M. Junginger, and M.K. Patel. Learning energy efficiency – experience curves for household appliances and space heating, cooling, and lighting technologies. Utrecht University. Utrecht, 31 May 2008; J. Sathaye and S. Murtishaw. ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY. Market Failures, Consumer Preferences, and Transaction Costs in Energy Efficiency Purchase Decisions. November 23, 2004; KORZHUBAEV, D. LAMERT, L. EDER. Associated petroleum gas effective use's problems & prospects in Russia. Bureniye i neft. April 2012; Opportunity Assessment for the Pulp and Paper, Chemical Manufacturing, and Petroleum Refining. Resource Dynamics Corporation prepared this report for the U.S. Department of Energy's Office of Industrial Technologies. October 2002; and data from energy efficiency programmes of Russian companies.

[22] Resource of energy efficiency in Russia: scale, costs and benefits, www.cenef.ru.

with: Cc – incremental capital cost of energy efficiency measure; Cop – evolution of current operation costs or additional effects – increased output, improved quality, etc.; ASE – annual savings of final energy; CRF – capital recovery factor, which is calculated as follows:

$$CRF = \frac{dr}{1-(1+dr)^{-n}} \quad (5.4),$$

with *dr* – discount rate, *n* – equipment life cycle.

6% discount rate was used to assess the economic potential[23], and 12% and 20% discount rates were used to assess the market potential for all investments[24]. A certain lifetime is used for each type of equipment[25].

Additional costs or benefits (*Cop)* can include annual change in operational and maintenance costs, neutralization of externalities related to a concrete energy efficiency project. Benefits (for instance, additional production determined by higher reliability of equipment, or reduction of products losses due to frequent failure of obsolete equipment, or avoided repair costs, or reduction of downtime or factory rejects) are shown in Cop as negative costs.

A simple example illustrates (5.3): purchasing a compact fluorescent lamp (CFL), 11 W, 100 rubles, to replace an incandescent lamp, 60 W, 20 rubles. We assume that residential consumers' discount rate is 50%, lighting is used 2,000 hours/year, and the lifetime of an incandescent lamp is 1,000 hours versus 10,000 hours for the CFL. Then the costs of 1 kWh saved is 0.26 rubles (given over 3 rubles/kWh electricity tariff in Moscow):

$$CSE = \frac{0.58 * (100-20) - 20}{0.049 * 2000} = 0{,}26 rubles$$

If the estimates were based on full, rather than incremental, capital intensity, the costs of saved energy would be 0.39 rubles, i.e. almost 3 times higher. With 6% discount rate corresponding CSE becomes negative: -0.08 rubles/kWh, because annualized incremental capital costs (0,24*80) are below incandescent lamp replacement costs.

Evaluation of additional costs and benefits (Cop) is very important for the assessment of CSE curve, but also very difficult. A special research on the evaluation of additional effects of 81 energy efficiency projects in the U.S. came up with a finding that they contribute on average 44% to the project effects and reduce project paybacks to 1 year. It is exactly these effects that sometimes make the cost of saved energy a negative value[26].

A special attention should be given to the assessment of additional costs and benefits. More than two thirds of all industrial energy efficiency technologies not only bring energy savings, but also enhance productivity and reduce reject rates. A research exploring 77 energy efficiency projects in the OECD countries found 224 additional (non-energy) positive effects, including increased productivity, reduced consumption of raw materials and water, reduced noise and equipment wear and tear, etc. Monetization of these effects more than halves average project paybacks: from 4.1 to 1.9 years[27]. This paper does not account for additional effects, only for incremental capital costs (Cc). On the other hand, it does not account for additional transaction costs of

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[23] In this paper, the same discount coefficients are used, as in the research by the World Bank Group and CENEf "Energy efficiency in Russia: untapped reserves", Moscow, 2008.

[24] For residents, sometimes 33% discount rate can be used.

[25] For projects assessments NEFCO uses 5% discount rate and 10 years equipment lifetime. See Methodology and basis for calculation regarding emission reductions and environmental impact within NEFCO's projects portfolio. NEFCO. March 2007. In this paper, 25 years is the maximum lifetime of equipment before capital repair.

[26] R. Lung, A. McKane, R. Leach, D. Marsh. Ancillary Savings and Production Benefits in the Evaluation of Industrial Energy Efficiency Measures, 2005.ACEEE 2005.

[27] Worrell, E., Laitner, J.A., Ruth, M., and Finman, H., 2003. Productivity Benefits of Industrial Energy Efficiency Measures. *Energy,* 28(11), pp. 1081-1098; Industrial Development Report 2011. UNIDO. 2011.

energy efficiency projects and measures. These would include the costs of project business-plans development and assessment, negotiations on financing, project management and monitoring costs. For relatively small projects, these costs might be as high as 20% of the equipment costs. We can assume that additional effects and transaction costs overlap.

For each measure, final energy savings were assessed. Cost rating of measures helps make a CSE curve. This curve is made for the average estimates of the costs of saved energy with the indication of these costs range (Fig. 5.9). In fact, several curves are made: for public and private discount rates (Fig. 5.10).

In order to make estimates of the cost of saved energy more comparable, it is possible, with an account of indirect effects, to convert final energy savings to primary energy savings. Then (2.1) will be converted to (2.5), and final energy savings curve to primary energy savings curve. In this case the formula of the cost of primary energy savings will look as follows:

$$CSE = \frac{CRF * Cc + Cop}{ASE * m_i} \qquad (5.5),$$

with: Cc – incremental capital cost of energy efficiency measure;

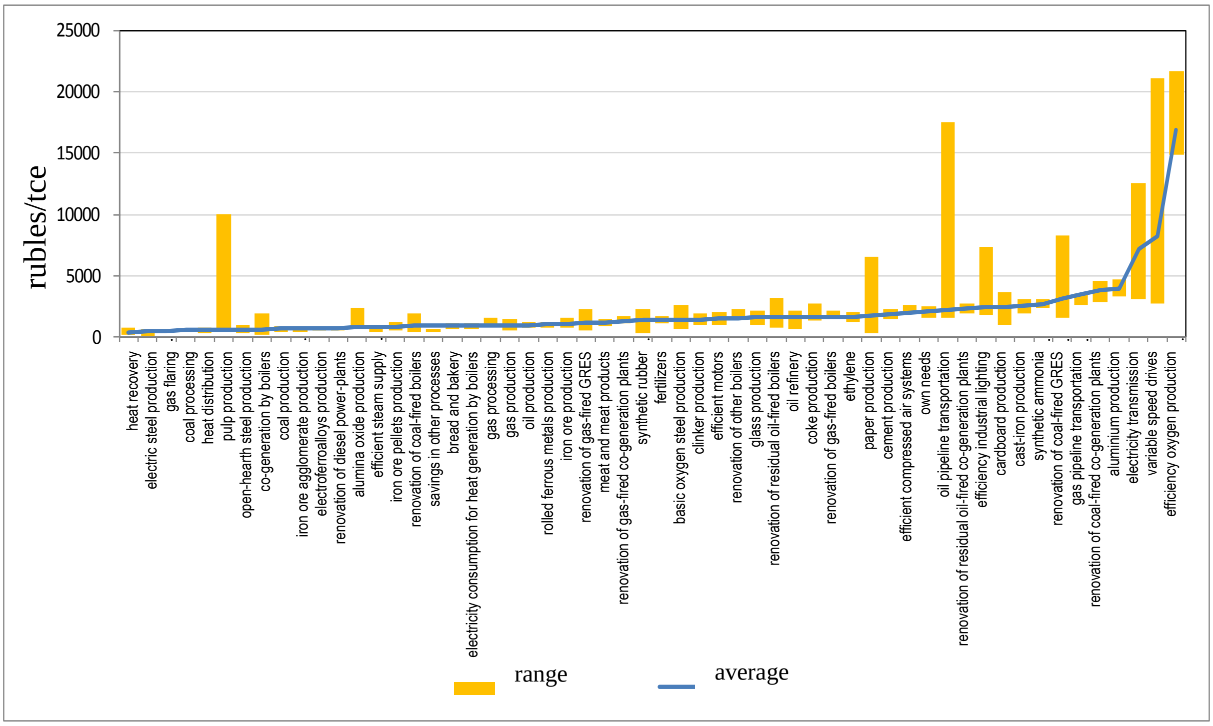
Cop – evolution of current operation costs or additional effects (increased output, improved quality, etc.);

ASE – annual savings of final energy;

m_i – multiplier of total primary energy savings;

CRF – capital recovery factor.

Figure 5.9 Cost of saved final energy in industry (for 6% public discount rate)

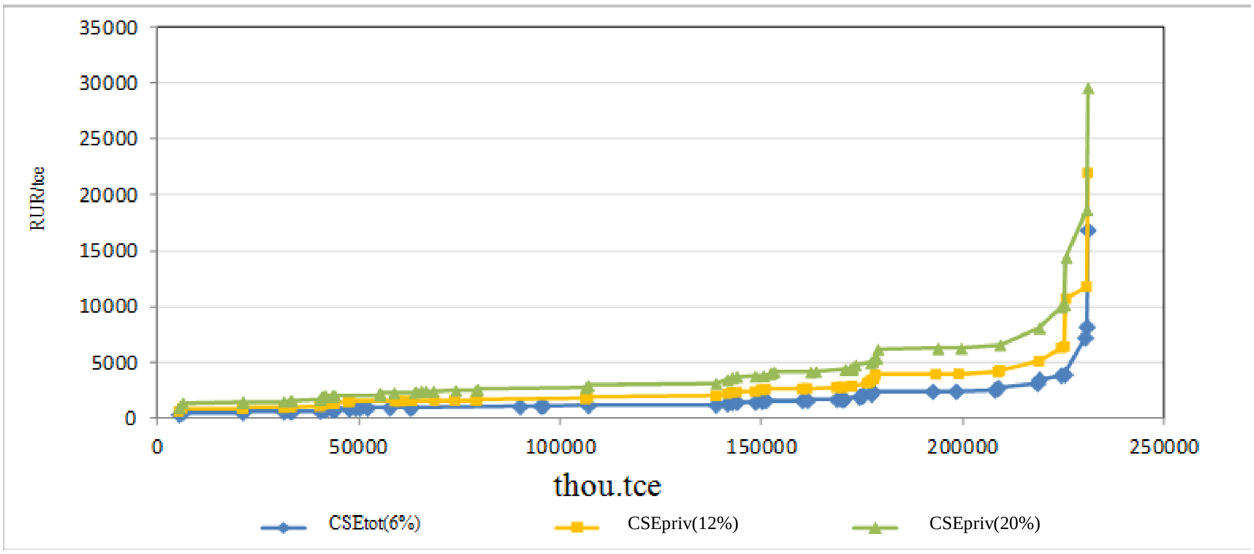


Source: CENEf

To answer the question, if a technical measure is economically or financially effective, the cost of primary energy savings (CSE) is compared to the energy price. With primary energy, CSE can be compared to the imputed primary energy price, which can be taken as Russian natural gas export price. Mid-term pricing policy of the Russian government aims at bringing domestic gas prices up to the export gas price level. Imputed price is the difference between the gas export price and transportation costs and excise duties. In most industries, average energy price is above 5,000 rubles/tce. The cost of saved energy for most measures is below this value, so investments in energy efficiency are cost-effective (Fig. 5.9).

The difference between economic and market energy saving potentials, *inter alia*, is in taking external factors into account. Reduction of pollution and GHG emission is the most important external factor of energy efficiency projects. An additional economic benefit of energy savings and emission reduction can be obtained through reduced pollution charges or through emissions trading. Reduction of pollution charges or the cost of emission quotas can be included as an additional effect (negative Cop) in the cost of saved energy estimates. While assessments of the economic energy saving potential using primary energy method are well justified, they are hardly applicable for the market potential, because settlements between market participants are based on the savings of concrete energy resources and purchase prices.

Figure 5.10 Costs of saved energy curves for Russia's industry (for different discount rates)



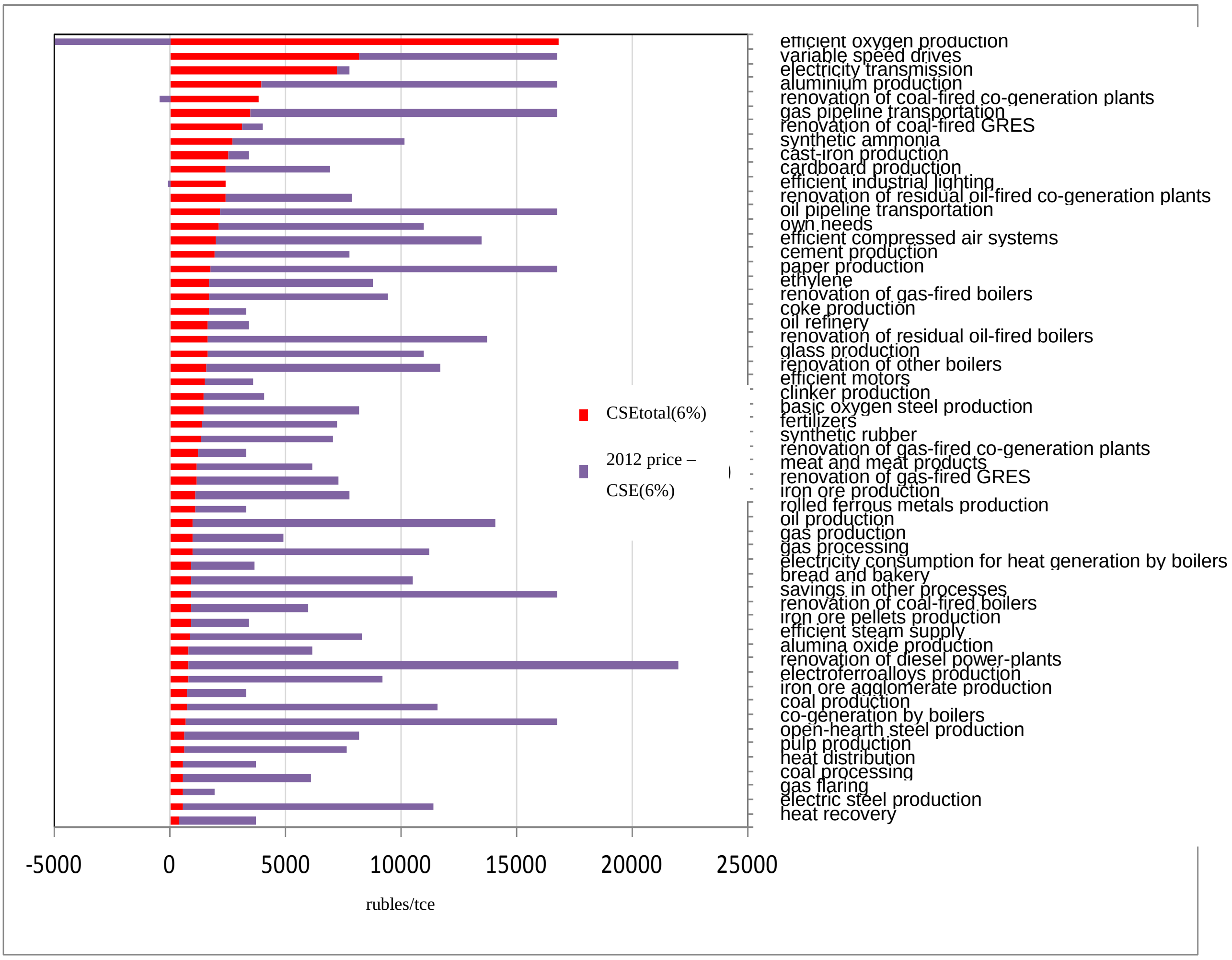
Source: CENEf

5.6.3 Economic and market energy saving potentials

Evaluation of the technical energy saving potential is the sum of savings of energy resources, which differ in their quality, exergy potential and costs, so this is not a correct thing to do. While evaluating electricity and heat savings potential, this method of revealing the economic and market potential becomes complicated with substantial price fluctuations for these energy resources. In energy prices were the same in all sectors, then the crossing of the first curve (6% discount rate) in Fig. 5.10 with aggregated energy price would be the estimate of the economic potential, and with the second and third curves would be the market potential. Obviously, both potentials increase, as energy resource prices grow. However, in order to identify the economic and market potentials, the cost of saved energy has to be compared not with the average price across sectors, but with the average price in each sector, so as to reveal the effects of each typical measure. The latter are identified as the average weighted price with weights equal to the savings of various energy resources obtained through a concrete typical measure.

The method developed by I. Bashmakov requires that average price of various energy resources saved through a typical energy efficiency measure be compared to the cost of saved energy. 2012 energy prices were used in the estimations. All measures, for which energy price minus the cost is positive (Fig. 5.11-5.13), are cost effective. Then the cost-effective technical potential is identified. For the economic potential evaluation, the savings generated by all measures, that are not cost-effective, are subtracted from the technical potential. Similarly, for the market potential evaluation, the savings generated by all measures, that have not passed the market efficiency test, are subtracted from the economic potential. The proposed modification of the CSE curve allows it to graphically identify cost-effective energy efficiency measures.

Figure 5.11 Evaluation of the economic energy saving potential for the Russian Federation (with 6% discount rate)

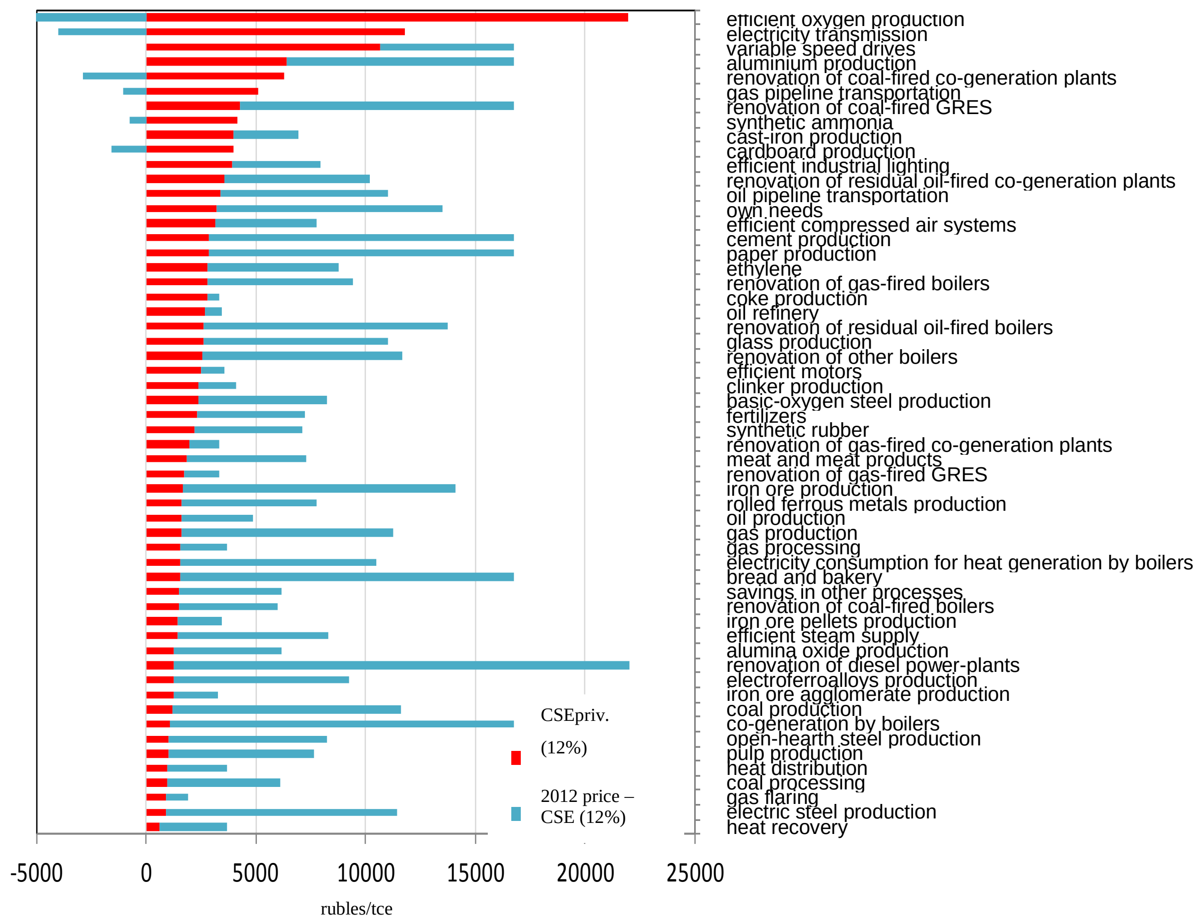


Source: CENEf

Economic energy saving potential in the industrial sector is 210 mln. tce (91% of the technical potential) with independent implementation of all measures, which is 21 mln. tce below the technical potential. For the purpose of identifying economic energy efficiency potential the cost of saved energy was determined based on the data on incremental capital investments with 6% discount rate. Efficient oxygen production units, coal-fired co-generation plants, and improved efficiency of cast-iron production do not pass the cost-effectiveness test (Fig. 5.11).

Depending on how tough payback requirements to energy efficiency investments are, **market energy saving potential equals 183-186 thou. tce, or nearly 80% of the technical potential** and 89% of the economic potential (estimated for independent implementation of all measures). In order to estimate market energy saving potential, the cost of saved energy was determined based on the data on incremental capital investments with 12% and 20% discount rates.

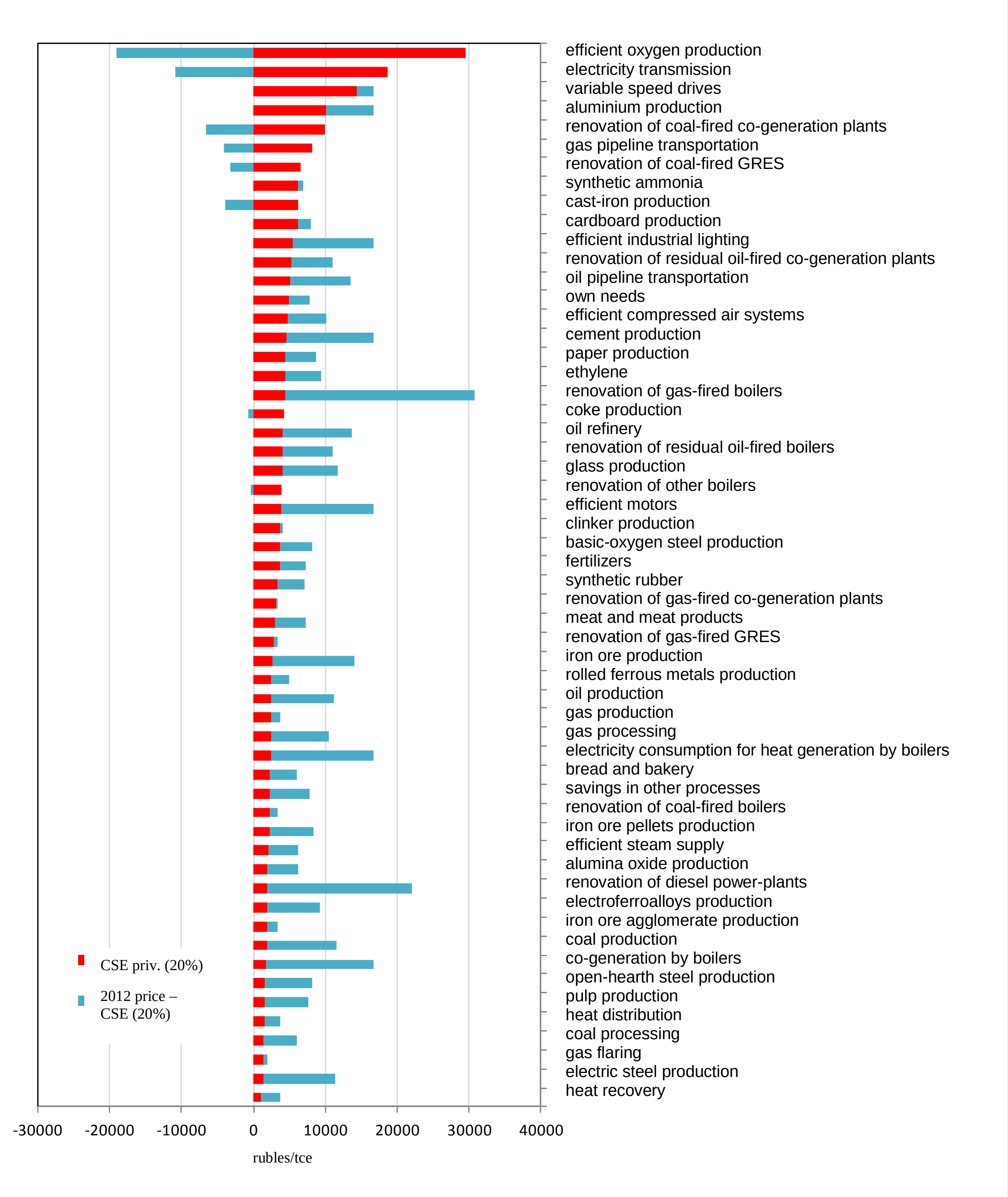
Figure 5.12 Evaluation of the market energy saving potential for the Russian Federation (with 12% discount rate)



Source: CENEf

In the first case, efficient oxygen production, coal-fired co-generation plants, improving the efficiency of cast-iron production, electricity transmission projects and renovation of coal-fired GRES do not pass the market efficiency test. Gas pipeline transportation projects do not pass this test either, for the low price of gas saved at gas fields and in the pipelines. With estimates based on the gas purchase price, these projects get into the market potential. In the end, market energy saving potential with 12% discount rate is 186 mln. tce with independent implementation of all measures, which is 45 mln. tce below the technical potential and 24 mln. tce below the economic potential.

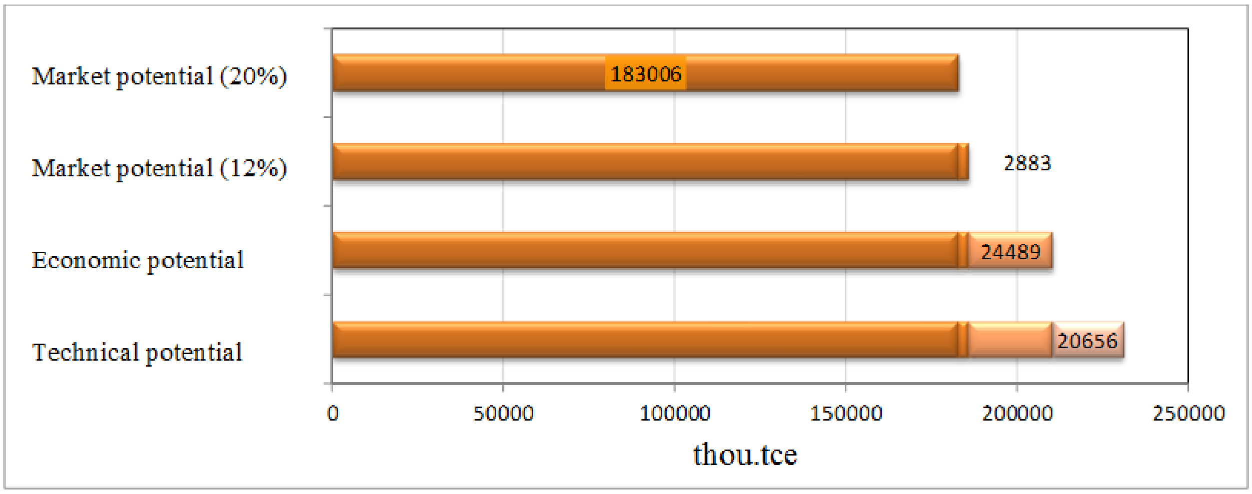
Figure 5.13 Evaluation of the market energy saving potential for the Russian Federation (with 20% discount rate)



Source: CENEf

In the second case (Fig. 5.13), efficient oxygen production, coal-fired co-generation plants, improvement of the efficiency of cast-iron production, electricity transmission projects, renovation of coal-fired GRES, gas pipeline transportation, improvement of the efficiency of coke and synthetic ammonia production and other liquid fuels-fired boilers (for the low price of other liquid fuels). In the end, market energy saving potential is 183 mln. tce with independent implementation of all measures, which is 48 mln. tce below the technical potential and 27 mln. tce below the economic potential (Fig. 5.14).

Figure 5.14 **Comparison of technical, economic and market energy saving potentials in Russia as of 2012**



Source: CENEf

The analysis shows, that federal energy efficiency policies in the industrial sector are to be targeted to providing economic incentives for investment decision-making. Such decision bring the market potential closer to the economic potential and increase cost-effective energy savings by nearly 50 mln. tce. Besides, feasibility studies of such projects as renovation of gas transportation system or renovation/construction of peat- or biomass-fired boiler-houses, should be based on the cost of end-use energy savings, or the cost of substituted resource, rather than on energy resource purchase price.

5.7 Prize: energy savings in value terms

For the sake of estimating the cost of energy savings obtained through the implementation of technical energy saving potential, savings generated through the implementation of all the above measures/groups of measures (in value terms) were assessed by the multiplication of energy savings by 2012 energy prices. The results (Table 5.7) show, that with 2012 domestic energy prices:

  - ❖ overall annual energy cost savings, irrespective of the implementation of all considered measures, including fuel&energy complex, is 1,210 bln. rubles, or nearly USD 40 bln. (Table 5.7). This is equivalent to 42% of all Russia's industrial energy supply costs in 2012;

- with fuel-and-energy industries excluded, the savings equal 509 bln. rubles per annum;
  - ❖ with fuel&energy complex excluded, annual savings equal 509 bln. rubles. This is equivalent to 27% of overall Russia's industrial energy supply costs (excl. fuel&energy complex) in 2012.

Table 5.7 Energy cost savings from complete implementation of the technical energy saving potential in Russia's industry (mln. rubles in 2012 prices)

	Cost savings	Coal	Petroleum products	Natural gas	Other solid fuels	Electricity	Heat
Renovation of gas-fired GRES	**88860**	0	0	88860	0	0	0
Renovation of coal-fired GRES	**26445**	26445	0	0	0	0	0
Renovation of gas-fired co-generation plants	**104765**	0	0	104765	0	0	0
Renovation of coal-fired co-generation plants	**14852**	14852	0	0	0	0	0
Renovation of residual oil-fired co-generation plants	**0**	0	0	0	0	0	0
Renovation of diesel power plants	**718**	0	0	718	0	0	0
Own needs	**24686**	0	0	0	0	23792	895
Electricity transmission	**33280**					33280	0
Renovation of coal-fired boilers	**6502**	6502	0		0	0	0
Renovation of residual oil-fired boilers	**6454**	0	6454		0	0	0
Renovation of gas-fired boilers	**22418**	0	0	22418	0	0	0
Renovation of other solid fuels-fired boilers	**5812**		0	0	5812	0	0
Electricity consumption for heat production by boilers	**21995**		0		0	21995	0
Heat distribution	**62372**	0	0		0	0	62372
Co-generation by boilers	**117904**	0	0		0	117904	0
Heat recovery	**32473**	0	0		0	0	32473
Oil refinery	**26093**	236	0	1673	713	9482	13989
Gas processing	**8131**	0	0	429	0	4463	3239
Coal processing	**930**	176	0	0	0	476	278
Oil production	**65711**	0	0	4804	0	57868	3039
Associated gas flaring	**22827**	0	0	22827	0	0	0
Gas production	**3397**	0	0	2346	0	808	242
Coal production	**4495**	7	0	0	0	3537	951
Iron ore production	**6567**	12	0	0	0	6304	252
Iron ore agglomerate production	**4230**	3364	0	74	0	725	67
Iron ore pellets production	**201**	0	0	54	0	129	18
Coke production	**10696**	7988	0	32	0	852	1825
Cast iron production	**112322**	100489	0	9627	0	1529	677
Open-hearth steel production	**1100**	0	0	791	0	191	117
Basic oxygen steel production	**11051**	253	0	1790	0	8065	943
Electric steel production	**11939**	4	174	770	0	10625	366
Ferrous metal rolled	**25984**	2570	0	9278	0	11661	2475

	Cost savings	Coal	Petroleum products	Natural gas	Other solid fuels	Electricity	Heat
products							
Electroferroalloys production	**5035**	421	0	14	69	4503	29
Aluminium production	**14716**	0	0	0	0	14716	0
Alumina oxide production	**3408**	0	0	0	0	0	3408
Synthetic ammonia	**44052**	0	0	8582	0	25128	10342
Fertilizers	**8891**	0	0	472	0	3245	5174
Ethylene	**3044**	208	0	155	0	757	1924
Synthetic rubber	**17940**	369	0	1048	0	4910	11613
Pulp production	**11511**	0	0	125	45	3748	7593
Paper production	**4923**	0	0	39	0	2812	2072
Cardboard production	**2584**	1	0	9	0	1109	1465
Cement production	**861**	30	0	152	0	665	14
Clinker production	**15750**	654	106	13913	17	1041	19
Glass production	**1360**	0	0	650	0	334	375
Meat and meat products	**5315**	7	0	335	3	2759	2212
Bread and bakery	**2219**	18	109	528	22	973	568
Efficient motors	**34870**	0	0	0	0	34870	0
Variable speed drives	**6499**	0	0	0	0	6499	0
Efficient compressed air systems	**9495**	0	0	384	0	8982	130
Efficient oxygen production	**3498**	0	0	0	0	2814	684
Efficient industrial lighting	**8285**	0	0	0	0	8285	0
Efficient steam supply	**69301**	0	0	0	0	0	69301
Fuel savings in other industrial processes	**51343**	54	8468	2645	33	24111	16033
Total	**1210111**	**164661**	**15311**	**300307**	**6713**	**465945**	**257174**
Total, excl. fuel&energy complex	**508990**	**116442**	**8857**	**51467**	**188**	**192338**	**139698**

Source: CENEf

Total energy cost savings from the implementation of:

- the economic energy saving potential – 1,020 bln. rubles;
- the market energy saving potential – 959 bln. rubles.

6 Integrated cost/benefit analysis of energy efficiency measures in Russia

Sections 6 and 7 showed possibilities for energy savings in some energy intense industries and for basic cross-industry equipment. This section will show overall costs and benefits of industrial energy efficiency measures until 2030.

The inertial scenario (or conservative[28], in terms currently used by the RF Ministry of economic development) suggests keeping Russian industry as uncompetitive, as it is now, and smaller-scale financing secured for the development of infrastructural sector companies. This scenario is characterized by moderate long-term economic growth rates, active renovation of only fuel&energy and materials sectors, and unbridged gap in civil high- and medium-tech production (Table 6.1).

Table 6.1 Basic parameters of economic development scenarios

	Conservative (energy resource)	Innovative
Competitive advantages	Loss of pricing advantages. Oil&gas sector and transit potentials are used	Growing technology competitiveness and declining energy intensity
Evolution of economic structure	Strengthened domination of the resource sector. Development of energy intense industries. Growing import of goods and technologies	Diversified economy and export. Growing share of high technology industries and of knowledge-driven economy
Position in the global economy	Strengthened dependence on hydrocarbons and resource markets, as well as on the import of technologies. Energy superpower	Specialization in resource markets with deep processing and high technology products. Implemented diversified integration and development of a strong Eurasian regional union

Source: Long-term social and economic development scenarios for the Russian Federation until 2030.

Economic renovation in this scenario is more imported-technology-and-knowledge-oriented. Private and public investments in human capital will be far behind those in the developed countries.

The conservative scenario is more likely, than the innovative scenario. Resources employed and business organization in the innovative sectors are much poorer, than in the energy and materials sectors (nearly one third of employees and 10% of GDP). The innovative, socially oriented scenario suggests a much more complex management model for both the government and business. It deals with investment in high-tech projects. The RF Ministry of economic development points out, that the basic barriers are determined by the lack of competitive (by global criteria) professionals both at the corporate and federal levels, and inefficient coordination mechanisms.

The Ministry further underlines, that in the “conservative – energy resource scenario”:

- ❖ Russia’s potential annual economic growth rates do not exceed 3.5-3.6%. Contribution made by the cumulative factor productivity (joint effect of the growing productivity, return on invested capital, and reduced energy- and material intensity) drops from 2 percentage points in 2015 to 1.2 percentage points in 2030. Between 2015 and 2030, contribution made by the increase of fixed assets to GDP growth will be around 1.5 percentage points per year;

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[28] In the Long-term social and economic development scenarios for the Russian Federation until 2030 by the RF Ministry of Economic Development a scenario titled “inertial” no longer exists. Instead, the assumptions of another scenario, titled “conservative, or energy resource, scenario (option En)”, were used. “Option 1 (conservative)” is also included in the “Explanatory notes to the development of the social and economic projections for 2013-2015”. In other words, the RF Ministry of Economic Development has replaced “inertial” with “conservative”.

- small contribution of the innovative factor does not make up for the reduction of cumulative efficiency of production and capital factors;
- the share of fuel&energy and other materials in the structure of export will not drop below 80% by 2030. The share of materials will be growing, while the share of fuel&energy will be declining, albeit will not drop below 50%.

The price part of the projection by the Ministry of economic development suggests that:

- domestic energy prices (electricity, gas) will approach, but not reach, the world market prices before 2020-2024;
- cross-subsidies will be eliminated: residential prices for gas and electricity will first reach the industrial tariffs and by 2030 will go beyond, so the ratio of residential and industrial energy prices will be close to the similar ratio in Europe;
- more moderate energy price growth requires an innovative scenario, which would take care to prevent inflation and consumer bills growth and to provide an environment for industrial growth and energy efficiency improvement.

In other words, in the “conservative – energy resource” scenario, prices grow faster (Table 6.2):

- wholesale gas prices will be growing at a 15% per year rate for all consumer categories, except residential, until they reach a complete netback parity with gas export. In 2015-2021, the prices will grow 2.7-fold, and in 2015-2030 4.2-fold (which is 1.4 times higher, than in the innovative scenario;
- in 2015-2030, wholesale gas prices will grow 4.3-4.4-fold on average for all consumer groups and by 2030 will reach fantastic from today’s point of view USD 350-360;
- the ratio between fuel prices (gas/coal/residual oil) in tce will be 1.0/0.5/1.7 in 2020, and by 2030 it will be 1.0/0.4/1.4 as determined by faster gas price growth;
- in 2015-2030, electricity prices will grow 2.4-2.5-fold, partially overlapping higher gas price growth with an account of enhanced efficiency (the share of gas cost in electricity end-use price is around 35%);
- average retail electricity prices for all consumer categories will grow 2.6-2.65-fold on average during 2015-2030 and by 2030 will be 16.5-17 cents per kWh;
- heat tariffs will grow 1.9-2-fold in 2015-2020, and in 2015-2030 will grow 3.7-fold.

Development under the “conservative energy” scenario will increase industrial energy supply costs from 2.7 trillion rubles in 2011 to 6.9 trillion rubles in 2020 and to 15.3 trillion rubles in 2030. In other words, they will grow at least 5-6-fold!

While the share of energy costs in the overall costs of shipped Russian products in 2011 was 7%, and for manufacturing 8.7%, in the U.S. it was only 3%. Energy tariffs, if not compensated by substantial energy efficiency improvement, will lead to further decline of competitiveness of the Russian industry.

Slow modernization in this scenario hampers industrial energy intensity reduction to only 22% of the 2007 level and of practically similar 2011 level. Large gap in industrial energy efficiency between Russia and other countries (to say nothing of BAT) will not be bridged.

Transition to the innovative scenario and intensification of Russian industrial retrofits will allow it to use an additional resource of energy efficiency (which is at least 64 mln. tce in 2030) (Fig. 6.1).

Table 6.2 Gas-, electricity-, and heat price growth in 2015-2030 (%)

	Scenarios	2015-2020	2021-2030	2015-2030
Gas price growth for all consumer categories	Inn	202	160	323
	En	231	189	435
Price growth for all consumer categories, excl. residential	Inn	200	154	307
	En	231	182	421
Price growth for residents	*Inn*	*231*	*229*	*529*
	En	*231*	*268*	*620*
End-use electricity retail price growth for all consumer categories	Inn	161	144	233
	En	158	165	261
Price growth for all consumer categories, excl. residential	Inn	158	137	215
	En	153	159	244
Price growth for residents	*Inn*	*182*	*186*	*338*
	En	*192*	*192*	*368*
Heat	Inn	175	172	302
	En	188	196	369

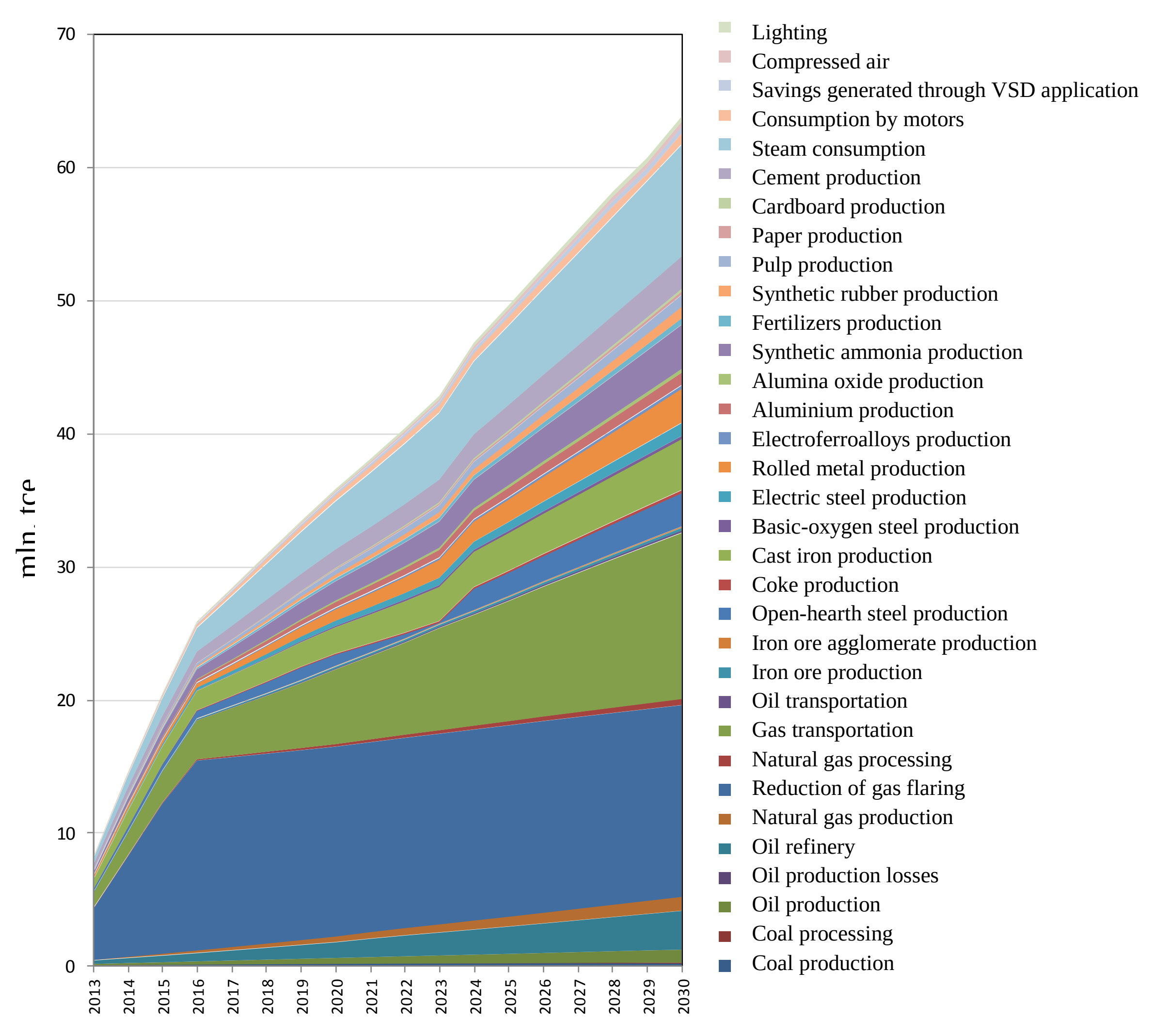
Inn – innovative scenario.
En – “conservative energy” scenario.

Source: Long-term social and economic development scenarios for the Russian Federation until 2030. RF Ministry of Economic Development.

This would allow it to reduce industrial energy intensity by 27% in 2020 and by 42% in 2030. It will also help reduce industrial GHG emission by 85 mln. t $CO_{2\text{-eq}}$. in 2020 and by 152 mln. t $CO_{2\text{-eq}}$. in 2030. The latter figure equals 10% of Russian energy-related GHG emission in 2010. Let us point out that this emission reduction is additional compared to the inertial scenario.

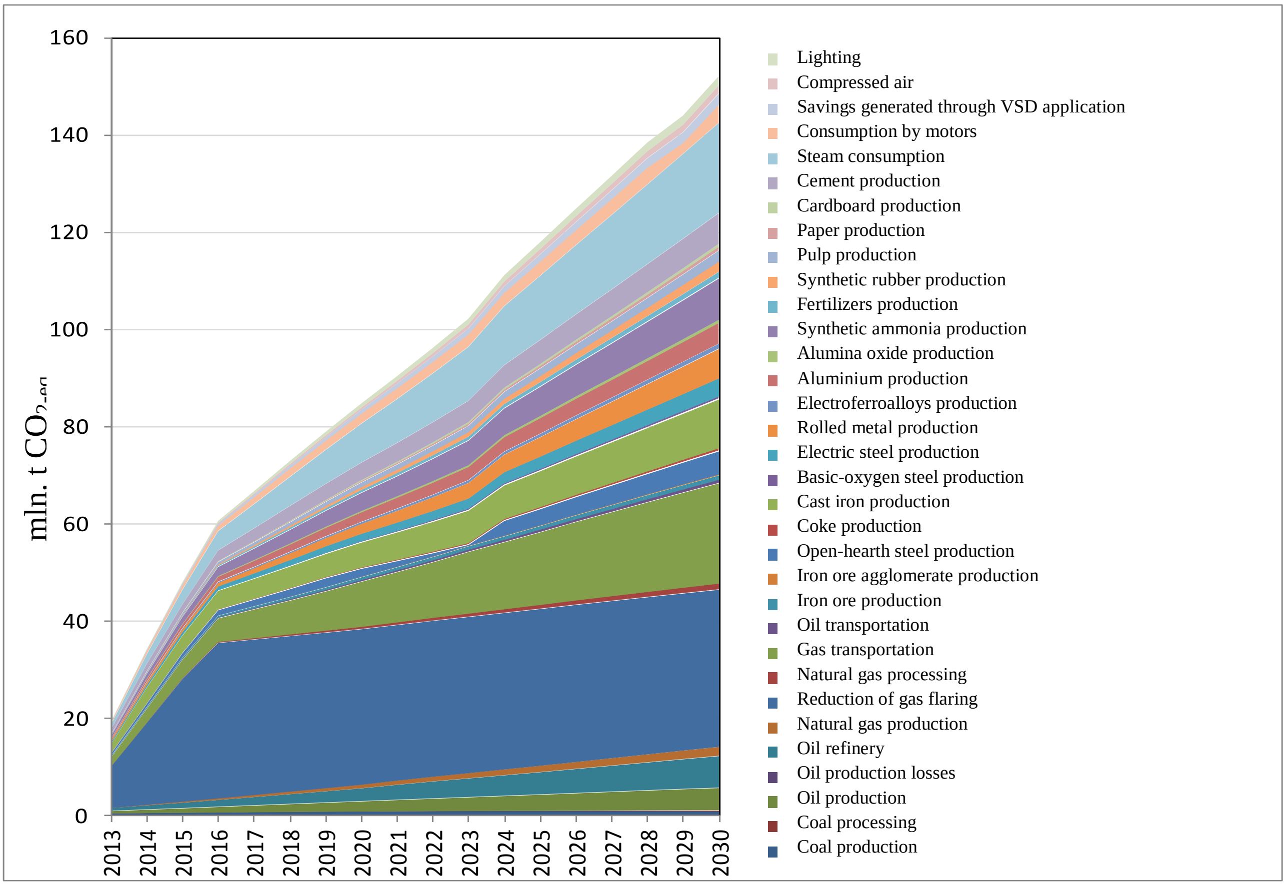
Cumulative emission reduction in 2013-2030 equals 1,673 mln. t $CO_{2\text{-eq}}$, which is more than Russia’s energy-related GHG emission in 2011, and more than annual CO_2 emission from fuel combustion of Great Britain, Germany, and Italy taken together.

Figure 6.1 Reduction of energy consumption through additional energy efficiency measures in industry



Source: CENEf

Figure 6.2 GHG emission reduction through additional energy efficiency measures in industry

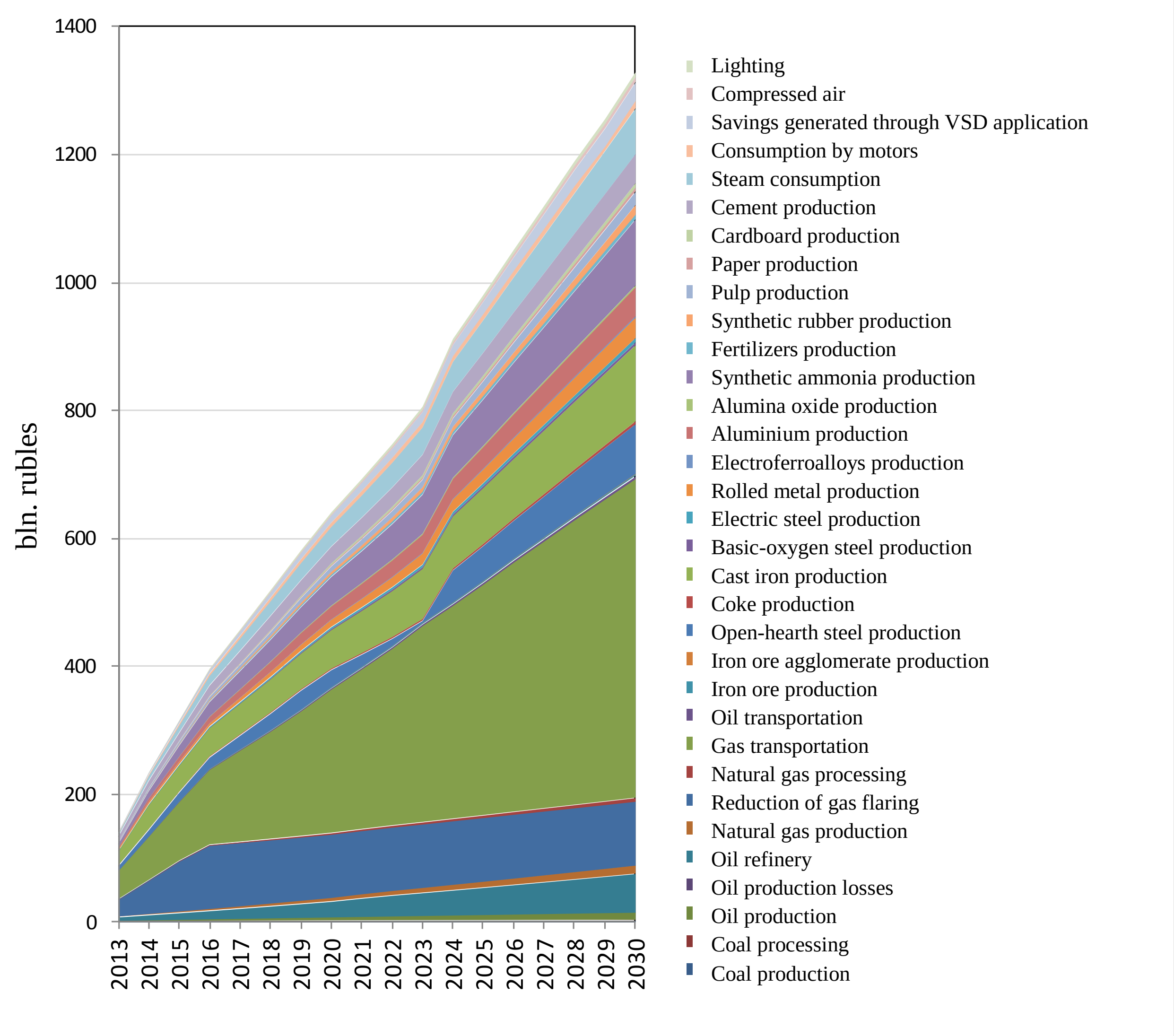


Source: CENEf.

Substantial financial resources are needed to implement these measures within 18 years: 1,330 bln. rubles (nearly USD 44 bln.), or around 74 bln. rubles on average per annum (Fig. 6.3), including 500 bln. rubles for the modernization of the gas transportation system. Excluding this latter component, the cost would be 830 bln. rubles (around USD 26 bln., or 46 bln. rubles per annum).

According to the IEA, in 2011 Russia spent USD 5,700 mln., or nearly 174 bln. rubles, for energy efficiency. CENEf's estimates are close: USD 5,200-5,900 mln. Of these, around USD 1,000-1,200 mln., or 30-36 bln. rubles, were spent on industrial energy efficiency. Therefore, the goal is to practically double average annual energy efficiency investment until 2030.

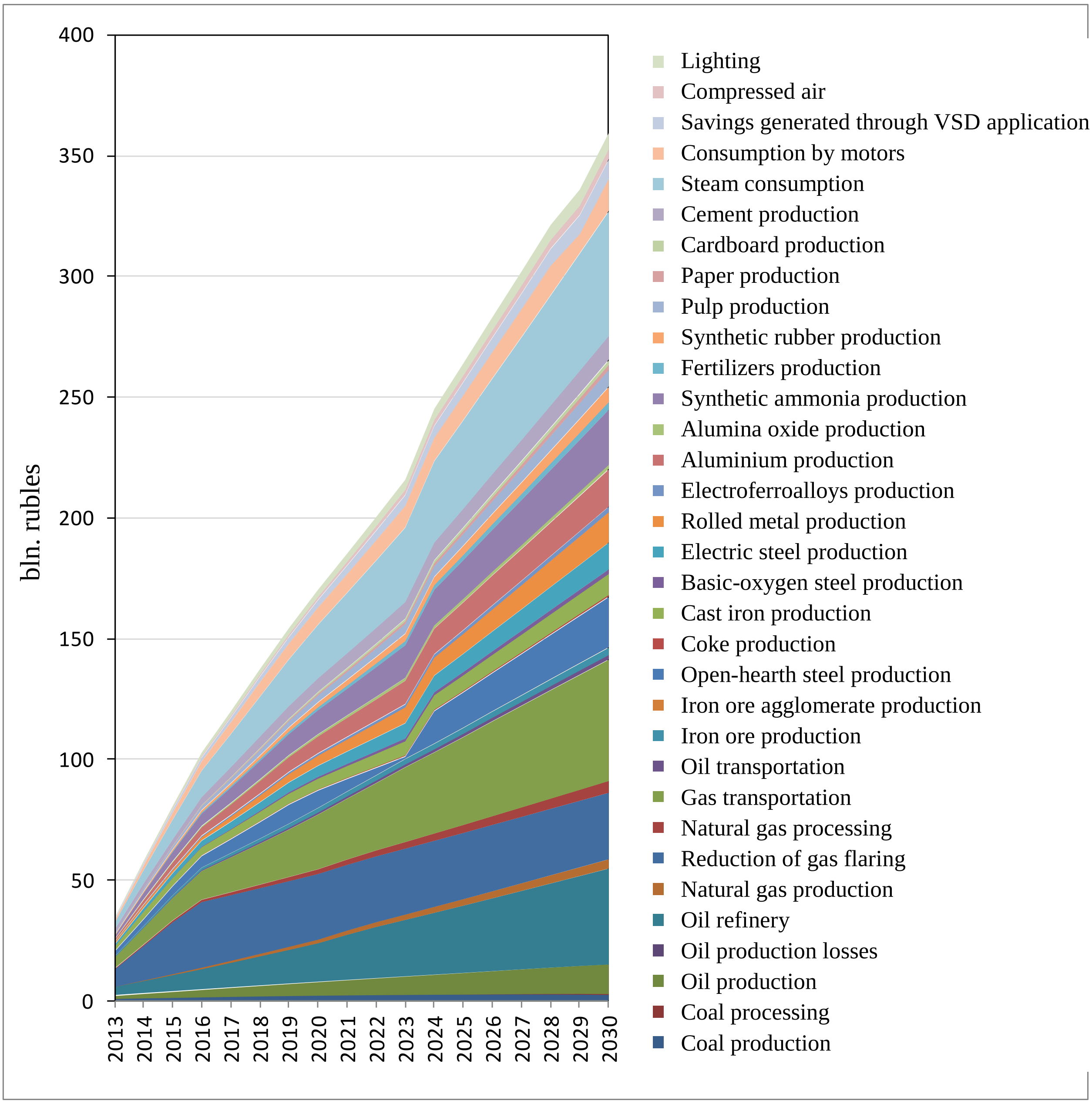
Figure 6.3 Implementation costs of additional energy efficiency measures in industry



Souce: CENEf.

- What difference can these investments make? They will bring 170 bln. rubles in 2020 and 360 bln. rubles in 2030 in 2012 prices in annual energy cost savings (Fig. 6.4). Overall savings in 2013-2020 will account for 857 bln. rubles, and in 2013-2030 for 3,570 bln. rubles, or USD 117 bln. This is as much as:
  - 1.3 years' overall energy supply costs of the whole industrial sector;
  - 67% of oil export revenues in 2011;
  - 183% of gas export revenues in 2011;
  - 10 times fertilizers export revenues in 2011;
  - more than 5 times iron and steel export revenues in 2011.

Figure 6.4 **Energy cost savings through additional energy efficiency measures in industry**



Source: CENEf.

With energy tariffs growth over 2013-2030 in mind, energy savings in the industrial sector in then-year rubles will be substantially larger. In all, over 2013-2020 for industry they will be 1,090 bln. rubles; for the electricity sector nearly 800 bln. rubles; for the heat sector another 280 bln. rubles; for pipeline transportation 470 bln. rubles. Total: 2,640 bln. rubles. Otherwise industrial energy supply costs in 2020 would be 40% higher.

Summing up, let us point out that implementation of additional energy efficiency measures in industry in 2013-2030 would help:

- reduce industrial energy consumption by 64 mln. tce in 2030 and by 706 mln. tce in 2013-2030;
- reduce GHG emission by 85 mln. t $CO_{2\text{-eq.}}$ in 2030 and by 1,673 mln. t $CO_{2\text{-eq}}$. in 2013-2030;
- over 17 years cumulatively reduce the costs of energy supply to Russian industry by USD 117 bln. and limit their growth by 2030 to 40% compared to the conservative scenario.

In order to achieve this, it is important to at least double average annual investment in industrial energy efficiency projects in the coming 17 years and for this purpose develop an effective private-public partnership in industrial energy efficiency improvement.

7 What's interfering? Barriers to energy efficiency improvement in industry

Energy efficiency potential, like oil deposits, can be large, but it will stay "in situ" until a "well" is drilled. Deposit development should start from going through the dense rock of barriers to energy efficiency. These barriers are very diverse: pricing and financial; those related to the structure and organization of the economy and market; institutional barriers; social, cultural, behavioral, etc. Practically all of them are removable through targeted energy efficiency policies. So that these policies were effective, it is important to clearly realize the main barriers to the introduction of energy efficiency technologies and behavioral patterns.

All barriers to energy efficiency can be split into four large groups: lack of motivation; lack of information; lack of financing and "long" money; and lack of organization and coordination. There used to be a fifth barrier: lack of technologies. But today it no longer exists in Russia, or it is not so important, as it used to be. The market provides a large variety of energy efficient equipment, materials, and consulting.

Lack of motivation is determined by soft budget limitations, confiscation of savings in the business-to-business, budgetary, and tariff processes, and comparatively low tariffs. Limited competition and a possibility to shift increased costs to consumers (until their solvency thresholds are reached), cross subsidies, lack of consumption control and metering – all this brings energy efficiency motivation down. Economic mechanisms are such that it is not always clear, who benefits from energy savings, and the beneficiary is not institutionally defined. Today, it is not always possible to get an answer to a simple question: who in person is interested in energy efficiency improvement? Judgments on the role of tariffs should build on determining the share of energy bills in the income or production costs, rather than on blind comparisons of tariffs in Russia and abroad. (However, even with such comparisons, Russian tariffs are hardly below those in many other countries and will be fast growing). Consumer reactions are provoked by the growing share of energy costs in the income. If consumers can compensate tariff growth by improved energy efficiency, then energy price hikes do not hamper economic growth, or accelerate inflation, or reduce payment discipline. Confiscation of savings in the business-to-business, budgetary, and tariff processes is the major problem. Under such circumstances, energy price growth provides incentives for the justification of further tariff growth or for additional financing demand, rather than for energy efficiency improvement. Energy efficiency ought to be included in the set of indicators used for performance budgeting and is to be used by the governance bodies to assess the performance of industrial energy systems operators.

Lack of financial support of energy efficiency measures from the federal, oblast, and municipal budgets makes these measures hardly visible from the political point of view to the government bodies and very dull.

Lack of information. Information and motivation are often ignored while developing and implementing solutions. This aspect of decision-making is not quite realized in Russia so far. Anyone needs information to make an informed and timely decision. Not many people spend time and money looking for information, the majority act by stereotypes. Behavioral stereotypes ("Do as everybody does!") are so popular exactly because they relieve from having to look for information and from decision-making. People get cold in their homes, yet do not take any insulation measures, which could help increase indoor air temperature by 3-5°C; industrial firms and municipalities fight for natural gas "limits" instead of implementing energy efficiency programmes.

Borne by the market price information alone cannot spur energy efficiency improvement. Market signals should be put on prepared soil, pass through unclogged channels, if they are to be picked up, providing there is a technical opportunity to react to the market signals. In many cases, for example in residential space heating, price elasticity of demand is practically zero. Introduction of energy efficiency standards is a barrier to inefficient technologies and equipment, and so is quite effective in the sectors where information barrier is most important.

Lack of financing and "long" money determines insufficient financing of energy efficiency activities and of the maintenance of energy supply systems. Large companies and banks have much stricter payback and cost reduction requirements to energy efficiency projects, than to new construction projects. Banks do not provide loans to energy supply companies with large debts. Those who have financial difficulties and no own capital, who cannot attract loan capital, are most vulnerable in terms of energy inefficiency. They will never pass the financial sustainability test. But they could use a pledge scheme, using consumers' utility payments cash flow as collateral for the bank that provides a loan.

Lack of organization and coordination takes place at all decision-making levels. In Russia, so far there are few federal authorities responsible for the coordination of energy efficiency activities in industry (a sector with thousands of jobs). The problem of improving energy efficiency has been realized by the federal government as a means of addressing a large variety of economic problems. However, economic modernization programmes and the Federal programme "Energy conservation and energy efficiency improvement until 2020" require higher qualifications and efforts in the industrial sector.

Barriers to energy efficiency improvement exist in each sector. Being common to all industries, they can manifest differently. Some 20 years ago, a list of 16 barriers to energy efficiency improvement in industry was developed, which is still viable[29]:

1. Lack of detailed and comprehensive information on energy consumption by industrial processes by plant divisions;
2. Lack of information on energy efficiency technologies;
3. Lack of energy efficient equipment, meters and controls in the market;
4. Competing responsibilities of the management;
5. Unwillingness to be a pioneer in the implementation of new ideas and introduction of new technologies;
6. Lack of benefits (or unawareness of any benefits) provided by the state or energy utilities for the implementation of energy efficiency projects;
7. Restraining influence of threshold paybacks at the project initiation stage;
8. Project implementation delayed until previously installed equipment is completely depreciated;
9. Low rank of cost reduction projects in companies' strategic plans;
10. Unlikelihood of obtaining financing for projects which rank low in the strategic plan;
11. Growing share of obligatory projects in the overall investment programme;
12. Limited financing for small cost reduction projects;
13. Inertial process of capital distribution by types of projects;
14. Inefficient combination of segments of the energy efficient equipment market;
15. High threshold requirements to investment performance during investment distribution by projects;
16. Higher requirements to the profitability of small projects compared to large ones.

Relative importance of these 16 barriers can substantially vary by both energy consumption sectors and time. But even if all of them were equal (say, 2% of the technical potential), total loss of energy efficiency opportunities is quite high (one third).

Many energy efficiency experts argue that low payback thresholds are to be used for cost-effectiveness assessment of energy efficiency projects. However, even with very "soft" cost-effectiveness requirements energy efficiency projects can be rejected. The scale of project (normally measured in the volume of secured financing), its visibility are extremely important to

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[29] I. Bashmakov. Financial and economic analysis of energy efficiency projects. Moscow, CENEf. 1993.

the decision-makers at the project selection stage. Small resource saving projects are often ignored.

Research shows, that enterprises have many possibilities to “buy” energy efficiency at a much lower cost than the cost of energy purchase. In a theoretical world of perfect information and economic people this finding would be unacceptable: companies would never miss investment opportunities which would allow them to reduce production costs. But the accomplished analysis shows, that energy efficiency investment decision-making is not always based on the optimal options, because the real world differs very much from theory.

In its research dating back to the early 80’s[30], ACEEE made a focus on the project nomination process. Before any project is accepted or rejected, it needs to be nominated. ACEEE came up with a finding that many projects are nominated at the enterprise level, often by an engineer, who is full- or part-time involved in energy supply issues. This finding is important for a number of reasons.

The first reason: expertise and experience of people responsible for project development determine the number and quality of new ideas. Qualifications of engineers at an enterprise, their access to information on new energy efficiency possibilities, are very important. There can be a large variety of new, very efficient technologies, which just do not come to the attention of the plant’s energy staff.

Therefore, lack of accurate and complete information on technical possibilities for energy efficiency projects by the plant energy manager or top management is the first “razor” that “shaves off” energy efficiency opportunities.

The second reason deals with the lack of detailed information on energy supply and the scale of process energy losses by shops. A voluntary energy audit by the enterprise personnel, *possibly* with the help of external experts, or federal requirement for statistical energy forms can make an enterprise look at its energy consumption structure and energy saving opportunities. Lack of data is often a result of bad data collection or lack of meters. Therefore, relatively small investment in these two can launch many new energy saving initiatives. Energy audits are one of the most important sources of information on energy efficiency improvements. They are about providing the plant management with information on energy use and energy costs, revealing energy efficiency opportunities and developing an action plan.

A good energy audit provides information, which the enterprise often lacks: energy consumption structure by shops; major factors that determine energy consumption; energy losses; efficiency of the key energy equipment. With this information in hand, it is possible to improve energy consumption management system. Development of the improvement action plan requires not only information obtained through meters, but also interviews with engineers and workers. Some energy efficiency measures can be implemented in the course of the audit: for example, regulation of combustion process can improve the efficiency of boilers by 1-2%. Other measures require project development.

The third reason: some managers know that their work is assessed largely by the quality and quantity of product. An innovation installed at one process unit increases risk perception by a manager even if parallel units keep working old style. Certain key process components have no reserve units, and so something as simple as a sensor replacement can be perceived as highly hazardous, because can affect operation of the whole unit[31]. Another effect deals with the desire to reduce equipment downtime: if the enterprise or its suppliers have no efficient unit to replace the equipment that went out of order, the plant is likely to purchase a standard unit to reduce downtime.

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[30] Industrial Investment in Energy Efficiency: Opportunities, Management Practices, and Tax Incentives. 1983. Alliance to Save Energy. July 1983. Washington D.C., USA. 267 p.

[31] Industrial Energy Use. 1983. U.S. Congress, Office of Technology Assessment. June 1983.p. 1-128.

Sometimes a director's perception of what is good or bad for him personally can bring energy efficiency down. Energy manager of "Seisware Company" noticed, that top management of enterprises like to get workers paint motors and other equipment to make the shop look nicer for important visitors. But an additional layer of paint makes motors run hotter, reducing their lifetime and efficiency. Looks like in the U.S. they, too, like this practice.

Responsibility is a key word. A manager will not focus on energy efficiency, if he is not responsible for production costs, or if energy costs are not high compared to other cost components. However, even if a manager *is* responsible for energy efficiency, but among numerous other duties, he may have no time left for this particular task. According to an ex-manager of a paper mill, where the ASE made an audit, the leaking steam may be hissing right in the energy manager's ear, but he may have no time and/or staff to fix it.

The fourth reason. Many companies stand against new ideas. Partially this opposition is determined by a concern that new equipment may be not as reliable as the old one. A manager often waits for his competitor to fail with the new idea, often losing as much as a year before he makes sure that the new thing really works. A year is a long time in the electronic industry, but it is not so much in energy intense industries.

The fifth reason is again the information barrier, namely a manager's awareness of economic incentives, which to a large extent determines if these incentives will affect project initiation. If there are any energy efficiency incentives, which project initiators are unaware of, these incentives can improve the return on energy efficiency investment after it is made, but will not increase the number of projects.

The sixth reason: high requirements to energy efficiency project paybacks hamper project initiation and nomination.

The seventh reason: machine building industry can produce a certain amount of efficient equipment at each particular moment of time. Increase in production takes time. Shortage of such equipment in the market (for example of efficient gas turbines) or relatively high prices of this new equipment at the initial stage of production hampers the use of new equipment at the project initiation stage and reduces project cost-effectiveness.

The eighth reason: projects dealing with equipment repairs and replacement normally have the largest energy efficiency potential, but they are not initiated until the equipment is depreciated.

The eight above barriers at the project initiation stage lead to the fact that some energy efficiency opportunities do not come into focus for the lack of expertise and information, and others do not appear as proposals, because key personnel have many other duties (many of which are far more important for their careers), as well as for a number of economic limitations. To the best of our knowledge, there have been no attempts to assess, which part of the energy efficiency potential is lost at this initial stage. This loss is obviously quite large.

Project estimation is a relatively complicated process. It involves a division of labor between the enterprise management levels. In has been mentioned above, that many projects are initiated at the enterprise or shop level, and so preliminary project estimation takes place at the same level. A reference to the strategy plan and a correct understanding of the project cost-effectiveness "threshold values" are an important factor in investment decision-making. A recent research showed, that 55% of companies' management regard energy efficiency investments as less risky compared to a company's core business projects; however, energy efficiency projects must have shorter (nearly 1 year shorter) paybacks. Importantly, the strictest payback requirements were made by those who can initiate such projects: energy managers (they are inclined to consider projects with less than 5 years' paybacks or with more than 35% internal rates of return) and experts in sustainable development (less than 4 years' paybacks, more than 15% IRR), while the top management would consider projects with longer paybacks (6.8 years, 12% IRR)[32]. But if a project was not initiated by an energy manager (makes 44% of decisions) or by an expert in sustainable development (makes 32% of decisions), the company top management will never see it (make 24% of decisions). Only large projects proceed to the board decision-making stage.

There are as many methodologies for the development of strategic plans, as there are companies. Five basic factors that determine strategic decision-making can be pointed out: product demand; competition (within the industry and in the domestic and international markets); price and value of capital (sources of capital: loans, equity, own financing); cost of materials, labour, and the economic environment; reliability of supply (if at some point a company is unable to meet demand because the enterprise was closed down for the lack of energy or materials, it can lose its customers forever; so it is not unusual to include two factors – price and reliability of supply – in one strategic decision).

Based on the strategic plan, a corporation's enterprises and activities are rated, giving the investment priority to the enterprises which rate the highest. In some corporations, the decision-making process is very formal, investments being made only to the most efficient production lines and enterprises. A low-ranking enterprise has little chance of getting any investment.

In other words, if there are energy saving opportunities at an enterprise which ranks low in the corporation's strategic plan, they are hardly to get any financing. This practice considerably reduces energy efficiency investment. It is barrier number one at the project estimation stage.

The second barrier dealing with companies' decision-making practices is that many investment proposals even at high-ranking enterprises are to refer to the strategic plan. The degree to which a project acts to the achievement of strategic goals substantially affects the perception of the project value. In other words, even if a project is less cost-effective, than an energy efficiency project, it is more likely to get into the focus of the top management, if it is related to the strategic plan. Being well aware of this, the board of an enterprise, which is part of a corporation, is unlikely to develop new energy efficiency projects, if they already have a portfolio of projects which are in line with the corporate strategic plan.

Distribution of capital is a very important element of project estimation. A company chooses not to invest in many energy efficiency technologies, no matter how cost-effective, merely because it cannot provide financing. There are two basic models of distribution of capital: flexible distribution and rationing. The behavior of five of fifteen firms audited by the ASE was determined by the flexible distribution model, the rest use rationing while making investment decision.

Flexible distribution of capital is characterized by investing in any process that gives an effect higher than a certain minimum. The capital rationing model suggests that capital is distributed until it is exhausted. With this model less investment is made in projects, than could be justified with flexible distribution and a specified project cost-effectiveness threshold. Two thirds of firms use capital rationing, and so part of profitable energy efficiency projects are ignored.

Whether flexible distribution or rationing of capital is used, a project cost-effectiveness is not the only factor that determines investment decision-making. Apart from the cost-effectiveness of separate projects, there are parameters that characterize the corporation as a whole (for example, debt/equity ratio, the ratio of debt service to bonds issue), and most important, the above mentioned corporate strategic considerations.

Another, often decisive, factor of decision-making is the director's confidence in the project importance and success. The perception of risk factor diminishes, as the confidence factor grows. Qualitative estimates are often used by companies to make up for the poor quantitative analysis,

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[32] E. Boland and S. Duquesnoy. ARE COMPANIES UNDER-INVESTING IN ENERGY EFFICIENCY? Imperial College London Energy Futures Lab. 28th September 2012.

which is often made by a simplified, standard form. Risk perception, which is normally based on the qualitative assessments and the director's experience, is an important supplement to the quantitative analysis. The latter is equally, or even more, important. The higher the decision-making level, the more the reliance on the qualitative analysis.

30 years ago the ACEEE came to four important conclusions, which help understand, why many cost-effective energy efficiency projects are not financed by corporations[33]:

1. The amount of financing allocated by a company for small-scale projects, including many energy efficiency projects, is normally fixed. This helps delegate certain responsibility for project implementation to the level of a separate enterprise, but limits financing for energy efficiency projects. The amount of financing allocated for small-size projects aiming at the reduction of production costs is not in any way related to the attractiveness of some perspective projects and can be easily increased to implement emerging possibilities. In two thirds of the audited firms financing energy efficiency investments was strictly limited.
2. Second: decision-making related to the distribution of capital is an inertial process. Last fiscal year expenses in such functional sphere as reduction of production costs is an important factor determining decision-making in shop- or enterprise-level project financing. Unusually high investment demand normally requires thorough justification.
3. Third: many firms use very high threshold coefficients for investment effectiveness in the distribution of capital. ACEEE found out, that in companies that used the capital rationing model minimum investment effectiveness requirements varied in the range of 30-50%.
4. Fourth: lower cost-effectiveness thresholds are applied to large strategic projects, than to small cost-reduction projects. This trend is observed in firms that use the capital rationing model, and they are the great majority, as mentioned above. This is determined by a number of reasons: since most energy efficiency projects are small-scale and implemented to reduce production costs, they are not given a priority in the process of funds allocation, and so do not deserve attention in the eyes of managers. A project rank in the eyes of the top management is very important for the carrier of a manager, and so it is very unlikey that substantial additional funding will be sought for numerous small-scale projects.

The energy efficient equipment market is very complex and involves a lot of stakeholders. Their interaction largely affects market penetration of this equipment. The major market agents include: end-users; energy efficient equipment vendors and suppliers; vendors of original equipment (that includes energy efficient elements, for example, a motor in a pump or in a fridge); designers and consultants; vendors of accompanying equipment (belts for electric motors, etc.); energy utilities; energy service companies; trade and industrial associations; universities and research institutions; governments (local and federal). End-users are normally represented by company officials responsible for equipment operation and procurement, who often make purchase decisions without a prior engineering analysis.

Looking at the minimization of storage costs, end-users and distributors often specify a standard set of equipment of certain types and dimensions to be always available at the storehouse. This practice often leads to the underutilized equipment capacity. For example, if an electric motor goes out of order, it will be replaced with one available from the storehouse. This latter motor can be of a larger capacity, than required. It is also important, how equipment is ordered. Equipment repairs occupy a certain position in the market structure. Repair can substantially reduce equipment efficiency. Such efficiency reduction can be so significant, that it would be more cost-effective to replace such equipment with a model.

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[33] Industrial Investment in Energy Efficiency: Opportunities, Management Practices, and Tax Incentives. 1983. Alliance to Save Energy. July 1983. Washington D.C., USA. 267 p.

The structure of energy efficient equipment can significantly affect the price of this equipment. Depending on the size of order, the purchase price may be 50-70% below the reference price. Consultants and contractors normally put reliability and safety first, rather than efficiency. Installing new, unfamiliar to assemblers, equipment involves the "risk factor", and therefore additional expenses. On the other hand, the share of fixed price contracts is growing, so the client, paying for the result, has no control of the project cost structure. This motivates contractors to reducing initial costs, rather than total project lifetime costs.

Through regulations, legislature and least-cost energy efficiency planning, dissemination of information on energy efficient equipment, outreach campaigns federal and regional governments can seriously affect market saturation with energy efficient equipment and technologies.

As time goes by, new research efforts are taken on the role of barriers to energy efficiency in general and industrial energy efficiency in particular. In 2012 World Energy Outlook IEA points out, *inter alia*, the following barriers[34]:

1. **Inadequate rating** (visibility) of energy efficiency projects for decision-makers. IEA puts this barrier first.
2. **Lack of information** on the size of energy efficiency potential and on the economic effects it can bring.
3. **Unclear beneficiaries.** This is an aspect of motivation and of finding an answer to the question: who personally benefits from energy savings? A department of the enterprise, which is responsible for equipment procurement, is not responsible for equipment operation. Sometimes project effect is expected beyond a decision-maker's time in office, etc.;
4. **Lack of financing.** More stringent payback requirements to energy efficiency projects and lack of ready-to-use bank products to help reduce overheads of small-size projects;
5. **Incorrect risk estimation** of investment in cost reduction projects;
6. **Unsatisfactory qualifications** for the development and implementation of energy efficiency projects and lack of federal support for improving qualifications and experience exchange;
7. **Lack of coordination** in decision-making at various levels; considering energy supply and energy efficiency issues separately.

Insufficient financing is the major barrier to energy efficiency policies. This is the opinion of 47% of 700 interviewed EU energy efficiency experts. This is an extremely important barrier not only for the new member-states (the Czech Republic 80%, Slovenia 67%), but also for relatively rich countries (Germany 42%). Second comes inadequate regulatory base followed by the lack of information[35].

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[34] WORLD ENERGY OUTLOOK. 2012. OECD/IEA, 2012.

[35] Source: SURVEY REPORT. Progress in energy efficiency policies in the EU Member States – the experts perspective. Findings from the Energy Efficiency Watch Project. 2012.

Authors of a special research on the barriers to energy efficiency decision-making in Dutch industry split all barriers by groups and came up with the following findings[36]:

- **economic barriers** (on a 4-grade scale): energy price evolution (possibility of reduction: 2.9); market environment (phase of cycle: 2.4); accessibility of internal or external financing (2.4); sustainability of provided benefits or other market tools (2);
- **social and economic barriers** (on a 4-grade scale): budgetary limitations and investment priorities (4.3); rules for investment decision-making (3.9); information on energy efficiency opportunities (2.4); energy efficiency technologies (2); and energy use (1.8);
- **technology barriers** (on a 4-grade scale): applicability of technology for a concrete process (3.7); inability to go back, if needed, to the use of the equipment, that was once replaced (3.1); high equipment installation costs (2.6); high overheads (1.4);
- **institutional barriers:** insufficient attention to energy efficiency; lack of qualification.

These barriers are universal, and little depend on the business location. For example, Johnson Controls has identified the following major barriers to energy efficiency in Chinese industry based on energy managers' opinions: large paybacks (21% of respondents); insufficient expertise (18%); lack of financing (17%); uncertainty in terms of energy savings volume and sustainability (17%); and little attention paid to energy efficiency issues (13%). In Europe, barriers rank practically in the same order.

Practically all these barriers can be removed through energy efficiency policies in the industrial sector.

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[36] T.A. Currás. Barriers to investment in energy saving technologies. Case study for the energy intensive chemical industry in the Netherlands. 2010.

8 Energy efficiency policies in Russian industry and policy experience in other countries

8.1 IEA recommendations and Russian energy efficiency measures in industry

Industry is a sector, where energy efficiency policies are very limited. They primarily deal with energy audits and do not meet IEA's recommendations (Table 8.1). There is practically no such thing as long-term energy efficiency agreements between the government and energy intense industrial holding companies. Mechanisms to set market energy efficiency commitments have not been adopted so far. There is no experience in voluntary or mandatory target-setting in GHG emission reduction. Motor energy efficiency standards are missing. There is no package of measures to promote energy efficiency at small- and medium-size enterprises. Energy managers certification is missing.

RF Government decree No. 2446-r dated 27.12.2010 "On the Federal programme "Energy conservation and energy efficiency improvement until 2020"" sets several indicators for energy intense industries and introduces monitoring to trace energy efficiency indicators in industry. Article 16 of Federal Law No. 261-FZ requires obligatory energy audits from organizations with state or municipal participation; organizations performing regulated activities; organizations involved in water, natural gas, heat, electricity production and/or transportation, or natural gas, oil, coal, petroleum production, natural gas processing and oil refinery, oil and petroleum products transportation; organizations whose annual natural gas, diesel and other fuel, residual oil, heat, coal, and electricity bills exceed 10 mln. rubles.

U.S. and European legislature pay much more attention to industrial energy efficiency. Investigation in the framework of MURE project of the number of policies applied in the EU industry shows, that 30 policies are applied in Germany, 14 in France, 13 in Great Britain, 9 in the Netherlands.

Federal regulation of industrial energy efficiency may look at two basic groups of industrial enterprises:

- large, energy intense plants (fuel&energy complex, iron and steel, non-ferrous metals, chemistry and petrochemistry, pulp and paper, cement production). Agreements to reach target energy efficiency indicators are the major tool for energy intense industries. Modernization of basic technologies in energy-intense economic activities is an important method of reaching the target values.
- small- and medium-size enterprises. Large-scale implementation of typical technical projects, i.e. projects which include a set of cross-industry measures, is the basic tool for non-energy intense industries. Modernization of cross-industry equipment is an important direction of energy efficiency improvements in these industries.

RF Government Decree No. 1222 dated December 31, 2009 "On the types and characteristics of goods, information on the energy efficiency class of which is to be provided in the attached technical documentation, on labels and stickers, and on the rules of determining energy efficiency classes of goods by manufacturers and importers" identifies the list of goods, for which energy efficiency class information is to be displayed in the technical documentation attached to these goods, stickers and labels.

Order of the RF Ministry of industry and trade No. 769 dated September 7, 2010 "On the categories of goods, which must have information on their energy efficiency classes in the attached technical documentation" specifies a list of categories of goods (including their characteristics), which must have information on their energy efficiency classes in attached technical documentation, labels and stickers; and a list of exemptions from the categories of goods and characteristics of goods, which do not need to have information on their energy efficiency classes in the attached documentation, stickers and labels.

RF Government Decree No. 857 dated October 25, 2010 "On approving the list of top energy efficient facilities and technologies investing in which makes eligible for investment tax credits" specifies a list of facilities and technologies investing in which makes eligible for an investment tax credit. The list includes condensing boilers, heat pumps, cogeneration units (up to 25 MW), and LED bulbs.

Another requirement of the Federal law No. 261-FZ deals with federal and municipal procurement and stipulates that only top energy efficient goods, work and services are to be procured.

RF Government Decree No. 562 dated July 12, 2011 “On approving the list of top energy efficient facilities and technologies, investing in which makes eligible for investment tax credits” specifies, that an organization which invests in the production of highly energy efficient facilities or technologies is eligible for an investment tax credit. The list of such facilities and technologies was revised and includes 56 items (used to be 4). For example, it includes facilities and technologies related to the production of high temperature superconductor, light-duty vehicles, cardboard, paper, pulp, synthetic rubber, fertilizers, electroferroalloys, and LED lights. It also includes optimization of heating and electricity networks, automation of heating process in various furnaces, gas and oil pipeline transportation, etc. Investment tax credit means that for a certain term and within a certain limit a company may reduce its tax payments with subsequent gradual repay of this credit and interest in steps. This investment tax credit can be granted for the profit tax, as well as for regional and local taxes. The credit amounts up to 100% of the costs of equipment purchased to develop such facilities and technologies.

Table 8.1 IEA policy recommendations and Russian energy efficiency regulation on industry

IEA EE policy recommendations	Russian regulatory acts enacting corresponding policies
Governments should support the IEA energy efficiency indicator work that underpins critical policy analysis by ensuring that accurate energy intensity time series data for industrial sectors is reported regularly to the IEA. Governments should consider adopting mandatory minimum energy performance standards for electric motors in line with international best practice. Governments should examine barriers to the optimization of energy efficiency in electric motor-driven systems and design and implement comprehensive policy portfolios aimed at overcoming such barriers Governments should consider providing effective assistance in the development of energy management (EM) capability through the development and maintenance of EM tools, training, certification and quality assurance. Governments should consider developing and implementing a package of policies and measures to promote energy efficiency in small and medium-sized enterprises (SMEs).	*RF Government Resolution No. 2446-r dated December 27, 2010 "On adopting the Federal program «Energy conservation and energy efficiency until 2020»"* Sets several indicators for energy intense industries and a system of program monitoring to track energy efficiency indicators in industries. *Federal program "Energy efficiency and energy development"* contains no energy efficiency indicators for the industrial sector. *Federal law No. 261-FZ "On energy saving and improving energy efficiency and on amending some legislative acts of the Russian Federation"* Mandates energy audits for organizations with federal or municipal involvement; organizations involved in regulated activities; organizations involved in the production and/or transportation of water, natural gas, heat, electricity, production of natural gas, oil, coal, petroleum, transformation of natural gas and oil, transportation of oil and petroleum products; organizations with overall annual natural gas, diesel and other fuels, residual oil, heat, coal, electricity bills exceeding 10 million rubles. *RF Government Decree No. 391 dated June 1, 2010 "On the procedure for developing a federal energy conservation and energy efficiency information system and on the conditions for its operation"* Specifies that the RF Ministry of regional development is to present to the operator of the federal information system data on the availability of information on energy efficiency classes in the technical documentation attached to industrial goods, as well as on labels and stickers. *RF Government Decree No. 19 of 25 January, 2011 "On approving the requirements for the collection, processing, systematization, analysis, and use of the data of energy passports, based on mandatory and voluntary energy audits"* *Order of the RF Ministry of energy No. 182 dated April 19, 2010 "On approving the requirements for energy passports based on mandatory energy audits and for energy passports based on design documentation, and on the rules of forwarding a copy of the energy passport developed based on a mandatory energy audit"* Provides a format for energy passport, but does not set mechanisms for further processing of energy passports, or further analysis and decision-making. Energy efficiency performance standards for motors are missing. A package of measures to promote energy efficiency at SME is missing. Certification of energy managers is missing.

Source: CENEf

This Decree borrowed equipment energy efficiency selection criteria from the list of target indicators of the Federal programme "Energy conservation and energy efficiency improvement until 2020" (Appendix 13). These indicators were estimated by CENEf as average for 2020. So specific energy consumption by new equipment should normally be below the target values for 2020 for the entire equipment stock. For example, electric steel BAT is 55 ktce/t, and purchases of equipment with exactly these parameters should be encouraged, whereas the Decree targets at 73 kgce/t average specific consumption. For this reason, in a number of instances tax benefits will be granted to the buyers of not top efficient equipment.

The so-called cooperation mechanisms, i.e. development of long-term (5-12 years) energy efficiency agreements between the government and industrial associations (self-regulatory organizations) and/or large holding companies, are the basic policy tool for *energy intense* industries. Such agreements set energy efficiency targets; coordinate energy efficiency plans at the company and/or unit level; provide reporting and monitoring formats; develop tax and other incentives for energy efficiency plans and supporting programs[37].

Energy efficiency agreements are a partnership between the government and business community to improve energy efficiency, reduce GHG emissions and environmental pollution. In the framework of this partnership the government develops and signs agreements with industrial associations or large holding companies, which specify energy intensity reduction targets for basic industrial products. Regional governments can sign such agreements with local enterprises, in the same way as the Chinese government is implementing a program for 1,000 most energy intense enterprises, which are responsible for 48% of the total industrial energy consumption.

Enterprises and holding companies, which make such commitments, may be eligible for benefits and subsidies for energy efficient equipment procurement or for reduced emission tax rates. Besides, this can be their way of demonstrating their social responsibility, and their credit rating will be growing, as their “carbon footprint” gets smaller.

In the Netherlands, this mechanism was launched in 1992. Agreements are signed with companies which consume more than 17 thousand tce per annum. The target is to reduce specific energy consumption by 30% over 2005-2020. 900 companies are taking part in the program. In 1998-2007, energy intensity of the Dutch industry was going down on average by 2.4% per annum versus average 1.7% in the EU.

The following 10 steps are needed to implement energy efficiency agreements:

1. Specify industrial energy intensity reduction target to be achieved by 2020;
2. For some industries, the RF Ministry of energy, RF Ministry of economic development and/or RF Ministry of industry and trade should develop “Guidance to specify industrial energy efficiency indicators”, like it has been done in many countries. Targets may be formulated as absolute savings, reduction of specific energy consumption, or evolution of energy efficiency indices;
3. Identify industrial groups and holding companies, and possibly, unions and associations, which can become parties to energy efficiency agreements. Determine the energy consumption threshold for a company to become a party to the agreement;
4. Decompose industrial energy efficiency target into a system of low-level energy efficiency targets for separate industries (as average weighted by major products) and/or for industrial products;

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[37] L. Price, C. Galitsky, K.J. Kramer. International experience with key program elements of industrial energy efficiency of greenhouse gas emissions reduction target-setting programs. Ernst Orlando Lawrence Berkeley Laboratory. Environmental Energy Technologies Division. February. 2008. For example, in Great Britain, 44 agreements have been signed in a number of sectors to involve 5,000 companies. In the Netherlands, 29 agreements have been signed to involve 1,000 of companies. In Japan agreements have been signed for 38 sectors. In South Korea, 1,400 companies have signed the agreements.

5. Develop a benchmarking system for enterprises, so they can compare their specific energy consumption to average values across the industry and to the world "best practices" for similar conditions. In addition, the benchmarking system shall provide energy efficiency recommendations and display energy efficiency rating of the enterprise after it implements energy efficiency recommendations;
6. Industrial groups, companies, unions, or associations, which are to become parties to such agreements, make energy audits and develop plans to meet their energy efficiency commitments. "Energy efficiency plan development guides" are to be developed. Companies make commitments to implement projects with up to 5 years paybacks and to introduce energy management standards;
7. Representatives of the federal government and of industrial associations coordinate energy efficiency targets and plans; the targets and plans shall be revised at least once every five years;
8. Coordinate formats for annual reports on the plan implementation and energy efficiency targets achievement, and develop a monitoring system. Develop a system to verify monitoring results and assign a federal agency with monitoring and verification responsibilities;
9. Specify financial incentives for parties to the agreements, who successfully implement their plans and reach their energy efficiency targets, and specify penalties for those who fail to comply with their commitments;
10. An analytical center authorized by the government estimates the effectiveness of the energy efficiency agreements at least once every three years. The estimates focus on the development of recommendations on how to improve the program and assess its direct and indirect effects.

While developing the RF Federal program "Energy conservation and energy efficiency improvement until 2020" CENEf suggested using this mechanism for large industrial enterprises, which qualify for sovereign guarantees for their energy efficiency programs. The first two agreements have been signed.

The RF Government decree No. 7 dated 08.01.2009 "On measures to enhance reduction of atmospheric pollution with combustion products from associated petroleum gas flaring" and supplementing RF Government decree No. 1148 dated November 8, 2012 "On the assessing the charge for the emission of polluting matter from associated petroleum gas flaring and/or diffusion" can be viewed as the first long-term energy efficiency agreement between the government and the business community (see Chapter 6). In July 2011 an agreement was signed between the government and 11 largest oil&gas companies about the modernization of Russia's oil refineries by 2020. In early 2012, the RF Government (Rostechnadzor) held a discussion of the first such agreement with steel-workers to upgrade industrial equipment. The draft agreement specifies the list of facilities, upgrade schedule, the costs of the investment programs, and penalties for non-compliance with deadlines[38]. Steel-workers ask for economic incentives instead: investment allowances for profit tax, reduced customs duties for new equipment, soft loans, etc.[39] In reality, modernization commitments are to be a fee for economic incentives obtained.

Apart from long-term agreements, a considerable experience has been accumulated in industrial energy efficiency policies. The following measures should be taken to launch and successfully operate these mechanisms:

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[38] Kommersant. R. Asankin and D. Skorobogat'ko. Investment programme spelled out for steelworkers. 26.0.1.2012.

[39] Kommersant. D. Skorobogat'ko and R. Asankin. Steelworkers joined Resistance. 07.0.2.2012.

- Development of a statistical monitoring system for industrial energy efficiency and for the shape of energy equipment;
- Introduction of a system to set energy efficiency targets, a benchmarking system, and a system to monitor achievement of energy efficiency targets and the effectiveness of typical projects implementation;
- Enforcement of new standards and technical regulations for industrial equipment;
- Energy audits, including specialized audits by types of industrial process equipment and development of energy efficiency plans;
- Enforcement of energy management standards, personnel training and providing informational support;
- Support for energy service business to maintain, and improve the efficiency of, basic types of industrial equipment;
- Introduction of subsidies and tax benefits;
- Encouraging utilities to support energy efficiency activities in the industrial sector;
- Energy tariff regulation;
- Support to R&D in industrial energy efficiency.

Statistical monitoring of energy efficiency in the industrial sector is primarily based on statistical form 11-TER. The list of indicators in this form needs to be further developed to improve monitoring and set up a federal energy efficiency information system, and data on non-ferrous metallurgy should be unclassified. Besides, this form needs to be supplemented with a specific form on industrial energy efficiency. This latter form should include data necessary to estimate target indicators of the federal energy efficiency program for the industrial sector.

Federal energy register can become an important data source for the energy efficiency information system, since it includes data on organizations and their basic activities; major products, work, and services; energy consumption; efficiency of energy use; energy audit reports; and reports on the implementation of energy audit recommendations. Federal energy register should lay a basis for an energy efficiency clearing house and development of energy efficiency improvement directions by economic activities and top energy intense products and services, in the public sector, municipal utilities, and other sectors of economy. These integrated data on the efficiency of energy use and directions of energy efficiency improvement should be in the open access, except restricted information, as defined by law.

The RF Ministry of economic development with the help of the Federal statistical service subordinate thereto, and of a specially selected consulting company, shall develop an energy efficiency benchmarking system for enterprises producing similar products. This system will help enterprises compare their specific energy consumption with average values across the industry and with the world “best practices” for similar conditions. In addition, the benchmarking system shall provide energy efficiency recommendations and display energy efficiency rating of the enterprise after it implements recommended energy efficiency measures. The system shall be operating in two modes:

- ***Mandatory*** and depersonalized, which provides data on specific energy consumption by plants for product manufacturing, without mentioning the plants’ names. This system shall be based on, but not limited to, annually published data of 11-TER statistical form and the federal energy register. It will also use foreign data, including data from special benchmarking information systems and world best energy efficiency practices[40];

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[40] This is the way many systems operate in Canada.

- ***Voluntary,*** which shall provide the names of companies. In this case, the company rating system builds on the work of industry associations and is supported by industrial scientific and information centers[41]. The system operation includes annual workshops, an Internet website and columns is specialized periodicals.

When developed, this system will form a reliable information base for target-setting for energy efficiency agreements; help obtain reliable express-estimates of companies' energy efficiency potentials; and form a basis for the development of companies' energy efficiency plans.

A special information campaign would help Russian enterprises assess and implement their energy efficiency potentials. It is important to provide access to the information on energy efficiency projects to industrial plants and make this information more helpful.

In 2012, the United States launched a certification program titled Superior Energy Performance (SEP), which will provide industrial facilities with a roadmap for achieving continual improvement in energy efficiency while maintaining competitiveness. The program will provide a transparent, globally accepted system for verifying energy performance improvements and management practices. A central element of the program is implementation of the global energy management standard, ISO 50001, with additional requirements to achieve and document energy performance improvements. Experts estimate, that the SEP and ISO 50001 can improve industrial energy efficiency by 10-30%.

The goals of an energy audit include: technical and economic analysis of the efficiency of energy use and of the energy efficiency potential; filling in the energy passport; developing, and monitoring the implementation of, an energy efficiency plan. Mandatory energy audits are not a common practice abroad. They are primarily performed in Bulgaria, Latvia, and Romania[42].

It is important to develop methodological recommendations and guides on how to develop an energy efficiency plan for an industrial enterprise[43]. This would help standardize plan development and technical&economic analysis to compare and generalize indicators. A plan should include: a description of an enterprise, energy balance sheet, assessment of the energy efficiency potential of measures included in the plan, energy price projections, investment demand, plan implementation schedule, and expected energy and cost savings.

A performance measurement and verification protocol should be developed to assess the effects of energy efficiency plans implementation[44].

It is important to develop energy efficiency standards and technical regulations for cross-industry equipment: electric motors, compressors, lighting systems. Directive 2005/32/EC on eco-design became an important measure aiming at industrial energy efficiency improvement in the EU. This document set standards for 40 types of cross-industry equipment (including electric motors, pumps, refrigerators, lighting systems, furnaces, etc.). Another important document was

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[41] This is the way the system operates in South Korea.

[42] Energy Efficiency Trends and Policies in the Industrial Sector in the EU-27. Lessons from the ODYSSEE MURE project. ADEME. 2009.

[43] In Japan and South Korea, ministers of industry and foreign trade can give the status of an "enterprise with an energy conservation plan" to a plant with annual fuel consumption over 4,300 tce or electricity consumption over 12 million kWh. Director of such plant must appoint several energy managers (between 1 and 4) who will be responsible for energy efficiency improvements and will annually report on the plant energy consumption. The government can provide a grant up to US$ 150 thousand to develop such plan. Alternatively, express energy audits can be performed by the Energy Efficiency Center of Japan (ECCJ). ECCJ makes express energy audits free of charge (2 experts x 1 day) for small- and medium-size enterprises (up to US$ 1 million capital). For larger companies, **also free of charge**, ECCJ makes more detailed audits (1 or 2 experts make a 4-day preliminary audit followed by a detailed audit of the production process). After that the plan implementation is monitored by the ministry of industry and foreign trade.

[44] IPMVP – International performance measurement and verification protocol, US DOE, 1997, may serve an example.

Directive 2004/8/EC on the promotion of cogeneration[45]. Standards are being introduced in steps, gradually getting more rigorous.

It is also important to develop a guide on the enforcement of energy management standards at enterprises. This will help integrate energy efficiency into existing company management structures. A large part of industrial energy savings is determined not so much by the equipment, as by energy consumption patterns, and – even more widely – by energy cost management[46]. Quite often Chief energy manager has no impact on the management decision-making, and so the company's energy costs are too high. Energy management standards are set in compliance with ISO 50001 and provide a format for the integration of energy costs management[47]. Central cores of this system include: integration of energy cost reduction in the company's strategic plan; energy efficiency targets and indicators; energy efficiency plan and inter-department implementation group; development of energy efficiency guides; regular reporting on energy efficiency improvements[48].

If an energy efficiency plan is to be successfully implemented, it is necessary to coordinate the activities of all company departments, to have policies and procedures related to the procurement of new equipment, to monitor basic energy efficiency indicators, and to continuously demonstrate the effects of the energy efficiency plan implementation to the company management team. It is also important to develop energy consumption metering at the unit level, computer processing of data and gradual establishment of energy consumption dispatch. Besides, the system of energy consumption rationing, currently in place at many enterprises, is to be further developed[49].

Launching a voluntary system, similar to those already operating in the U.S., Denmark, Ireland, Sweden, requires technical assistance to the industrial sector, consulting support (primarily to small- and medium-size enterprises, which lack the necessary qualifications), and, possibly, economic incentives for achieving the target parameters. In the U.S., more than 100 largest and 50 thousand small companies have already integrated energy efficiency in their management structures. There is a need for an energy management guide and for a system of certification of industrial energy management systems for compliance with standards. All enterprises, which are parties to energy efficiency agreements, should have certified energy management systems. This measure is rarely mandated; maybe only in Greece.

Industrial systems designed with energy efficiency criteria in mind are more reliable and productive and ensure energy cost reduction. In order to optimize industrial energy using systems, it is necessary to develop an energy balance sheet[50] and a power supply master-plan for the enterprise to provide a framework for the development of major technical solutions, ensure project implementation flexibility and a possibility to commission various elements of the system, as needed. This would allow it to reduce excessive installed capacity of the equipment. Optimization includes implementation of all projects with up to 2 years' paybacks.

Part of the achieved savings should be used as financial incentives for the Chief energy manager's service and to proceed with the energy efficiency program implementation. Today, energy efficiency in Russia is basically financed with enterprises' own funds, and so it is

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[45] Energy Efficiency Trends and Policies in the Industrial Sector in the EU-27. Lessons from the ODYSSEE MURE project. ADEME. 2009.

[46] A. McKane. Industrial Energy Efficiency Programs. National and International Trends. California Public Utilities Commission. November 5, 2007.

[47] S.A. Khokhlyavin. What will ISO 50001 in energy management be like. Technical regulation library.

[48] For example, in 1994-2005 Dow Chemical implemented a plan which helped reduce energy costs by 22% and developed a new plan to further reduce them in 2005-2015 by 25%. Target values for a plant may be based on agreements with industrial associations or large holding companies manufacturing top energy intense products.

[49] See Energy audit and energy resource rationing. Methodology materials inventory. NICE. Nizhny Novgorod. 1998.

[50] See Guidance for energy efficiency improvements in the food industry. Dena and CENEf. Moscow, 2002.

important to decide, how the savings will be used. If savings are used to finance some other needs of the enterprise, there will be no motivation for the program participants. It is advisable to launch a revolver mechanism to finance further energy efficiency measures with the savings achieved at preceding stages.

A system of energy supply contracts is an important prerequisite for effective energy management. It is important that penalties for savings are eliminated and energy supply contracts are improved in favour of industrial enterprises. The RF Government Decree No. 877 dated November 4, 2011 "On amendments to some Acts of the RF Government to improve the relations between electricity suppliers and consumers in the retail market" determined, that customers with 750 kVA or less connected capacity, who did not choose the 5th or 6th pricing categories for bills payable, should not be mandated to pay for electricity they contracted but never consumed. Billing should be based on the meters readings for the corresponding period. It is forbidden to include in the final retail price the cost of electricity purchased by distribution companies under direct contracts, should the price in this case be higher, than in the wholesale market. Capacity balancing mechanism, which enabled distribution companies to sell more capacity in retail trade, than they purchased in the wholesale market, was eliminated. Enterprises should improve long- and medium-term output planning to better project resource consumption and reduce overconsumption charge.

It is important that contracts have a special provision to mandate an energy utility to cover damage incurred by the enterprise, should this damage occur through the fault of the energy utility (resource supply break or low quality resource). This primarily relates to electricity supply, because meters allow it to compare most parameters with the standard values. This measure requires that damage evaluation mechanisms be developed.

It is important to develop schemes to support ESCO in terms of running cross-industry equipment: electric motors, compressors, lighting systems, steam supply, etc., and to tune mechanisms to leverage comparatively short-term financial resources to projects focusing on equipment modernization. Banks with state participation can be the first to get involved in these schemes, and then these banking products can be further spread across the whole banking system.

In Russia, there is practically no public-private partnership experience in energy efficiency. However, there is a vast foreign experience (see below). Cooperation between the government and Russian industrial enterprises can spur the implementation of the energy efficiency potential and neutralize the negative effect of the fast growing energy costs. By mandating energy audits for large enterprises the government motivates them to develop energy efficiency plans; and by providing subsidies for the implementation of energy efficiency measures it will help implement the energy efficiency potential and so keep production output levels and employment, will obtain additional tax revenues and repay the subsidy costs. Besides, each unit of energy saved in the industrial sector brings another unit of additional savings along the whole energy chain, extending the energy export potential and bringing additional budget revenues. The government can also provide grants to enterprises for the development of energy efficiency programs[51]. In the

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[51] With a focus on providing incentives for industrial energy efficiency NOVEM (the Netherlands) manages two subsidy programs. Under the first program ("Industrial energy efficiency tender") subsidies are provided for the implementation of energy efficiency programs developed by enterprises. Under the second program ("Energy efficiency and environmental protection consulting scheme") small- and medium-size plants are eligible for subsidies to hire a consultant to develop an energy efficiency or an emission reduction plan. In the Czech Republic, federal program to support industrial energy efficiency offers bonuses for energy audits (80% of the cost, but not to exceed US$ 7,000) and for demo projects to small- and medium-size industrial firms (up to 500 workers). Should the audit recommendations not be implemented within 3 years, the entire amount of federal support is to be repaid. The federal share in financing these projects is 24%. Energy audits are also subsidized in Poland and Slovenia (up to 50% of the audit costs are covered by the government). Besides, Slovenia provides investment grants of up to 15% of the project costs.

U.S., grants can be provided to industrial associations to support energy efficiency programs. In Sweden, grants are provided to industrial plants. Sweden, Italy, Germany, Japan, South Korea, and other countries provide subsidies and tax benefits for the procurement of energy efficient industrial equipment.

Government can provide financial support to enterprises, which invest in energy efficiency improvements. This can be done in the form of partial reimbursement of loan interest payments. Federal subsidies can be provided for projects focusing on natural gas, heat, or electricity consumption reduction through installation of top efficient equipment and renewable energy use. Other possible instruments include accelerated depreciation of energy efficient equipment and investment tax credits.

Special financial support packages can apply to typical low-risk energy efficiency projects at industrial enterprises: replacement of electric motors, lighting systems, and refrigerators; modernization of compressed air and steam supply systems, etc.

It is necessary to formulate eligibility criteria for federal funding to reimburse part of loan interest payments for those who invest in energy efficiency improvements. It is also important to identify categories of economic agents eligible for two thirds of the refinancing rate; 95% of the refinancing rate; and 100% of the refinancing rate of the RF Central Bank.

It is important to develop standardized banking technologies to finance energy efficiency projects in the industrial sector. It is possible to considerably reduce pledge and other requirements to a project financed, *inter alia*, through a government grant. A simplified process of project development, analysis, and evaluation can help minimize overheads and reduce risks. This can be quite simple, because for many reputed technologies, such as efficient boilers, energy management systems in buildings, efficient lighting, and condensers, project development is easy, and end-users and financial institutes are well aware of risks. Acting to a template while developing and evaluating a new project is not difficult.

The Commission for modernization and technological development of Russia’s economy should identify priorities for R&D in energy efficiency. At the first meeting of the Commission on June 18, 2009, the RF President recognized energy efficiency improvement as a priority for the modernization and technological development of Russia’s economy. The RF Ministry of education and science should ensure that these R&D take place.

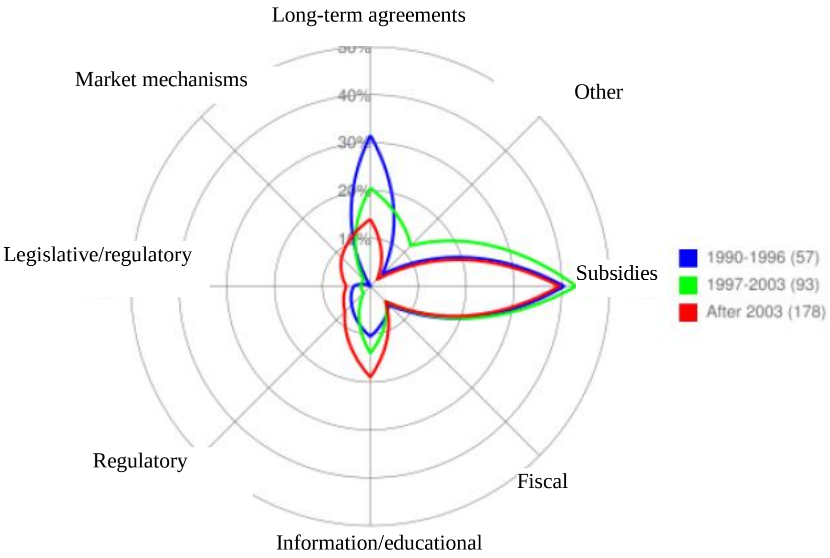
9 Basic recommendations

9.1 Industry

9.1.1 Major policies to improve industrial energy efficiency

Russian industry is a sector, where energy efficiency policies are very limited. There is practically no such thing as long-term federal energy efficiency policy. Existing policies primarily deal with energy audits and do not meet IEA's recommendations (Table 9.1). U.S., European, and Chinese legislature pay much more attention to industrial energy efficiency. Investigation of the number of policies applied in the EU industry shows, that 30 policies are applied in Germany, 14 in France, 13 in Great Britain, 9 in the Netherlands. On average, nearly 10 policies are applied in each EU country. They form sort of a "shamrock" of industrial energy efficiency policies (Fig. 9.1). Countries that meet with more difficulties in industrial energy efficiency improvement apply more policies. Most popular policies deal with co-generation units, motors, compressed air, and lighting.

Figure 9.1 Distribution of energy efficiency measures in EU industry by types and compliance dates



Source: Energy Efficiency Policies in Industry. Lessons Learned from the ODYSSEE-MURE Project. ADEME. Draft September 2012.

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Source: CENEf

Apart from the Federal Law No. 261 on mandatory energy audits, RF Government Decree No. 562 dated August 12, 2011 “On approving the list of top energy efficient facilities and technologies, investing in which makes eligible for investment tax credits”. It stipulates, that if a company invests in top energy efficient facilities and technologies, it is eligible for an investment tax credit.

Similarly, RF Government decree No. 308 dated 16 April 2012 “On approving the list of top energy efficient facilities, which do not need to be assigned with an energy efficiency class” includes a list of such facilities. The decree allows for accelerated depreciation and grants property tax benefits.

Regretfully, the above federal incentives for purchasing efficient products are not used by consumers and the benefits do not work.

Federal regulation of industrial energy efficiency may look at two basic groups of industrial enterprises:

1) **Large, energy intense plants** (fuel production and processing, iron and steel, non-ferrous metals, chemistry and petrochemistry, pulp and paper, cement production).

“500-500” programme can bring 160 mln. tce in 2013-2020 and 500 mln. tce in 2013-2030 in energy savings obtained by 500 large energy intense enterprises.

Agreements to reach target energy efficiency indicators are the major tool for energy intense industries. Modernization of basic technologies in energy-intense economic activities is an important method of reaching the target values.

There are two examples of such agreements in Russian industry:

- **Reduced share of associated gas flaring.** RF Government decree No. 7 dated 08.01.2009 “On measures to enhance reduction of atmospheric pollution with combustion products from associated petroleum gas flaring” can be viewed as the first long-term energy efficiency agreement between the government and the business community. Many oil companies have not yet reached the target levels. As of early 2012, only Surgutneftegas and Tatneft have reached the prescribed level of associated petroleum gas recovery. Good progress has been also made by SRP, TNK-BP, and Bashneft. Federal companies Rosneft (49% flaring; 1 bln. m^3 absolute flaring increase in 2011) and Gaspromneft (39% flaring) are outsiders in associated petroleum gas recovery. Absolute flaring increase is also observed in 2011 at TNK-BP and Russneft.

In 2011, investments in associated petroleum gas recovery in Russia accounted for nearly 82.2 bln. rubles; around 75 electricity sector facilities and 171 petroleum gas preparation facilities were commissioned; nearly 2,000 km of pipelines were built. However, despite the declared plans and gas recovery measures implemented in the last 3 years, the share of gas recovery not only failed to grow up to 95%, but on the contrary, dropped from 84.1% to 76%. Russia keeps increasing the volume of gas flaring. Partially it is determined by the commissioning of new oil deposits in areas with poor gas processing and transportation infrastructure along with reduced production at old, well developed deposits.

Having realized that, in 2012 the RF Government adopted a package of additional economic incentives for gas flaring reduction[52]. If the share of gas flaring exceeds 5% of total associated petroleum gas production, environmental pollution charge is calculated as for pollution in excess of established limits with an additional multiplier, which is 12 in 2013 and 25 since 2014. If there is no metering of associated petroleum gas, the pollution charge is estimated by normative

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[52] RF Government Decree No. 1148 of November 8, 2012 “On the assessing the charge for the emission of polluting matter from associated petroleum gas flaring and/or diffusion”.

values with 120 as an additional multiplier. However, there is no increased charge, if gas recovery projects implementation costs exceed the pollution fee calculated with the scale-up multipliers.

- **Modernization of oil refineries.** In July 2011 an agreement was signed between the Russian government and 11 largest oil&gas companies for the modernization of Russian oil refineries by 2020 so that all produced fuel complied with the EURO-5 standard. In order to increase the investment attractiveness of oil refinery retrofits, on October 1, 2011 the government introduced a new tax scheme 60-66-90 to make export-oriented residual oil production economically unviable.

The “500-500” programme was targeted to develop, entrench and extend this mechanism to large industrial companies involved in fuel production and processing, ferrous and non-ferrous metals, chemistry and petrochemistry, pulp and paper, and cement production to further possibly extend this list of industries.

2) **Medium- and small-size industrial companies**. Large-scale implementation of typical energy efficiency projects, i.e. projects which include a set of cross-industry measures, to encourage industrial energy consumers for energy efficiency improvements and provide information and consulting support to small- and medium-size enterprises are the basic tools for non-energy intense industries. Replacement and modernization of cross-industry equipment is an important direction of energy efficiency improvements in these industries.

Implementation mechanisms:

- ❖ standards for cross-industry equipment, energy efficiency classification and labeling;
- ❖ subsidies or tax exemptions for purchase of highly efficient cross-industry equipment;
- ❖ launching the “white certificates” scheme (providing support to industrial energy efficiency by energy utilities) to also involve medium- and small-size industrial companies;
- ❖ and/or setting up regional revolver energy efficiency funds financed through tariff deductions and using these funds to finance projects of medium- and small-size industrial companies;
- ❖ development of BAT reference books, information bulletins and mailouts by industries, enacted and perspective energy consumption standards by types of equipment;
- ❖ development of a training and education system to improve energy efficiency competences of small- and medium-size companies;
- ❖ providing subsidies from regional energy conservation programmes budgets for energy audits and development of energy efficiency programmes for medium-and small-size industrial companies.

All industrial companies. Apart from long-term agreements, a considerable experience has been accumulated in industrial energy efficiency policies. The following measures should be taken to launch and successfully operate these mechanisms:

- ❖ Development of a statistical monitoring system for industrial energy efficiency and for the shape of energy equipment;
- ❖ Introduction of a system to set energy efficiency targets, a benchmarking system, and a system to monitor the meeting of energy efficiency targets and the effectiveness of typical projects implementation;
- ❖ “Soft” gradual ban of inefficient industrial technologies and equipment;

- Enforcement of energy management standards and certification, personnel training and providing informational support[53];
- Support to the energy service business and outsourcing to maintain, and improve the efficiency of, cross-industry equipment;
- Energy tariff regulation;
- Support to R&D in industrial energy efficiency.

Statistical monitoring of energy efficiency in the industrial sector is primarily based on statistical form 11-TER. The list of indicators in this form needs to be further developed to improve monitoring and set up a federal energy efficiency information system, and data on non-ferrous metallurgy should be unclassified. Besides, this form needs to be supplemented with a specific form on industrial energy efficiency. This latter form should include data necessary to estimate target indicators of the federal energy efficiency program for the industrial sector.

Consolidation of energy efficiency efforts and transition to comprehensive environmental permits can become another direction of cooperation with **large enterprises in key industries**. Such permits are about introduction of best available technologies (BAT), dissemination of which has been discussed in Russia since late 90's. BAT are identified through benchmarking by specific energy- and resource efficiency, as well as by the environmental performance of enterprises. Draft Federal law on the necessary amendments to the environmental legislation has been discussed in Russia since 2008. The decision on the consolidation of efforts is a "double dividend". On the one hand, it would finally allow for the implementation of the idea originally promoted by the RF Presidential Decree No. 889 dated June 4, 2008 "On some measures to improve energy and environmental efficiency of the Russian economy" of coordinated resource efficiency and pollution mitigation activities. On the other, it would be possible to optimize the costs of benchmarking necessary to identify best available technologies and energy efficiency solutions for the key industries.

The RF Ministry of energy in cooperation with the RF Ministry of economic development with the help of the Federal statistical service subordinate thereto, and of specially selected consulting companies, should develop an energy efficiency benchmarking system for enterprises producing similar products. This system will help enterprises compare their specific energy consumption with average values across the industry and with the world "best practices" for similar conditions. In addition, the benchmarking system shall provide energy efficiency recommendations and display energy efficiency rating of the enterprise after it implements recommended energy efficiency measures. The system can be operating in two modes:

- ***Mandatory*** and depersonalized, which provides data on specific energy consumption by plants for product manufacturing, without mentioning the plants' names. This system shall be based on, but not limited to, annually published data of 11-TER statistical form and the federal energy register. It will also use foreign data, including data from special benchmarking information systems and world energy efficiency best practices[54];

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[53] In 2012, the U.S. launched a certification programme Superior Energy Performance, which will provide industrial companies with technology road maps for continuous energy efficiency improvement. The Programme provides a transparent and acknowledged system to monitor energy efficiency improvements and management methods. The central element of the programme is introduction of energy management systems meeting the ISO 50001:2011 standard with additional requirements to the achievement and documentation of energy efficiency improvements. According to expert assessments, SEP programme and ISO 50001:2011 can improve industrial energy efficiency by 10 to 30%.

[54] This is the way the system works in Canada.

- ***Voluntary,*** which shall provide the names of companies. In this case, the company rating system builds on the work of industry associations and is supported by industrial scientific and information centers[55]. The system operation includes annual workshops, an Internet website and columns is specialized periodicals.

When developed, this system will form a reliable informational base for target setting for energy efficiency agreements; help obtain reliable express-estimates of companies' energy efficiency potentials; and form a basis for the development of companies' energy efficiency plans.

It is important to study foreign benchmarking guidelines and learn how best practice and BAT parameters are identified, select those that best fit Russian conditions, translate them and adapt for Russian industry[56].

A special information campaign would help Russian enterprises assess and implement their energy efficiency potentials. It is important to provide access to the information on energy efficiency projects (and best practices) to industrial plants and make this information more helpful.

All this requires that financing be secured to:

- launch pilot version of this information portal;
- publish the "Energy Manager" magazine to describe success stories;
- translate into Russian and adapt energy management guidelines for various industries and various energy consumption processes (electric motors, compressed air systems, heat- and steam supply, lighting, etc.)[57];
- translation, annual updates, and adaptation to the Russian conditions of BAT reference documents by industries.

It is important to develop **methodological recommendations and guidelines on how to develop an energy efficiency plan for an industrial enterprise, BAT manuals**[58]. This would help standardize plan development and technical&economic analysis to compare and generalize indicators. A plan should include: description of the enterprise, energy balance sheet, assessment of the energy efficiency potential of measures included in the plan, energy price projections, investment demand, plan implementation schedule, and expected energy and cost savings.

A **performance measurement and verification protocol** should be developed to assess the effects of energy efficiency plans implementation[59]**.**

It is important to develop energy efficiency standards and technical regulations for cross-industry equipment: electric motors, compressors, lighting systems. Directive 2005/32/EC on eco-design

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[55] This is the way the system works for South Korea.

[56] In the framework of some international projects (primarily Harmonization of environmental standards II – Russia) BAT reference documents for cement, lime, glass, ceramics, etc. production were translated into Russian, discussed with the expert community and used for the development of national standards. The standards include methods to improve energy efficiency and environmental effectiveness applicable in Russia.

[57] The following Reference document for energy efficiency BAT issued in 2009 and 2012 in Russian can be used as the basis for further work: http://14000.ru/projects/energy-efficiency/EnergyEfficiency2012RUS.pdf

[58] In Japan and South Korea, ministers of industry and foreign trade can give the status of an "enterprise with an energy conservation plan" to a plant with annual fuel consumption over 4,300 tce or electricity consumption over 12 million kWh. Director of such plant must appoint several energy managers (between 1 and 4) who will be responsible for energy efficiency improvements and will annually report on the plant energy consumption. The government can provide a grant up to US$ 150 thousand to develop such plan. Alternatively, express energy audits can be performed by the Energy Efficiency Center of Japan (ECCJ). ECCJ makes express energy audits free of charge (2 experts x 1 day) for small- and medium-size enterprises (up to US$ 1 million capital). For larger companies, **also free of charge**, ECCJ makes more detailed audits (1 or 2 experts make a 4-day preliminary audit followed by a detailed audit of the production process). After that the plan implementation is monitored by the ministry of industry and foreign trade.

[59] IPMVP – International performance measurement and verification protocol. US DOE. 1997 can serve an example.

became an important measure aiming at industrial energy efficiency improvement in the EU. This document set standards for 40 types of cross-industry equipment (including electric motors, pumps, refrigerators, lighting systems, furnaces, water supply, etc.). Another important document was Directive 2004/8/EC on the promotion of cogeneration[60]. Standards are being introduced in steps, gradually getting more rigorous.

Major benefits expected from the energy management system deal with correct prioritizing, setting feasible targets, and general systematization of energy efficiency activities. External confirmation of introduction of the energy management system (certification) may be needed only by some industrial companies. At this point, there are a number of voluntary certification systems of energy management systems. Harmonization of certification procedures, unification of requirements to voluntary certification systems, methodology and information support to industrial companies, pilot projects can and should lay a basis for a wide dissemination of energy management tools in Russia.

Promotion and certification of voluntary energy management systems similar to those already operating in the U.S., Denmark, Ireland, Sweden, requires technical assistance to the industrial sector, consulting support (primarily to small- and medium-size enterprises, which lack the necessary qualifications), and, possibly, economic incentives for achieving the target parameters. In the U.S., more than 100 largest and 50 thousand small companies have already integrated energy efficiency management in their management structures. Despite the fact that energy efficiency agreements had been developed and fulfilled before the international energy management standards were adopted, at this point most countries assume that all enterprises, which are parties to energy efficiency agreements, should have certified energy management systems. However, this measure is rarely mandated; maybe only in Greece.

Industrial systems designed with energy efficiency criteria in mind are more reliable and productive and ensure energy cost reduction. In order to optimize industrial energy using systems, it is necessary to develop **Guidelines for a plant's energy balance sheet development and a power supply master plan for the enterprise** to provide a framework for the development of major technical solutions, ensure project implementation flexibility and a possibility to commission various elements of the system, as needed. This would allow it to reduce excessive installed capacity of the equipment. Optimization includes implementation of all projects with up to 2 years' paybacks.

It is also important to develop **typical recommendations for providing financial incentives for the Chief energy manager's service for successful energy efficiency program implementation**. Today, energy efficiency investment in Russia is basically provided from enterprises' own funds, and so it is important to decide, how the savings will be used. If savings are used to finance other needs of the enterprise, there will be no motivation for the program participants. Alternatively, a revolver mechanism can be launched to finance further energy efficiency measures with the savings achieved at preceding stages.

A **system of energy supply contracts** is an important prerequisite for effective energy management. It is important that penalties for savings are eliminated and energy supply contracts are improved for industrial enterprises. The RF Government Decree No. 877 dated November 4, 2011 "On amendments to some Acts of the RF Government to improve the relations between electricity suppliers and consumers in the retail market" determined, that customers with 750 kVA or less connected capacity, who did not choose the 5th or 6th pricing categories for bills payable, should not be mandated to pay for electricity they contracted but never consumed. Billing should be based on the meter readings for the corresponding period. It is forbidden to include in the final retail price the cost of electricity purchased by distribution companies under

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[60] Energy Efficiency Trends and Policies in the Industrial Sector in the EU-27. Lessons from the ODYSSEE MURE project. ADEME. 2009.

direct contracts, should the price in this case be higher, than in the wholesale market. Capacity balancing mechanism, which enabled distribution companies to sell more capacity in retail trade, than they purchased in the wholesale market, was eliminated. Enterprises should improve long- and medium-term output planning to better project resource consumption and reduce overconsumption charge.

It is important that contracts have a special provision to mandate an energy utility to cover damage incurred by the enterprise, should this damage occur through the fault of the energy utility (resource supply breaks or low quality resource). This primarily relates to electricity supply, because meters allow it to compare most parameters with the standard values. This measure requires that damage evaluation mechanisms be developed.

It is important to develop **tax benefit schemes to support ESCO in terms of running cross-industry equipment**: electric motors, compressors, lighting systems, steam supply, etc., and to tune mechanisms to leverage comparatively short-term financial resources to projects focusing on equipment modernization. Banks with state participation can be the first to get involved in these schemes, and then these banking products can be further spread across the whole banking system.

It is important to develop **standardized banking technologies to finance energy efficiency projects in the industrial sector**. It is possible to considerably reduce pledge and other requirements to a project financed, *inter alia*, through a government grant. A simplified process of project development, analysis, and evaluation can help minimize overheads and reduce risks. This can be quite simple, because for many reputed technologies, such as efficient boilers, energy management systems, efficient lighting and compressed air systems, project development is easy, and end-users and financial institutes are well aware of risks. Acting to a template while developing and evaluating a new project is not difficult.

The Commission for modernization and technological development of Russia’s economy should identify priorities for R&D in energy efficiency. The RF Ministry of education and science should ensure that these R&D take place.

9.2 Roadmap

A simplified roadmap to launch industrial energy efficiency motivation mechanisms is shown in Table 9.2.

Table 9.2 Simplified roadmap of launching industrial energy efficiency incentives

	2013	2014	2015	2016-2020
«500-500» programme	• Development of the programme concept – *May* • Selection of industries for the programme - *June* • Development of a list of 500 companies - *June* • Indicative energy saving targets for industries – *June-July* • Identification of enterprises selection criteria – *June-July* • Development of financial incentives to encourage the programme participants; evaluation of related costs to the budget – *July-August* • Development of the agreements reporting and monitoring system – *August-September* • Draft Federal regulation on the procedure and rules for signing long-term agreements – *September* • Development of a pilot programme to include three industrial companies – *September-October* • Launching long-term agreements - *December*	• Assessment of results of the pilot programme for 3 industrial companies; • Verification of the programme implementation; • Negotiations with holding companies, that own 500 enterprises which will be signing the agreements; • Signing the agreements; • Secure financing for the programme participants; • Identification of the programme operator and reporting format development; • Enactment of the RF Government decree to launch the "500-500" programme from 2015	• Launching large-scale programme; • Providing subsidies to encourage programme participants; • Programme management by the programme operator and monitoring; • Providing the necessary information materials to the programme participants	• Programme implementation; • Providing subsidies to encourage programme participants; • Programme management by the programme operator and monitoring; • Evaluation of the programme implementation and verification, as needed • In 2019, evaluation of the programme format and coverage of industrial companies in 2021-2030; • Proposals on the programme development beyond 2021

	2013	2014	2015	2016-2020
Standards for cross-industry equipment	• Inventory of energy efficiency standards for cross-industry equipment in Russia and compliance assessment; • Analysis of foreign standards and selection of those applicable in Russia; • Selection of standards system for Russia; • Energy efficiency classification; • Selection of incentives to encourage purchase of highly efficient equipment • Legislation and regulations proposals to launch these incentives	• Development and enactment of the RF Government Decree to introduce standards for cross-industry equipment and to encourage purchase of efficient equipment • Development of testing cross-industry equipment for standards compliance; • Identification of the programme operator and reporting format; • Energy efficiency labeling for cross-industry equipment; • Monitoring compliance of labels with the energy efficiency parameters	• Monitoring compliance of labels with the energy efficiency parameters of cross-industry equipment; • Extending the list of cross-industry equipment for standards and labeling; • Assessment of energy efficiency cross-industry equipment promotion to the market;	• Monitoring compliance of labels with the energy efficiency parameters of cross-industry equipment; • Extending the list of cross-industry equipment for standards and labeling; • Assessment of energy efficiency cross-industry equipment promotion to the market; • Considering the extension of the equipment list
"White certificates"	See Sections 1 and 2.			
Subsidies for energy efficiency programmes development by SME	• Identification of the concept, rules, and financial sources (energy efficiency funds, subsidies under regional energy efficiency programmes, tax benefits, etc.); • Identification of the format for monitoring the implementation of energy efficiency programmes by medium- and small-size industrial companies	• Development and enactment of the RF Government decree on subsidies for energy efficiency programmes development by medium- and small-size industrial companies; • Secure financing to encourage the programme participants; • Identification of the programme operator and reporting format	• Large-scale launch of the programme; • Providing subsidies to encourage the programme participants; • Programme management by the programme operator and monitoring; • Providing the necessary information materials to the programme participants	• Programme implementation; • Providing subsidies to encourage the programme participants; • Programme management by the programme operator and monitoring; • Evaluation of the programme implementation and verification, as needed • In 2019, evaluation of the programme format and coverage of industrial companies in 2021-2030; • Proposals on the programme development beyond 2021

	2013	2014	2015	2016-2020
Energy efficiency benchmarking	• Analysis of foreign benchmarking systems; development of a concept, the list of products and rules for similar systems in Russia and using the results for the “500-500” programme; • Identification of benchmarking operators by industries and financial sources to support their work. Identification of the format to monitor benchmarking efficiency by industries	• Development and enactment of the RF Government decree on benchmarking and using benchmarking results for the “500-500” programme; • Secure financing for benchmarking operators by industries; • Monitoring the development and effectiveness of benchmarking systems by industries	• Using the benchmarking results, including for the “500-500” programme implementation; • Secure financing for benchmarking operators by industries; • Monitoring the development and effectiveness of benchmarking systems by industries; • Monitoring approach to the BAT parameters	• Evaluation of the benchmarking efficiency, including for the implementation of the “500-500” programme; • Identification of format for further programme implementation and of energy efficiency indicators coverage; • Proposals on the programme development beyond 2021
Encouraging ESCO for cross-industry equipment operation	• Identification of cross-industry equipment to encourage ESCO activities in the industrial sector: motors, compressed air systems, lighting, steam supply, etc. • Development of proposals on how to encourage ESCO in this sector • Development of proposals to amend tax regulations or other regulations so as to launch this mechanism	• Development and enactment of the RF Government decree to encourage ESCO activities in the operation of cross-industry equipment; • Secure financing for the programme participants; • Identification of the programme operator and reporting format	• Large-scale launch of the programme; • Providing subsidies to encourage the programme participants; • Programme management by the programme operator and monitoring; • Providing the necessary information materials to the programme participants	• Programme implementation; • Providing subsidies to encourage the programme participants; • Programme management by the programme operator and monitoring; • Providing the necessary information materials to the programme participants
Improving industrial energy supply contracts	• Analysis of energy supply contracts of industrial companies with a view to reveal any provisions that set barriers to energy efficiency improvements	• Development and enactment of the RF Government decree on removing the provisions that set barriers to energy efficiency improvements		

	2013	2014	2015	2016-2020
Methodology support for industrial energy efficiency	Under the information support budget line of the Federal programme develop: • methodology recommendations and guidelines for the development of energy efficiency plan of an industrial company; • adaptation for industrial companies of the Performance measurement and verification protocol • Energy management standards introduction guidelines for enterprises	Under the information support budget line of the Federal programme develop: • Typical guidelines to introduce financial incentives for Chief energy manager's service for successful implementation of energy efficiency programmes • Energy efficiency guidelines for separate industries and cross-industry equipment	Under the information support budget line of the Federal programme develop: • Guidelines to develop energy balance sheet and energy supply master-plan of the enterprise	
Development of standard bank products to finance energy efficiency projects in industry	• Identification of the bank with state participation to act as the programme operator; • Identification of standard bank products to finance industrial energy efficiency projects; • Identification of requirements to borrowers	• Launching pilot marketing and implementation programmes for standard bank products to finance industrial energy efficiency projects; • Analysis of first projects implementation	• disseminate bank products to the whole bank system; • Dissemination of standard bank products from the bank with state participation – the programme operator to the whole bank system	• Involvement of other banks with state participation
R&D in industrial energy efficiency	• Commission for modernization and technological development of Russia's economy identifies R&D priorities in industrial energy efficiency	• RF Ministry of education and science should ensure that these R&D take place	• RF Ministry of education and science should ensure that these R&D take place	• RF Ministry of education and science should ensure that these R&D take place

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The report was prepared within the Prosperity Fund grant of the British Embassy in Moscow.

The participation of the British Embassy should not be considered as either agreement or disagreement of the paper's content.