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Russian energy and carbon emissions: coming from 2005 to 2050

First Workshop

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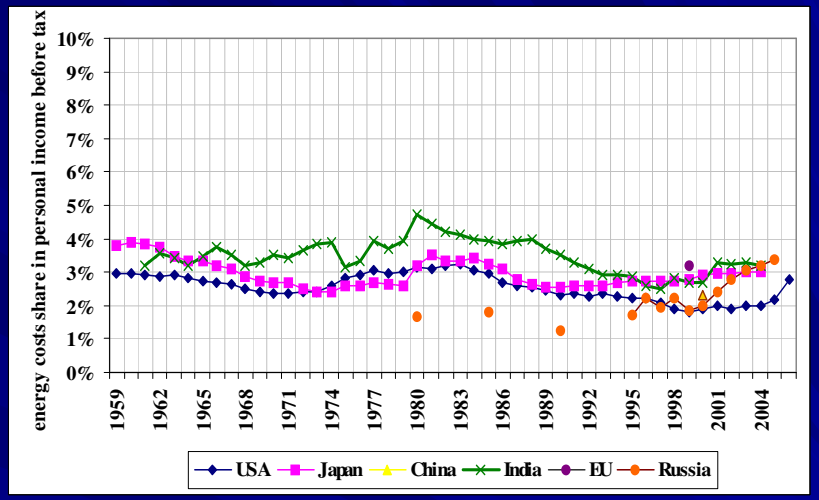
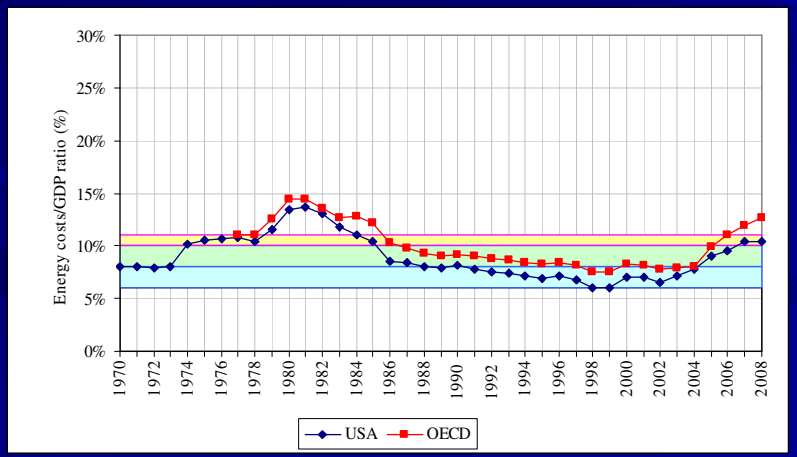
Three laws of global and regional energy transitions

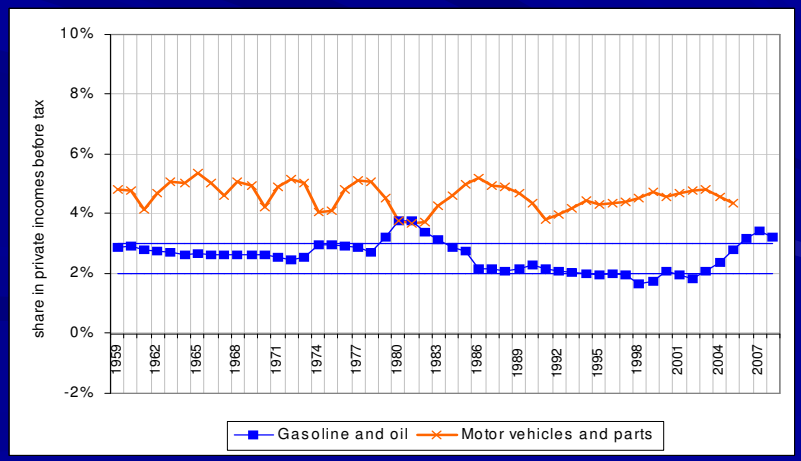
- For long-term projections the following three laws of energy transitions are to be taken into account:
  - **The law of long-term energy costs to income stability**
    - In the long-term, energy costs to income ratios are relatively stable with only a very limited range of variations
  - **The law of growing energy quality**
    - Growing overall productivity requires a better quality of energy services
  - **The law of growing energy efficiency**
    - As energy quality improves against a relatively stable costs-to-income ratio, energy productivity grows or energy intensity declines
- Do these three laws of energy transitions bring humanity to a low carbon society?
- Better efficiency – lower energy prices – less sufficiency and less efficiency – higher energy prices – better efficiency- …
- Can we have both ascelerated energy efficiency and sufficiency?
- Can efficiency make up for lack of sufficiency?

The law of long-term energy costs to income stability

- Energy costs to income proportions are stable over centuries and similar across regions and large countries
- Sustainable variations of energy costs to GDP ratio are limited to 8-10% for the USA and 9-11% for the OECD
- The ratio of housing energy costs to personal income varies in the range of ± 1% from 2-4% average in many countries, same as the ratio of fuel cost for personal transport to income

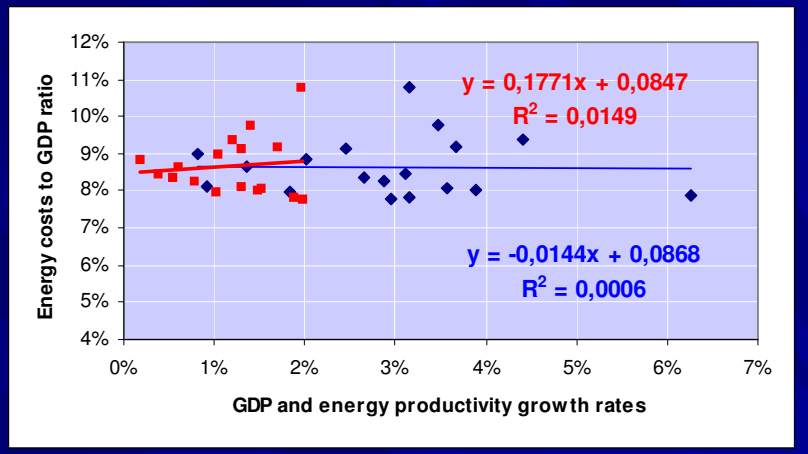


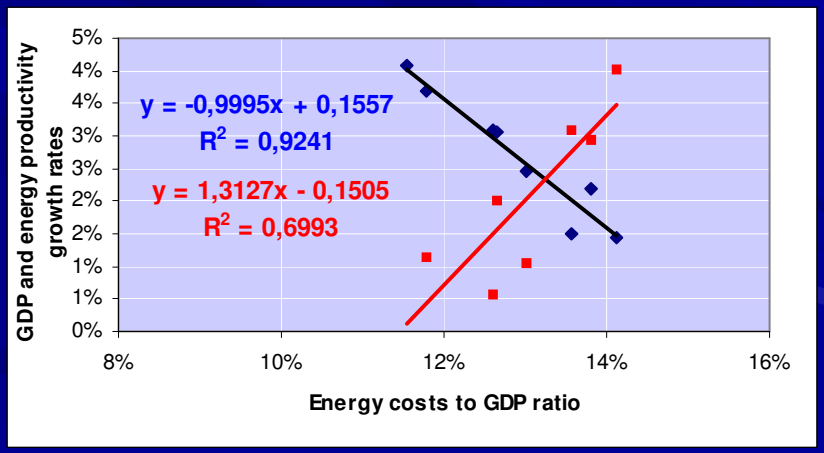




Energy costs to income ratios are to be kept close to thresholds to motivate more efficiency, but it slows down economic growth

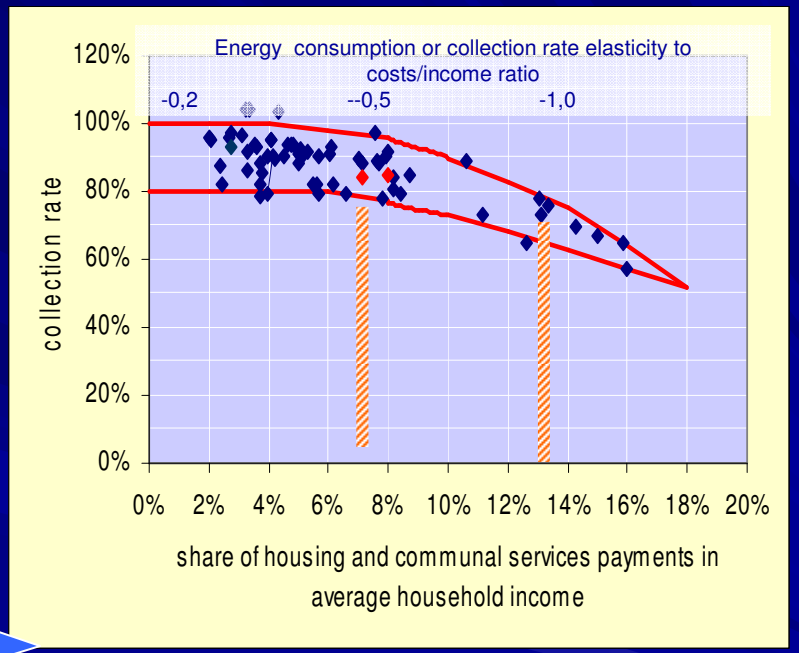
- When energy costs to income thresholds are exceeded:
  - economic activity slows down
  - energy productivity accelerates
  - as a result energy demand growth slows down until the ratio is back in the sustainable range
- When energy costs to income ratio is below threshold there is no correlation
- This effect makes price elasticity asymmetric
  - $E=A*Y^{ey}*P^{ep}$
  - $Te=ey*Ty + ep*Tp$
  - $Ty=Typ-b*Tp$
  - $Te=ey*Typ + (ep - ey*b)*Tp$





The law of long-term energy costs to income stability (cont'd)

- The approach used is based on the evaluation of limits to energy purchasing power
- Energy demand is more a function of energy to income ratio, rather than of income and price separately
- Elasticity coefficients are drifting, as purchasing power thresholds are approached or exceeded
- Energy demand functions have asymmetric elasticity
- "Bashmakov wing". Housing and communal services affordability thresholds
- Energy costs/GDP ratio for OECD will cross the thresholds in 2007- 2008. After that the oil price will go down

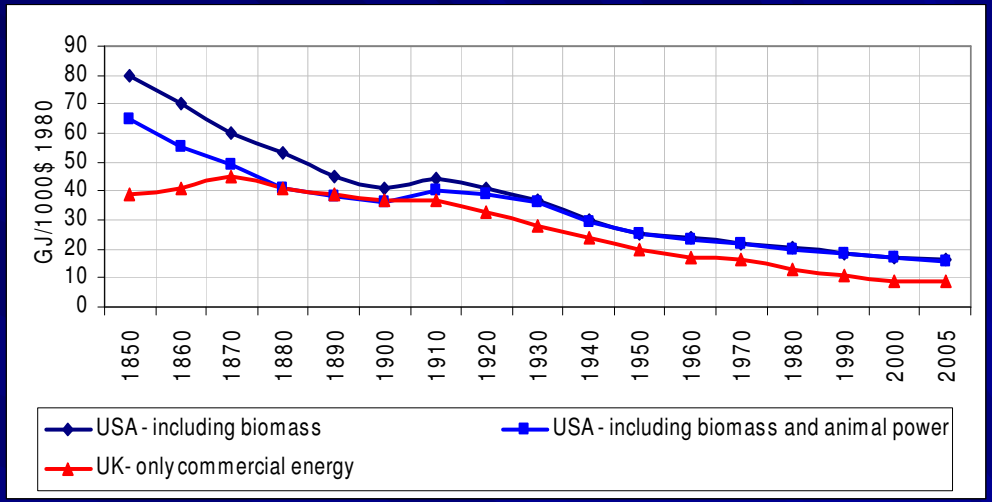


The law of growing energy quality

- Technological progress is accompanied by growing energy quality
- Demand for higher quality energy services means a demand for cleaner and easier-to-handle fuels and energy carriers
- They turn out more expensive, when it comes to lifecycle costs of energy service systems
- Long-term production factors costs to GDP ratio (or to gross output) stability implies that:
  - the theoretical postulate on substantial production factors substitution used in the production functions theory may be incorrect;
  - In reality, the change of economy technological basis leads to the substitution of low quality production factor with a costlier, but a better quality one. The quality is finally reflected by energy carrier costs, not by energy conversion factors
  - Carbon to energy factor is also a good indicator of energy quality: globally, this ratio declined by 1,8% over 1990-2003

The law of growing energy productivity

- Staying within relatively stable long-term energy costs to income thresholds means, that
  - more expensive, better quality energy services have to be accompanied with
  - improved energy productivity
- Energy productivity improvement is a centuries-long trend of the civilization development
- All energy carriers, not only commercial ones, are to be considered
- Global long-term sustainable average rate of energy productivity growth is 1.0-1.5 percent per year
- Can we go further?



- Annual rates of energy productivity growth
  - Maximum sustainable possible rates:
    - For GDP AGRs 5% - 3-5%
    - For GDP AGRs 10% - 5-7%
  - Average annual energy productivity growth rates decline, as time frame expands:
    - Russia 1998-2005 – 5,0%
    - China 1971-2003 – 4.2%
    - Japan 1960-2004 – 1,9%
    - UK 1960-2004 – 1,5%
    - USA 1850-2004 – 1,0%

Russia has started facing energy shortage

In 1998-2005

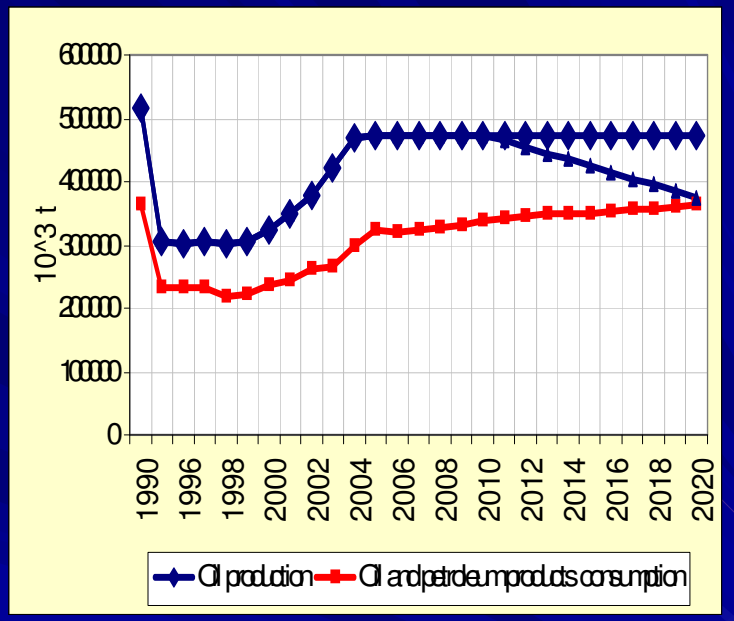
- GDP AAGR: 6.8%
- Non-oil-and-gas GDP AAGR: 7.7%.
  - This sector mainly generates energy demand
- Oil production went up from 303 to 470 million t
- Gas production went up from 591 to 636 billion m3
- Absorptive capacity of economy is overloaded, so Stabilization Fund is expected to exceed 100 billion US$ by the end of 2006
- GDP Energy Intensity AAGR: - 5.0%
- Energy Consumption AAGR: 1.5-2%
- Production capacities, including those in energy sector built in the Soviet Era, are fully loaded
- The economic development model: switch from development by loading (previously built capacities) to development by building (expanding capacities)
- Shortage of power capacity and natural gas is becoming a hurdle for the economic growth
- There is no federal energy efficiency improvement policy
- Energy intensity decline was mainly driven by GDP growth, which in turn was promoted by growing oil production and services, while industrial energy intensity stayed about the same since 1990

Poor Energy Strategy and re-establishment of governmental control over the energy sector

- In 2004, it was already clear, that “Energy Strategy of the Russian Federation” adopted in 2003 was a poor quality document
- Both energy demand and supply were growing much faster, than anticipated
- The energy sector was not ready to meet the challenges of fast economic growth with low energy efficiency
- Ability to raise tariffs to mobilize investments in the energy sector is limited by low purchasing power of 80% of the Russian population
- All oil and gas production growth in 1998-2004 was ensured by independent private companies
- In 2005, after governmental control was re-established over the oil and gas industry, production stagnated
- President wanted control over oil and gas rent and centralized rent distribution
- Oil and gas industry became less cost effective due to the fact, that part of oil and gas rent is distributed through higher production costs
- Property rights were weakened, and energy planning horizons for investors shrank
- Gas and power markets are not competitive or transparent, and are controlled by the government
- Access of foreign capital to oil and gas reserves development is limited to small fields only
- No one can “buy time”. Russian energy sector was not ready to switch from development by loading to development by building

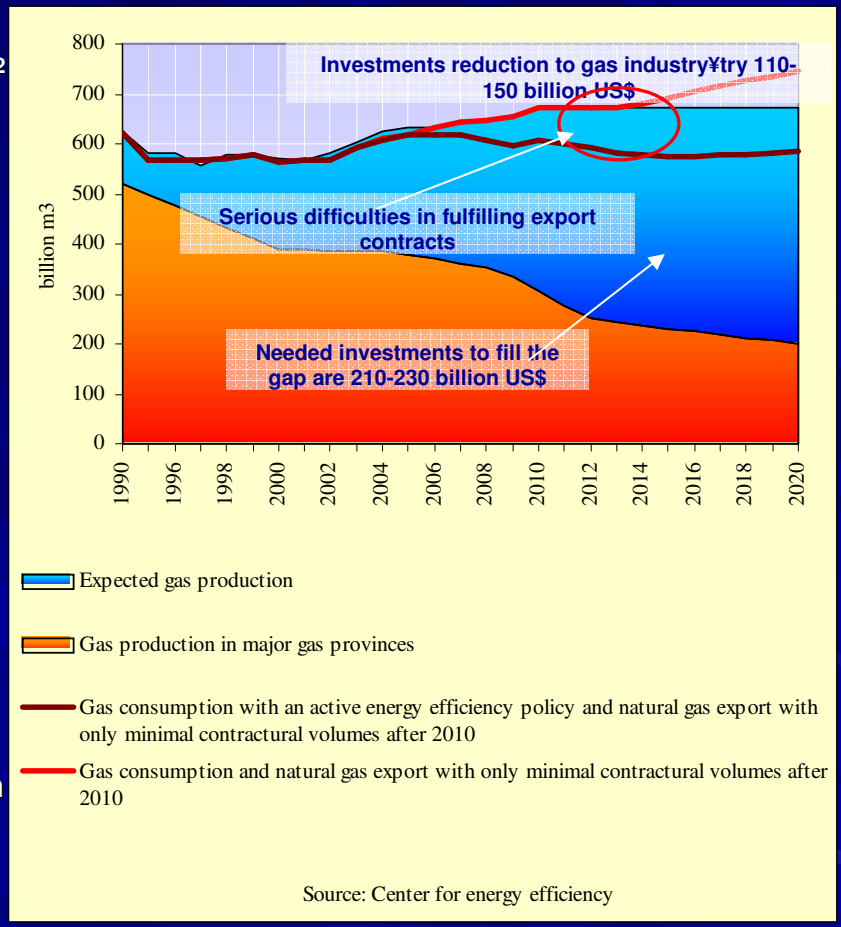
Oil: production and export may start declining after 2010 - 2015

- Oil resources are 44 billion t
- Proven reserves are estimated at 19-25 billion t. Over the last 15 years, they declined by 4 billion t
- Exploratory drilling is limited
- Only reserves developed 30-40 years ago are being exploited
- At least US$ 3 billion annual investments in exploration are needed, otherwise oil production may start declining sharply after 2010 -2015
- The legislation does not guarantee to the explorer a right to develop recovered field
- Average oil recovery factor declined to 28%
- No differentiation of oil exploration tax
- The government is back to the oil industry, partly through expropriating and partly by purchasing the assets
- Private business does not have clear investment perspectives
- The share of light products in the refinery output is only 70%
- Much of diesel fuel and heavy oil produced by Russian refineries is sold as feedstock for western refineries



Natural gas: production stagnates, domestic consumption grows, export may decline

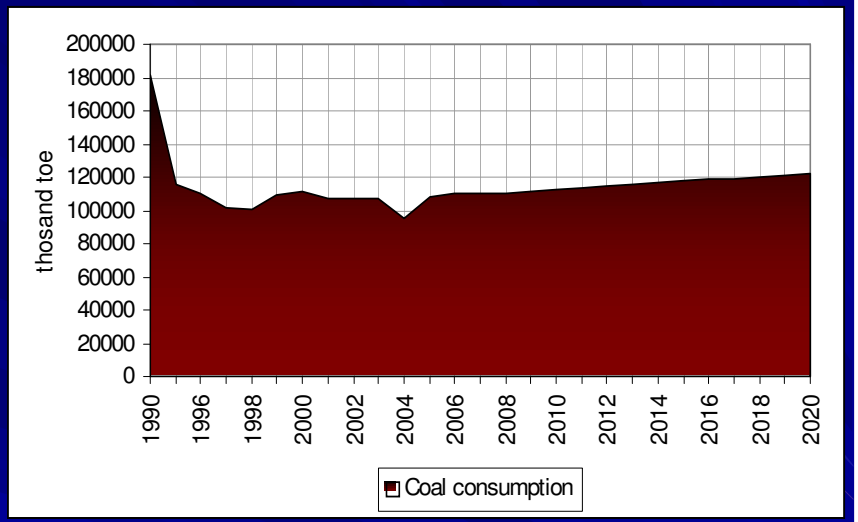
- Proven reserves of Russian natural gas are 29.1*10^12 m^3
- Reserves additions prior 2030 are to reach at least 22*10^12 m^3
- In 2005 for the first time after 1993 reserves additions exceeded the production
- Gasprom blocks potential production growth from independent private producers
- Gasprom is not an economically effective company: its labor productivity is only 10% of that of independent Russian gas producers
- Expanding gas production is not Gasprom's investment priority
- Production conditions are becoming more severe (about all new fields are in the Arctic Zone), and production costs are doubling
- Transport capacity is limited, and transportation system is obsolete
- Lack of experience with LNG and off-shore gas production
- Inefficiency of gas use brings demand up and export down
- Domestic prices are growing. After they are around US$ 100 per 1000 m^3, local consumers will be as attractive as foreign ones
- Gas price growth not necessarily will stop the growth of domestic demand



Source: Center for energy efficiency

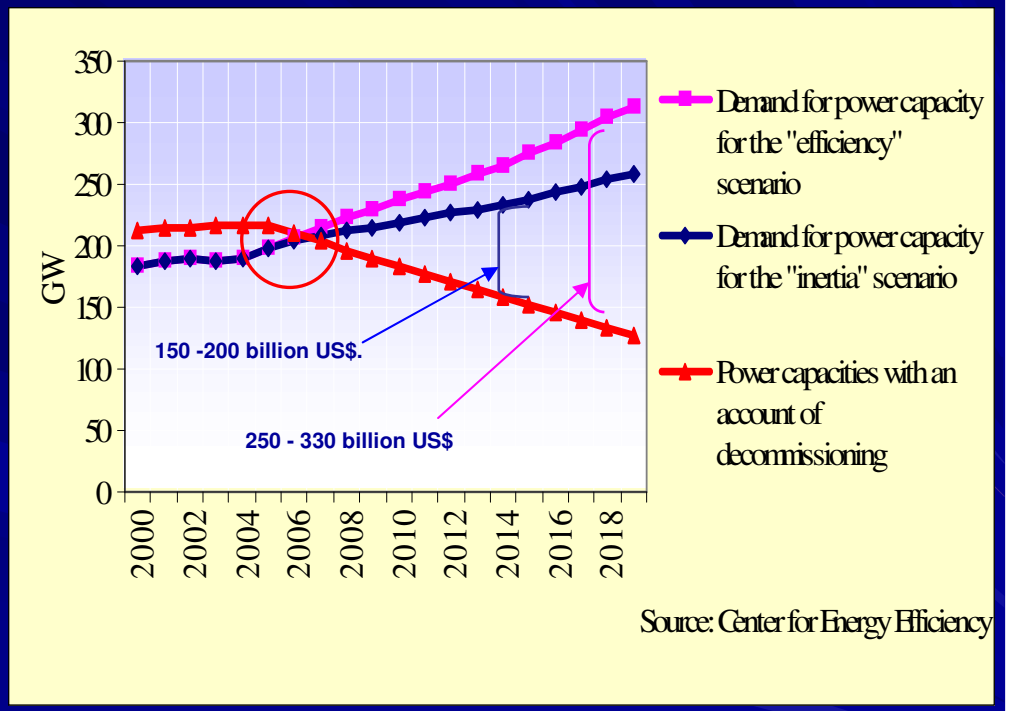
Coal: lack of clean technologies limits the scale of application

- The share of coal in TPES declined from 21% in 1990 to 17% in 2005 and will further decline to 14% in 2020
- The share of coal in electricity generation went down from 66% in 1955 to 25% in 2005
- Russian coal-fired power stations
  - Have efficiency of 34%
  - Each designed to very special coal grades
  - Designed to very low grade coal
- Lack of coal enrichment facilities
- Small number of dual fuel (coal and gas) power stations
- The costs of coal transportation for long distances are high
- There are efficient breakthrough technologies, but their application experience is very limited:
  - Only at one station fluidized bed technology is used (Barnaul CHP-3)
  - Coal-water fuel is used at a very limited scale
- Possibility to switch back from gas to coal is very limited: maximum of 7 billion m3 may be replaced with coal



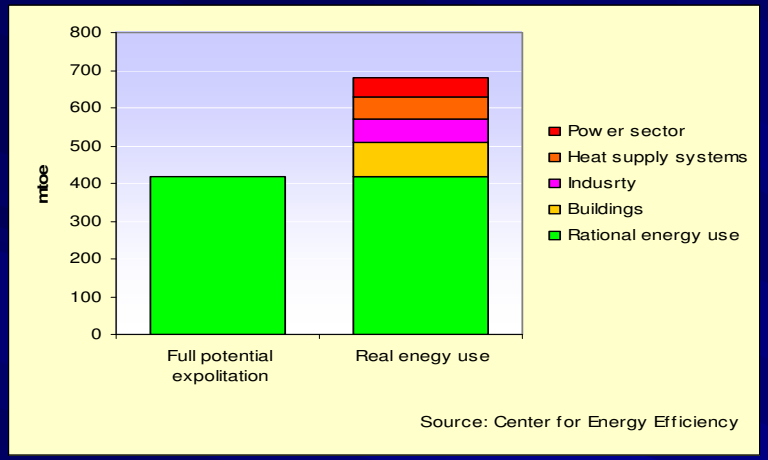
Power sector: Russian economy faces shortage of power capacities

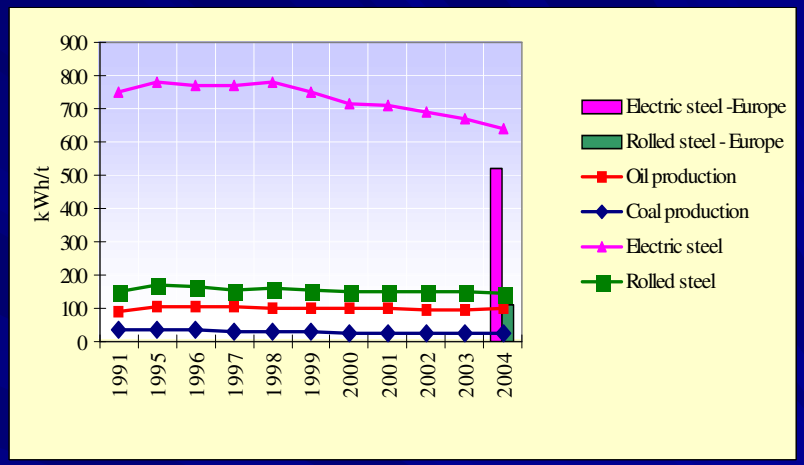
- Power capacities built in the Soviet Era are fully loaded
- In 2004, only 32% of industrial applications for power connections were met; in 2005 - 21%, in 2006 - 16%, in 2007 – 10%
- Before 2010, US$ 87 billion are to be raised, and US$ 250-330 billion before 2020
  - To the date, power sector reform fails to mobilize sufficient investments to bridge the capacity gap
  - Federal government is ready to privatize part of power generators, but may be mainly to Gasprom
  - Federal funds will be used for much of construction in the next five years
- Only a small part of the market is liberated. The free trade market section is going to expand by 5% per annum
  - Power sector consumes fuels very ineffectively
  - Average efficiency of power stations is 36%
- With the “inertia” strategy, efficiency will keep declining every year
- Blind tariff policy squeezes the CHP market niche with a “competitive vice”
- Power machinery industry is not ready for large-scale investments
- “Efficiency” scenario is able to save US$ 150-200 billion in the power sector

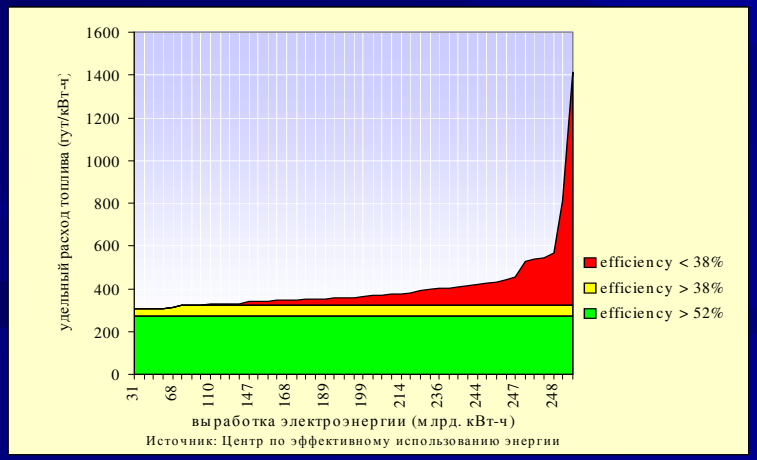


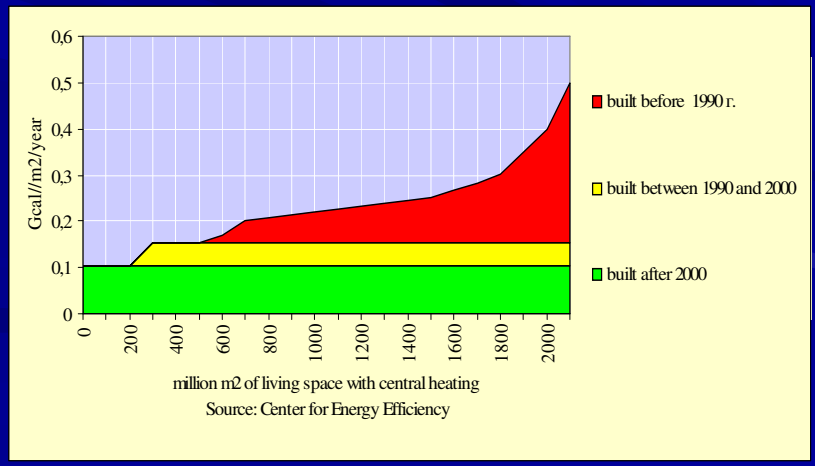
Source: Center for Energy Efficiency

Energy efficiency: the least exploited Russian energy resource and the cheapest way to “buy time” to go beyond “energy capacity limits of growth”. Potential is 260 mtoe









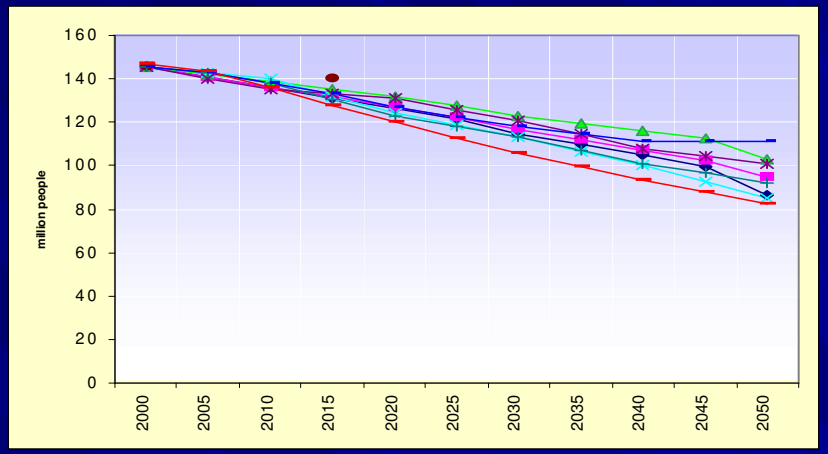
Long–term energy demand drivers

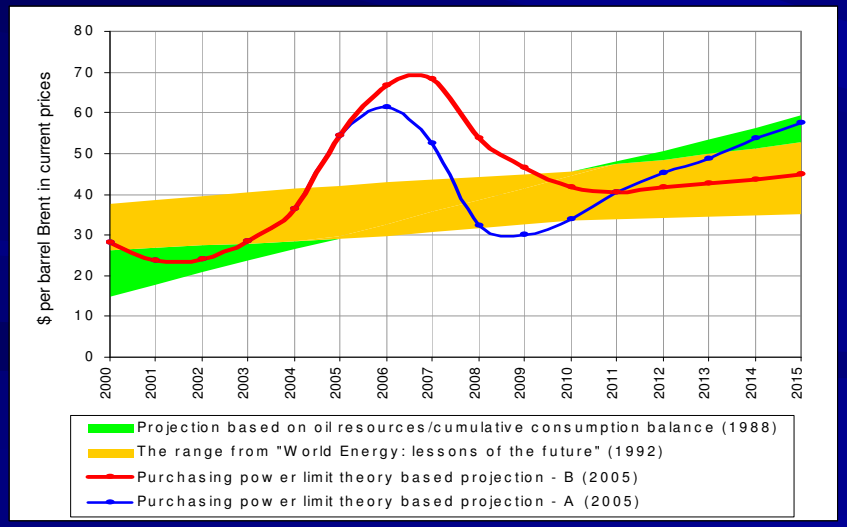
Russian population may decline from 143 million people in 2005 to 82-121 million people in 2050

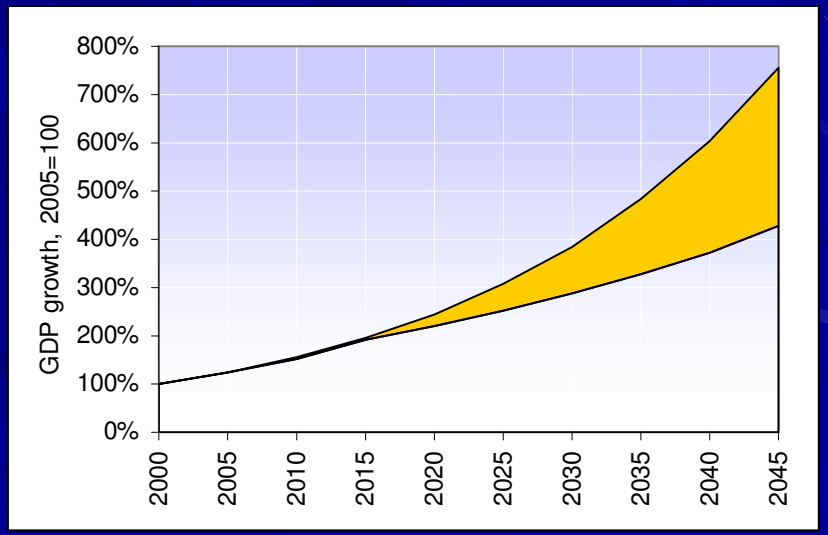
GDP may grow by 4.3-7.3 times in 2005-2050, depending on the growth of population and oil price evolution

Oil prices will vary around the general upraise trend

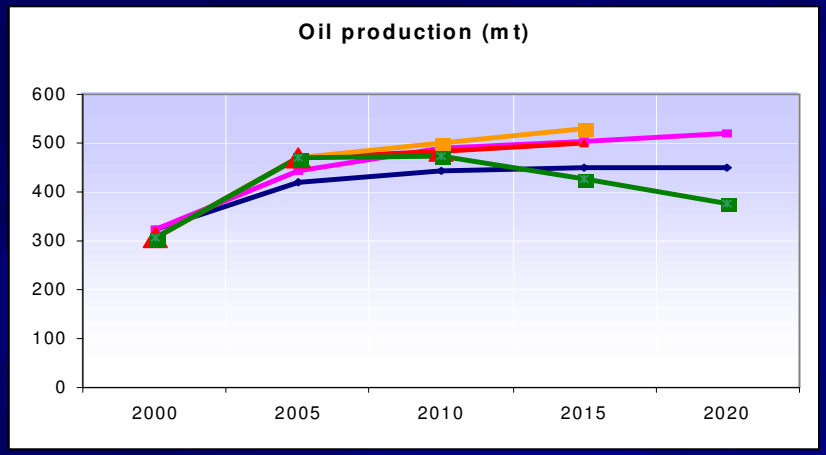
More energy efficiency technologies will penetrate the market in all sectors

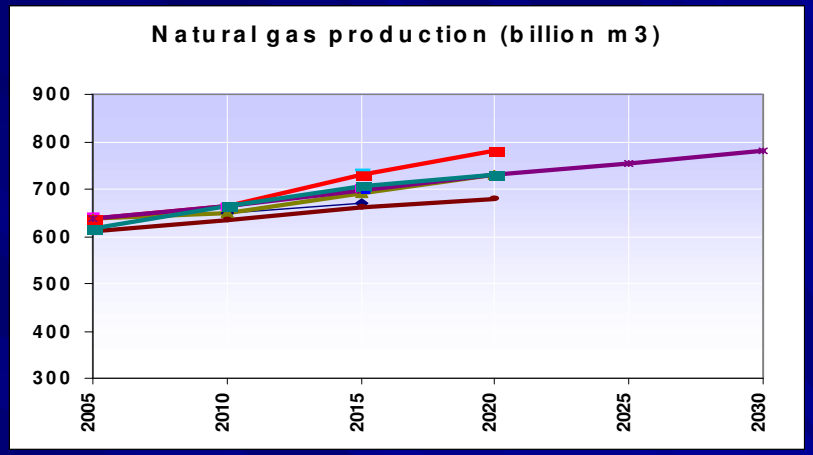


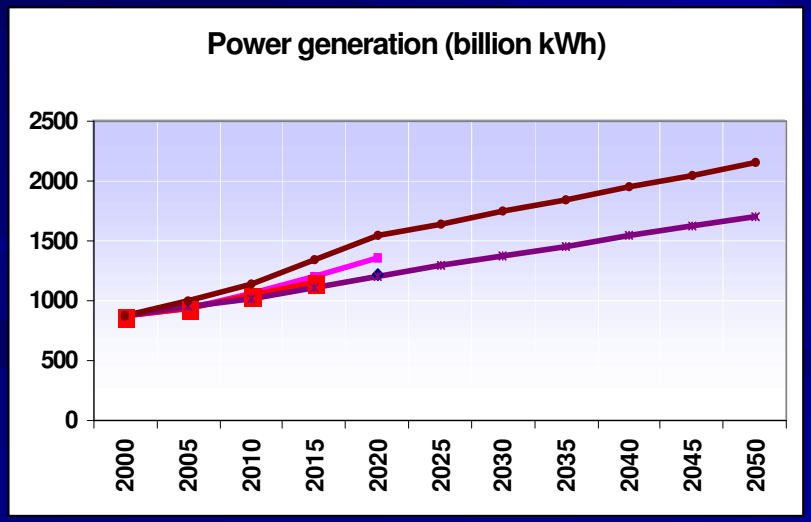


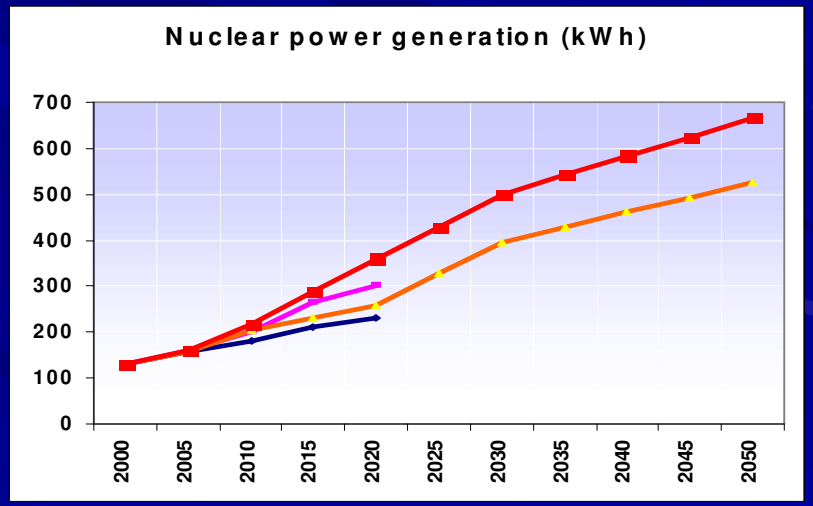


Projections of Russian energy supply in 2005-2050





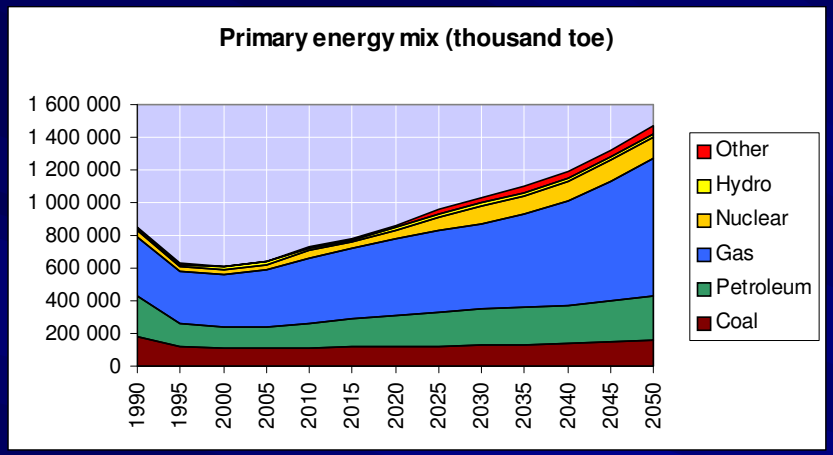


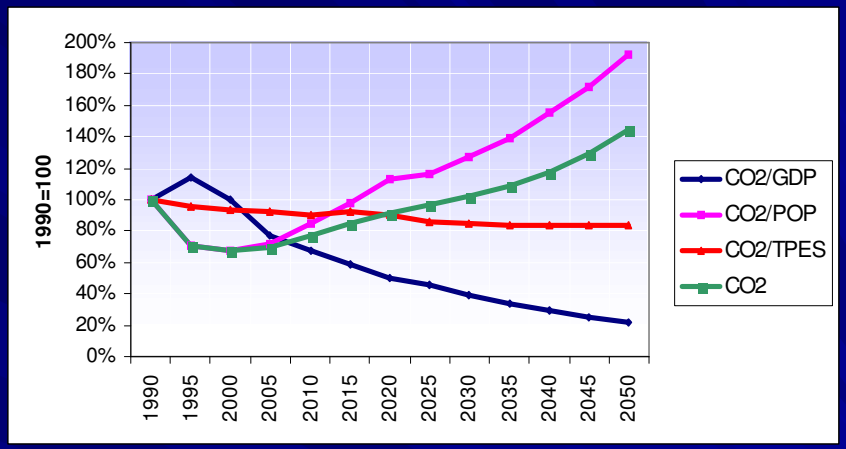


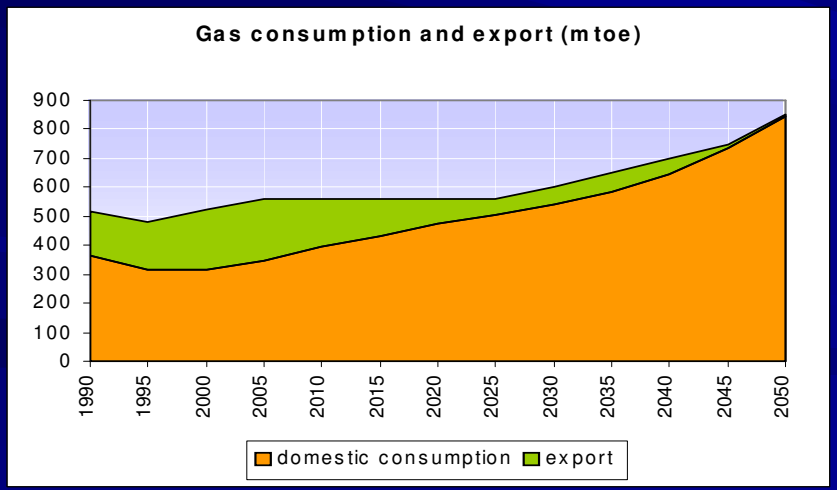
RUSEN - 2050 model outcomes: high emission scenario

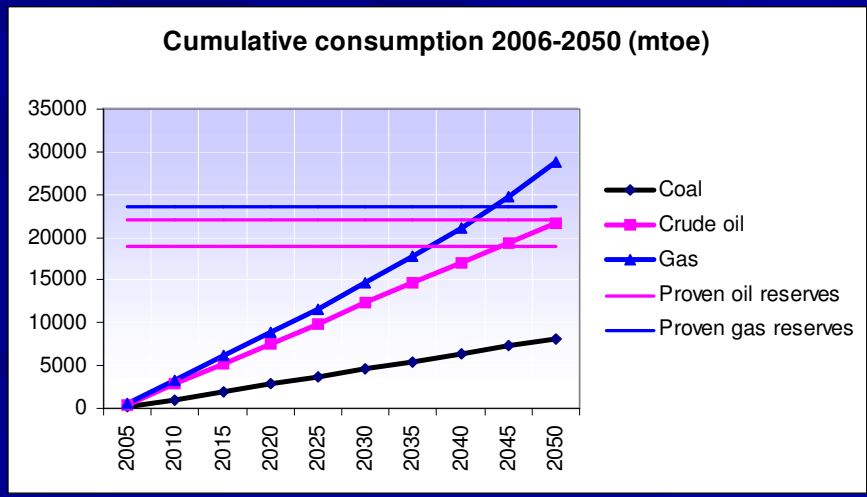
This scenario is not realistic: needed gas production volumes exceed all overbold gas production estimates

To implement this scenario, Russia has to add as much proved gas and oil reserves as it has today









RUSEN - 2050 model outcomes: realistic emission scenario

It is very likely that Russia will nor exceed its 1990 emission level before 2050

The less energy efficiency improvements Russia will manage to achieve, the lower economic growth it will have, with CO2 emission nearly stable in all foreseeable scenarios