Moscow Energy Strategy in the Framework of the Russian Energy Strategy*

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Abstract. In this article we focused on the assessment of energy-efficiency promoting policy mixes for Moscow Region from multicriteria perspective with an emphasis on greenhouse gas (GHG) emission reduction. For this purpose we analyzed the energy balances of the city of Moscow for the period 2005–2013. Then official documents of the city of Moscow and the Russian Federation, which affect or may affect the energy efficiency of the city, were analyzed. Based on these documents, forecasts were prepared. On the basis of these materials we obtained three scenarios that describe the possible trends of Moscow energy development: business-as-usual, optimistic and pessimistic. Scenarios are calculated for the period until 2025. Scenarios are modeled in Long-Range Energy Alternatives Planning (LEAP) environment. The results are long-term forecasts of greenhouse gas emissions in the city of Moscow. The analysis done shows that the best scenario in terms of reduction of greenhouse gas emissions is the optimistic scenario.

Аннотация. В данной статье анализируется эффективность политики города Москвы в области повышения уровня энергоэффективности. Основным критерием оценки политик выбран уровень сокращения выбросов парниковых газов в атмосферу. Для этого сначала анализируются энергетические балансы города Москвы за период 2005–2013 гг. Далее рассматриваются законодательства города Москвы и Российской Федерации, которые влияют или могут повлиять на энергоэффективность города. Анализ законодательства дополняется прогнозами, взятыми из официальных государственных и международных источников. На основании данных материалов строятся три сценария, которые описывают возможные траектории развития энергетики города Москвы: базовый, оптимистичный и пессимистичный. Сценарии рассчитываются на период до 2025 г. Моделирование сценариев осуществляется в программе Long-Range Energy Alternatives Planning (LEAP). Результатом моделирования являются долгосрочные прогнозы выбросов парниковых газов в городе Москве. Проведенный анализ свидетельствует о том, что наилучшие показатели по сокращению количества выбросов имеет оптимистичный сценарий.

Key words: Long-range energy alternatives planning (LEAP), energy policy, energy efficiency, GHG emissions.

INTRODUCTION

Moscow is one of the biggest cities in the world and the biggest one in the Russian Federation in terms of area and population. Moscow provides 21% of retail trade, 30% of turnover in wholesale trade of food products, 14% of foreign trade, and has 25% of the total volume of paid services to the population. Moscow's share in the total volume of Russian investments in fixed assets is 12%. Average annual growth of gross regional product, since 2000, amounted to 108%, industrial production — 115.6%, real disposable income — 110.4%, investment in fixed assets — 106.7%, retail trade turnover — 106.1%, turnover in wholesale trade of food products — 105.5%[1].

Currently, there are positive trends in demographic development: growth of fertility, mortality reduction, and increased life expectancy.

On the other hand, problems are exacerbated in the development of transport, engineering and social infrastructure.

However, sustainable growth of Moscow economy still directly depends on energy efficiency of various region industries. The energy sector of Moscow is complex because of a number of factors:

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* Московская энергетическая стратегия в рамках энергетической стратегии России.

[1] Law of the City of Moscow № 47 of 26.10.2011 «On General Plan of the City of Moscow».

• energy, being an ingredient for any Moscow industry, its availability or lack of it affects the society and consequently, there are greater societal concerns and influences affecting the sector;
• the energy sector of Moscow is influenced by interactions at different levels (international, regional, national and even local);
• the constituent industries tend to be highly technical in nature, requiring some understanding of the underlying processes and techniques for a good grasp of the economic issues;
• each industry of the sector has its own specific features, which require special attention.

Energy sector is one of the main foundations of the whole economy. Therefore, efficiency of the economy depends directly on the sustainable development of the energy sector[2]. On the other hand, the sustainability of the energy sector depends on the government policies and climate changes, and non-effective government policy mixes may lead to serious environmental problems, such as increase of greenhouse gas emission. Thus, improving the energy efficiency of Moscow economy is among top priorities for both Moscow and Russian policy makers.

STRUCTURE OF FINAL ENERGY CONSUMPTION IN MOSCOW REGION

In order to estimate Moscow energy strategy scenarios, let me analyze the latest final energy consumption data that is available.

In 2012 final energy consumption in Moscow is 31 712 thousand tons of fuel equivalent. There is a growing trend in 2010–2012.

Table 1. Final energy consumption in Moscow in 2010–2012, thousand tons of fuel equivalent.

Year	Coal and other fuels	Oil	Oil products	Natural gas	Hydro-power	Electricity	Heat	Total
2010	26	0	8 345	3 297	0,0	5134	12 130	28 932
2011	22	0	9 581	3 224	0	5334	12 064	30 224
2012	51	0	9 724	3 600	0	5455	12 882	31 712

Average growth rate in this period was on 4,5–5% annually. The highest growth rate is observed in Coal and other fuels, but their share in total energy consumption is insignificant. The highest growth in absolute numbers is observed in Heat. However, an important assumption is that energy consumption growth in 2012 is mainly connected with the inclusion of new territories in the territory of Moscow, which occurred on the 1 June 2012 after the decree of the President of the Russian Federation.

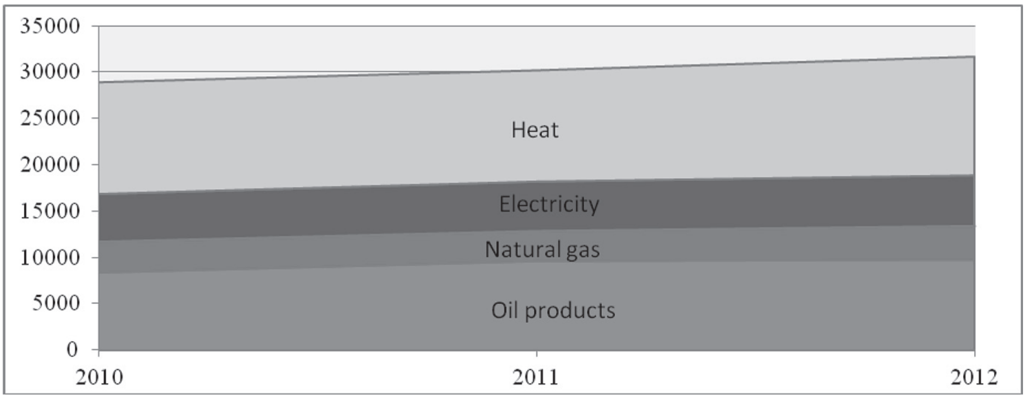

Figure 1. Changes in energy consumption by types of fuels in 2010–2012, thousand tons of fuel equivalent.

Structure of final energy consumption corresponds with the economy of postindustrial benchmark regions. Non-production sector — population and services — consumes around 69% of energy resources, and together with transport and telecom, they occupy more than 82%. Production sector consumes only 15% of final energy consumption.

[2] Bhattacharyya, S.C. Energy Economics. Concepts, Issues, Markets and Governance / — London: Springer, 2011–645.

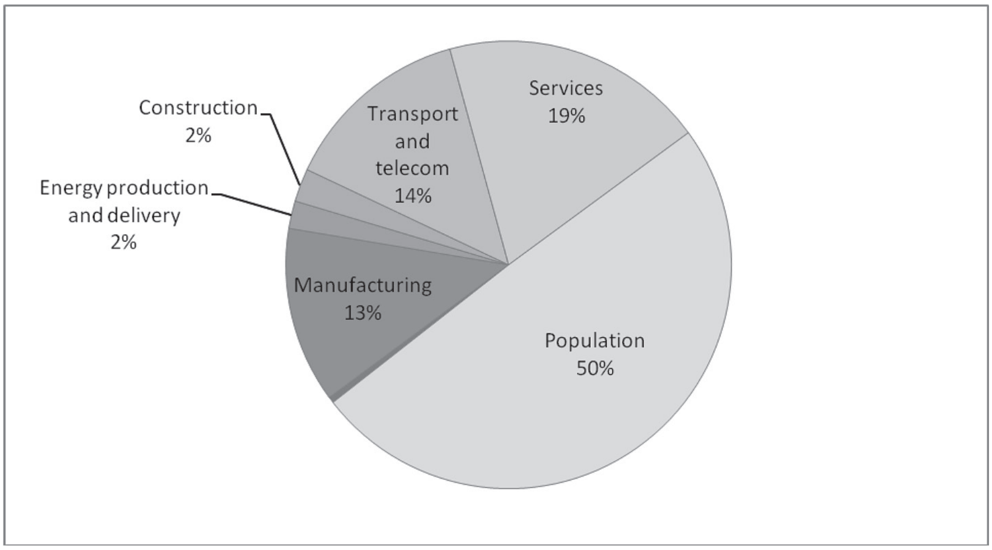

Figure 2. Structure of final consumption in Moscow in 2012.

In the structure of final consumption, heat occupies around 41% and is mainly consumed for heating and hot water supply for housing units (around 84% of total heat consumption) and less for production purposes. Oil products are mainly consumed by private automobiles, trucks and public service vehicles. Oil products occupy around 31% of final consumption, while electricity — 17%, natural gas — 11%.

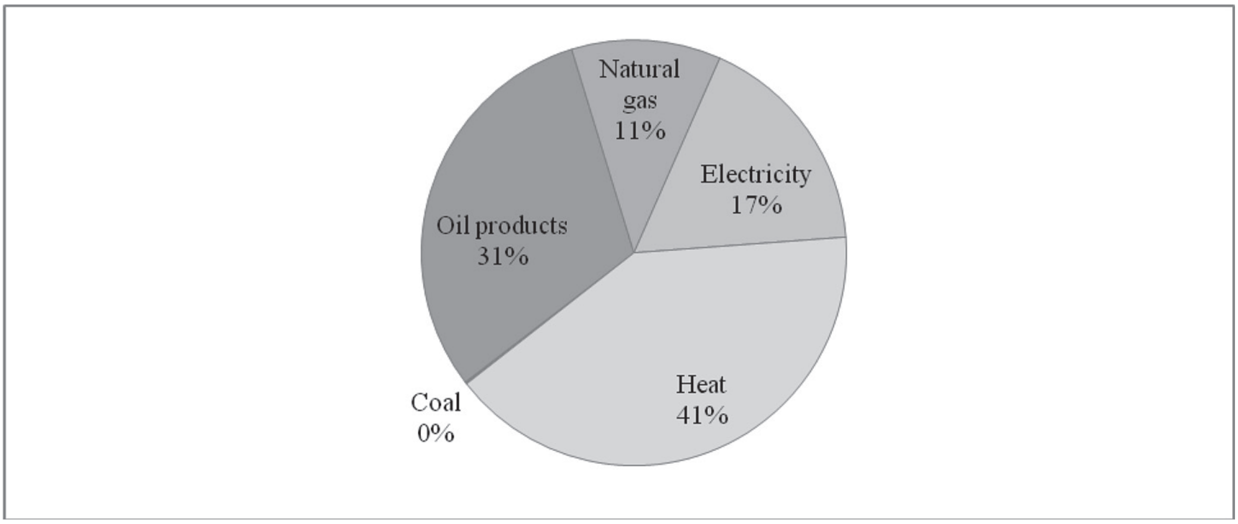

Figure 3. Fuel structure of final consumption in Moscow in 2012.

SCENARIO ANALYSIS OF MOSCOW REGION ENERGY STRATEGY

There are various ways of further development of Moscow, so I grouped them into three scenarios in order to simplify the analysis process. The scenarios are the following: Business-as-Usual, Optimistic and Pessimistic.

BUSINESS-AS-USUAL SCENARIO

Business-as-Usual (BAU) scenario is based on the policy portfolio effective as of October 26, 2011 and corresponds mainly with the General Plan of Moscow[3].

Several groups of assumptions, or key assumptions for BAU scenario, are of great importance for the correct estimation by the model, so they are described below.

[3] Law of the City of Moscow № 47 of 26.10.2011 «On General Plan of the City of Moscow».

Population

Population dynamics follows dynamics that is forecasted in the General Plan of Moscow. This forecast contains saving the current level of the number of births, reduction of the number of deaths and stabilization of the net migration at the level of 50–75 thousand people per year. Thus, total population of Moscow by the end of 2025 will exceed 12 million people. This will bepossible due to improvement of health, life capacity, fertility growth and migration mobility of population, including:

- Improving the health status of the population of working age;
- Strengthening and improving the health of children, adolescents and the elderly;
- An increase in life expectancy to 77–80 years;
- Reducing the gap in life expectancy between men and women up to 6–7 years;
- A decline in infant mortality;
- The creation of socio-economic conditions for the growth of fertility;
- The formation of positive public opinion on encouraging and increasing fertility, strengthen the family;
- Strengthening of differentiated social support for families, depending on the number of children, encouraging the birth of the second and third child;
- Regulation of the volume and structure of labor and non-labor migration flows on the basis of demographic needs of the city;
- Effective use of foreign and nonresident workforce, reduction of illegal migration, creating conditions for a socially useful adaptation and integration of migrants into the urban community;
- Creation of socio-economic conditions for adaptation and rehabilitation of the disabled.

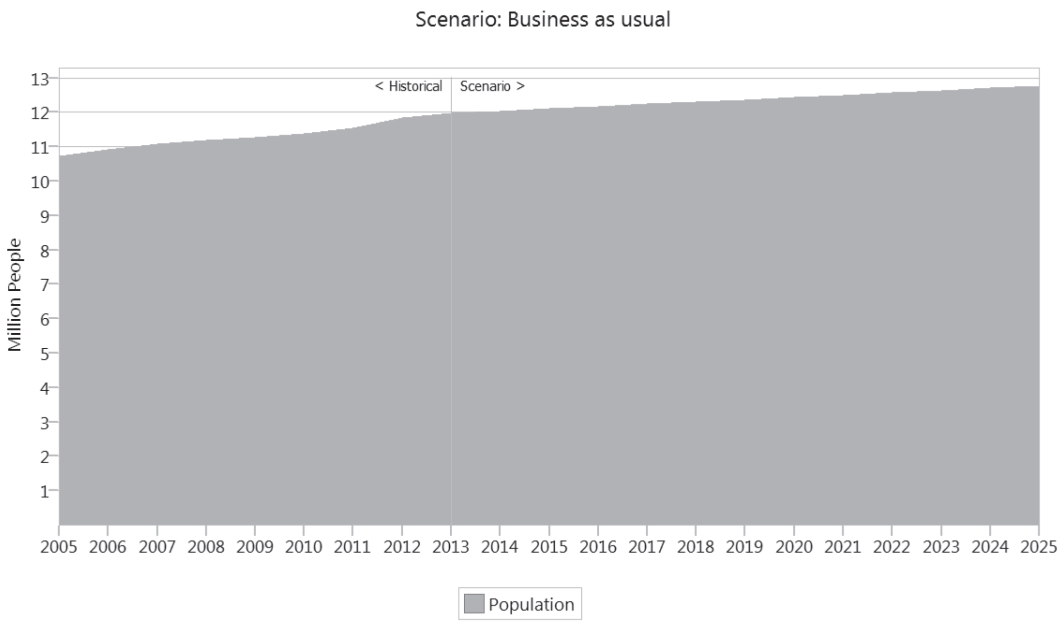

Figure 4. Demographics: population. BAU scenario.

Climate

Climate forecasts are based on the Roshydromet weather forecast reports and are results of a simple regression of the data gained analysis.

Economy

Real GRP as an indicator of an economic activity is the key factor for forecasting GHG emission in the BAU scenario. In Moscow, this interplay is even higher, moderated by low energy efficiency and significant role of energy sector in the economy. Real GRP dynamics, with energy-efficiency dynamics and structural change in the economy are, thus, key factors of energy demand and, accordingly — GHG emissions.

If the goals of the current policies would be reached, experts forecast that GRP growth rate would be 0.5% on average and, thus, would reach around 263 billion euro by 2025.

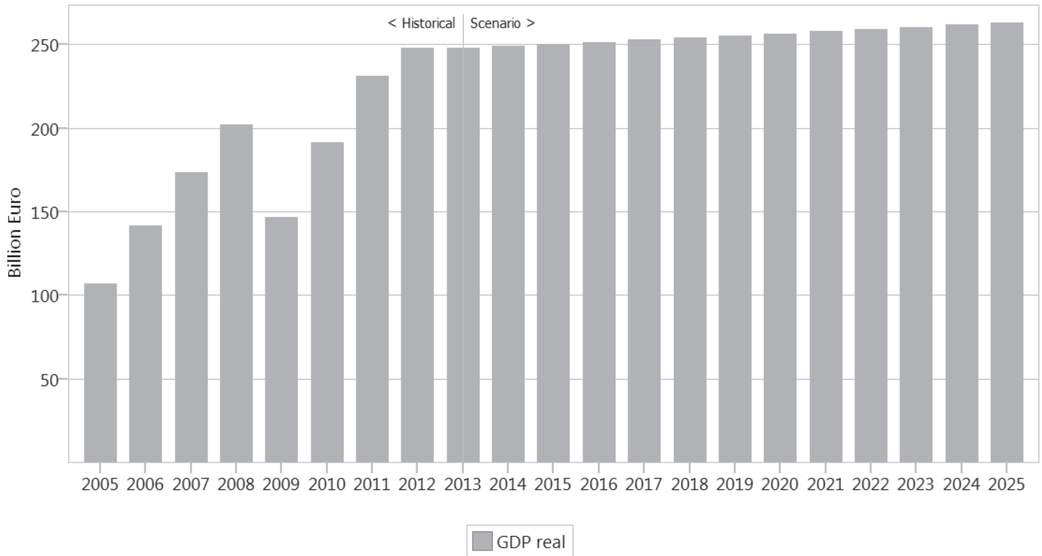

Figure 5. Economy: GRP real. BAU scenario.

Sectoral distribution of GRP will also follow the dynamics of total real GRP. However, the structure of GRP in 2025 differs from the one in 2013 as the share of services increases[4].

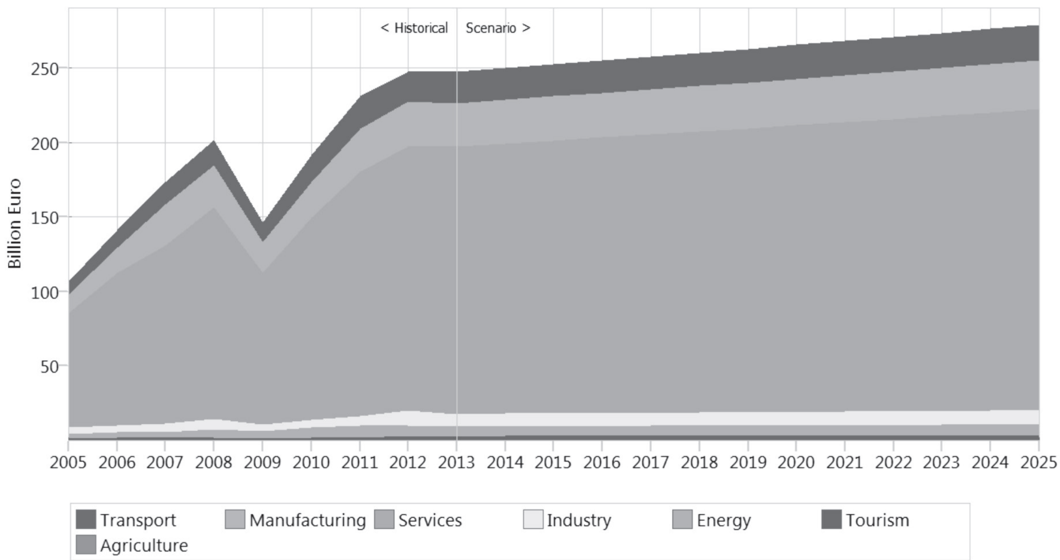

Figure 6. GRP distribution per sector. BAU scenario.

Energy Demand

In the BAU scenario the final energy demand in households sector will be decreasing as the result of energy saving policy of the Moscow government[5], which should allow consuming less heat and oil in this sector. Household sector, being the main consumer of total energy produced in Moscow, is thus of high importance in terms of GHG emission.

[4] The Government of Moscow. Report on the socio-economic development and implementation of the Moscow government programs in 2012, Moscow, 2013–133.
[5] Government Decree of the City of Moscow № 1075-ПП of 02.12.2008 «On the Moscow Energy Strategy until 2025»

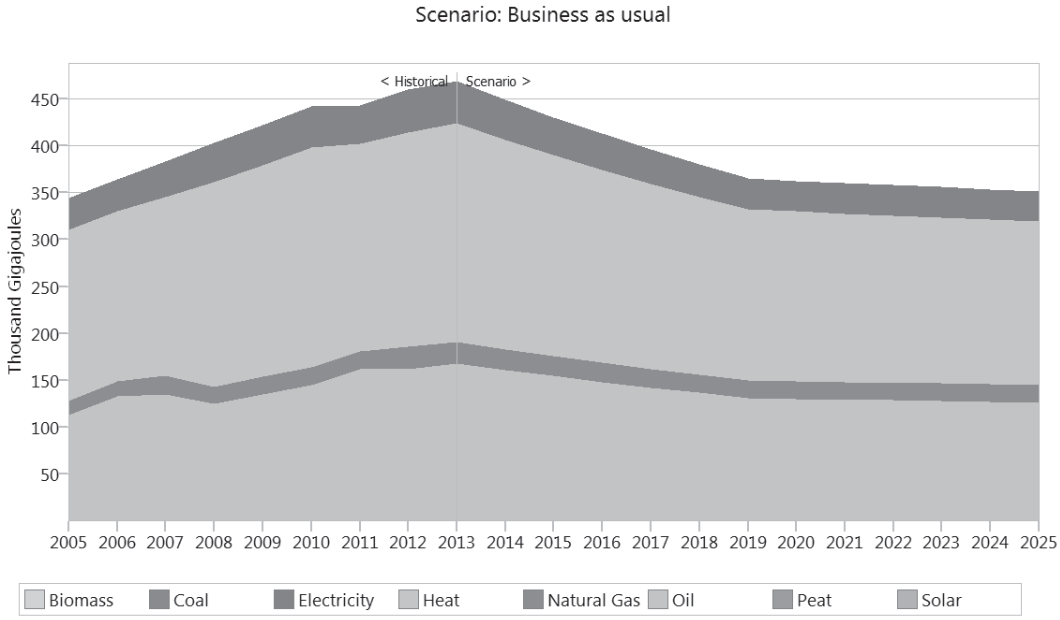

Figure 7. Final energy demand in household sector. BAU scenario.

Agriculture has a significant contribution to the national economy, but a small share in the final consumption of commercial energies. The assumption for the growth rate of energy demand in the BAU scenario is that it follows its respective growth rate as described earlier in the GRP distribution per sector. Fuel shares are considered to be almost the same across the years since no influencing policy instrument is applied.

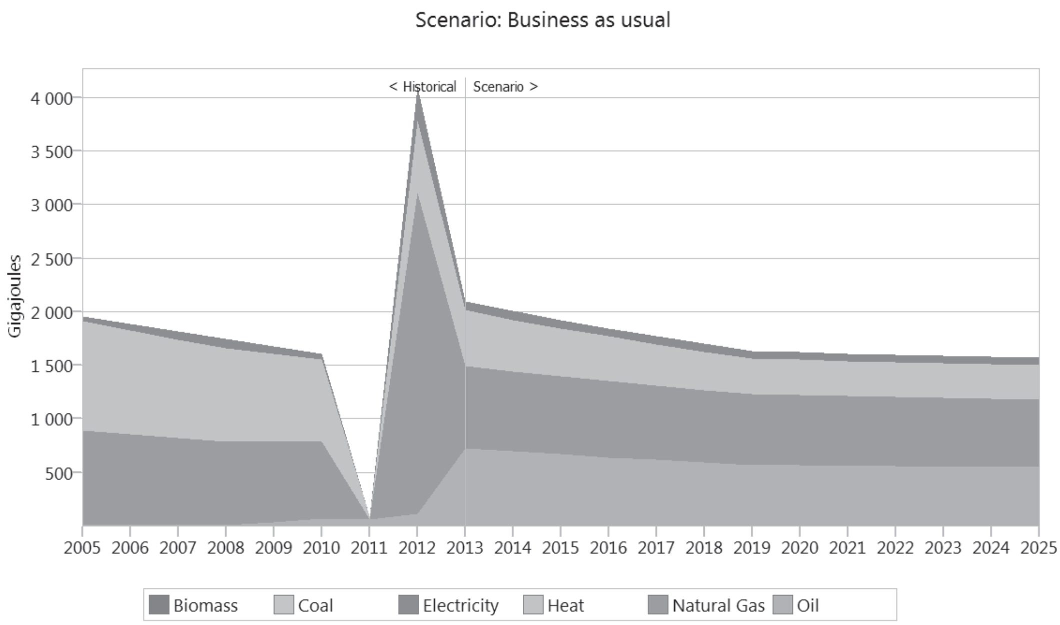

Figure 8. Final energy demand in agriculture sector. BAU scenario.

Due to lack of data for the activity level, the industrial energy demand structure (industry sector) was formed mainly by experts' evaluations and partly by GRP structure. The growth rate of activity level and the growth rate of energy demand are equal to its respective growth rate described earlier in the GRP distribution per sector section. Fuel shares are considered steadily since no policy instruments are applied.

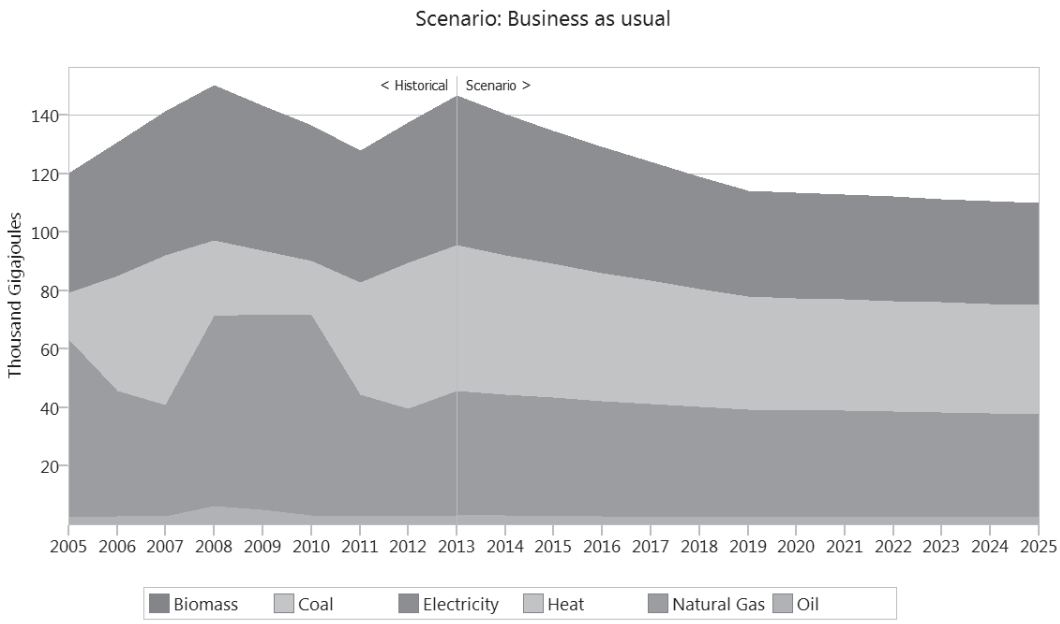

Figure 9. Final energy demand in industry sector. BAU scenario.

Transport sector is one of the most discussed sectors by Moscow government, as it needs to become more modern and developed. Therefore, successful realization of transport strategy of Moscow is crucial not only for the population of Moscow, but also for the current management of Transport Department. Based on the experts' expectations on the successful transport strategy realization, final energy demand in transport sector is estimated.

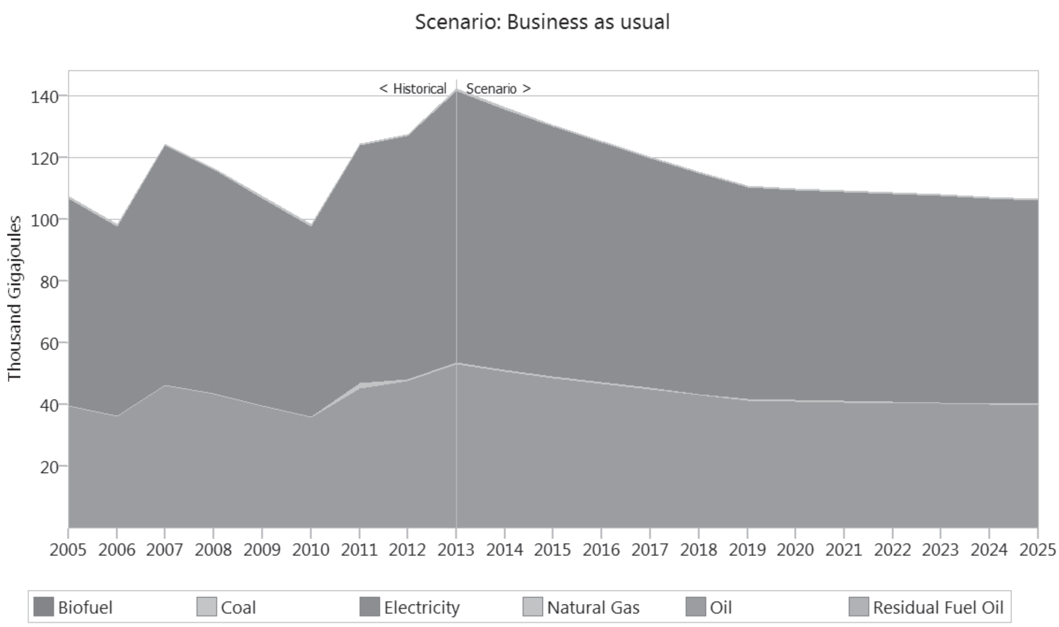

Figure 10. Final energy demand in transport sector. BAU scenario.

Transformation

Total transformation energy losses are over 28%. Most of the losses are connected with electricity and heat and each of them loses about 8% during transmission and distribution. Assuming that no modernization is planned that could influence this situation and that the equipment is slowly aging, the growth rate of transformation efficiency is close to zero.

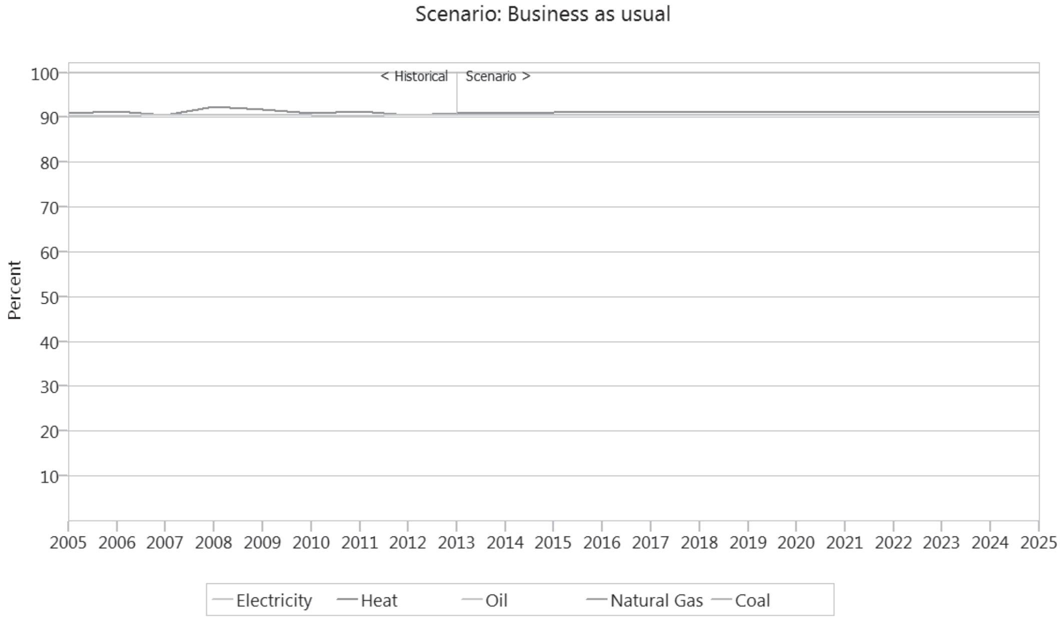

Figure 11. Transformation efficiency — transmission and distribution. BAU scenario.

Own use losses are less than that in transmission and distribution and equal about 10% (2% — heat and 8% — electricity). Assuming that no innovations would be implemented, own use losses are considered to remain steady.

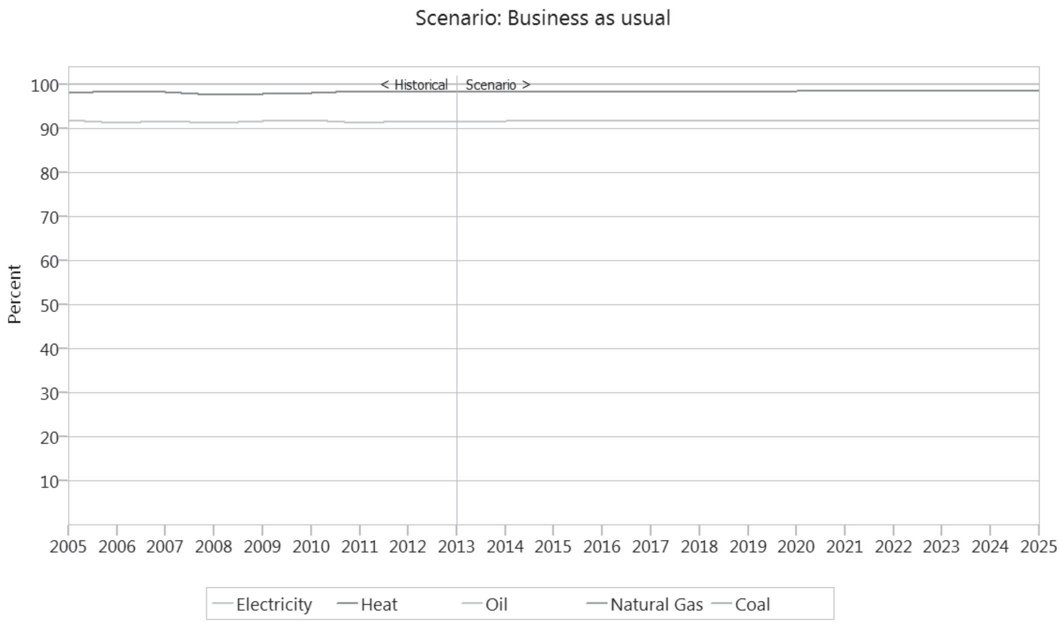

Figure 12. Transformation efficiency — own use. BAU scenario.

Global Warming Potential (GHG Emissions)

The BAU scenario shows us that comparing to 2013 the GHG emission will be reduced steadily and in 2015 will reach the reduction of 7%, in 2025 it will achieve the total reduction equal to 22%.

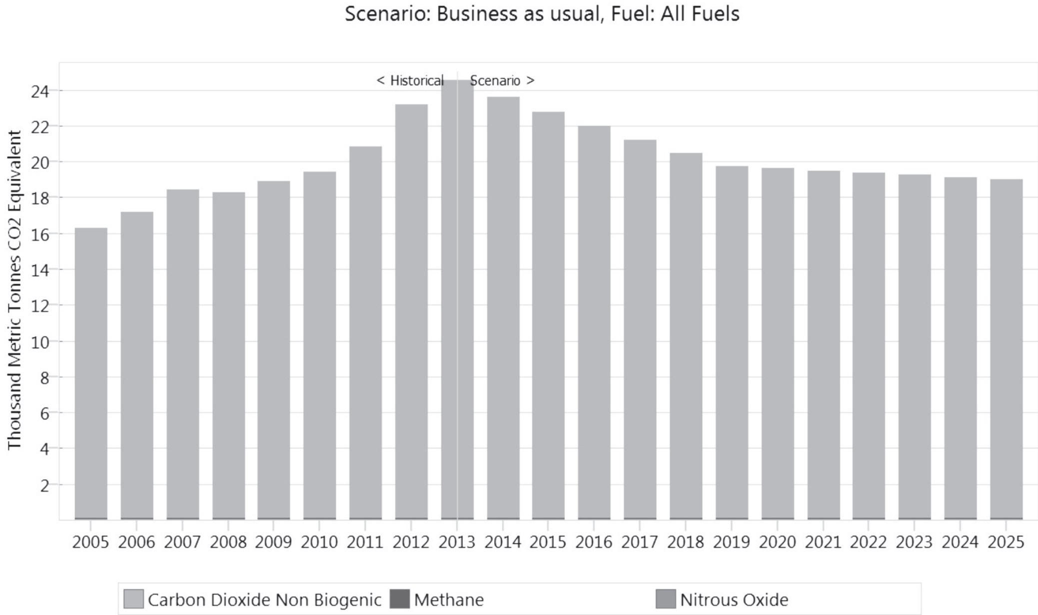

Figure 13. Global warming potential by GHGs. BAU scenario.

Optimistic Scenario

Optimistic (OPT) scenario is based on the bigger effect of the policy portfolio effective as of October 26, 2011 and corresponds mainly with the projections of the experts.

Several groups of assumptions, or key assumptions for OPT scenario, are of great importance for the correct estimation by the model, so they are described below.

Population

Population dynamics follows dynamics that is forecasted in the General Plan of Moscow. This forecast contains saving the current level of the number of births, reduction of the number of deaths and stabilization of the net migration at the level of 50–75 thousand people per year. Thus, total population of Moscow by the end of 2025 will exceed 12 million people. This is possible due to the realization of the improvement of health, life capacity, fertility growth and migration mobility of population.

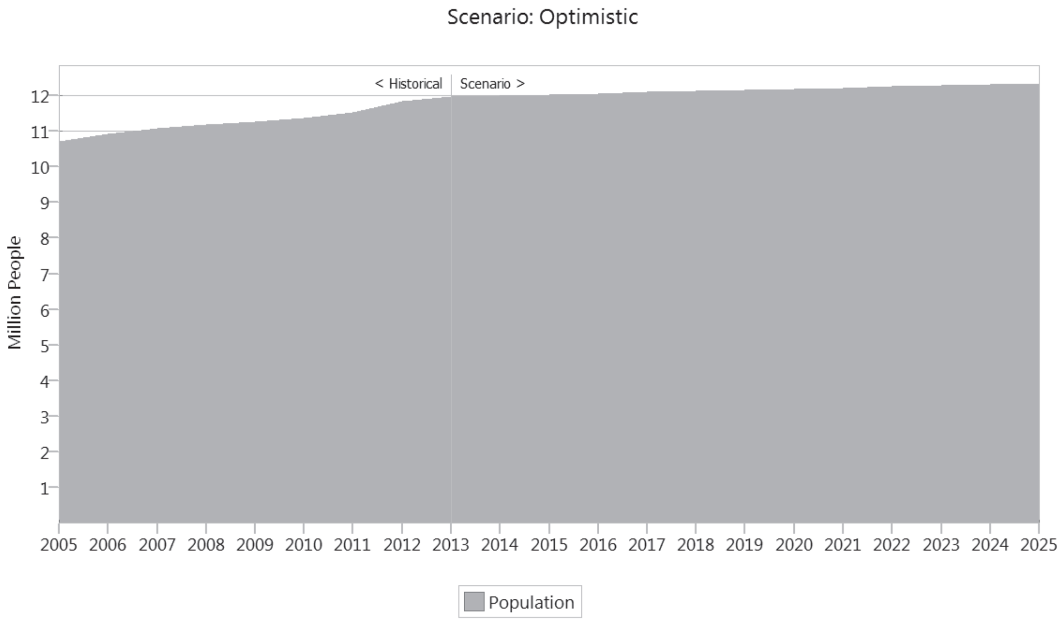

Figure 14. Demographics: population. OPT scenario.

Climate

Climate forecasts are based on the Roshydromet weather forecast reports and are results of a simple regression of the data gained analysis.

Economy

Real GRP as an indicator of economic activity is the key factor for forecasting GHG emission in the OPT scenario as well. In Moscow, this interplay is even higher, moderated by low energy efficiency and significant role of energy sector in the economy. Real GRP dynamics, with energy-efficiency dynamics and structural change in the economy are, thus, key factors of energy demand and, accordingly — GHG emissions.

If the goals of the current policies would be reached, experts forecast that GRP growth rate would be 2.5% on average and, thus, would reach around 333 billion euro by 2025.

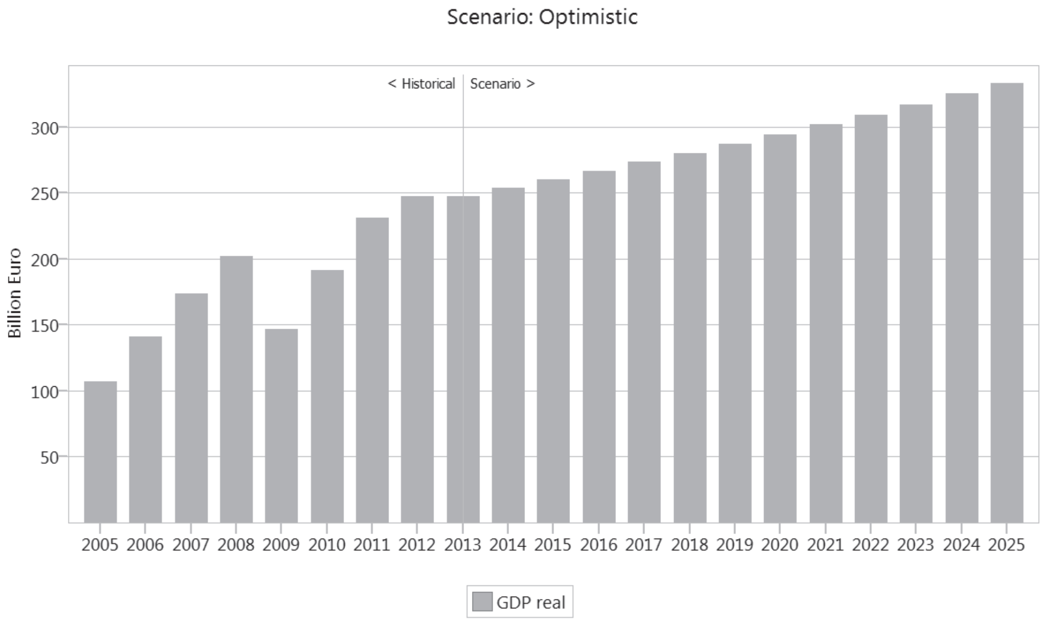

Figure 15. Economy: GRP real. OPT scenario.

Sectoral distribution of GRP will also follow the dynamics of total real GRP. However, the structure of GRP in 2025 differs from the one in 2013 as the share of services increases even more than in BAU scenario.

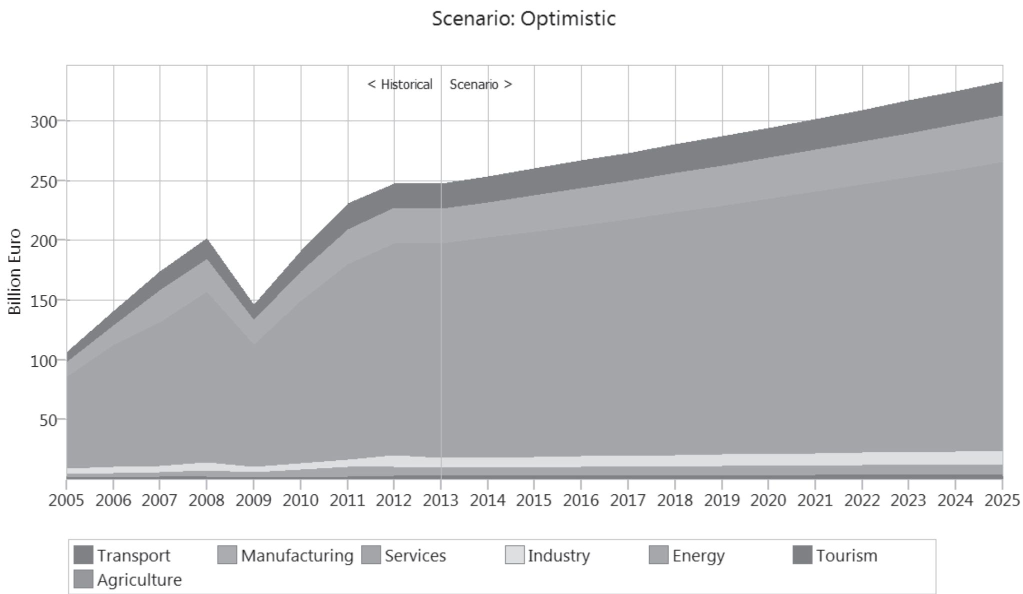

Figure 16. GRP distribution per sector. OPT scenario.

Energy Demand

In the OPT scenario the final energy demand in households sector will be decreasing as the result of energy saving policy of the Moscow government[6] and the global trend of consuming less energy and being closer to nature, which should allow to consume less heat and oil in this sector. Household sector, being the main consumer of total energy produced in Moscow, is thus of high importance in terms of GHG emission.

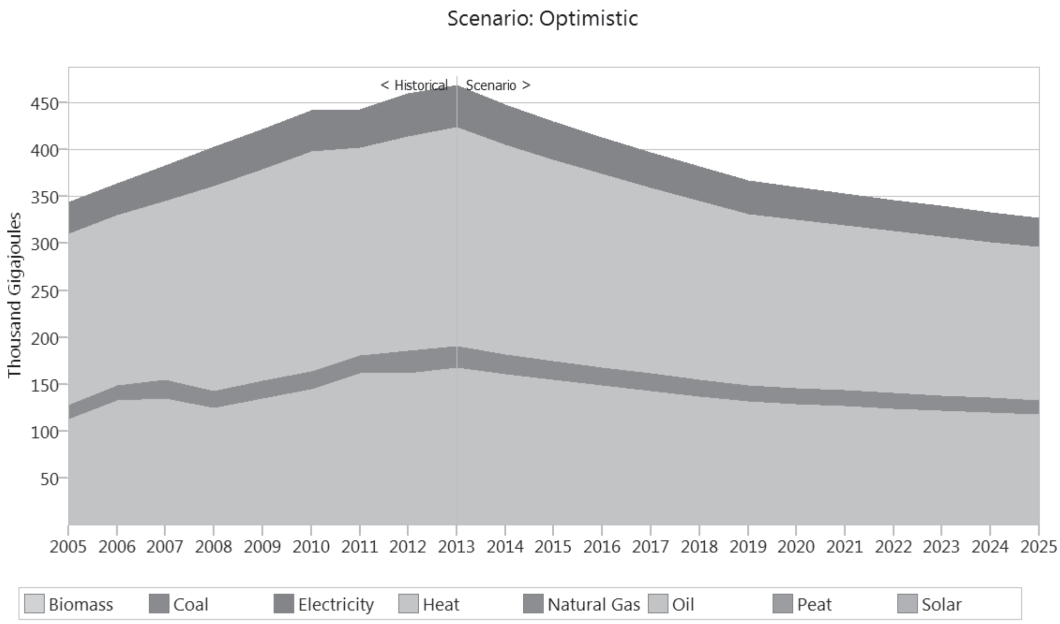

Figure 17. Final energy demand in Household sector. OPT scenario.

Agriculture has a significant contribution to the national economy, but a small share in the final consumption of commercial energies. The assumption for the growth rate of energy demand in the OPT scenario is that it follows its respective growth rate as described earlier in the GRP distribution per sector and in the BAU scenario as well. Fuel shares are considered to be almost the same across the years since no influencing policy instrument is applied.

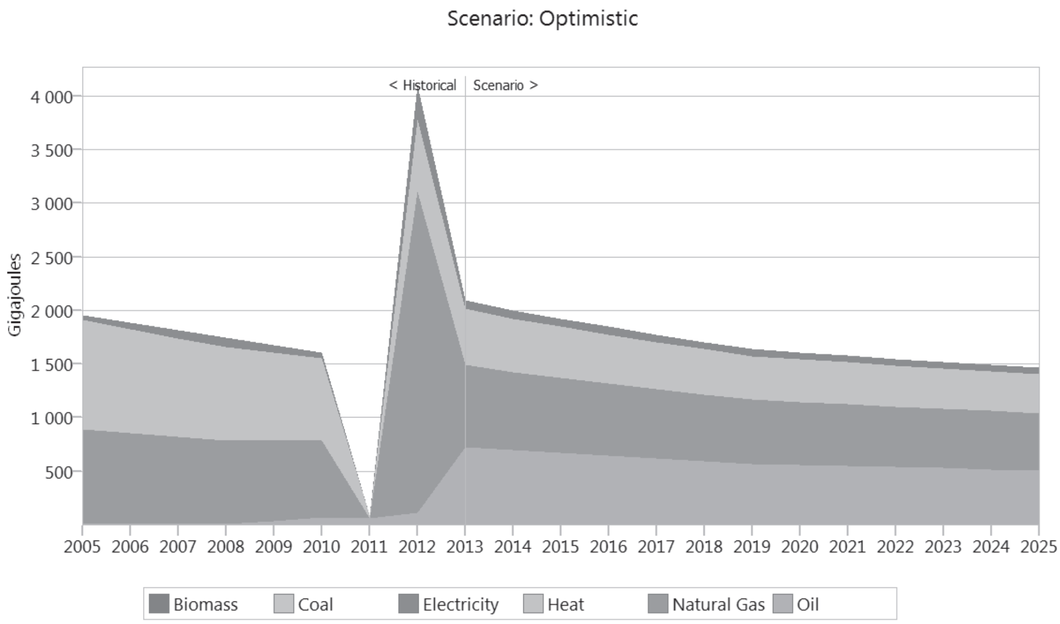

Figure 18. Final energy demand in agriculture sector. OPT scenario.

[6] Government Decree of the City of Moscow № 1075-ПП of 02.12.2008 «On the Moscow Energy Strategy until 2025».

Due to lack of data for the activity level, the industrial energy demand structure (industry sector) was formed mainly by experts' evaluations and partly by GRP structure. The growth rate of activity level and the growth rate of energy demand are equal to its respective growth rate described earlier in the GRP distribution per sector section. Fuel shares are considered steadily since no policy instruments are applied.

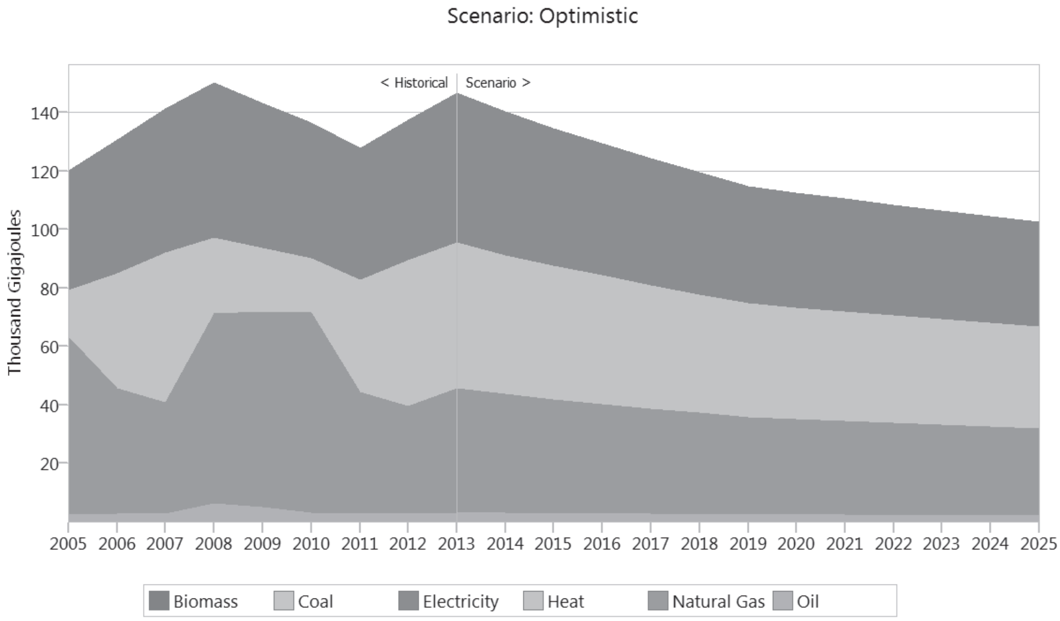

Figure 19. Final energy demand in Industry sector. OPT scenario.

Based on the experts' expectations on the successful transport strategy realization, final energy demand in transport sector is estimated.

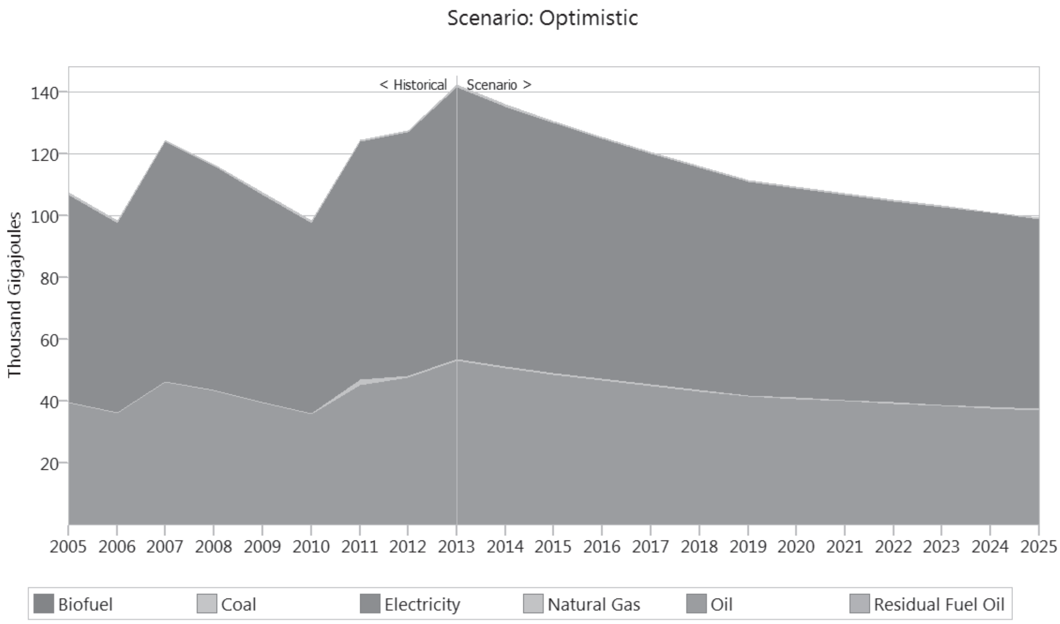

Figure 20. Final energy demand in transport sector. OPT scenario.

Transformation

Total transformation energy losses are over 28%, but by 2025 they will be reduced by almost 5 percentage points. Most of the losses are connected with electricity and heat and each of them loses about 8% during transmission and distribution. Assuming that little modernization is planned that could influence this situation and that the equipment is slowly aging, the growth rate of transformation efficiency is no more than 1–2%.

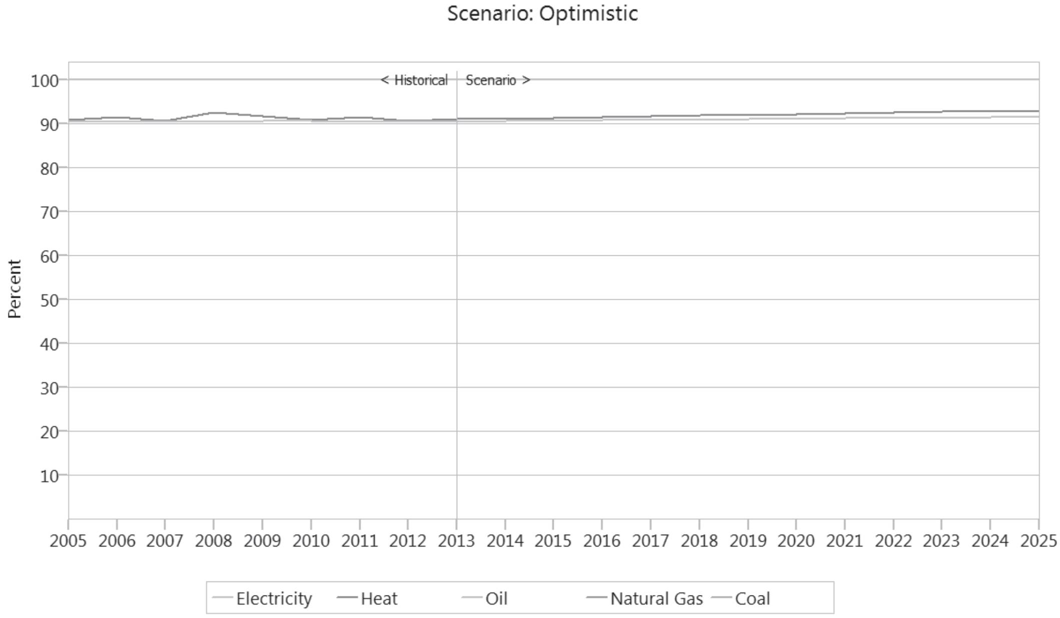

Figure 21. Transformation efficiency — transmission and distribution. OPT scenario.

Own use losses are less than that in transmission and distribution and equal to about 10% (2% — heat and 8% — electricity). Assuming that no innovations would be implemented, own use losses are considered to remain steady.

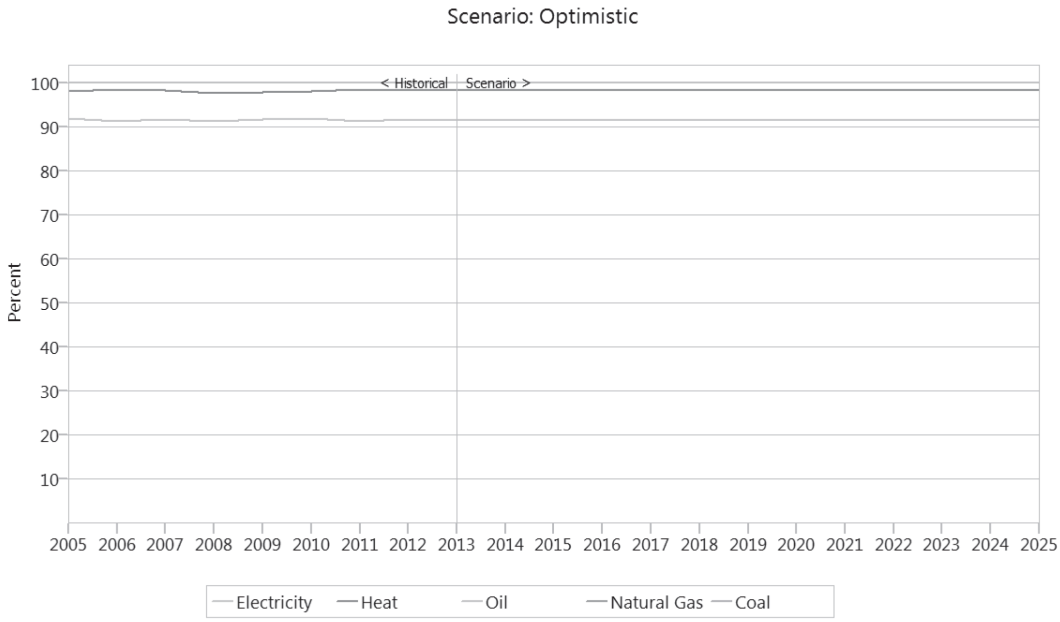

Figure 22. Transformation efficiency — own use. OPT scenario.

Global Warming Potential (GHG Emissions)

The OPT scenario shows us that comparing to 2013 the GHG emission will be reduced steadily and in 2015 will reach the reduction by 9%, in 2025 it will achieve the total reduction equal to 30%.

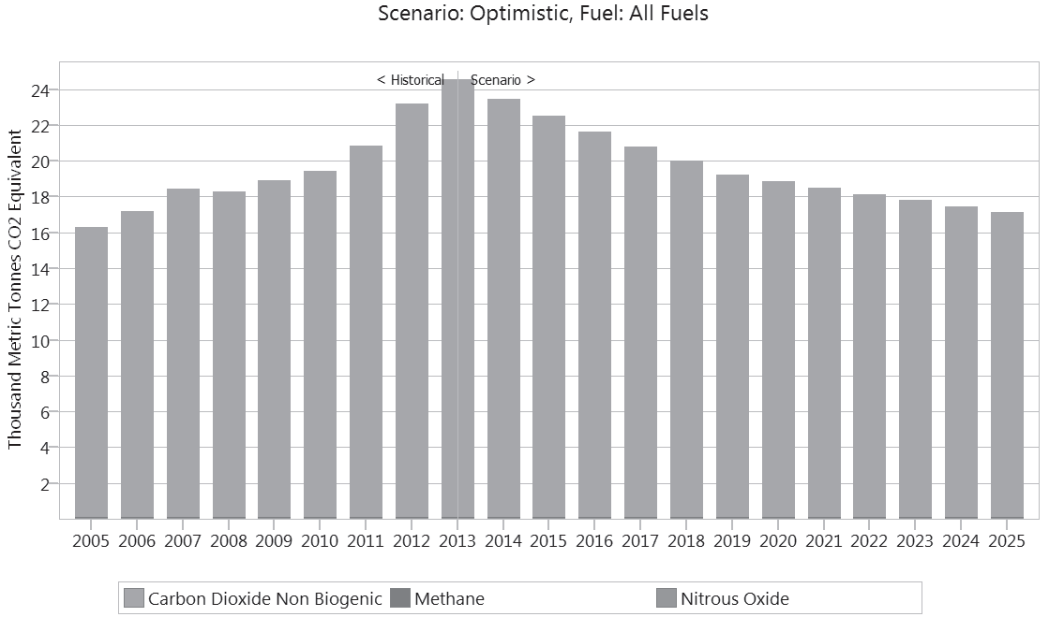

Figure 23. Global warming potential by GHGs. OPT scenario.

PESSIMISTIC SCENARIO

Pessimistic (PES) scenario is based on the bigger effect of the policy portfolio effective as of October 26, 2011 and corresponds mainly with the projections of the experts.

Several groups of assumptions, or key assumptions for PES scenario, are of great importance for the correct estimation by the model, so they are described below.

Population

Population dynamics follows dynamics that is forecasted in the General Plan of Moscow. This forecast contains saving the current level of the number of births and stabilization of the net migration at the level of 50–75 thousand people per year, however, the number of deaths will show an insignificant growth. Thus, total population of Moscow by the end of 2025 will not exceed 12 million people and will show a decrease comparing to 2013. This is a possible scenario due to the partial realization of the improvement of health, life capacity, fertility growth and migration mobility of population.

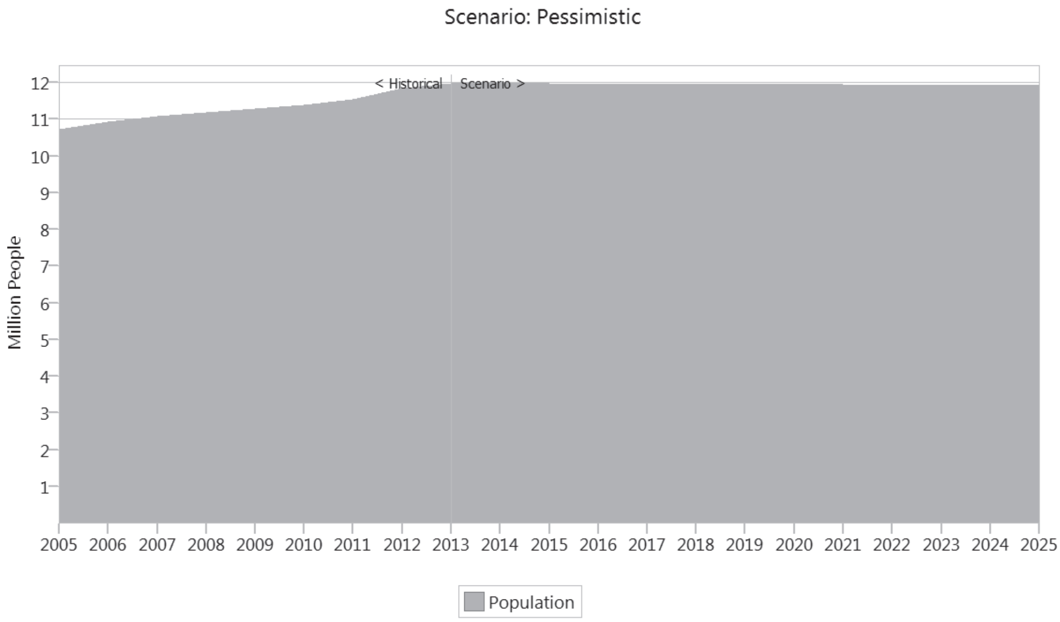

Figure 24. Demographics: population. PES scenario.

Climate

Climate forecasts are based on the Roshydromet weather forecast reports and are results of a simple regression of the data gained analysis with the only assumption that the situation with the greenhouse effect would become worse.

Economy

Real GRP as a key indicator of economic activity for forecasting GHG emission in the PES scenario too. In Moscow this interplay is moderated by low energy efficiency and significant role of energy sector in the economy. If the goals of the current policies would be reached, experts forecast that GRP growth rate would be 0.1% on average and, thus, would reach not more than 251 billion euro by 2025.

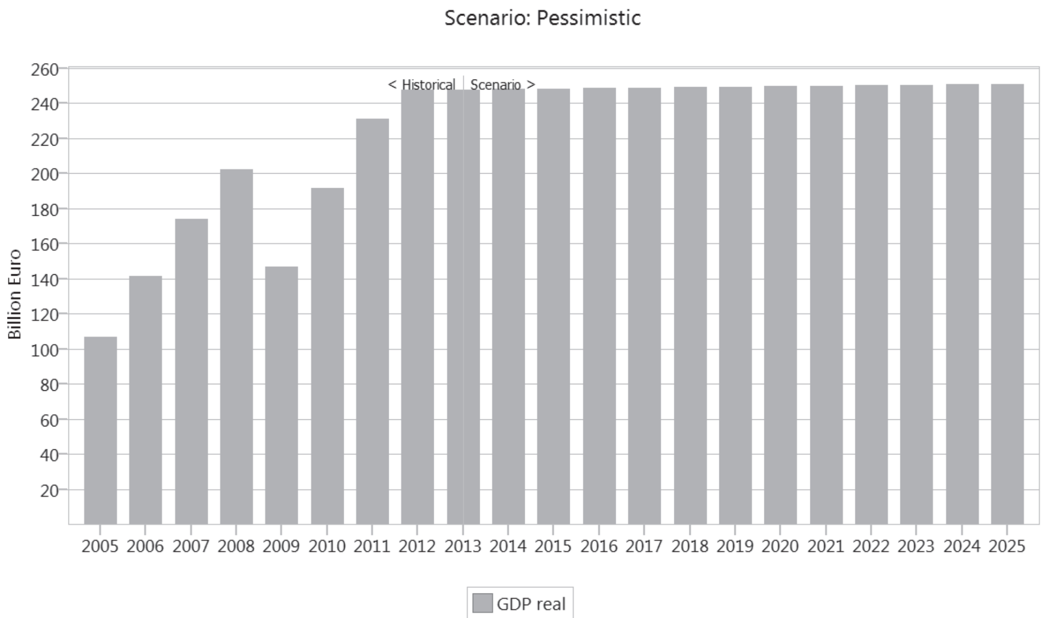

Figure 25. Economy: GRP real. PES scenario.

Sectoral distribution of GRP will also follow the dynamics of total real GRP. The structure of GRP in 2025 is almost the same as the one in 2013.

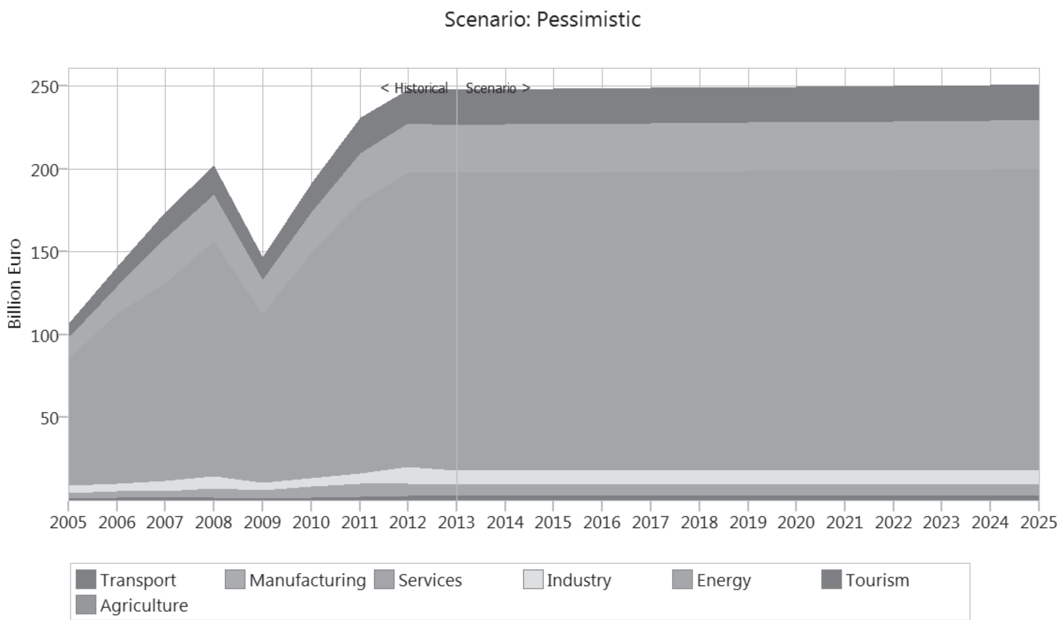

Figure 26. GRP distribution per sector. PES scenario.

Energy Demand

In the PES scenario the final energy demand in households sector will be decreasing as the result of energy saving policy of the Moscow government, which should allow consuming less heat and oil in this sector. Household sector, being the main consumer of total energy produced in Moscow, is thus of high importance in terms of GHG emission.

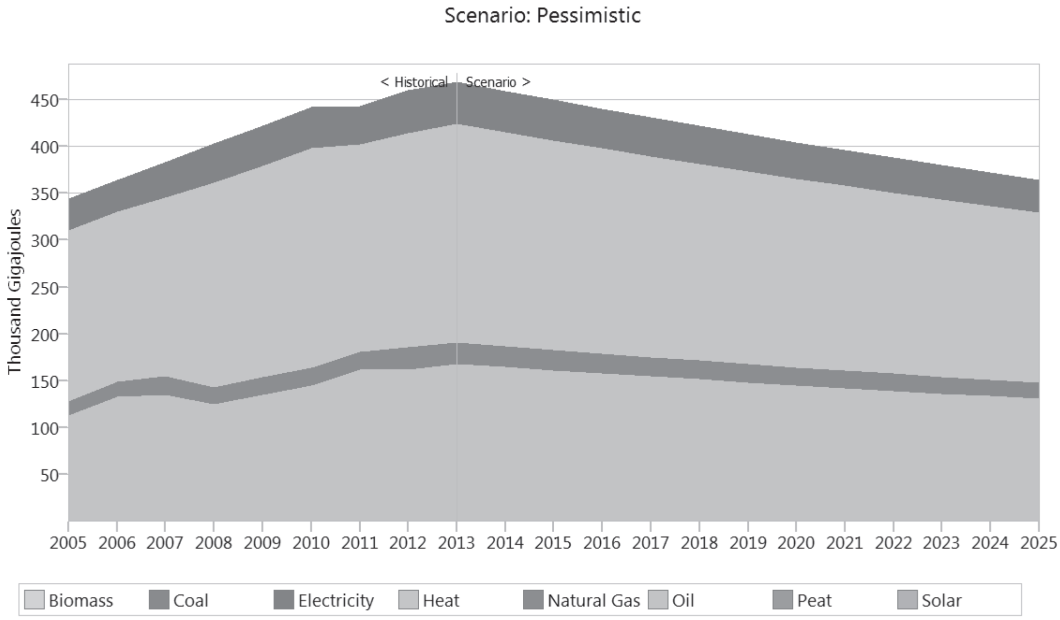

Figure 27. Final energy demand in household sector. PES scenario.

Agriculture has a significant contribution to the national economy, but a small share in the final consumption of commercial energies. The assumption for the growth rate of energy demand in the OPT scenario is that it follows its respective growth rate as described earlier in the GRP distribution per sector and in the BAU and OPT scenarios as well. Fuel shares are considered to be almost the same across the years since no influencing policy instrument is applied.

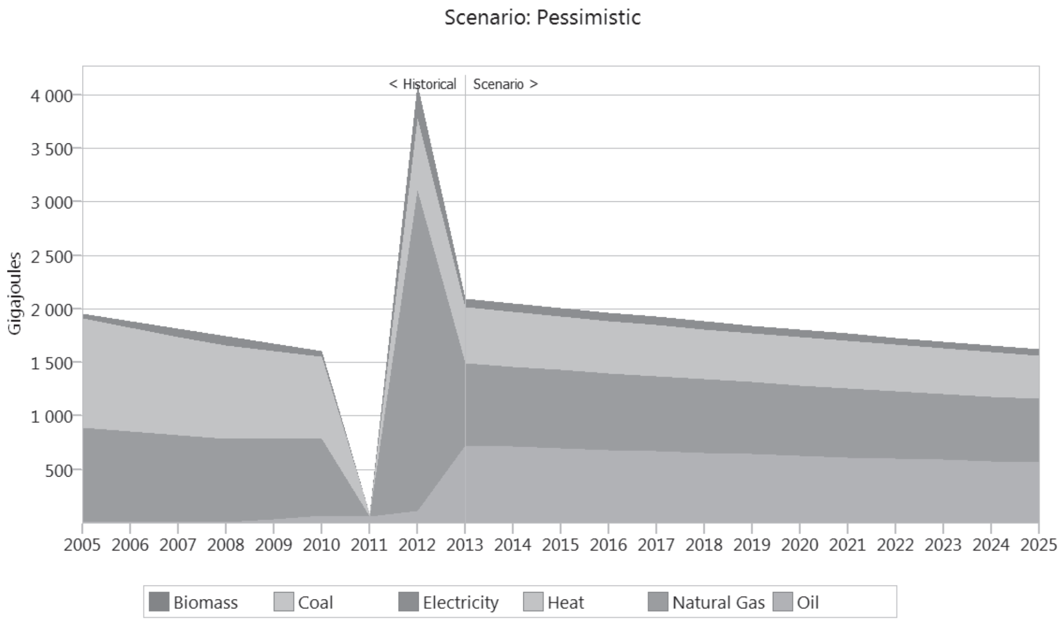

Figure 28. Final energy demand in agriculture sector. PES scenario.

Due to lack of data for the activity level, the industrial energy demand structure (industry sector) was formed mainly by experts' evaluations and partly on GRP structure. The growth rate of activity level and the growth rate of energy demand are equal to its respective growth rate described earlier in the GRP distribution per sector section. Fuel shares are considered steadily since no policy instruments are applied.

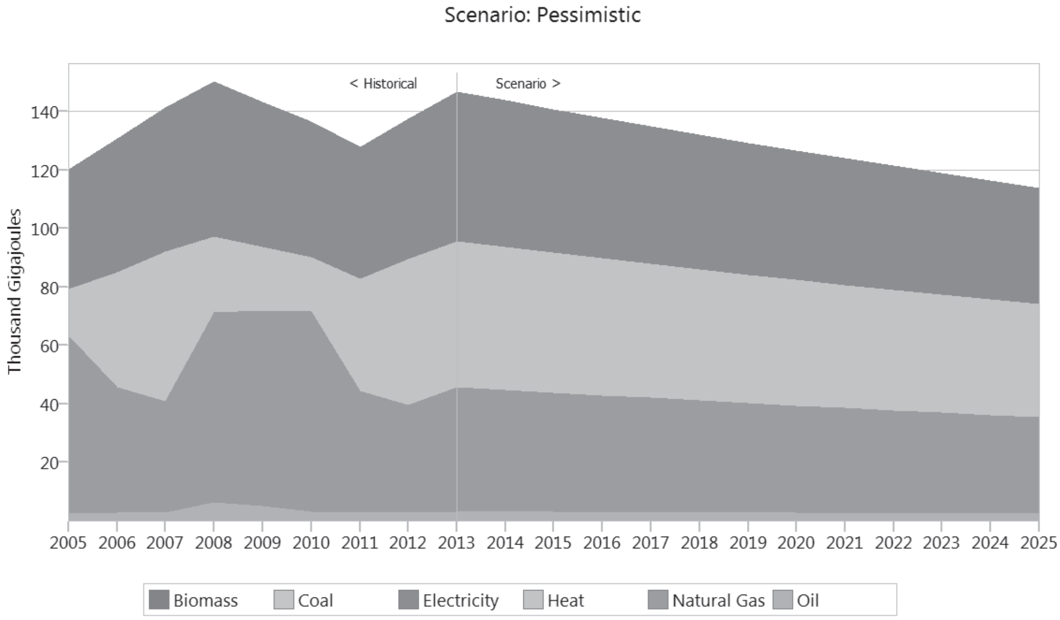

Figure 29. Final energy demand in industry sector. PES scenario.

Based on the experts' expectations on the successful transport strategy realization, final energy demand in transport sector is estimated.

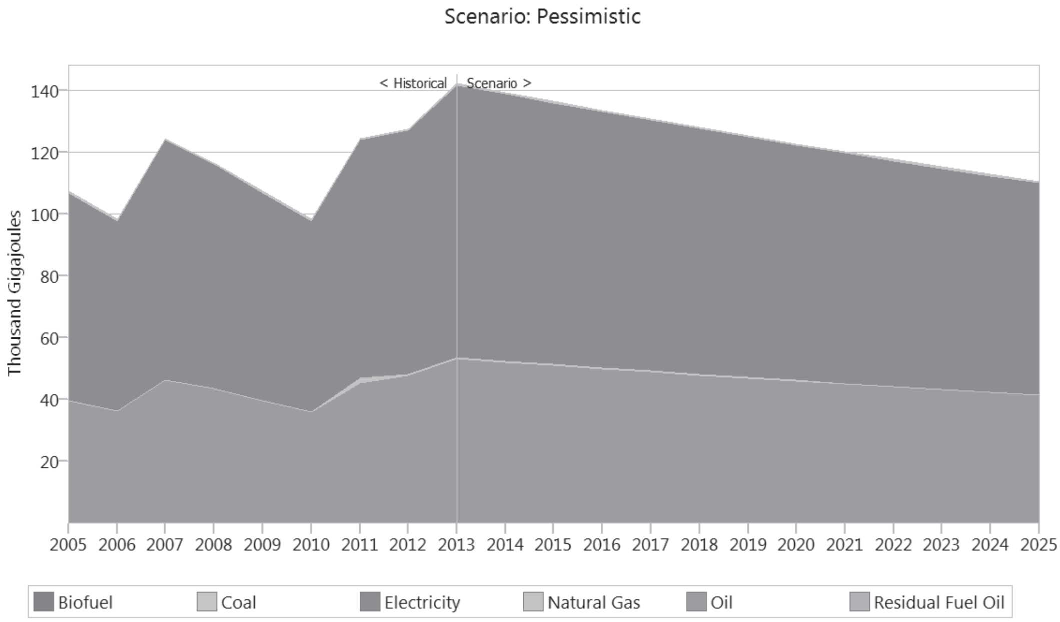

Figure 30. Final energy demand in transport sector. PES scenario.

Transformation

Total transformation energy losses are over 28%. Most of the losses are connected with electricity and heat and each of them loses about 8% during transmission and distribution. Assuming that no modernization is planned that could influence this situation and that the equipment is slowly aging, the growth rate of transformation efficiency is close to zero or even negative.

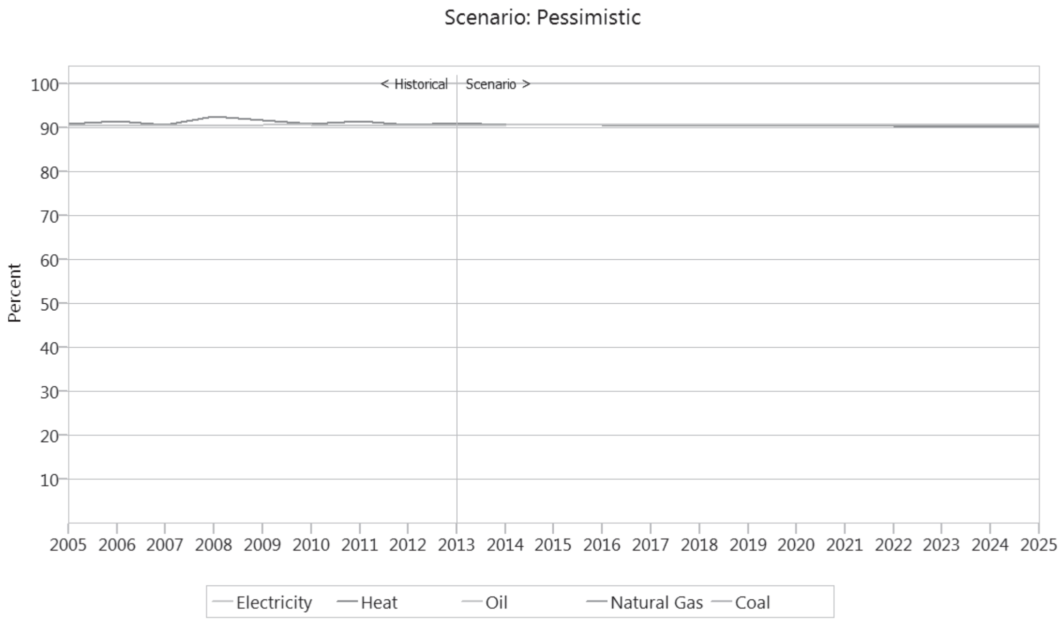

Figure 31. Transformation efficiency — transmission and distribution. PES scenario.

Own use losses are less than that in transmission and distribution and equal about 10% (2% — heat and 8% — electricity). Assuming that no innovations would be implemented, own use losses are considered to remain steady.

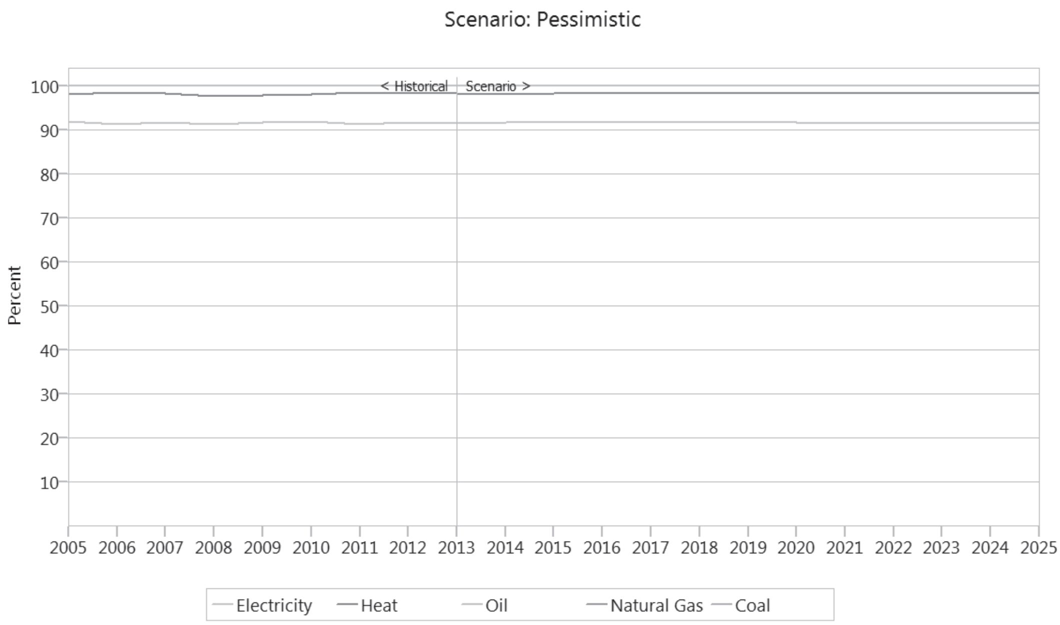

Figure 32. Transformation efficiency — own use. PES scenario.

Global Warming Potential (GHG Emissions)

The PES scenario shows us that comparing to 2013 the GHG emission will be reduced steadily and in 2015 will reach the reduction by 4%, in 2025 it will achieve the total reduction equal to 22%.

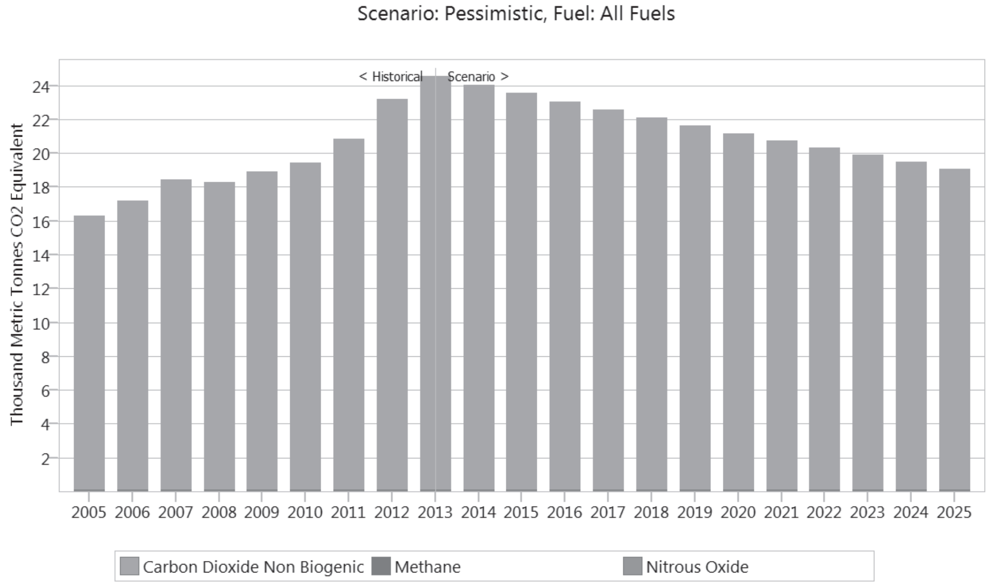

Figure 33. Global warming potential by GHGs. PES scenario.

RESULTS OF LONG-RANGE ENERGY ALTERNATIVES PLANNING SYSTEM (LEAP)

Based on the analysis of official documents and governmental programs, three scenarios of economic development of Moscow until 2025 were developed. Mentioned scenarios accounted for greenhouse gas emissions from various sectors of Moscow economy.

As part of the research, an econometric model in LEAP environment was built, encompassing fuel and energy balances data, as well as historical and forecasted GRP, industry and energy structure, sectoral and total energy efficiency, and the demand for energy from sectors of economy forecasted for up to 2025.

According to the BAU scenario, GHG emissions will be reduced by 7% by 2015 and decrease by 22% by 2025. OPT scenario will achieve reductions in GHG emissions by 9% and 30% in 2015 and 2025, respectively. However, in the PES scenario the decrease in GHG emission is only 4% and 22% in 2015 and in 2025 correspondingly. Analysis of GHG emissions by sectors shows a non-monotonic behavior of the service sector in terms of GHG emissions in all scenarios, an increase in GHG emissions in 2020 from 2% to 12% in OPT and PES scenarios respectively. Calculations showed a decrease in energy intensity of GRP in 2020 to 7% for BAU and OPT, and by 4% for the PES scenarios. Modeling showed anticipatory reduction of GHG emissions by households, which reaches in 2025 24%, 30% and 22% for the BAU, OPT and PES respectively.

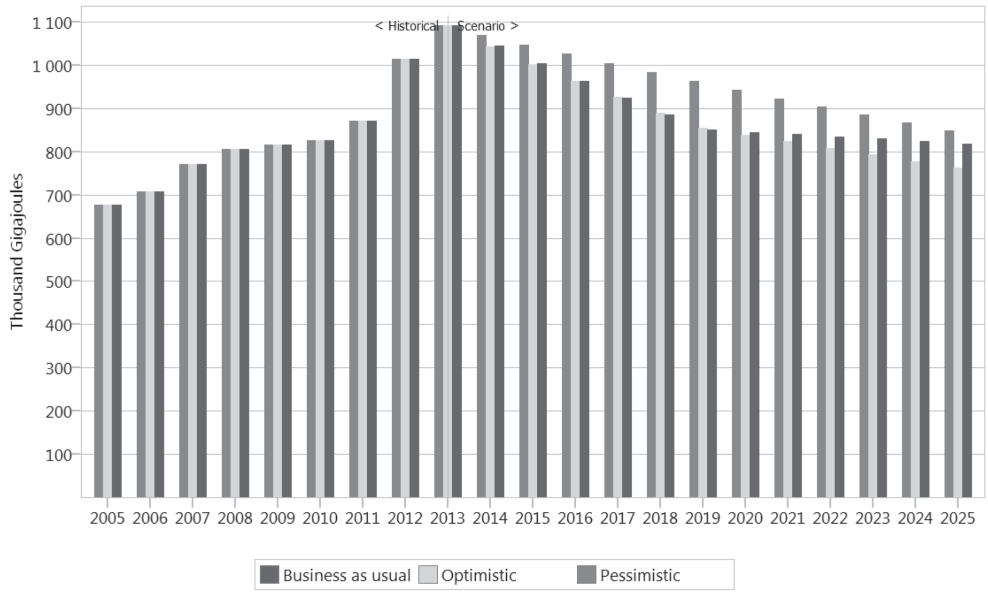

Figure 34. The final energy demand for all three scenarios.

The main outcome of the analysis is that the Pessimistic scenario shows the highest demand for energy. However, the Optimistic one shows the lowest demand on energy as it assumes the successful realization of energy saving programs.

As we can see on the chart below, the Optimistic scenario is the most environmentally friendly, the Pessimistic one is easier to implement, and Business-as-Usual balances interests of all stakeholders in charge. This might be interpreted as an evidence of lack of governmental regulation and motivation to intervene in energy sector to make it greener and more sustainable.

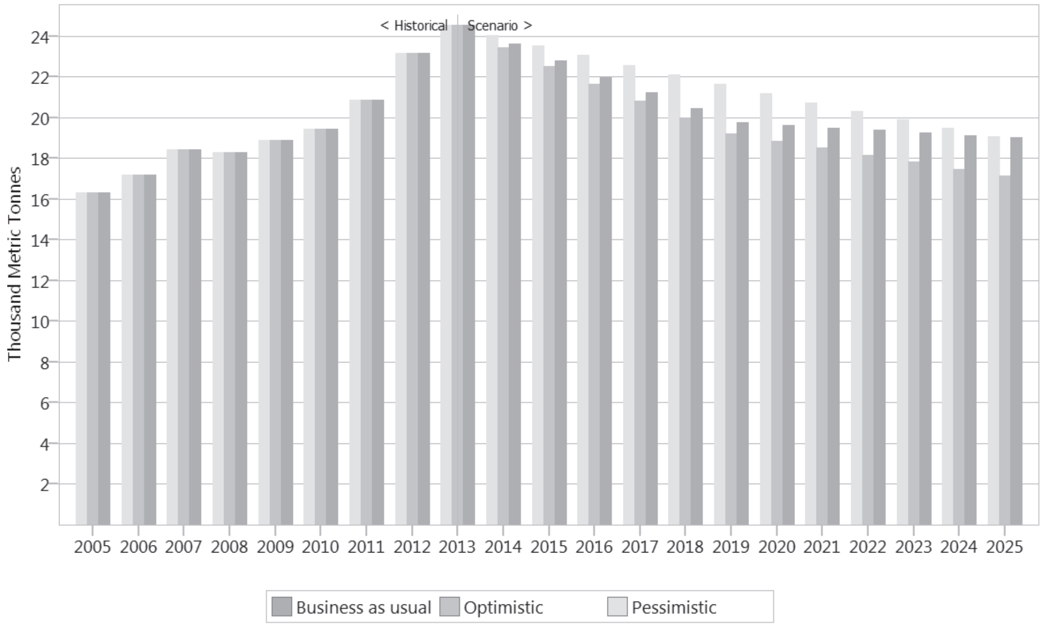

Figure 35. The evolution of the global warming potential for three analyzed scenarios.

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ANNEX

Table 2. Dynamics of energy capacity of GRP in Moscow and in the industries of Moscow for the period 2010–2012.

	Consumption, thousand tons of fuel equivalent			GRP, mln. RUR			Energy capacity of GRP, tons of fuel equivalent / mln. RUR		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
Full energy consumption	42944	43258	44008	8375864	8610388	8739544	5,13	5,02	5,04
Final energy consumption	28932	30224	31712	8375864	8610388	8739544	3,45	3,51	3,63
Agriculture	55	3	140	n/a	1499	1522	n/a	2,00	92,01
Manufacturing	5038	4751	5006	1072111	1111779	1127344	4,70	4,27	4,44
Production and delivery of electricity, gas and water	645	423	633	293155	292276	296615	2,20	1,45	2,13
Construction	730	742	760	217772	218644	223891	3,35	3,39	3,39
Transport and telecom	3355	4253	4357	862714	862714	875522	3,89	4,93	4,98
Services and others	5024	5955	6079	5930112	6123477	6214651	0,85	0,97	0,98
Wholesale and retail trade			1626			3233991			0,50
Hotels and restaurants			100			79179			1,26
Education			738			205433			3,59
Health and social services			373			263167			1,42
Other community, social and personal services			1485			232098			6,40
Other industries			936			2200782			0,43

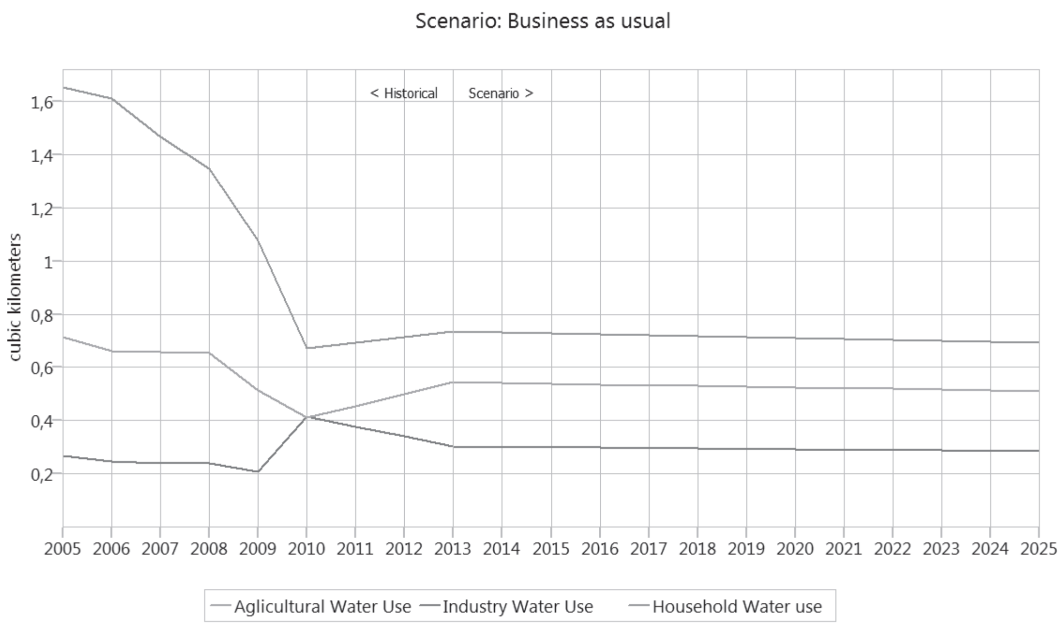

Figure 36. Water use — BAU scenario.

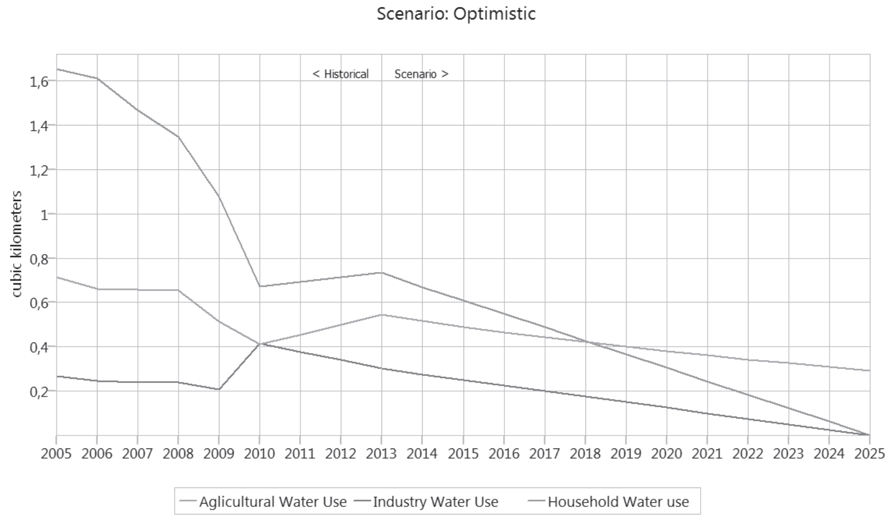

Figure 37. Water use — OPT scenario.

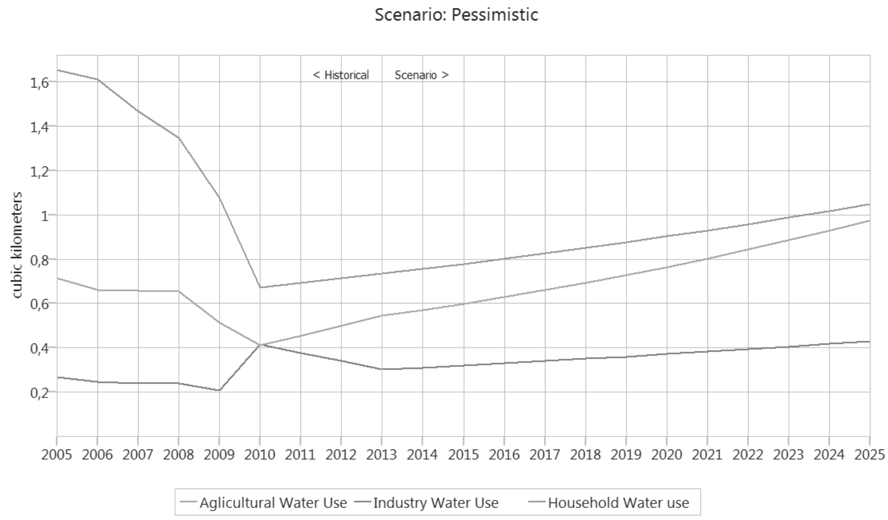

Figure 38. Water use — PES scenario.

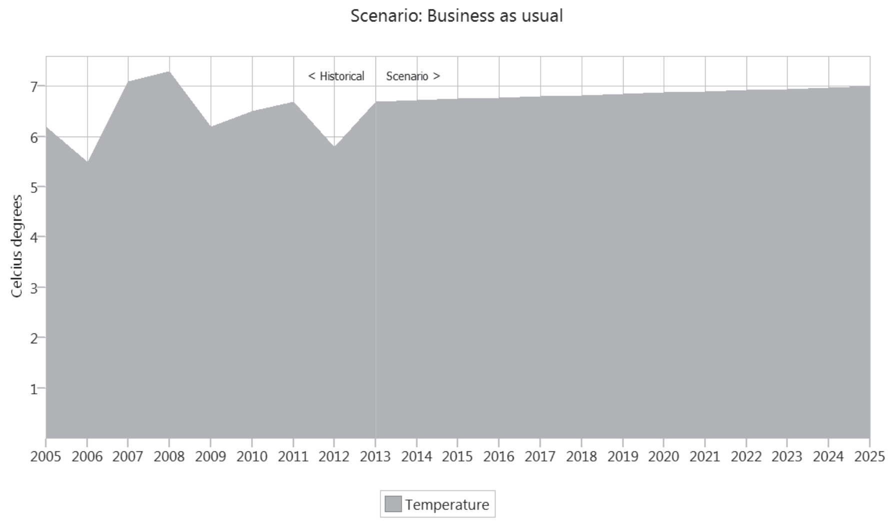

Figure 39. Average year temperature prognosis — BAU scenario.

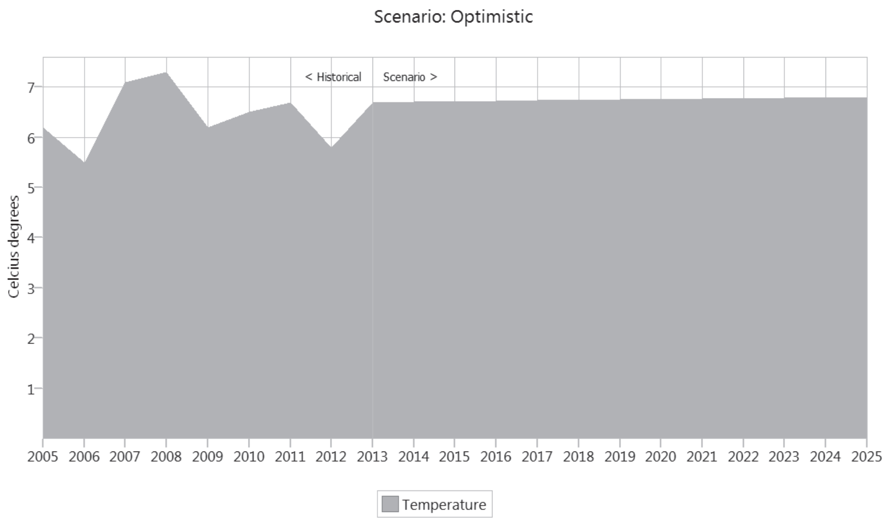

Figure 40. Average year temperature prognosis — OPT scenario.

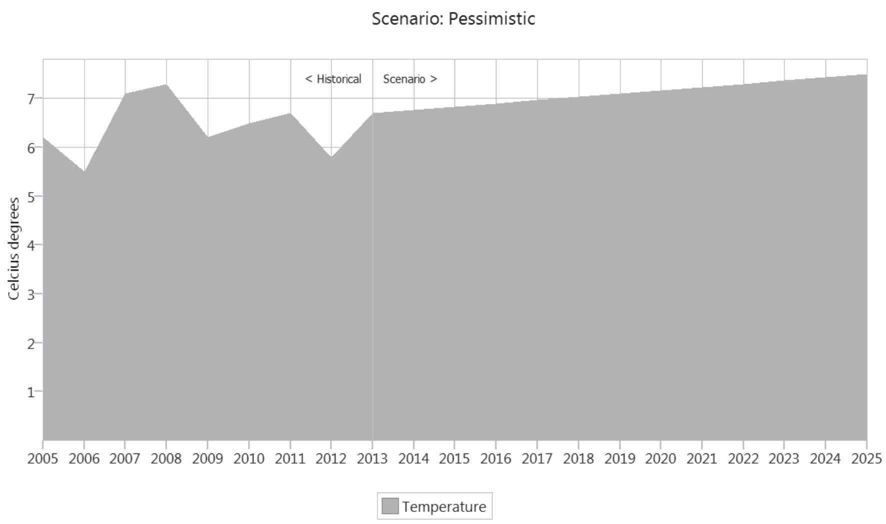

Figure 41. Average year temperature prognosis — PES scenario.

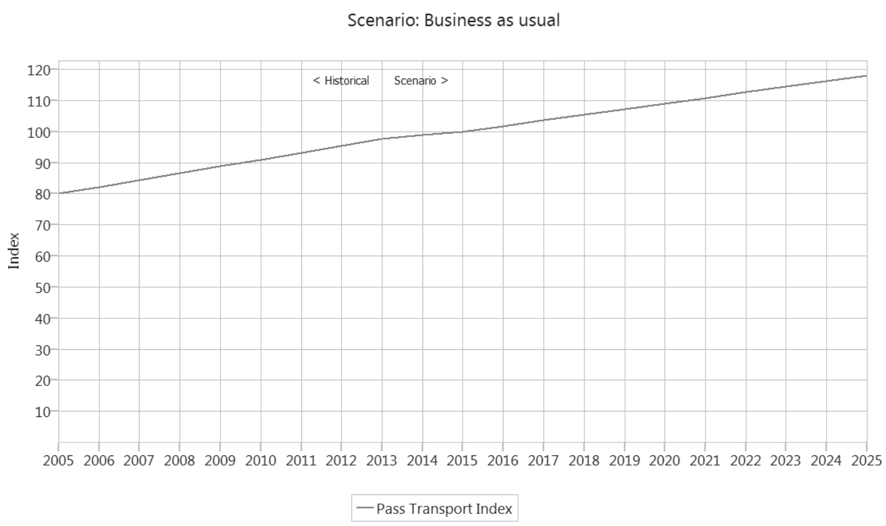

Figure 42. Passenger transport index — BAU scenario.

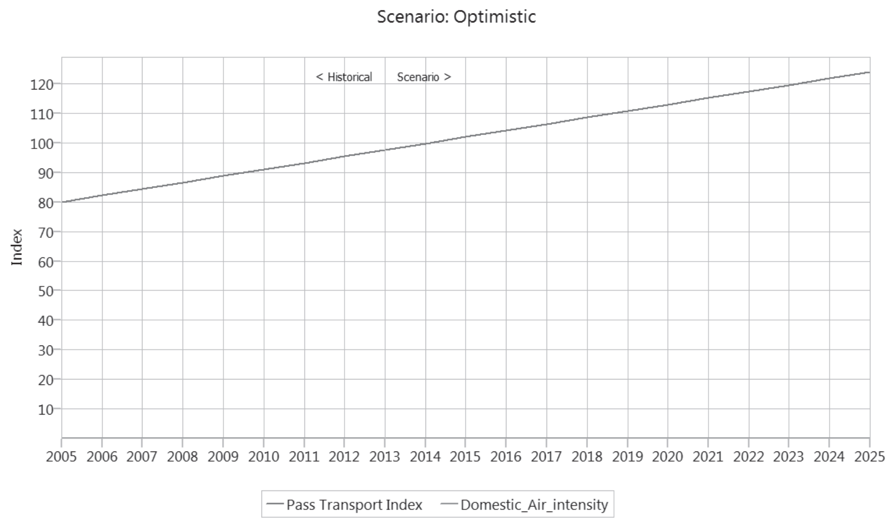

Figure 43. Passenger transport index — OPT scenario.

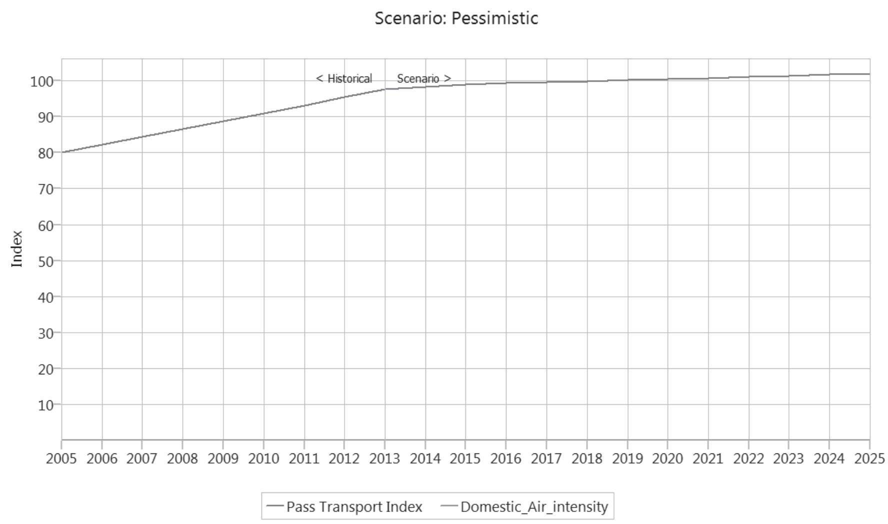

Figure 44. Passenger transport index — PES scenario.

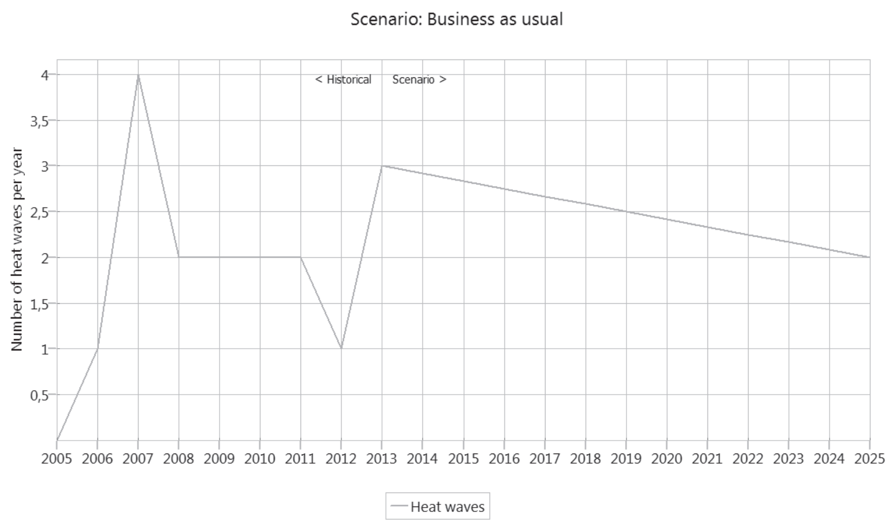

Figure 45. Extreme heat waves — BAU scenario**.**

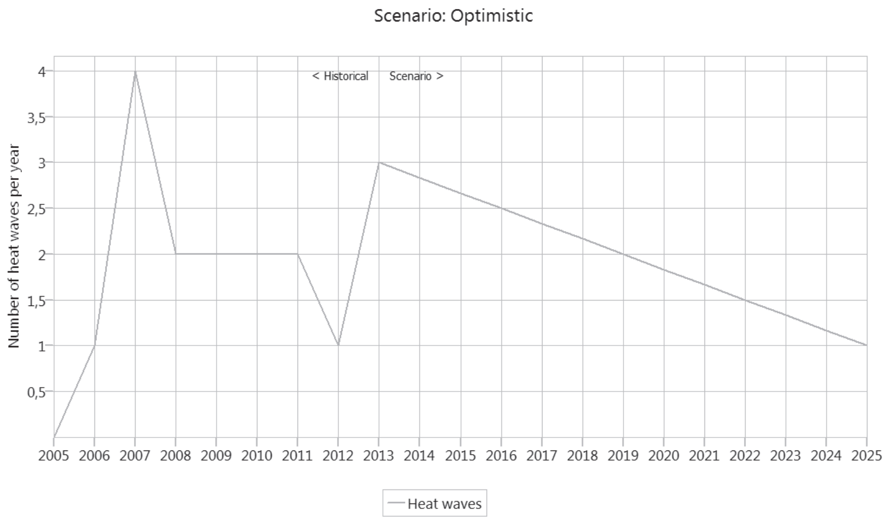

Figure 46. Extreme heat waves — OPT scenario.

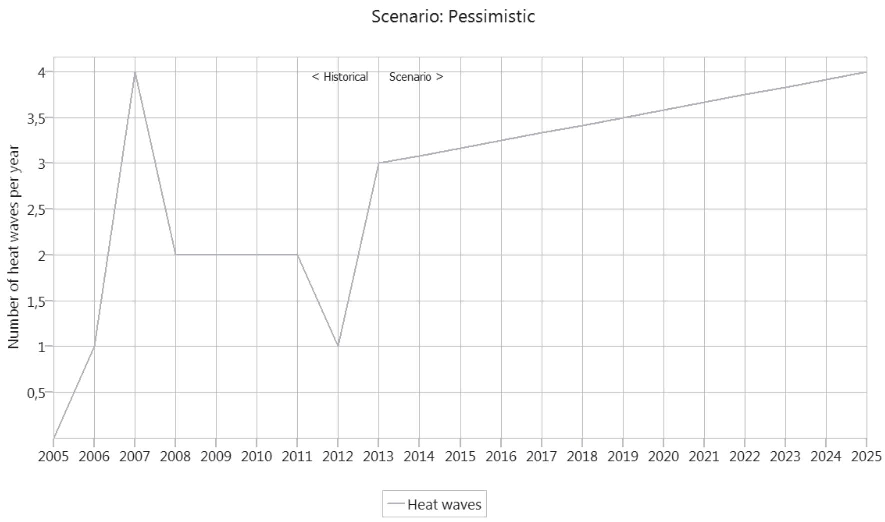

Figure 47. Extreme heat waves — PES scenario.

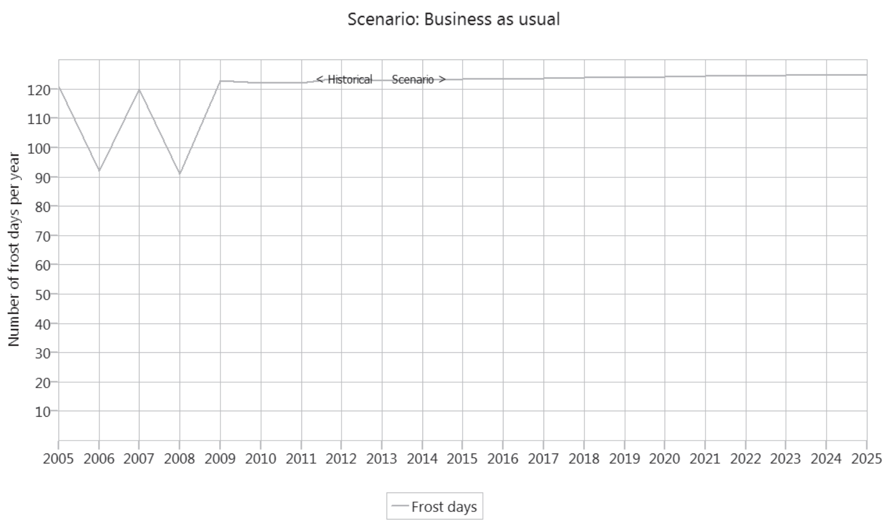

Figure 48. Extreme frost days — BAU scenario.

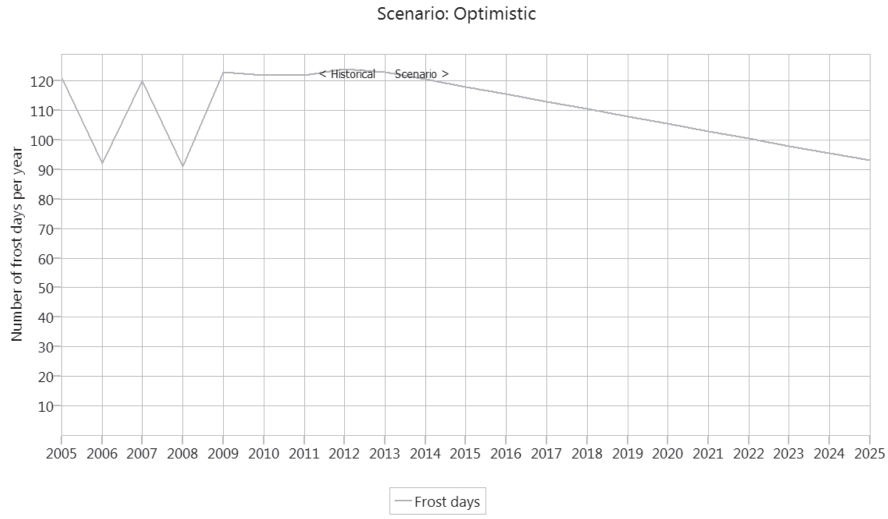

Figure 49. Extreme frost days — OPT scenario.

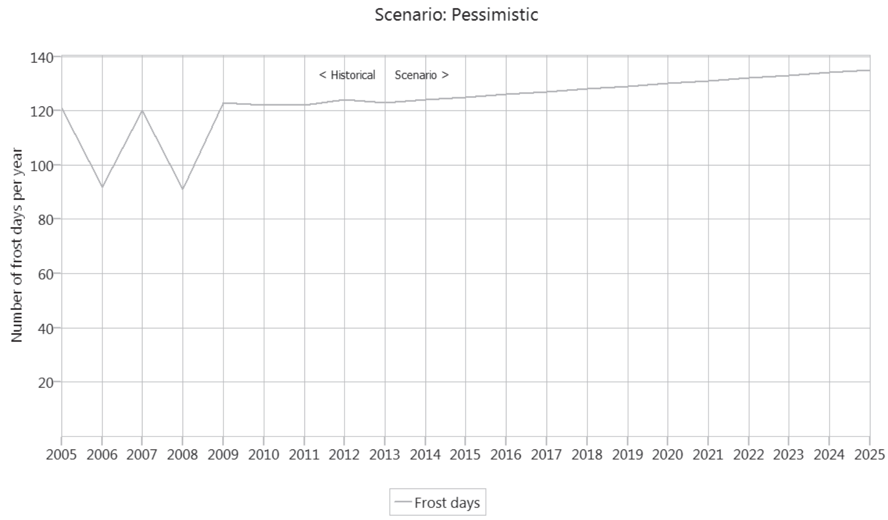

Figure 50. Extreme frost days — PES scenario.