JUST AND SECURE ENERGY TRANSITION (JSET) PROGRAM

Projections of Natural Gas Annual and Peak Demand in Georgia Through 2050

Final Report

SUBAGREEMENT NO. USEA/USAID - 7200AA22CA00028-2023-862-01
Tuesday, November 14, 2023

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Prepared for:

United States Agency for International Development and United States Energy Association

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List of Abbreviations

Abbreviation	Meaning
AC	Air conditioner
BAU	Business as usual
CCGT	Combined cycle gas turbine
GDP	Gross domestic product
GSE	Georgian State Electrosystem
HPP	Hydro power plant
NCV	Net calorific value
NECP	National Energy and Climate Plan
SPP	Solar power plant
TPP	Thermal power plant
TYNDP	Ten Year Network Development Plan
WPP	Wind power plant

EXECUTIVE SUMMARY

This project developed a forecast of future natural gas consumption in Georgia through 2050. It is intended as input to assist the Government of Georgia as it considers future supply contracts and infrastructure investment needed to ensure the security of Georgia's natural gas supply.

The 2050 forecast was developed by combining forecasted demand for gas in the industrial, transport, service, and household sectors with the forecasted demand for gas for power generation.

The non-electricity generation natural gas demand forecast used a bottom-up modelling approach to analyse three growth scenarios: 1) business-as-usual (BAU) growth; 2) growth led by decarbonization **Measures** inspired by the draft National Energy and Climate Plan (NECP); and 3) high growth.

The gas demand forecast for electricity generation considered the following five scenarios suggested by the Georgian State Electrosystem and the Ministry of Energy and Sustainable Development (MoESD):

1. Scenario 1: High Load – High Generation
2. Scenario 2: High Load – Base Generation
3. Scenario 3: Base Load - Low Generation
4. Scenario 4: High Load – Low Generation
5. Scenario 5: NECP

In total, the project analyzed 15 growth scenarios (three scenarios for non-electricity generation consumption growth multiplied by five electricity generation natural gas growth consumption scenarios).

Scenarios selected: The MoESD and the Georgian Oil and Gas Corporation selected the following scenarios as the basis for considering future natural gas supply contracts and expanding planning natural gas infrastructure:

a) Non-electricity generation demand –***Measures Scenario***

b) Electricity generation demand – ***Scenarios 2 and 3***

Explanation of the scenarios:

The *Measures Scenario*, reflects the state's active policy to decarbonize energy consumption. The scenario does not fully replicate the NECP policy drivers, but is inspired by and is consistent with it.

The *Electricity Generation Scenarios* 2 and 3 were developed to assess the demand for natural gas to fuel electricity generation:

Scenario 2: High Electricity Load + Baseload Renewable Generation → This is a relatively optimistic scenario combining high demand for electricity and baseload generation provided by renewable energy sources (RES), resulting in lower thermal power plant usage.

Scenario 3: Base Case Load + Low RES Generation → This is a relatively pessimistic scenario combining lower demand for electricity with lower generation from RES technologies, resulting in higher thermal power plant usage.

The combination (or sum) of the non-electricity generation demand for natural gas with the demand for natural gas for electricity generation results in the forecast for Total Natural Gas Demand in Georgia.

Final projections for the scenarios selected:

Total forecasted gas demand in Georgia (mcm) - Scenario with measures

	2021	2022	2025	2030	2035	2040	2045	2050
Scenario with measures 2	2,563	3,058	3,142	3,149	3,037	2,961	2,819	2,692
Scenario with measures 3	2,563	3,058	3,149	3,187	3,340	3,451	3,434	3,484

Total projected peak gas demand in Georgia (mcm/day) - Scenario with measures - GOGC Method (recommended for short-term planning purposes)

<table>
<tr><th></th><th>2021</th><th>2022</th><th>2025</th><th>2030</th><th>2035</th><th>2040</th><th>2045</th><th>2050</th></tr>
<tr><td>Scenario with measures 2</td><td rowspan="2">15.6</td><td rowspan="2">16.7</td><td>19.2</td><td>19.2</td><td>18.5</td><td>18.1</td><td>17.2</td><td>16.4</td></tr>
<tr><td>Scenario with measures 3</td><td>19.2</td><td>19.4</td><td>20.4</td><td>21.1</td><td>21.0</td><td>21.3</td></tr>
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1. INTRODUCTION

This report presents the findings of natural gas demand and peak demand modeling for Georgia for target year 2050. The study includes the following:

- Chapter 2: Final energy demand by all sectors, excluding electricity generation
- Chapter 3: Electricity sector annual gas demand
- Chapter 4: Total annual gas demand and peak gas demand
- Chapter 5: Conclusion

2. FINAL ENERGY DEMAND BY ALL SECTORS, EXCLUDING ELECTRICITY GENERATION

2.1 Introduction

This chapter includes detailed modeling of the final consumption of energy sources (for energy purposes), for all sectors, **excluding electricity generation**. Projections of electricity sector demand for gas are presented in the next chapter.

2.2 Timeframe

Energy planning includes various timeframes, each tailored to address distinct objectives and challenges. These timeframes are categorized as short-term, medium-term, and long-term planning, with each approach offering unique advantages and considerations.

2.2.1 Short-Term Planning (weeks, months, several years)

Short-term energy planning focuses on the immediate future, typically spanning weeks to a few months. This approach is primarily concerned with addressing the current state of the energy system. In this context, a **top-down approach is often preferred** for energy demand forecasting. This preference arises because many key relationships within the energy system do not change rapidly in the short term. For instance, factors such as the socio-economic structure of a country and the energy consumption patterns of its inhabitants evolve gradually. Additionally, most energy-consuming equipment has relatively long technical lifespans of 10-15 years. Energy supply facilities, with their extended lead times (5-10 years) and long technical lifetimes (15-30 years), also contribute to the inertia of the short-term energy landscape.

2.2.2 Long-Term Planning (15 to 30 Years)

Long-term energy planning covers a period ranging from 15 to 30 years. This approach includes the numerous uncertainties and dynamic factors that shape the long-term evolution of the national energy system. Consequently, a **bottom-up approach is often favored** for long-term energy analysis, as it includes a more detailed and granular examination of the relevant variables and their interplay.

Long-term energy planning considers the following:

- Population and Economic Growth: understanding how the population and economy will expand or contract over decades is crucial for projecting energy demand accurately.
- Technological Developments: technological advancements, particularly those leading to more efficient energy use, can significantly impact long-term energy consumption patterns.
- International Energy Market: availability and prices of energy resources in the global market play a pivotal role in long-term energy security and affordability.
- Emerging Energy Technologies: potential adoption and integration of new energy technologies, such as solar or other renewables, must be accounted for in long-term energy planning.

In summary, the choice between top-down and bottom-up forecasting methods depends on the specific planning objectives and the timeframe under consideration. Short-term planning leans towards top-down methods due to the stability of many relationships, while long-term planning often requires a more detailed bottom-up approach to account for the complexities and uncertainties that shape the distant energy landscape.

This study **will determine the long-term consumption of natural gas in Georgia (until 2050)** and will therefore apply a **bottom-up modeling approach**.

2.3 Methodology

To analyze the future energy demand of Georgia, an energy model was created that includes the household, service, industry, and transport sectors. The energy model was created using the software tool LEAP (The Low Emissions Analysis Platform)[1]. LEAP is a complex and versatile software system developed at the Stockholm Environment Institute for integrated energy planning and climate change mitigation assessment.

Energy demand projections were made by applying **the end-use model** with the **bottom-up approach**. In contrast to econometric models, the end-use model does not require perennial input data time series and is characterized by mathematical simplicity. A possible shortcoming to the end-use model is the extensive input data it requires.

The energy model evaluated future energy demand based on medium to long-term socio-economic, technological, and demographic development scenarios. The model systematically relates the energy demand necessary to produce goods and services to the corresponding social, economic, and technological factors that affect this demand. The nature and level of the demand for goods and services are a function of several determining factors, including **population growth, number of inhabitants per dwelling, number of electrical appliances used in households, people's mobility and preferences for transportation modes, national priorities for the development of specific industries or economic sectors, the evolution of the efficiency of certain types of equipment, market penetration of new technologies or energy forms**, etc. The expected future trends for these determining factors, which constitute a scenario, are introduced.

2.4 Base Year and Energy Balance

The energy balance of Georgia for 2021 is the basic data source for **calibrating** the disaggregated energy consumption model. It is a comprehensive source of data on the consumption of all energy forms and different sectors, which are necessary for the establishment of a calibrated model. The energy balance for each year is published by the National Statistical Office of Georgia (GEOSTAT), and these data are also published on EUROSTAT.

During the preparation of the study, specific data on the actual consumption of certain energy sources (electricity, natural gas) in 2022 and part of 2023 was available. In those years, some significant changes occurred in the structure and amount of consumption of these energy sources. Therefore, it was necessary to carry out the **adjustment** of certain variables in the model for the specified years for the model to calculate realistic values.

[1] Heaps, C.G., 2022. *LEAP: The Low Emissions Analysis Platform.* [Software version: 2020.1.80] Stockholm Environment Institute. Somerville, MA, USA. https://leap.sei.org

2.5 Scenarios

The Georgian LEAP energy model includes three final energy demand scenarios. The first scenario is the reference scenario, while the other two are alternative scenarios:

1. **Business as Usual (BAU)**
2. **Scenario with Measures**
3. **High Gas Consumption Scenario**

The **Business as Usual (BAU)** scenario as a reference scenario represents the future trends in energy flows following the expected improvements in technology and structural changes in energy consumption driven mainly by market principles and without the active role of the country in the proactive design and implementation of energy and climate measures.

The first alternative scenario, **Scenario with Measures**, is designed to reflect the state's active policy regarding energy transition and decarbonization in final energy consumption. The **scenario does not represent a replication of the NECP scenario** but is inspired by it and follows such trends.

The second alternative scenario, the **High Gas Consumption Scenario**, is designed to show the maximum but realistically possible consumption of natural gas.

The projections of key determinants, such as population, household size, GDP growth rates, GDP structure, and number of vehicles, **are the same for all three scenarios**. The key differences between the alternative scenarios compared to the BAU scenario are listed and explained in the chapters where their results are presented.

2.6 Key Model Assumptions and Results Benchmarking

The following presents the key assumptions used in modeling future energy demand.

2.6.1 Gross Domestic Product (GDP)

GDP projections reflect actual data for 2022 and part of 2023, in which high growth rates were recorded, after which they gradually decrease until 2030. This is followed by a period of relatively stable growth rates, and at the very end of the observed period, a decrease in the growth rate. Projections of GDP growth rate and resulting GDP per capita that are used in the model are presented in the following tables and charts.

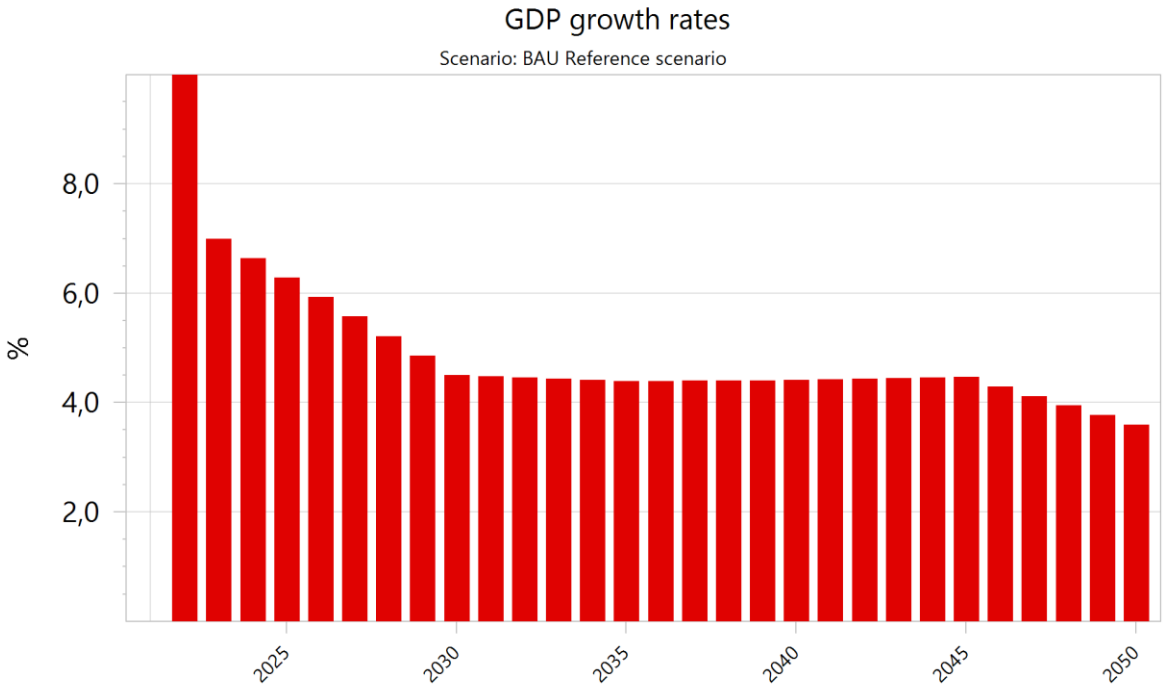


Figure 2-1 GDP growth rates

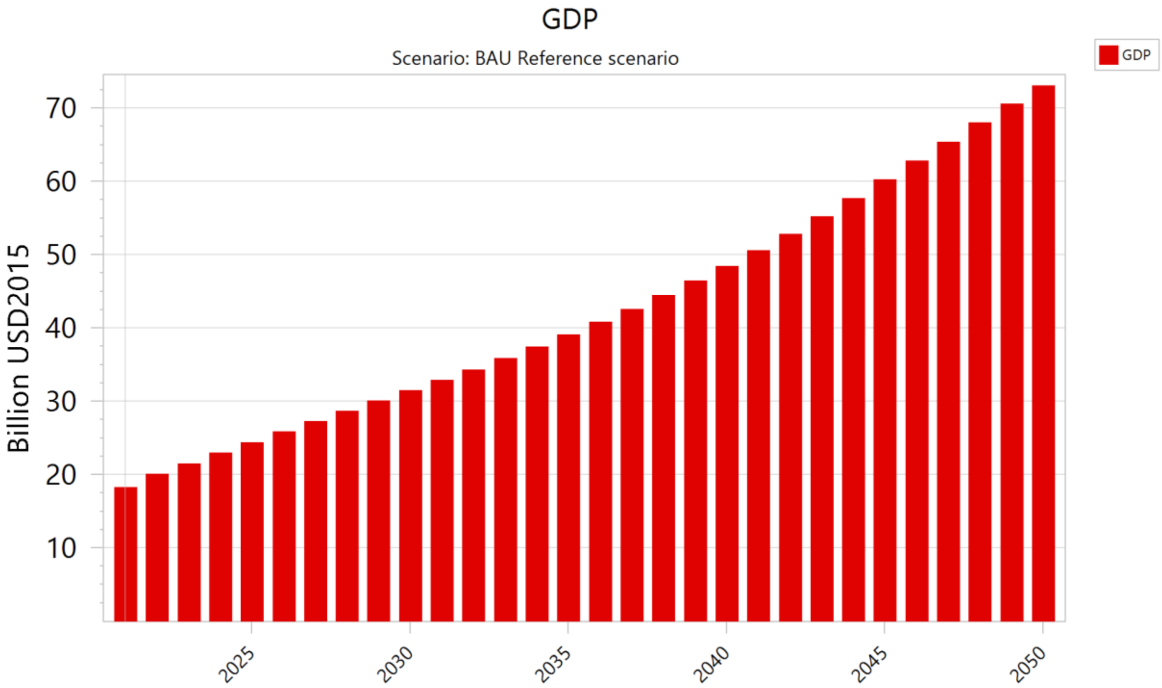


Figure 2-2 Total GDP expressed in USD_{2015}

Table 2-1 Real GDP per capita

	2021	2025	2030	2035	2040	2045	2050
GDP per capita (USD_{2015})	4,905	6,544	8,436	10,478	12,995	16,150	19,592

Since 2015, the GDP as well as GDP per capita for modeling purposes are expressed in **constant prices**, implying that GDP values are given in real values, excluding inflation.

2.6.2 Population

A constant population of 3.73 million inhabitants is assumed over the whole period. As was the case with the GDP growth, the assumption is in line with projections used in NECP.

Table 2-2 Population

	2021	2025	2030	2035	2040	2045	2050
Population (million)	**3.729**	**3.729**	**3.729**	**3.730**	**3.730**	**3.731**	**3.731**

2.6.3 Households

Some of the key indicators for the projection of energy consumption in residential buildings includes the projection of the population, the average size of dwellings, the rate of renovation of the existing housing stock, the rate of new construction, and the assessment of the housing stock that is not used for living. Based on these indicators, the report includes a projection of the total heated floor area of the housing stock of buildings as well as the area concerning the status of the building (old, renovated, new).

Housing stock was separated into **urban** and **rural**, whereby each category was modeled separately. The modeling includes analysis of future energy demand for five purposes (end-uses): space heating, hot water, cooking, cooling, and non-thermal purposes.

We assume that the **household size** (persons per household), will decrease from 3.26 persons per household in 2021 to 2.84 in 2050. This projection of the decrease in household size is made based on the known correlation between the increase in the standard of living (expressed through the GDP per capita indicator) and the decrease in the number of household members. Household size trends in correlation with GDP per capita are shown in the following figure, which also shows the projection for Georgia (thick solid red line).

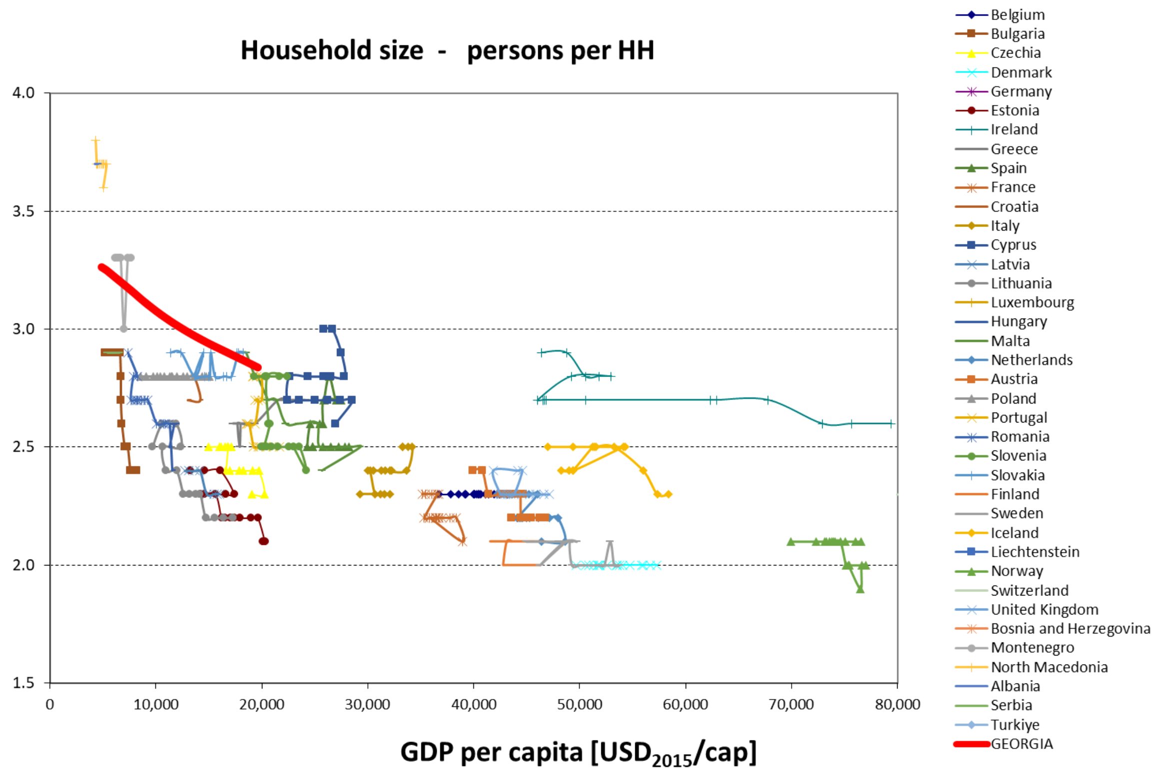


Figure 2-3 Household size projection (data source: WDI, Eurostat, EIHP)

Given the constant population assumptions, the decrease in household size results in an increase in the number of households from 1.14 to 1.34 million households. When bottom-up energy modeling, the basic unit in the household sector is the "household", which does not necessarily equate to the number of customers (number of the gas/electricity meters). It is often the case that the number of meters/customers is greater than the number of households. Therefore, the number of households considered in this model may differ from the data on the number of households used by stakeholders.

We assume a **demolition rate** of 0.5%. The annual demolition rate in the building sector is the percentage of buildings or structures that are torn down or removed from service within a year. It is calculated in relation to the initial building stock (in the base year). This evaluation of the demolition rate is the author's assessment based on knowledge of the situation in other countries and based on relevant scientific literature[2].

We assume a **renovation rate** of 0.5%. This weak renewal rate is driven solely by market principles, without active implementation of measures to encourage energy efficiency (business as usual). Figure 2-4 shows the assumed dynamics of the change in urban and rural households in terms of newly built and renovated households.

[2] N.H. Sandberg, et al., Dynamic building stock modelling: Application to 11 European countries to support the energy efficiency and retrofit ambitions of the EU, Energy Buildings (2016),

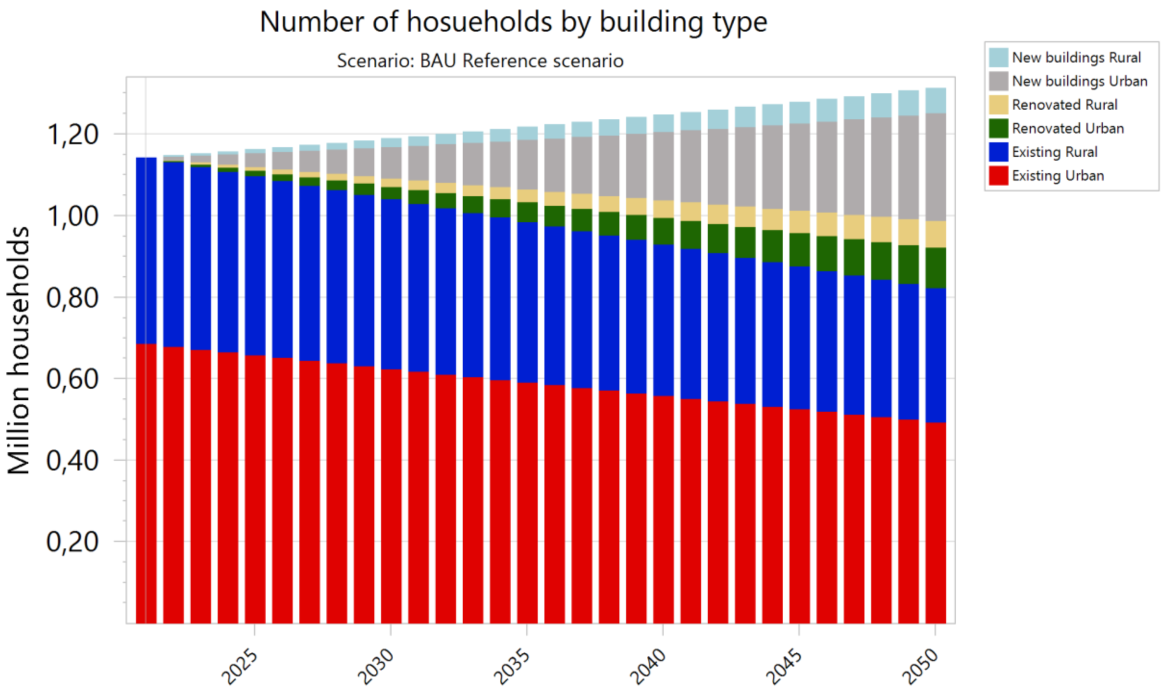


Figure 2-4 Number of households by categories

Source: EIHP (LEAP model results)

2.6.4 Services

The basic determinant of energy consumption in the service sector is the floor area. To predict the future area of the service sector, it is necessary to calculate the area of the service sector per inhabitant and compare this indicator with that of more economically developed countries. Based on this, the future increase in the service sector per inhabitant can be estimated, which will follow the economic development of the country. The total area of the service sector is calculated by multiplying the described indicator and population projection.

As part of the created BAU scenario, the total floor area of the service sector is estimated at 25 million square meters, which represents a ratio of 6.7 m² per capita. This parameter is projected to reach a value of 12 m² per capita in 2050. When considering the population projections, the future floor area is projected to be 31.1 million square meters in 2030 and 44,8 million square meters in 2050.

Additionally, an important parameter for determining the useful energy demand for heating and cooling is the load factor (the share of the surface that requires heating or cooling). In the base year, the load factor for the heated surface is set at 0.65 and it increases to 0.7 in 2030 and 0.8 in 2050, while the load factor for the cooled surface is 0.4 and increases to 0.65 by 2050. The heated surface factor value of 0.65 in the base year was determined during the calibration of energy consumption in the base year. This value is close to the value in other countries such as Croatia, where this factor was obtained based on a survey. The projections assume that the development of the service sector will manifest itself through the area of buildings that require space heating or cooling. The report assumes the existing service sector buildings will have a tendency to install space cooling devices. However, this load factor never reaches values above 0.8 as there is always a certain part of the surface of the service sector that does not require heating or cooling (warehouses, areas for special purposes).

A part of the electricity consumption in the serviced sector energy balance is classified into the consumption categories: "public lighting" and "other consumption". The category of "public lighting" includes electricity consumption associated with outdoor lighting fixtures, such as streetlights and other public infrastructure lighting. On the other hand, the "other consumption" category covers all electricity usage that occurs outside of buildings, encompassing various applications like outdoor equipment, signage, or other external electricity-dependent devices. By clearly distinguishing these two categories, we can attribute the remaining electricity consumption to activities occurring within buildings.

To model the final energy demand in the service sector we assume a **demolition rate** of 0.5% annually. Again, as in the case of households, the annual demolition rate in the building sector is the percentage of buildings or structures that are torn down or removed from service within a year. It is calculated in relation to the initial building stock (in the base year).

Furthermore, the **renovation rate** is assumed at 0.5% annually. A very weak renewal rate is also driven solely by market principles, without active implementation of measures to encourage energy efficiency (business as usual). The following figure shows the evolution of the floor area in the service sector in the observed period.

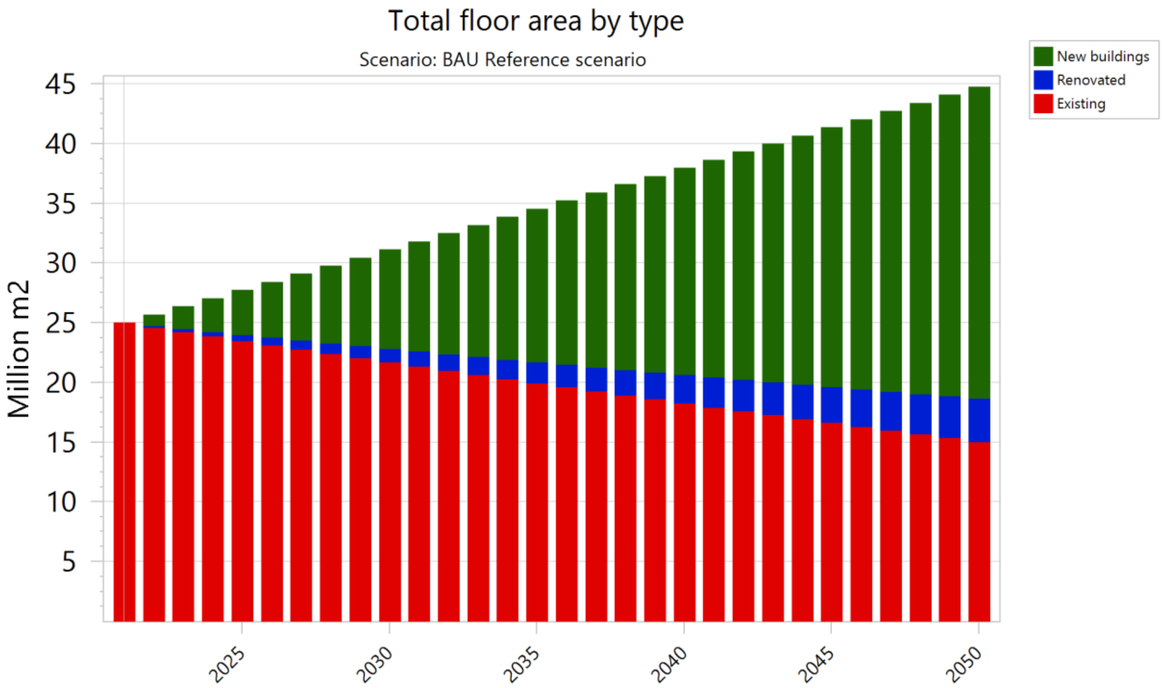


Figure 2-5 Floor area (m^2) of the service sector by categories

Source: EIHP (LEAP model results)

Furthermore, we assume a moderate increase (share) in the use of heat pumps. Most often, these are space cooling devices (AC split systems) that can also be used for space heating, especially in the transitional period between summer and winter. Sometimes such devices are the only source of heat, most often in smaller spaces for service activities (for example, hair salons, various trades, and small shops).

The energy obtained from the environment through heat pump operation is called **ambient heat** [3]and is included in the final energy consumption in the model.

After the calculation of the results of the final energy consumption based on the described assumptions, a check of the movement of the **energy intensities** of electricity as well as other energy sources that are primarily used for thermal uses was carried out. Projected energy intensities as well as indicators such as per capita consumption were compared with the historical trends of these values and other European countries. This is shown in the following charts.

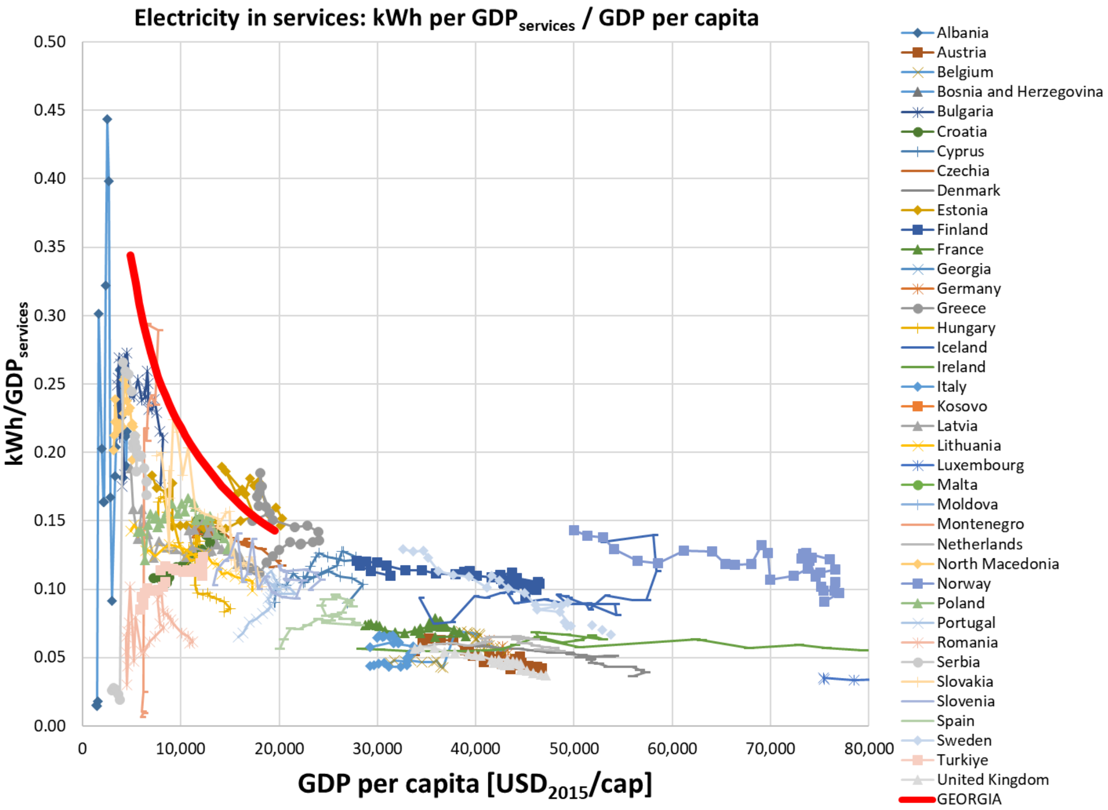


Figure 2-6 Final energy intensity of electricity in the service sector

Source: EIHP, data: WDI, EUROSTAT

[3] Ambient heat (heat pumps): heat pumps that are driven by electricity or other supplementary energy, to extract (stored) energy from the air, the ground or the water and converts/transfers this into energy to be used elsewhere (e.g. to heat space via underfloor heating systems and/or water in domestic buildings). Heat pumps can be used by individual households as well as at larger scale in industry and in commercial and public services. Energy flows related to heat pumps used for cooling are excluded, only heat pumps used for heating (hot water) are included. *(Source: Eurostat glossary)*

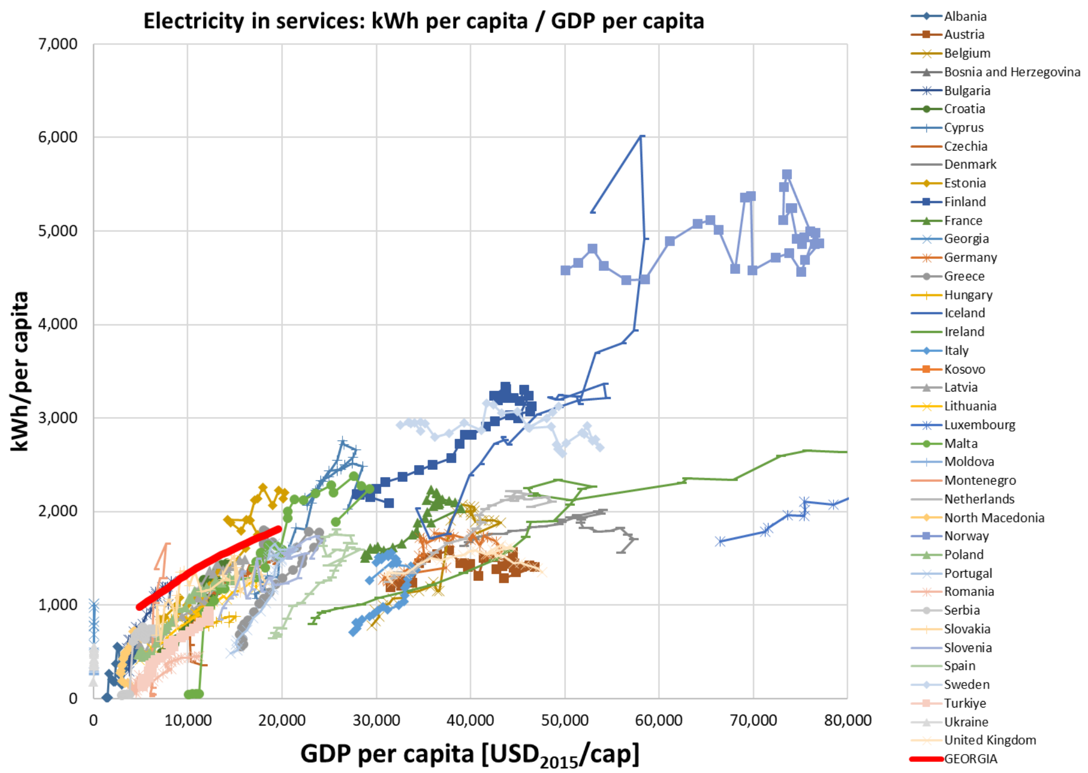


Figure 2-7 Final electricity consumption per capita in the service sector

Source: EIHP, data: WDI, EUROSTAT

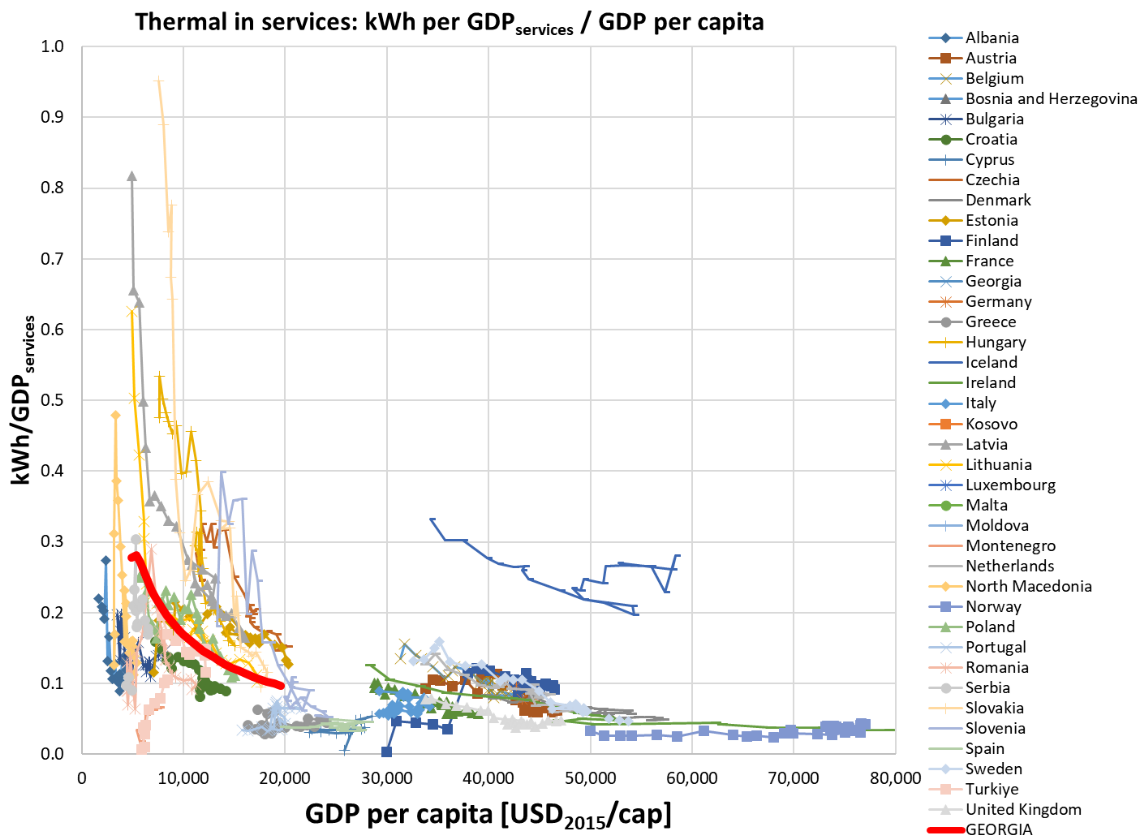


Figure 2-8 Final energy intensity for thermal uses in service sector

Source: EIHP, data: WDI, EUROSTAT

2.6.5 Industry

The main driver of energy consumption in the industry sector is GDP. Therefore, strong GDP growth which was used in the modeling but also the NECP, causes a significant increase in final energy consumption in the industry sector. This is especially relevant for the adjustment made for 2022 and part of 2023 when a marked increase in GDP was recorded. In the industry sector, the manufacturing, mining, and construction sectors were analyzed separately. Figure 2-9 shows the evolution of GDP in the industry sector.

The future energy demand in the industry sector is made based on expected changes in energy intensity, i.e. specific consumption of energy per monetary unit realized in that sector (sectoral GDP).

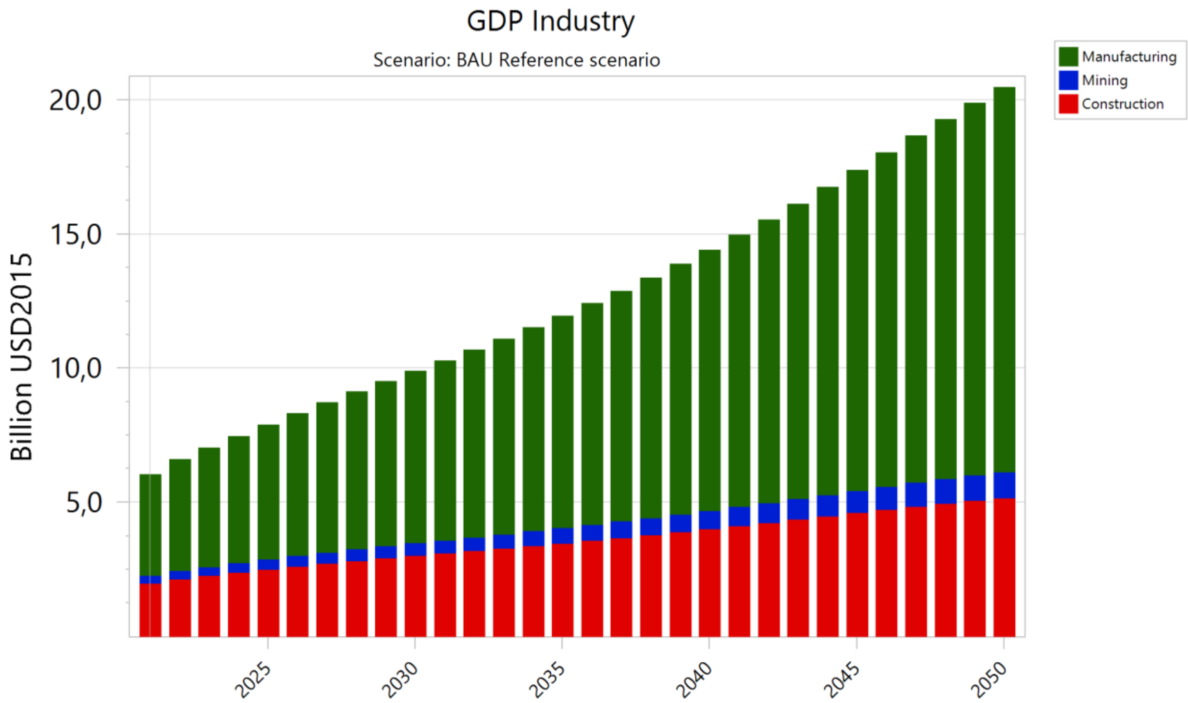


Figure 2-9 GDP projection of industry branches

Source: EIHP (LEAP model results)

The energy intensities determined for all three end-uses (thermal uses, electricity-specific uses, and motive power) are projected to decrease, which means that the growth rate of energy consumption in the industry will be lower than the growth of industry GDP, i.e. with the same energy to produce greater value added.

Projections of key energy intensities for Georgia in the industry sector are presented in the following charts. These represent the historical trends of final energy intensity in correlation with the growth of GDP per capita for a set of mostly European countries.

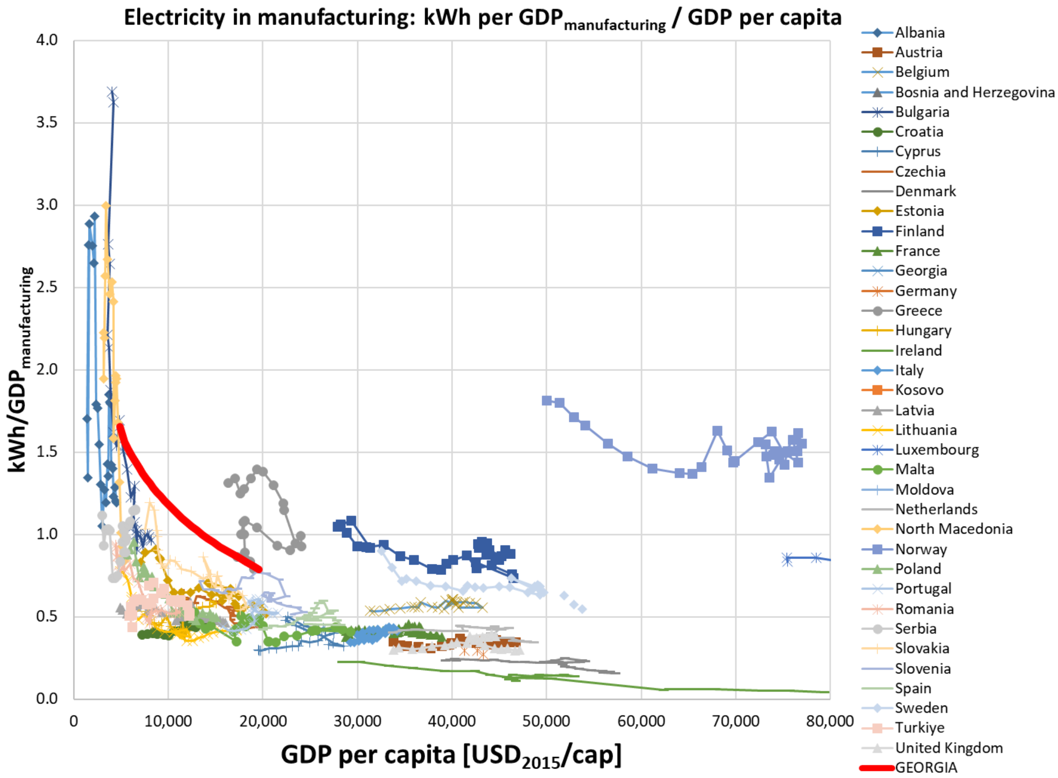


Figure 2-10 Final energy intensity of electricity in the manufacturing sector

Source: EIHP, data: WDI, EUROSTAT

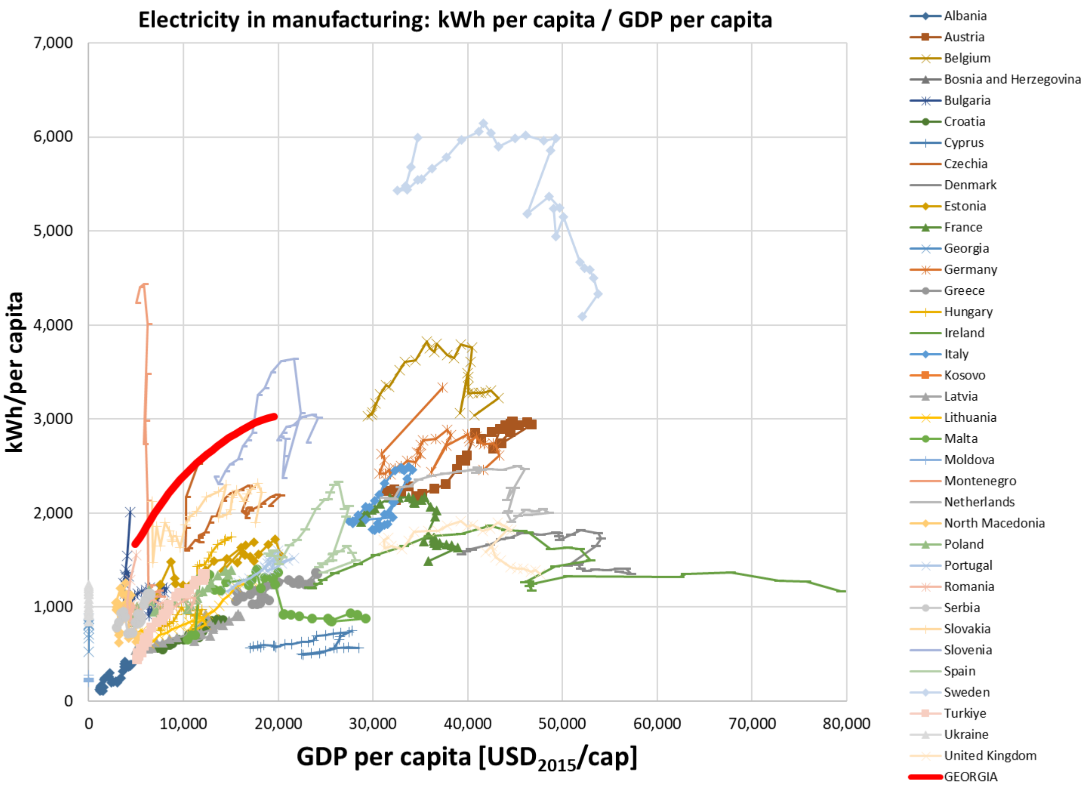


Figure 2-11 Final electricity consumption per capita in the manufacturing sector

Source: EIHP, data: WDI, EUROSTAT

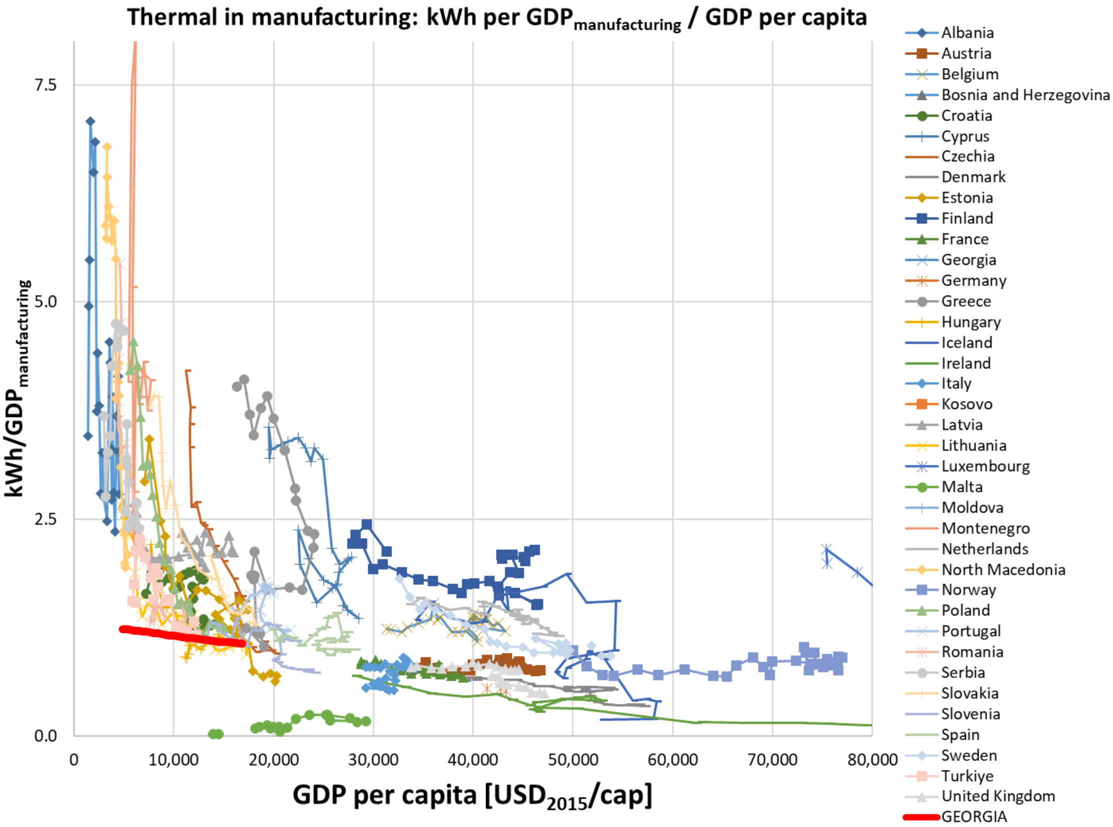


Figure 2-12 Final energy intensity for thermal uses in the manufacturing sector

Source: EIHP, data: WDI, EUROSTAT

In the BAU scenario, the energy intensities tend to move toward the upper limit. Meaning, in some alternative scenarios there is room for additional reduction in energy intensities.

The representation of energy sources in meeting the needs for thermal useful energy is slightly changed in favor of natural gas. The share of natural gas in final energy demand for thermal uses in manufacturing increases from 31% up to 43 %.

2.6.6 Agriculture

The agricultural sector is 0.55% of the total final energy consumption. Absolute energy consumption in the agriculture sector will increase by about 2.5 times by 2050. This is the result of the expected increase in the absolute amount of GDP of the agriculture sector and changes in energy intensity. The initial energy intensities determined for the base year are relatively low. Therefore, no drop in intensity is foreseen and their maintenance is at the same level. However, as the added value of the agriculture sector will grow, the absolute final energy demand is expected to be higher.

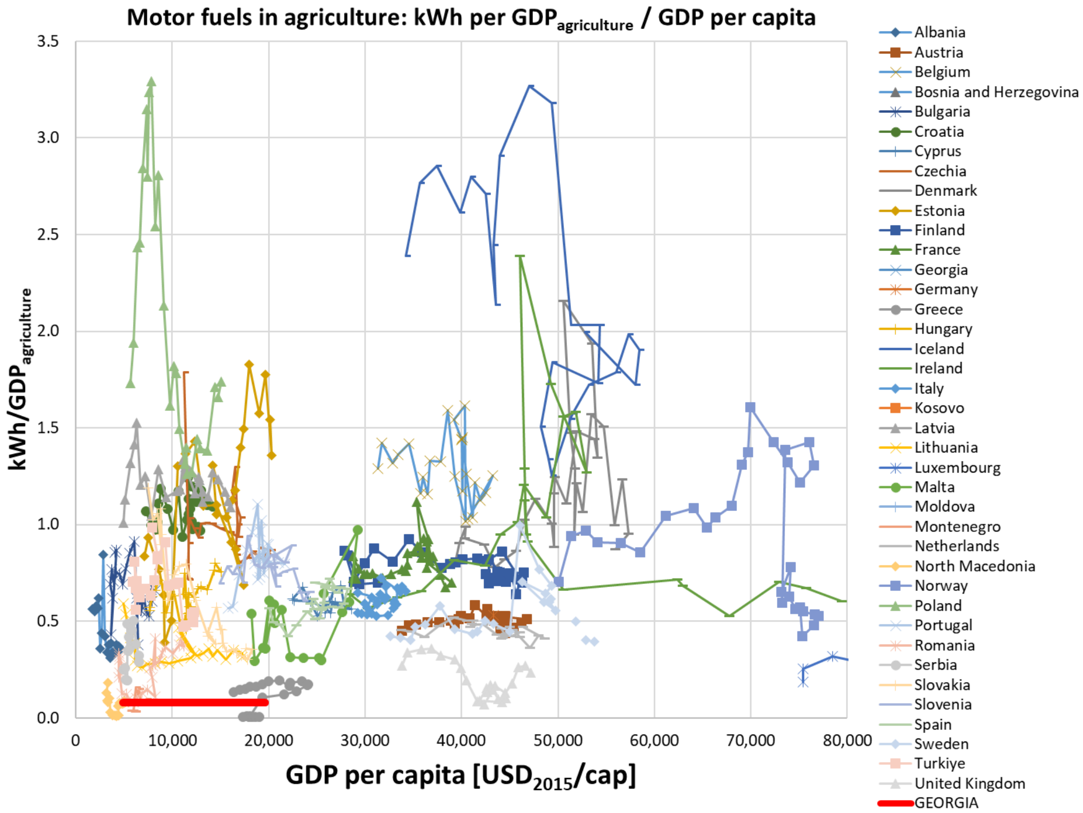


Figure 2-13 Final energy intensity of motor fuels in the agriculture sector

Source: EIHP, data: WDI, EUROSTAT

The calculated energy intensity of motor fuels in the base year is extremely low, pointing to the possibility that the consumption of motor fuels for agriculture is shown in the energy balance as part of another consumption sector. As this is not of significant importance to the study, it was not analyzed further.

2.6.7 Transport

The majority of energy consumption in the transportation sector refers to road transport. It is analyzed in most detail, particularly in the context of CNG vehicles and the long-term penetration of electric vehicles. The GEOSTAT Official data on the number of registered vehicles is used for the analysis of the vehicle fleet.

This scenario assumes a high increase in the number of passenger cars, especially in the first period. The projection of the total number of passenger cars is based on the projection of the "car ownership" indicator, which reflects the ratio of the number of people to cars. There is a well-known correlation between this indicator, which decreases with an increase in the standard of living, or GDP per capita. The chart below shows the historical time series of car ownership trends with GDP per capita growth as well as the car ownership projection for Georgia.

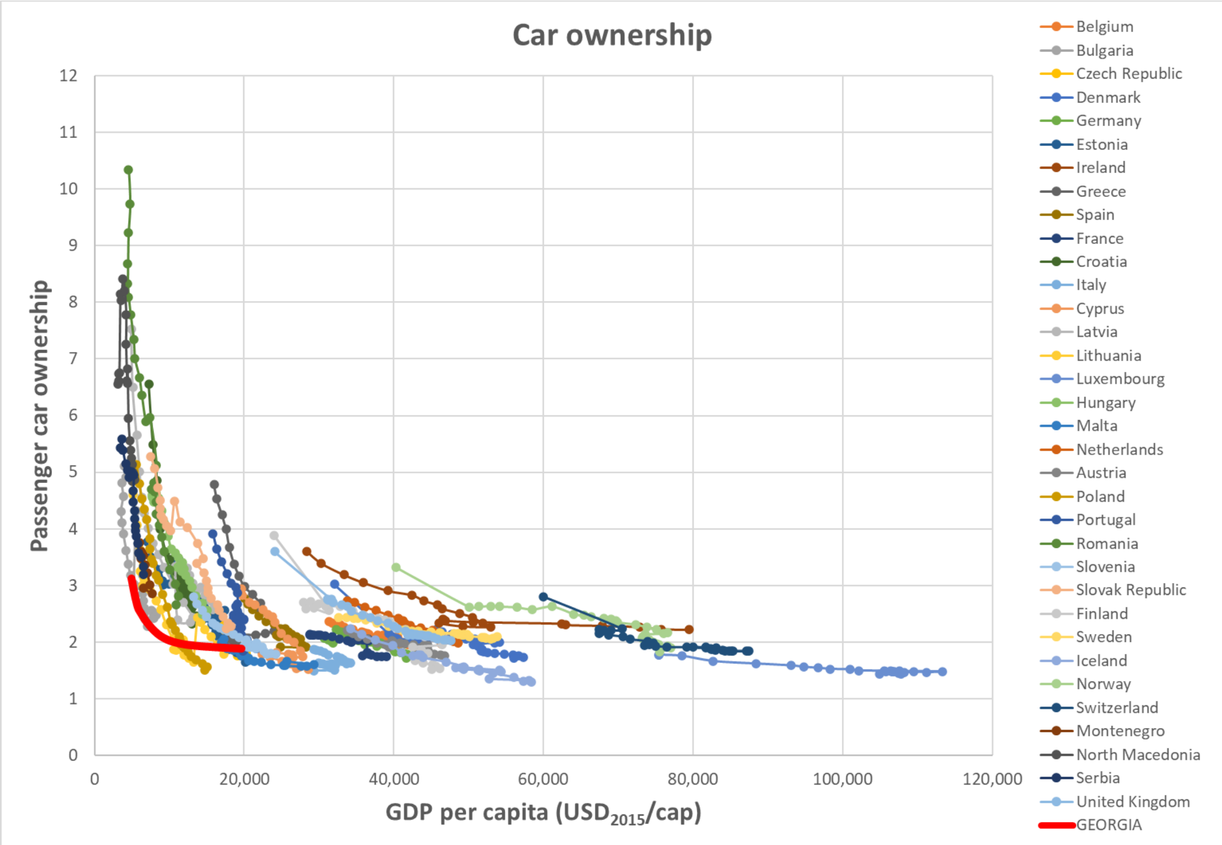


Figure 2-14 Car ownership

Source: WDI, EUROSTAT, EIHP

Table 2-3 Car ownership

	2021	2022	2025	2030	2035	2040	2045	2050
Persons per car	3.12	2.80	2.43	2.15	2.01	1.95	1.92	1.89

Figure 2-15 shows the evolution of the structure of vehicle types in the transport sector.

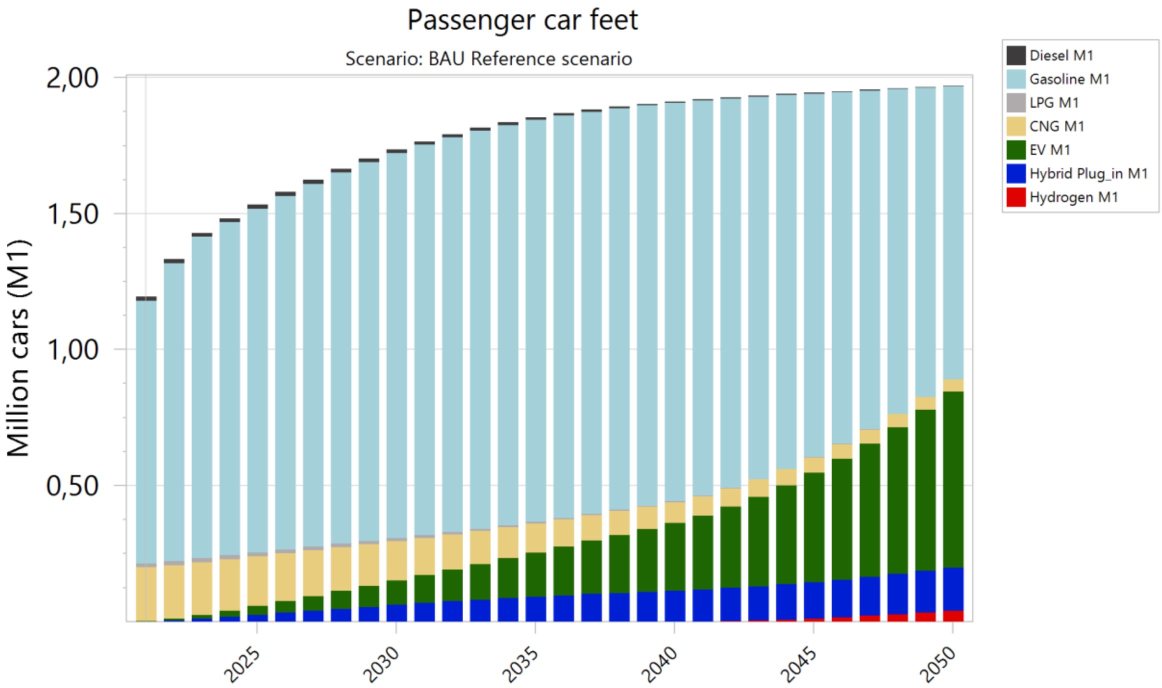


Figure 2-15 Assumed development of the passenger car fleet structure

Source: EIHP (LEAP model results)

Table 2-4 Passenger cars

1000 vehicles	2021	2022	2025	2030	2035	2040	2045	2050
Total passenger cars (M1)	**1,194**	**1,332**	**1,533**	**1,736**	**1,853**	**1,912**	**1,945**	**1,970**

Following these assumptions, the total number of passenger cars in 2050 will reach nearly 2 million cars.

Hybrid vehicles that do not have an external power source (i.e. that are not plug-in hybrids) are not considered, but are included in the "Gasoline" cars category. These vehicles do not consume electrical energy from the grid, but they do consume slightly less gasoline.

There is an assumed reduction of the share of CNG cars in newly registered vehicles, which will gradually lead to a significant reduction of CNG cars in the total vehicle fleet. As a result, a long-term reduction in the consumption of natural gas in road traffic is expected.

The natural gas consumption for pipeline transport, which is shown in the energy balance, is classified as a separate energy source called "natural gas foreign" to distinguish it from other natural gas consumption.

2.7 Modeling Results – Business as Usual Scenario (BAU)

In the following subsections, we present the modeling results in terms of final energy demand, electricity demand by sector, and gas demand by sector. The consumption of natural gas includes the consumption of gas as a feedstock in fertilizer production.

2.7.1 Final Energy Demand

Table 2-5 and Figure 2-16 show the final energy demand in the BAU scenarios (reference scenario).

Table 2-5 Final energy demand - reference scenario (BAU)

Fuel	Unit	2021	2025	2030	2035	2040	2045	2050
Electricity	TWh	13.12	15.06	17.33	19.50	21.80	24.48	27.49
Natural gas	TWh	19.78	23.98	26.36	27.69	29.12	30.69	32.21
Motor Gasoline	TWh	7.28	10.07	11.44	12.14	12.27	11.45	9.54
Kerosene type Jet Fuel	TWh	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Road diesel	TWh	6.81	8.63	9.77	10.31	10.31	9.73	8.58
Fuel oil	TWh	0.00	0.01	0.01	0.01	0.01	0.01	0.01
LPG	TWh	0.46	0.50	0.38	0.23	0.13	0.07	0.05
Coal	TWh	2.61	3.34	4.08	4.79	5.58	6.50	7.36
Fuelwood	TWh	2.74	2.63	2.07	1.74	1.38	1.00	0.62
Solar	TWh	0.04	0.06	0.07	0.09	0.12	0.15	0.17
Geothermal	TWh	0.17	0.19	0.19	0.19	0.19	0.19	0.19
Hydrogen	TWh	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Modern biomass	TWh	0.00	0.04	0.09	0.14	0.19	0.24	0.28
Heating and other gas oil	TWh	0.11	0.11	0.11	0.11	0.11	0.11	0.12
Ambient heat	TWh	0.27	0.38	0.52	0.69	0.88	1.10	1.35
Natural gas foreign	TWh	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Total	**TWh**	**55.91**	**67.48**	**74.92**	**80.13**	**84.59**	**88.24**	**90.48**

Source: EIHP (LEAP model results)

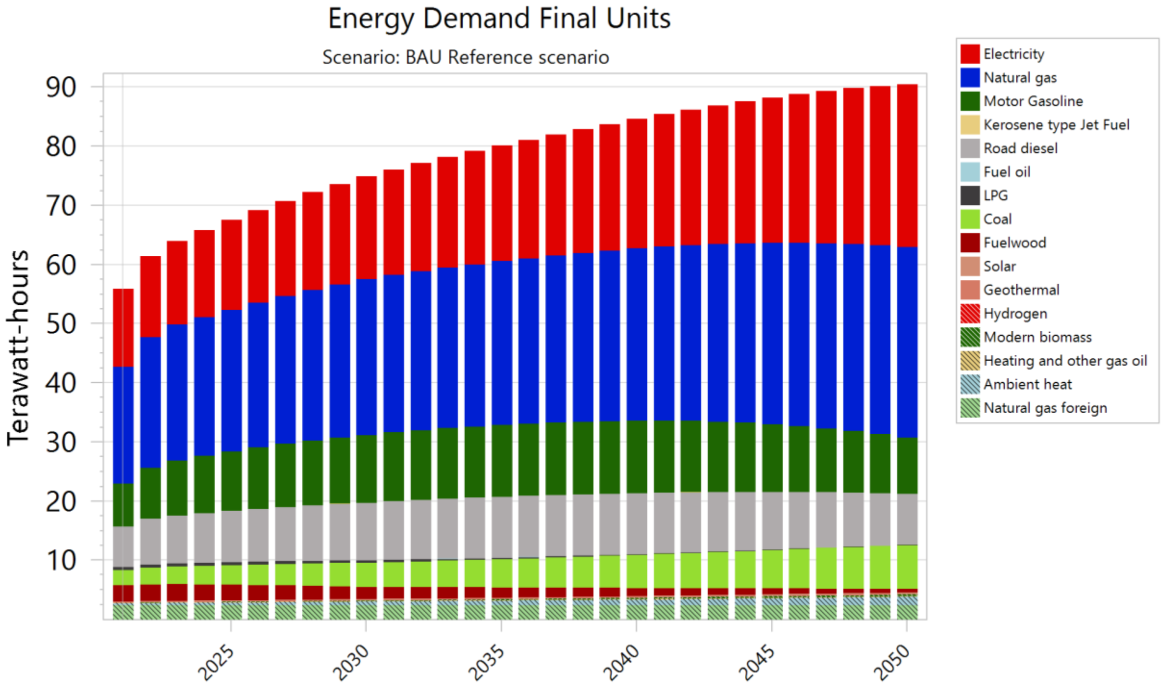


Figure 2-16 Final energy demand – BAU Reference scenario

Source: EIHP (LEAP model results)

Table 2-9 shows the total final energy demand expressed in terajoules.

Table 2-6 Final energy demand - reference scenario (BAU) - terajoules

Fuel	Unit	2021	2025	2030	2035	2040	2045	2050
Electricity	TJ	47,224	54,198	62,399	70,205	78,481	88,126	98,973
Natural gas	TJ	71,225	86,323	94,879	99,685	104,824	110,496	115,959
Motor Gasoline	TJ	26,226	36,237	41,173	43,688	44,158	41,231	34,353
Kerosene type Jet Fuel	TJ	26	26	26	26	26	26	26
Road diesel	TJ	24,528	31,067	35,159	37,108	37,101	35,041	30,899
Fuel oil	TJ	16	20	23	26	30	34	37
LPG	TJ	1,655	1,790	1,360	831	470	269	173
Coal	TJ	9,388	12,024	14,688	17,228	20,100	23,406	26,487
Fuelwood	TJ	9,849	9,478	7,462	6,256	4,958	3,603	2,225
Solar	TJ	141	199	261	341	428	524	627
Geothermal	TJ	629	669	676	677	680	683	685
Hydrogen	TJ	0	0	0	0	0	0	0
Modern biomass	TJ	0	143	326	504	679	851	1,018
Heating and other gas oil	TJ	379	387	394	400	406	413	417
Ambient heat	TJ	975	1,381	1,889	2,484	3,176	3,968	4,864
Natural gas foreign	TJ	9,002	9,002	9,002	9,002	9,002	9,002	9,002
Total	**TJ**	**201,261**	**242,944**	**269,718**	**288,462**	**304,518**	**317,673**	**325,745**

Source: EIHP (LEAP model results)

2.7.2 Final Energy Demand – Electricity

Table 2-7 and Figure 2-17 show the final electricity demand by sector. The consumption of electrical energy shown in the energy balance in the category "not elsewhere specified" is included in the industry sector. The reason for this categorization is the analysis of energy intensities in all sectors in the base year, which showed that a higher consumption of electricity is expected in the industrial sector.

This is the final energy consumption, meaning **the losses of the transmission and distribution system are not included** nor is the power plant's own consumption.

Table 2-7 Final energy demand - Reference scenario (BAU) - Electricity by sector

Sector	Unit	2021	2025	2030	2035	2040	2045	2050
Households	TWh	2.64	2.99	3.47	3.87	4.28	4.70	5.13
Services	TWh	3.64	4.07	4.57	5.08	5.62	6.19	6.77
Industry	TWh	6.52	7.56	8.65	9.60	10.52	11.42	12.04
Agriculture	TWh	0.09	0.13	0.16	0.19	0.23	0.28	0.32
Transport	TWh	0.22	0.31	0.49	0.75	1.14	1.89	3.22
Total	**TWh**	**13.12**	**15.06**	**17.33**	**19.50**	**21.80**	**24.48**	**27.49**

Source: EIHP (LEAP model results)

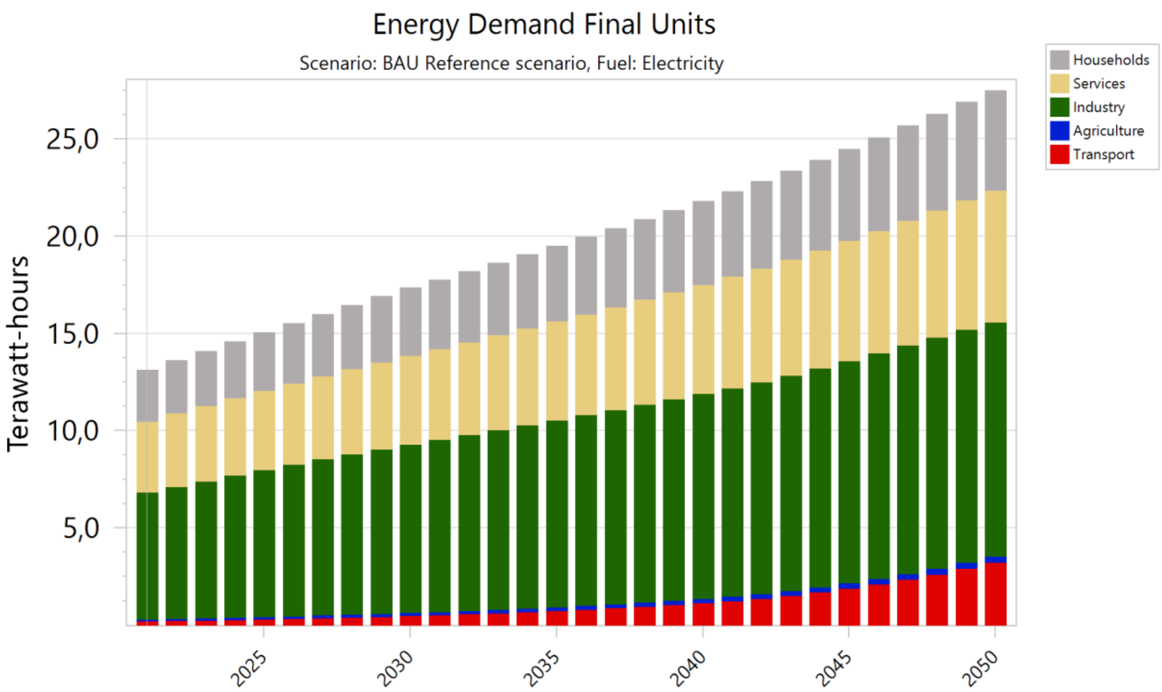


Figure 2-17 Final energy demand – BAU Reference scenario – Electricity by sector

Source: EIHP (LEAP model results)

2.7.3 Final Energy Demand – Natural Gas

Table 2-8 and Figure 2-18 show the projections of final energy demand for natural gas for different sectors. The analysis focused on the adjustment of certain model variables, resulting in a real increase in natural gas consumption in 2022 which aligned with known measured data.

Table 2-8 Final energy demand - Reference scenario - Natural gas by sector

Sector	Unit	2021	2022	2025	2030	2035	2040	2045	2050
Households	TWh	12.00	13.16	14.47	16.07	16.67	17.17	17.60	17.93
Services	TWh	2.56	2.86	3.00	3.11	3.20	3.29	3.38	3.45
Industry	TWh	2.27	2.56	3.08	3.92	4.79	5.80	7.00	8.20
Agriculture	TWh	0.09	0.10	0.12	0.14	0.17	0.19	0.22	0.24
Transport	TWh	1.24	1.51	1.48	1.28	1.04	0.83	0.67	0.55
Feedstocks	TWh	1.62	1.82	1.82	1.82	1.82	1.82	1.82	1.82
Total	**TWh**	**19.78**	**22.01**	**23.98**	**26.36**	**27.69**	**29.12**	**30.69**	**32.21**

Source: EIHP (LEAP model results)

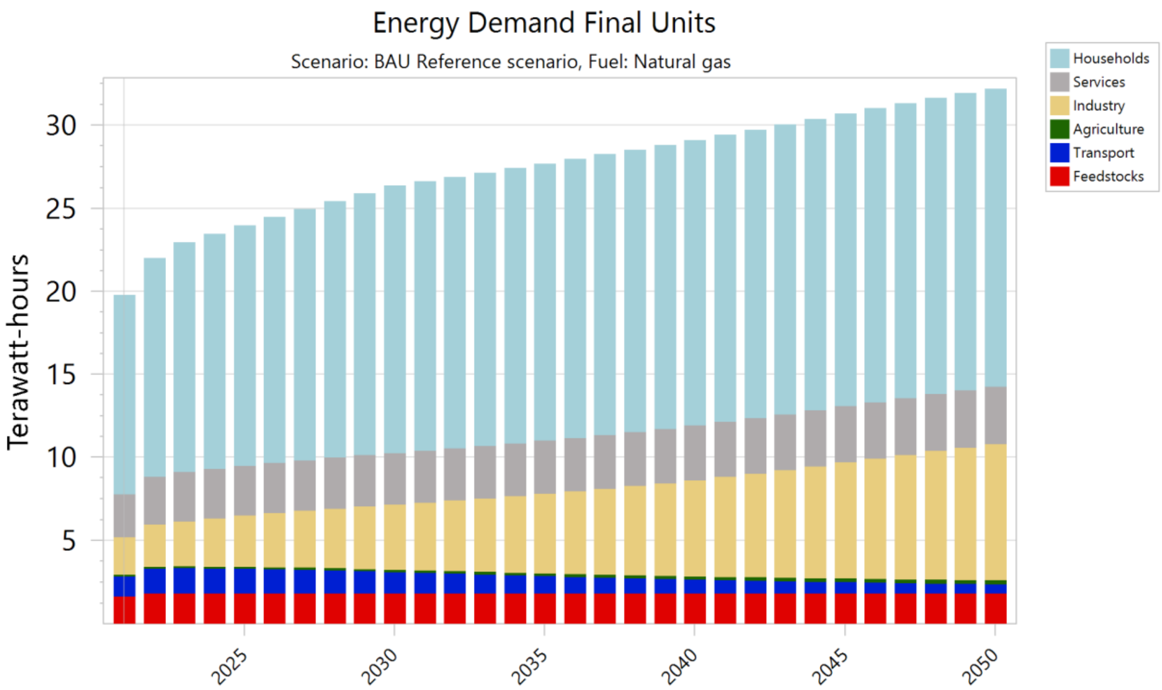


Figure 2-18 Final energy demand – BAU Reference scenario – Natural gas by sector

Source: EIHP (LEAP model results)

Regarding natural gas consumption growth rates, the model is adjusted by sector so that the calculated consumption (i.e. the increase in consumption in 2022) is aligned with the actual measured data. The rates of increase in the consumption of natural gas in a specific year compared to the previous year are shown in the following table.

Table 2-9 Final energy demand - BAU Reference scenario – Natural gas by sector - Percent Growth from Previous Year

Sector	Unit	2022	2025	2030	2035	2040	2045	2050
Households	%	9.64	2.27	2.02	0.67	0.56	0.44	0.34
Services	%	11.57	0.73	0.66	0.60	0.54	0.48	0.42
Industry	%	12.79	6.07	4.19	3.97	3.88	3.82	2.82
Agriculture	%	8.76	5.03	3.14	2.90	2.76	2.63	1.55
Transport	%	21.98	-1.39	-3.71	-4.23	-4.48	-4.03	-3.77
Feedstocks	%	12.50	0.00	0.00	0.00	0.00	0.00	0.00
Total	**%**	**11.25**	**2.15**	**1.74**	**0.99**	**1.02**	**1.08**	**0.88**

Source: EIHP (LEAP model results)

2.8 Scenario with Measures – Key Determinants and Modeling Results

In the following subsections, the results of the scenario modeling with measures in terms of final energy demand, electricity demand by sector, and gas demand by sector are presented. The consumption of natural gas also includes the consumption of gas as a feedstock in the production of fertilizers.

2.8.1 Key Determinants

This scenario is shaped by the three main determinants: **renovation of buildings** to reduce the need for useful energy, increasing the **energy efficiency** of technology, and **fuel switch** from fossil fuels towards renewable energy sources (including electricity).

The primary objective of this scenario is to decrease both final energy demand and emissions in comparison to the Business as Usual (BAU) scenario.

The key determinants of this scenario, including population, household size, GDP, and structure, remain consistent with those of the BAU scenario.

2.8.2 Scenario Modeling

The scenario determinants are implemented in the energy model by changing certain parameters. In this scenario, specific variables undergo changes across various sectors as follows:

Household Sector:

- An increase in the annual renovation rate (from 0.5% to 2.0%);
- A linear improvement in the energy efficiency of technologies for converting final to useful energy (a 10 percentage point increase linearly until 2050);
- A reduction in the share of fossil fuels in the energy sources used for space heating in new and renovated buildings, with replacement by renewable sources or electricity (starting from the base year and continuing linearly until 2050);
- An increased share of solar thermal energy for hot water preparation;
- A slight decrease in the use of natural gas for cooking, substituted by electricity (a 5-10 percentage point reduction).

Service Sector:

- An increased annual renovation rate (from 0.5% to 2.0%);
- A linear enhancement of energy efficiency in technologies converting final to useful energy (mainly by 10 percentage points linearly until 2050);
- A reduction in the share of fossil fuels in the energy sources for space heating in new and renovated buildings, replaced by renewable sources or electricity (starting from the base year and continuing linearly until 2050);
- A decrease in the share of fossil fuels used for other thermal purposes, replaced by solar thermal and electricity;
- An annual reduction of electricity consumption for public lighting (2%) through energy efficiency measures, such as renovating the public lighting system with new LED fixtures.

Industry Sector:

- Complete elimination of coal from the Manufacturing sector by 2050, replaced with hydrogen, natural gas, and electricity;
- A slight substitution of natural gas with electricity in the Construction and Mining sub-sectors;

- A linear increase in the energy efficiency of technologies converting final to useful energy (mainly by 10 percentage points linearly until 2050);

Transport:

- Changes in the vehicle registration structures across all categories, including a reduction in vehicles powered by fossil fuels and their replacement with vehicles using alternative drives (primarily electricity and hydrogen);
    - Electric Vehicle (EV) share in the passenger car fleet: 7% in 2030, increasing to 46.4% in 2050;
    - EV share in the light-duty vehicle N1 category: 9.2% in 2030, increasing to 60% in 2050;
    - Hydrogen vehicles in the bus M3 category: 0.5% in 2030, increasing to 14.5% in 2050;
    - Hydrogen vehicles in the freight N2 and N3 category: 25.3% in 2050.

2.8.3 Final Energy Demand

Table 2-10 and Figure 2-19 show the final energy demand in the Scenario with measures.

Table 2-10 Final energy demand - Scenario with measures

Fuel	Unit	2021	2025	2030	2035	2040	2045	2050
Electricity	TWh	13.12	15.29	17.87	20.22	22.76	25.89	29.31
Natural gas	TWh	19.78	23.15	23.93	23.69	23.55	22.52	21.21
Motor Gasoline	TWh	7.28	9.95	11.03	11.27	10.82	9.42	6.95
Kerosene type Jet Fuel	TWh	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Road diesel	TWh	6.81	8.61	9.62	9.84	9.29	8.12	6.43
Fuel oil	TWh	0.00	0.01	0.01	0.01	0.01	0.01	0.01
LPG	TWh	0.46	0.49	0.37	0.22	0.12	0.06	0.03
Coal	TWh	2.61	2.88	2.81	2.48	1.93	1.12	0.00
Fuelwood	TWh	2.74	2.45	1.67	1.19	0.79	0.48	0.26
Solar	TWh	0.04	0.06	0.10	0.15	0.22	0.29	0.38
Geothermal	TWh	0.17	0.18	0.18	0.18	0.18	0.18	0.18
Hydrogen	TWh	0.00	0.00	0.12	0.75	1.56	3.56	5.91
Modern biomass	TWh	0.00	0.12	0.31	0.48	0.65	0.80	0.95
Heating and other gas oil	TWh	0.11	0.11	0.11	0.11	0.11	0.11	0.12
Ambient heat	TWh	0.27	0.42	0.62	0.86	1.13	1.43	1.76
Natural gas foreign	TWh	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Total	**TWh**	**55.91**	**66.24**	**71.27**	**73.97**	**75.63**	**76.50**	**76.01**

Source: EIHP (LEAP model results)

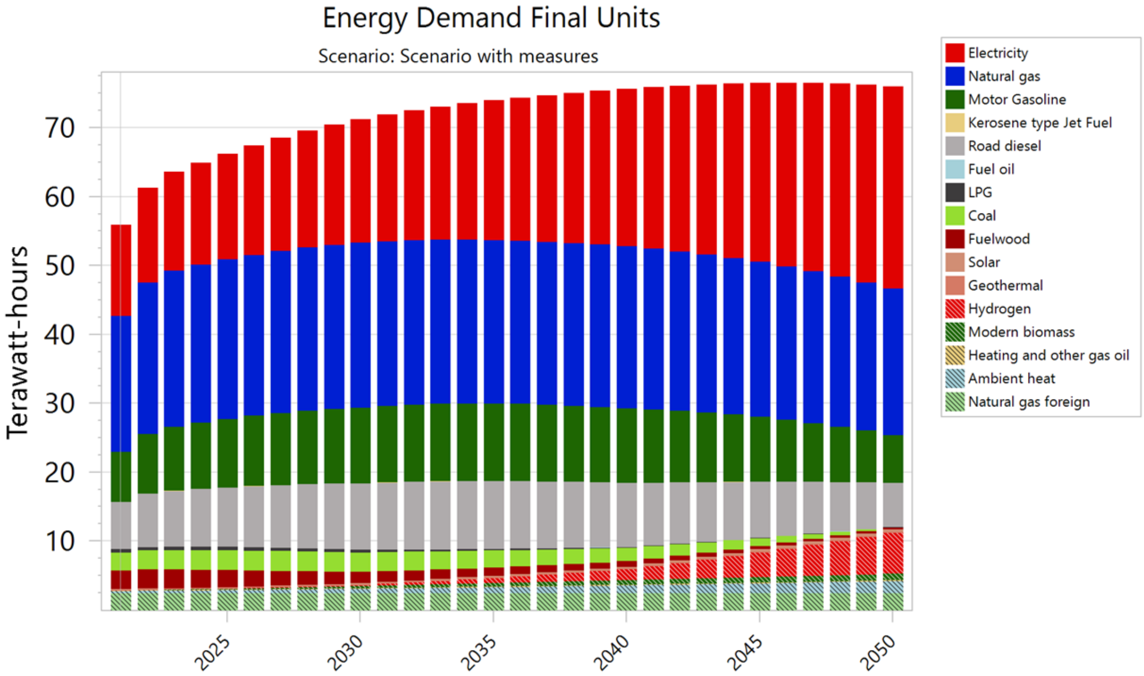


Figure 2-19 Final energy demand – Scenario with measures

Source: EIHP (LEAP model results)

Table 2-11 shows the total final energy demand expressed in terajoules.

Table 2-11 Final energy demand - Scenario with measures - terajoules

Fuel	Unit	2021	2025	2030	2035	2040	2045	2050
Electricity	TJ	47,224	55,031	64,339	72,788	81,926	93,213	105,529
Natural gas	TJ	71,225	83,354	86,145	85,295	84,796	81,058	76,356
Motor Gasoline	TJ	26,226	35,829	39,713	40,561	38,958	33,901	25,021
Kerosene type Jet Fuel	TJ	26	26	26	26	26	26	26
Road diesel	TJ	24,528	30,991	34,634	35,434	33,455	29,234	23,157
Fuel oil	TJ	16	19	22	25	28	31	33
LPG	TJ	1,655	1,781	1,332	790	421	217	122
Coal	TJ	9,388	10,367	10,133	8,916	6,939	4,045	10
Fuelwood	TJ	9,849	8,824	6,003	4,289	2,853	1,728	928
Solar	TJ	141	228	367	554	785	1,060	1,383
Geothermal	TJ	629	664	661	652	644	638	630
Hydrogen	TJ	0	0	430	2,712	5,623	12,809	21,276
Modern biomass	TJ	0	438	1,107	1,737	2,331	2,890	3,414
Heating and other gas oil	TJ	379	387	393	399	405	411	415
Ambient heat	TJ	975	1,510	2,249	3,098	4,063	5,143	6,336
Natural gas foreign	TJ	9,002	9,002	9,002	9,002	9,002	9,002	9,002
Total	**TJ**	**201,261**	**238,450**	**256,557**	**266,276**	**272,255**	**275,406**	**273,639**

Source: EIHP (LEAP model results)

2.8.4 Final Energy Demand – Electricity

Table 2-12 and Figure 2-20 show the resulting final electricity demand by sector.

This is the final consumption of energy, which means that **the losses of the transmission and distribution system are not included**, nor is the power plant's own consumption.

Table 2-12 Final energy demand - Scenario with measures - Electricity by sector

Sector	Unit	2021	2025	2030	2035	2040	2045	2050
Households	TWh	2.64	2.92	3.34	3.76	4.20	4.66	5.13
Services	TWh	3.64	4.11	4.60	5.11	5.64	6.20	6.79
Industry	TWh	6.52	7.79	9.15	10.08	10.96	12.03	12.86
Agriculture	TWh	0.09	0.13	0.16	0.19	0.23	0.28	0.32
Transport	TWh	0.22	0.34	0.62	1.08	1.72	2.72	4.21
Total	**TWh**	**13.12**	**15.29**	**17.87**	**20.22**	**22.76**	**25.89**	**29.31**

Source: EIHP (LEAP model results)

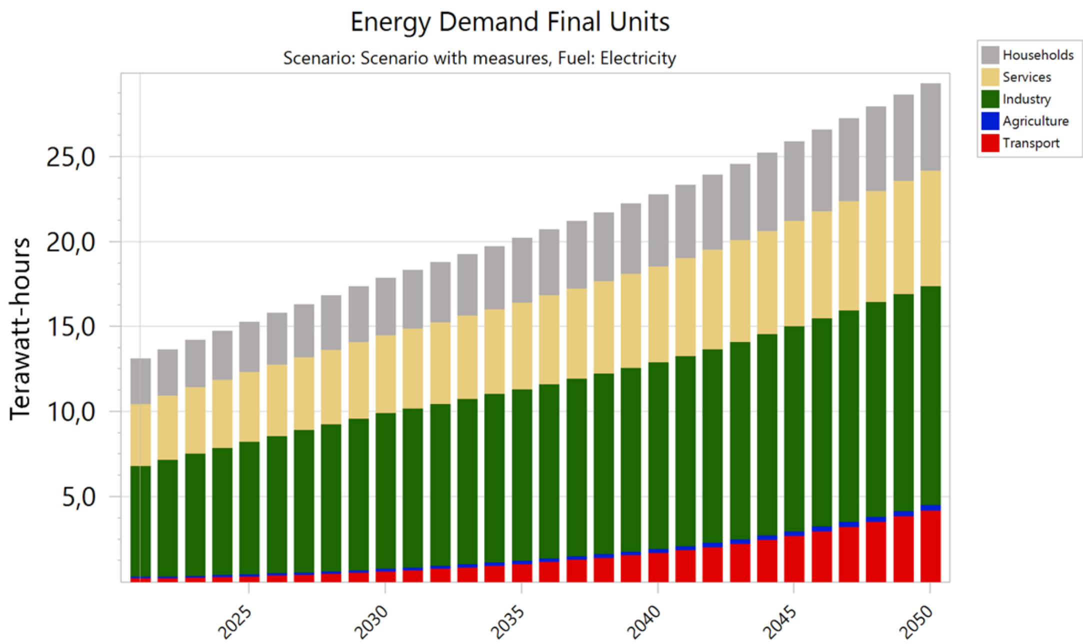


Figure 2-20 Final energy demand – Scenario with measures - Electricity by sector

Source: EIHP (LEAP model results)

2.8.5 Final Energy Demand – Natural Gas

Table 2-13 and Figure 2-21 show the projections of final energy demand for natural gas by different sectors.

Table 2-13 Final energy demand - Scenario with measures - Natural gas by sector

Sector	Unit	2021	2025	2030	2035	2040	2045	2050
Households	TWh	12.00	13.82	13.96	13.03	11.93	10.68	9.30
Services	TWh	2.56	2.72	2.45	2.20	1.98	1.78	1.60
Industry	TWh	2.27	3.19	4.27	5.43	6.81	7.38	7.76
Agriculture	TWh	0.09	0.12	0.14	0.17	0.19	0.22	0.24
Transport	TWh	1.24	1.48	1.28	1.04	0.81	0.63	0.49
Feedstocks	TWh	1.62	1.82	1.82	1.82	1.82	1.82	1.82
Total	**TWh**	**19.78**	**23.15**	**23.93**	**23.69**	**23.55**	**22.52**	**21.21**

Source: EIHP (LEAP model results)

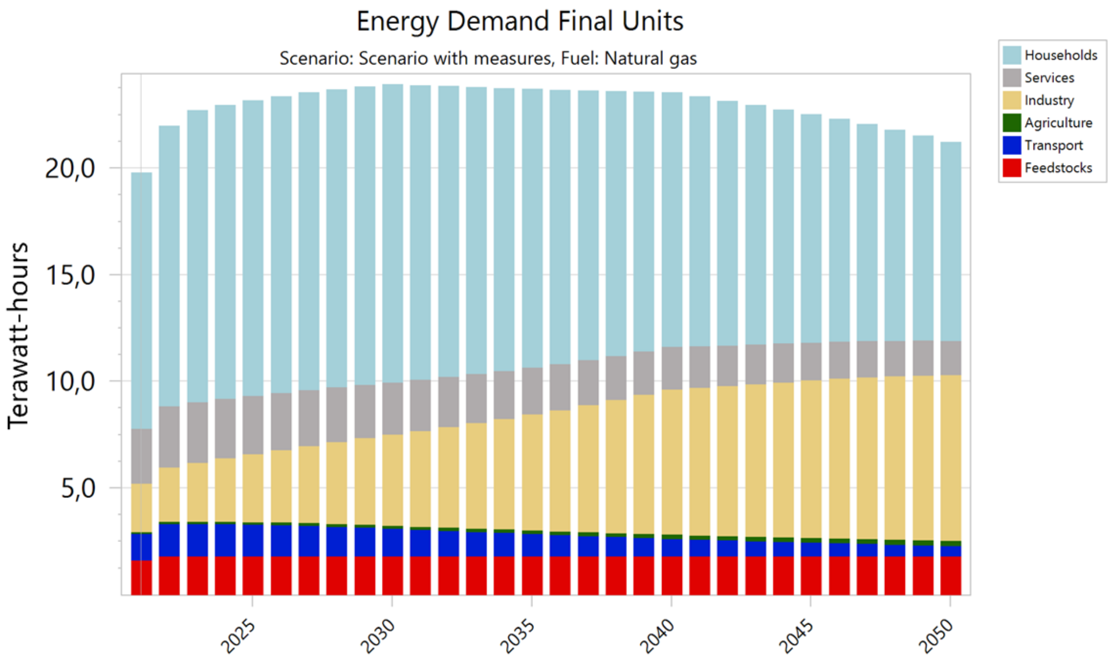


Figure 2-21 Final energy demand – Scenario with measures - Natural gas by sector

Source: EIHP (LEAP model results)

2.9 High Gas Consumption Scenario - Key Determinants and Modeling Results

The second alternative scenario, known as the **High Gas Consumption Scenario**, has been designed to illustrate the highest achievable but still within the bounds of realistic, natural gas consumption levels.

In the following subsections, we present the results of the modeling for the High Gas Consumption Scenario in terms of final energy demand, electricity demand by sector, and gas demand by sector. The consumption of natural gas also includes the consumption of gas as a feedstock in the production of fertilizers.

2.9.1 Key Determinants

The High Gas Consumption Scenario is based on the BAU scenario, and the projected useful energy demand is completely equal. This means that in the alternative scenario identical needs for thermal energy are assumed as the same as in the BAU scenario. However, the crucial difference is in the shares of final energy sources that are used to satisfy these thermal needs. In the High Gas Scenario, a higher proportion of natural gas is assumed to meet useful thermal energy needs than in the BAU scenario.

The key determinants of this scenario, including population, household size, GDP, and structure, remain consistent with those of the BAU scenario.

2.9.2 Scenario Modeling

The above-described scenario determinant is implemented in the energy model by changing certain parameters. In this scenario, specific variables undergo changes across various sectors as follows:

Household Sector:

- Increase in the share of natural gas in the representation of energy sources in all types of buildings for all thermal energy purposes (linearly until 2050).

Service Sector:

- Increase in the share of natural gas in the representation of energy sources in all types of buildings for all thermal energy purposes (linearly until 2050).

Industry Sector:

- Current coal consumption remains stable, with a slight shift towards natural gas as an alternative,
- In addition, nearly all newly established industrial facilities predominantly rely on natural gas to meet their thermal energy requirements.

Transport:

- Changes in the structures of newly registered vehicles in all categories - maintaining the popularity of CNG vehicles in the appropriate categories (stopping the downward trend in natural gas consumption in the transport sector).

Feedstocks:

- Increased consumption of natural gas used as raw material to produce mineral fertilizers (by 100% in 2030).

2.9.3 Final Energy Demand

Table 2-14 and Figure 2-22 show the final energy demand in the High Gas Consumption Scenario.

Table 2-14 Final energy demand - High Gas Consumption Scenario

Fuel	Unit	2021	2025	2030	2035	2040	2045	2050
Electricity	TWh	13.12	14.99	17.08	18.98	20.97	23.29	25.90
Natural gas	TWh	19.78	24.55	29.70	32.27	35.06	38.19	41.45
Motor Gasoline	TWh	7.28	9.97	11.13	11.65	11.72	10.92	9.03
Kerosene type Jet Fuel	TWh	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Road diesel	TWh	6.81	8.62	9.70	10.18	10.14	9.56	8.43
Fuel oil	TWh	0.00	0.01	0.01	0.01	0.01	0.01	0.01
LPG	TWh	0.46	0.50	0.38	0.23	0.13	0.07	0.05
Coal	TWh	2.61	3.01	3.18	3.14	2.97	2.66	2.10
Fuelwood	TWh	2.74	2.53	1.66	1.40	1.12	0.83	0.54
Solar	TWh	0.04	0.06	0.07	0.09	0.12	0.14	0.17
Geothermal	TWh	0.17	0.19	0.19	0.19	0.19	0.19	0.19
Hydrogen	TWh	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Modern biomass	TWh	0.00	0.03	0.06	0.08	0.10	0.12	0.13
Heating and other gas oil	TWh	0.11	0.11	0.11	0.11	0.11	0.11	0.12
Ambient heat	TWh	0.27	0.36	0.46	0.57	0.69	0.82	0.95
Natural gas foreign	TWh	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Total	**TWh**	**55.91**	**67.42**	**76.23**	**81.41**	**85.84**	**89.43**	**91.57**

Source: EIHP (LEAP model results)

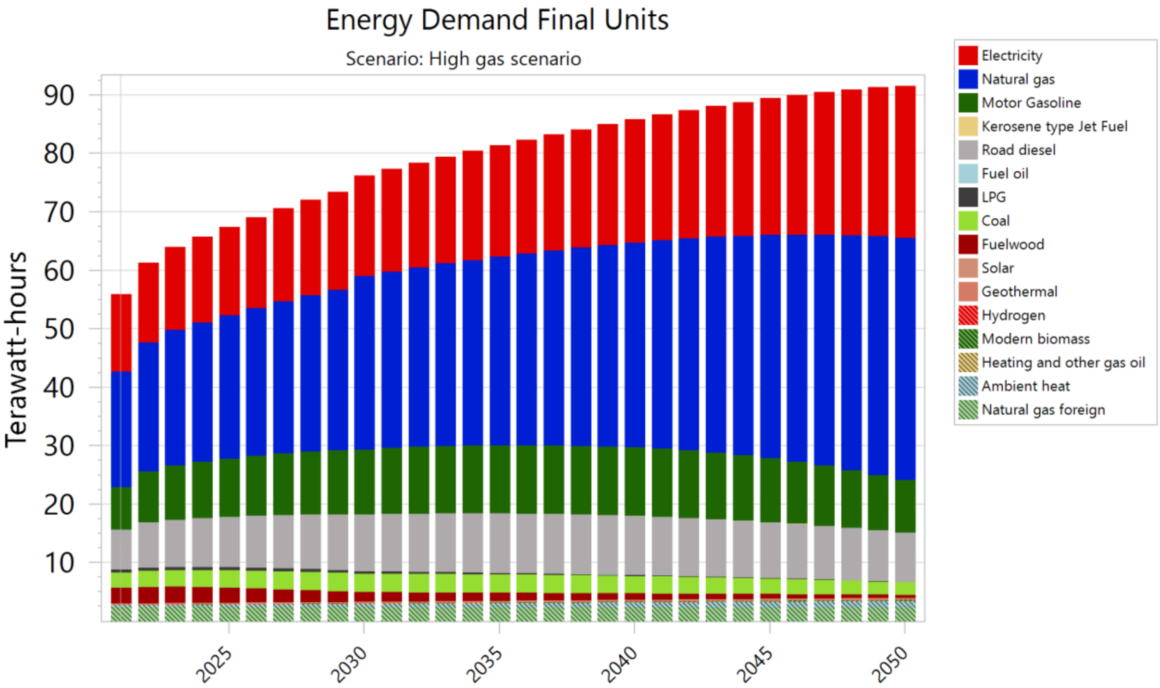


Figure 2-22 Final energy demand – High Gas Consumption Scenario

Source: EIHP (LEAP model results)

Table 2-15 shows the total final energy demand expressed in terajoules.

Table 2-15 Final energy demand - High Gas Consumption Scenario - terajoules

Fuel	Unit	2021	2025	2030	2035	2040	2045	2050
Electricity	TJ	47,224	53,972	61,489	68,327	75,482	83,831	93,257
Natural gas	TJ	71,225	88,369	106,923	116,186	126,199	137,500	149,202
Motor Gasoline	TJ	26,226	35,909	40,074	41,930	42,205	39,316	32,493
Kerosene type Jet Fuel	TJ	26	26	26	26	26	26	26
Road diesel	TJ	24,528	31,028	34,923	36,661	36,513	34,416	30,339
Fuel oil	TJ	16	20	23	26	30	34	37
LPG	TJ	1,655	1,790	1,360	831	470	269	173
Coal	TJ	9,388	10,840	11,434	11,291	10,699	9,577	7,575
Fuelwood	TJ	9,849	9,101	5,969	5,040	4,042	3,001	1,942
Solar	TJ	141	198	260	338	424	517	618
Geothermal	TJ	629	669	676	677	680	683	685
Hydrogen	TJ	0	0	0	0	0	0	0
Modern biomass	TJ	0	92	200	291	369	432	481
Heating and other gas oil	TJ	379	387	394	400	406	413	417
Ambient heat	TJ	975	1,302	1,667	2,061	2,487	2,939	3,411
Natural gas foreign	TJ	9,002	9,002	9,002	9,002	9,002	9,002	9,002
Total	**TJ**	**201,261**	**242,705**	**274,420**	**293,088**	**309,033**	**321,956**	**329,661**

Source: EIHP (LEAP model results)

2.9.4 Final Energy Demand – Electricity

Table 2-16 and Figure 2-23 show the resulting final electricity demand by sector.

This is the final consumption of energy, which means that **the losses of the transmission and distribution system are not included**, nor is the power plant's own consumption.

Table 2-16 Final energy demand - High Gas Consumption Scenario - Electricity by sector

Sector	Unit	2021	2025	2030	2035	2040	2045	2050
Households	TWh	2.64	2.97	3.42	3.75	4.08	4.42	4.77
Services	TWh	3.64	4.02	4.45	4.90	5.37	5.86	6.38
Industry	TWh	6.52	7.56	8.56	9.39	10.15	10.84	11.22
Agriculture	TWh	0.09	0.13	0.16	0.19	0.23	0.28	0.32
Transport	TWh	0.22	0.31	0.48	0.75	1.13	1.89	3.22
Total	**TWh**	**13.12**	**14.99**	**17.08**	**18.98**	**20.97**	**23.29**	**25.90**

Source: EIHP (LEAP model results)

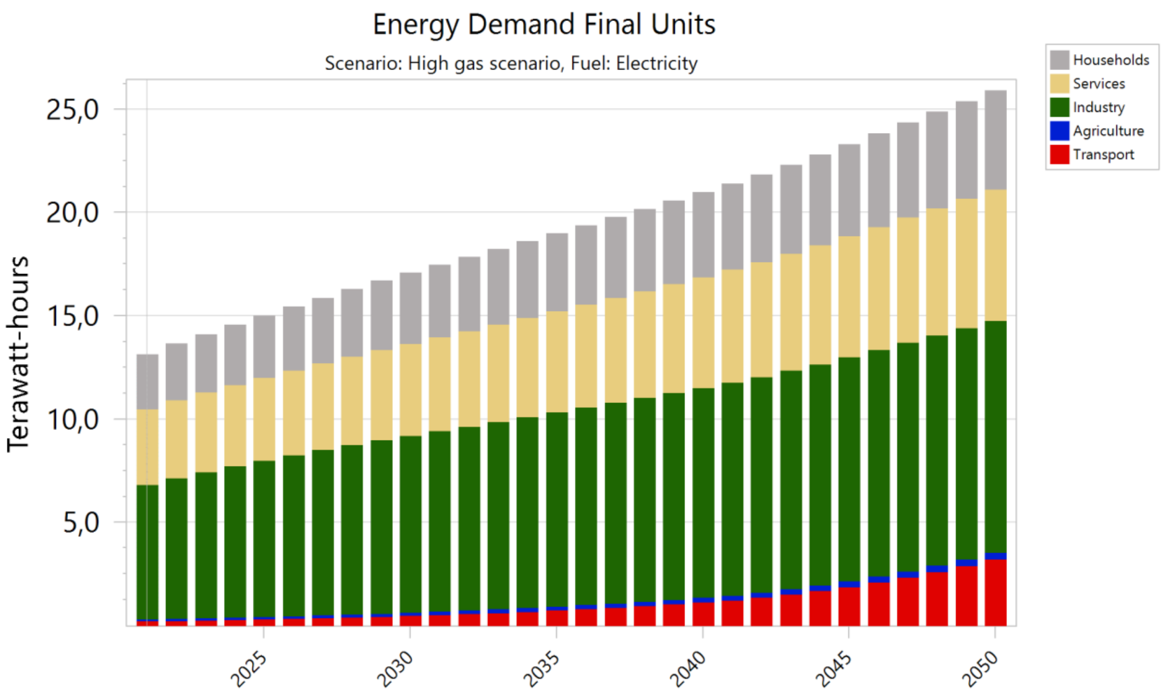


Figure 2-23 Final energy demand – High Gas Consumption Scenario - Electricity by sector

Source: EIHP (LEAP model results)

2.9.5 Final Energy Demand – Natural Gas

Table 2-17 and Figure 2-24 show the projections of final energy demand for natural gas by different sectors.

Table 2-17 Final energy demand - High Gas Consumption Scenario - Natural gas by sector

Sector	Unit	2021	2025	2030	2035	2040	2045	2050
Households	TWh	12.00	14.61	16.52	17.22	17.86	18.42	18.91
Services	TWh	2.56	3.07	3.28	3.49	3.72	3.95	4.18
Industry	TWh	2.27	3.36	4.81	6.44	8.44	10.89	13.50
Agriculture	TWh	0.09	0.12	0.14	0.17	0.19	0.22	0.24
Transport	TWh	1.24	1.56	1.62	1.62	1.52	1.39	1.28
Feedstocks	TWh	1.62	1.82	3.33	3.33	3.33	3.33	3.33
Total	**TWh**	**19.78**	**24.55**	**29.70**	**32.27**	**35.06**	**38.19**	**41.45**

Source: EIHP (LEAP model results)

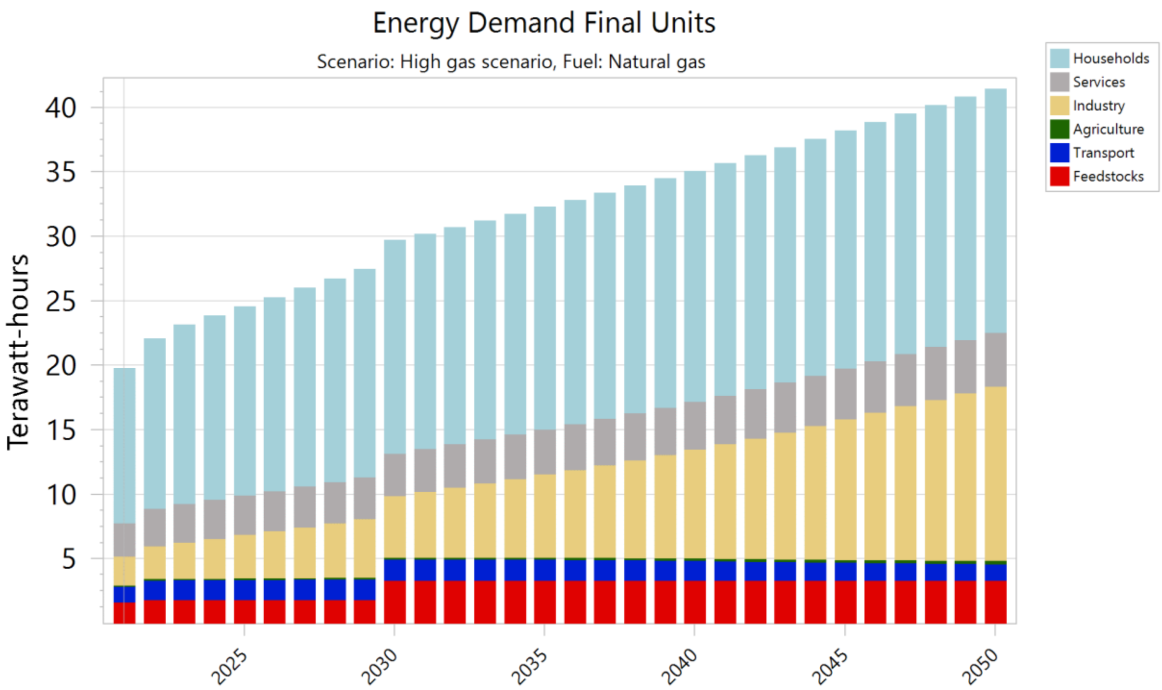


Figure 2-24 Final energy demand – High Gas Consumption Scenario - Natural gas by sector

Source: EIHP (LEAP model results)

2.10 Comparison of Scenario Results

This chapter presents a comparative presentation of the final consumption energy results for all three scenarios.

2.10.1 Final Energy Demand

The table and graph below show a comparative view of the total final energy demand projections by scenario.

There is no major difference in total demand between BAU and High Gas Scenario since the essential difference between them is only the representation of final energy fuels in meeting equal thermal energy needs. In the High Gas Scenario, a small jump in consumption is observed in 2030, resulting from doubling the consumption of natural gas, which is used as a feedstock in the production of mineral fertilizers.

Alternatively, in the Scenario with measures, the increase in total energy demand is mitigated until 2045, after which it starts to fall. In 2030, the total final energy demand in the Scenario with measures is 5% lower than in the BAU scenario, and 16% in 2050.

Table 2-18 Final energy demand – by scenario – all fuels

Scenario	Unit	2021	2025	2030	2035	2040	2045	2050
BAU Reference scenario	TWh	55.91	67.48	74.92	80.13	84.59	88.24	90.48
High gas scenario	TWh	55.91	67.42	76.23	81.41	85.84	89.43	91.57
Scenario with measures	TWh	55.91	66.24	71.27	73.97	75.63	76.50	76.01

Source: EIHP (LEAP model results)

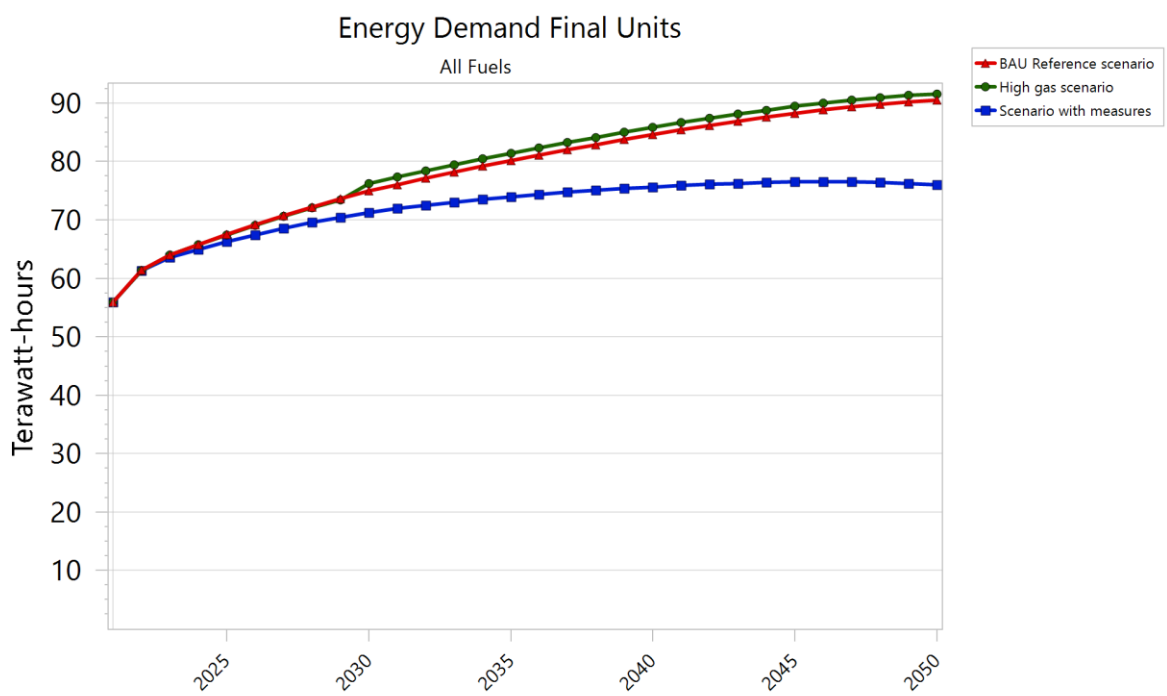


Figure 2-25 Final energy demand – by scenario – all fuels

Source: EIHP (LEAP model results)

2.10.1 Final Energy Demand - Electricity

The table and graph below show a comparative view of the electricity demand projections by scenario. In all three scenarios, a continuous increase in electricity consumption was recorded. The Scenario with measures shows slightly higher, and the High Gas Scenario slightly lower electricity consumption compared to the BAU scenario.

In the Scenario with measures, the higher consumption of electricity than in BAU is the result of the implementation of measures that imply a reduction in the share of fossil fuels that are gradually replaced by other energy sources, including electricity.

In the High Gas Scenario, a higher proportion of natural gas is assumed. This is particularly evident in the Manufacturing sector, where it is assumed that in the newly established industry, most of the thermal needs will be met with natural gas. All this leads to a reduction in the need for electricity compared to the BAU scenario.

Finally, the relative differences in electricity demand between the scenarios are not greater than +/- 3% in 2030 and +/- 7% in 2050.

Table 2-19 Final energy demand – by scenario – electricity

Scenario	Unit	2021	2025	2030	2035	2040	2045	2050
BAU Reference scenario	TWh	13.12	15.06	17.33	19.50	21.80	24.48	27.49
High gas scenario	TWh	13.12	14.99	17.08	18.98	20.97	23.29	25.90
Scenario with measures	TWh	13.12	15.29	17.87	20.22	22.76	25.89	29.31

Source: EIHP (LEAP model results)

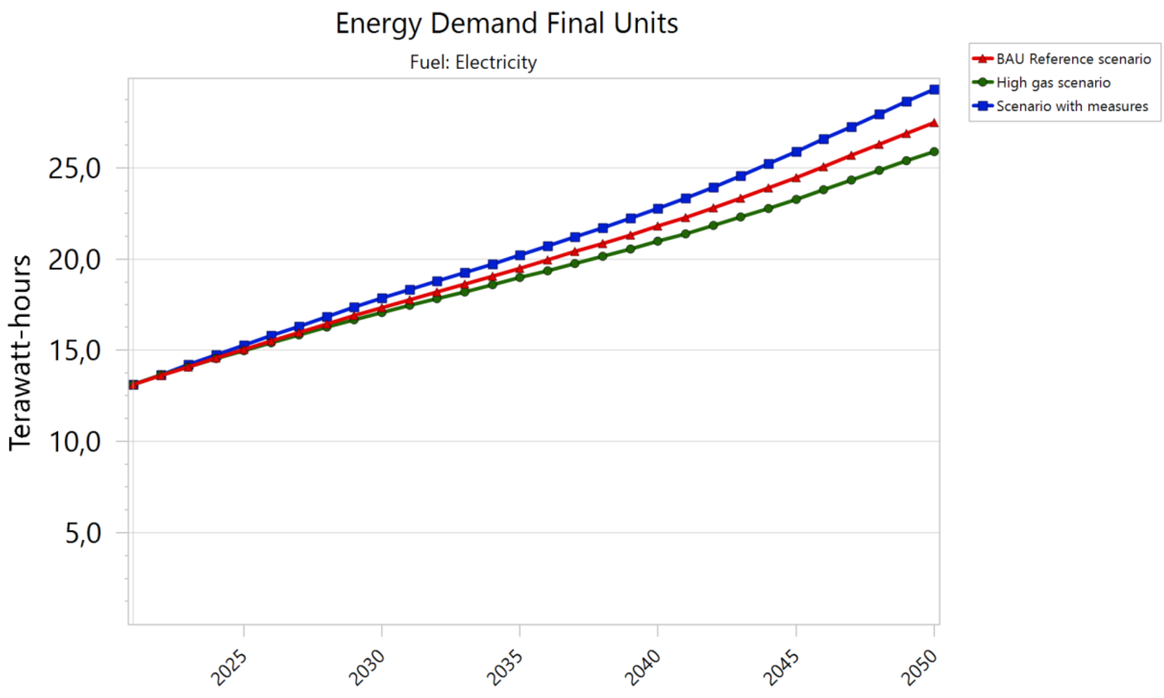


Figure 2-26 Final energy demand – by scenario – electricity

Source: EIHP (LEAP model results)

2.10.1 Final Energy Demand – Natural Gas

The table and graph below show a comparative view of the natural gas demand projections by scenario. The disparities in natural gas demand projections among the scenarios are quite substantial.

Business as Usual (BAU) scenario shows a consistent increase in natural gas demand, with slightly higher growth rates in the initial period up to 2030. This trend aligns with the anticipated GDP growth.

Scenario with Measures experiences an increase in natural gas demand until 2030, after which growth rates turn negative. This indicates a shift towards reduced natural gas usage.

The High Gas Scenario exhibits higher growth rates in natural gas demand compared to the BAU scenario. There's also a sharp spike in 2030, attributed to the assumption of doubling natural gas as a feedstock for mineral fertilizer production.

The scenario percentages are as follows:

- In 2030, the Scenario with Measures shows a 9% reduction in natural gas consumption compared to the BAU scenario.
- In contrast, the High Gas Scenario reflects an 11% increase in natural gas consumption in 2030 relative to the BAU scenario.
- These differences become more pronounced in 2050, with the Scenario with Measures demonstrating a 34% reduction in natural gas consumption compared to the BAU scenario, while the High Gas Scenario shows a 22% increase.

Table 2-20 Final energy demand – by scenario – natural gas

Scenario	Unit	2021	2025	2030	2035	2040	2045	2050
BAU Reference scenario	TWh	19.78	23.98	26.36	27.69	29.12	30.69	32.21
High gas scenario	TWh	19.78	24.55	29.70	32.27	35.06	38.19	41.45
Scenario with measures	TWh	19.78	23.15	23.93	23.69	23.55	22.52	21.21

Source: EIHP (LEAP model results)

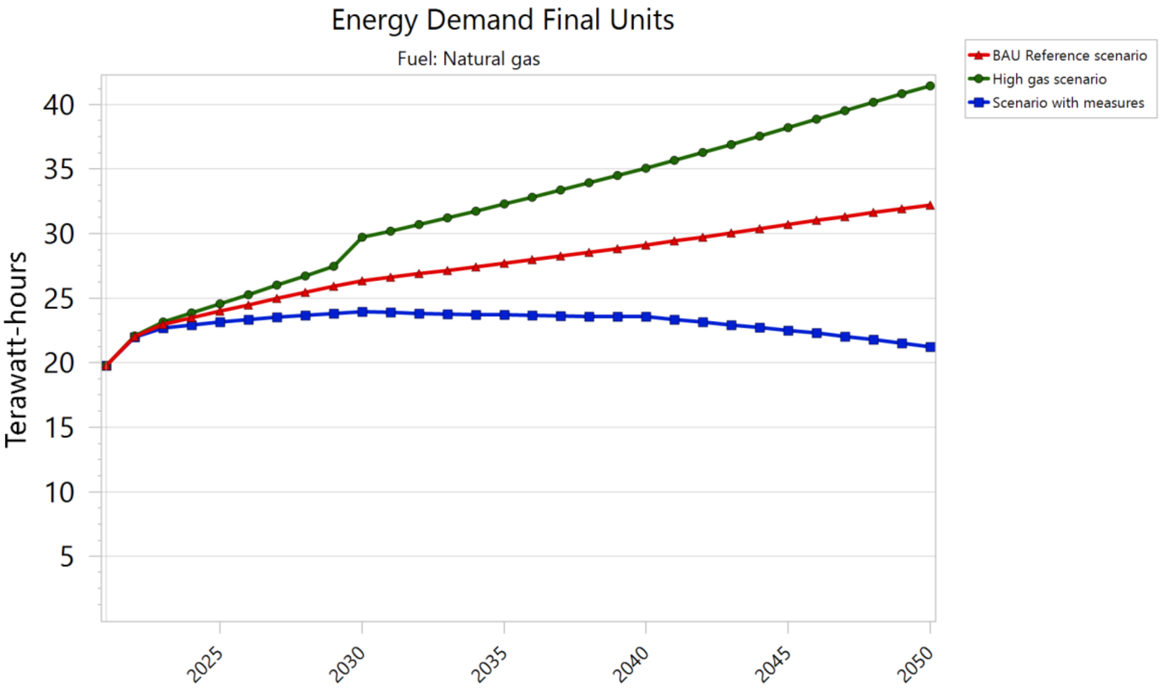


Figure 2-27 Final energy demand – by scenario – natural gas

Source: EIHP (LEAP model results)

3. ELECTRICITY SECTOR ANNUAL GAS DEMAND

This section describes the scenarios for electricity generation from gas power plants and in turn demand for natural gas by the power sector. The section is structured as follows:

1. Short description of the electricity sector in Georgia.
2. Description of the existing projections of electricity generation in Georgia.
3. Establishing the relevant electricity generation scenarios.

3.1 Georgian Power System

In this introductory chapter, we describe the existing thermal power plant (hereinafter: TPP) capacities and generation, as well as other sources, to present an overview of the Georgian power system. Figure 3-1 shows the structure of the capacities in 2023, based on data from the Ten-Year Network Development Plan of Georgia 2023-2033 (hereinafter: TYNDP).

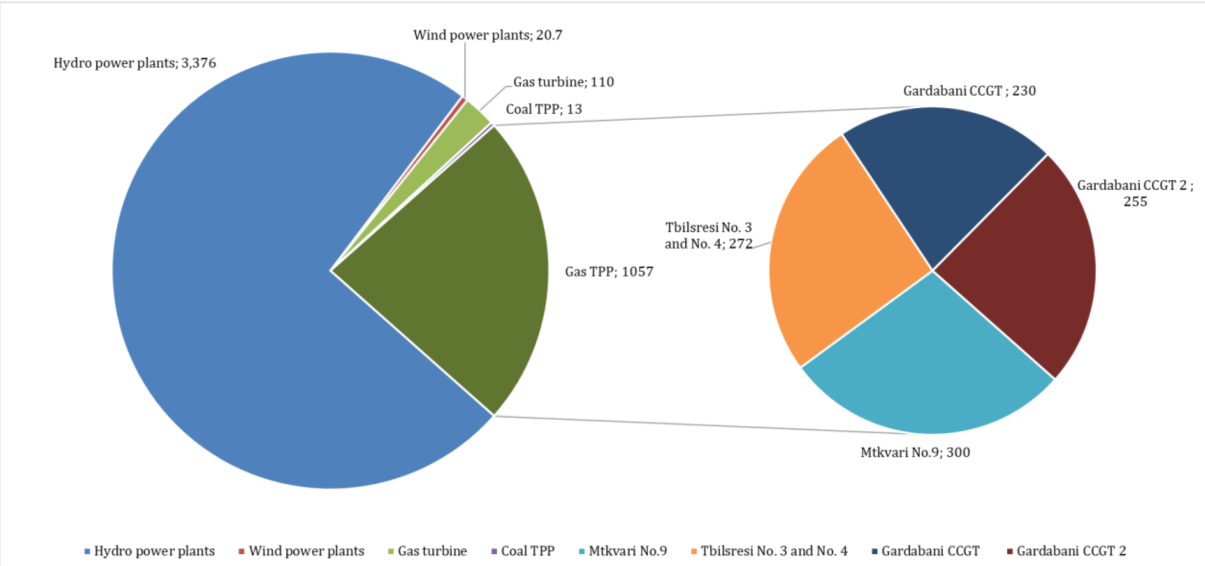


Figure 3-1 Georgian installed capacities from different sources in 2023

Source: TYNDP

According to the TYNDP, as of March 20th, 2023, the dominant generation source is hydropower plants with 3,376 MW of installed capacity, while wind power plants (hereinafter: WPP) contribute 20.7 MW. Thermal power plants amount to 1,164 MW of installed capacity, including both coal and gas-fired. In TYNDP, the following coal power plants are listed: Tkibuli Coal TPP and TPP Rustavi Azoti. Based on historical electricity balances listed by the Georgian State Electrosystem (hereinafter: GSE), Tkibuli coal TPP with a capacity of 13 MW has not generated electricity since 2019. It is highly unlikely to produce electricity in the future. Furthermore, the Rustavi Azoti is a nitric acid producer factory. Its steam turbine generates electricity for its own consumption only. Therefore, it will not be a subject in this analysis. Consequently, **when TPPs are mentioned in this analysis, the references are made regarding natural gas TPPs only**.

The TPPs which run on natural gas and are operational in 2023 are as follows[4]:

1. Mtkvari Unit No. 9 – a gas-fired power plant with a total capacity of 300 MW, commissioned in 1991.
2. Tbilsresi Units No. 3 and No. 4 – a gas-fired power plant that consists of two units with capacities of 130 MW and 142 MW (a total of 272 MW), commissioned in 1963.
3. Gpower – a 110 MW[5] gas turbine, commissioned in 2006.
4. Gardabani CCGT – a combined cycle gas turbine TPP consisting of three units with capacities 2x75 MW and 80 MW (a total of 230 MW[6]), commissioned in 2015.
5. Gardabani CCGT 2 – a combined cycle gas turbine TPP consisting of three units with capacities of 2x84 MW and 87 MW (a total of 255 MW[7]), commissioned in 2020.

For gas consumption modeling, the most important inputs are heat rates for TPPs. Heat rate is a measure of efficiency and as such depends on the type of power plant, operating conditions, fuel characteristics, etc[8]. GNERC delivered the historical efficiencies for each TPP, and the averages for the period 2021 – 2023 are as follows:

- Mtkvari Unit No. 9 – 35.15%,
- Tbilsresi Units No. 3 and No. 4 – 31.96%,
- Gpower – 34.92%,
- Gardabani CCGT – 50.54% and
- Gardabani CCGT 2 – 50.77%.

Based on these efficiencies, Table 3-1 shows the average heat rates per type of gas TPP for Georgia's power plants which will be used in further calculations.

Table 3-1 Heat rates based on the type of gas power plant

Type of gas power plant	Heat rate (TJ/GWh)
Gas turbine	10.31
Steam turbine	10.73
Combined cycle gas turbine	7.11

Source: Data delivered by GSE

Figure 3-2 shows the historical generation from specific thermal power plants in Georgia from 2018 to 2022[9]. Gpower (gas turbine) has the smallest percentage of the total generation. Steam turbine units, Mtkvari No.9, Tbilsresi No. 3 and No. 4 produce more than the gas turbine. However, there has been a visible decrease in their share since Gardabani CCGT 2 was commissioned in

[4] TYNDP

[5] GOGC suggests correcting this capacity to 85 MW. However, the Consultant recommends using the capacity from the official document TYNDP, because the difference is not very significant, and the overall capacities are closer to the GSE delivered capacities.

[6] GOGC suggests correcting this capacity to 235 MW. However, the Consultant recommends using the capacity from the official document TYNDP, because the difference is not very significant, and the overall capacities are closer to the GSE delivered capacities.

[7] GOGC suggests correcting this capacity to 2x76 MW + 83 MW = 235 MW. However, the Consultant recommends using capacities from the official document TYNDP, because the difference is not very significant, and the overall capacities are closer to the GSE delivered capacities.

[8] https://powerline.net.in/2023/01/04/heat-rate-improvement/, Accessed: July 11th, 2023

[9] This time frame was chosen because during this period all relevant inputs (capacities and generation) required for the analysis were available.

2020. Gardabani CCGT holds the highest share in TPP generation, but the Gardabani CCGT 2 exhibits a steady increase in generation over the observed period. This is in line with expectations, as it can be assumed that the TPPs that remain will be CCGT-type power plants since such power plants have the highest efficiency compared to the other gas power plants.

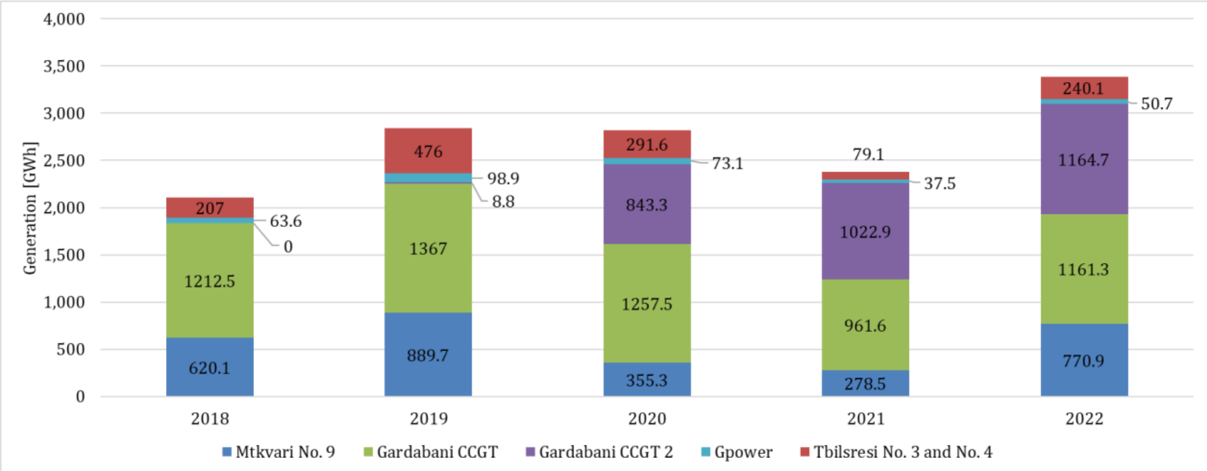


Figure 3-2 Electricity generation from thermal power plants in Georgia during 2018-2022

Source: GSE electricity balances

3.2 Existing Projections of Electricity Generation in Georgia

The following section provides an overview of the following: Georgian Ten-Year Network Development Plan, NECP, and projections provided by GSE.

3.2.1 Ten-Year Network Development Plan

The TYNDP predicts a pessimistic outlook of the energy mix, meaning that it shows an increase in capacities and generation from TPPs compared to the NECP data. Table 3-2 shows the distribution of capacities for 2023 and 2033 according to TYNDP. The numbers for 2023 were described in the previous subchapter 3.1. This section provides a brief overview of the energy mix in 2033.

In 2033 RES capacities are planned to increase significantly. This mostly refers to HPP capacities since WPPs will increase by approximately 800 MW. The plan is to install a relatively small amount of solar power plants (hereinafter: SPPs) – 174 MW. Regarding TPPs, the 110 MW gas turbine is expected be operational, while the rest of the TPPs will have a total capacity of 1,470 MW. This is an increase of 400 MW compared to the situation today, and it is predicted that those units will be highly efficient CCGT units.

Table 3-2 Georgia's power system capacities in 2023 and 2033

Installed technology	Unit	2023	2033
Steam turbines and Combined cycle gas turbines	MW	1,057[10]	1,457
Gas turbine	MW	110	110
Hydropower plants	MW	3,376	7,235
Wind power plants	MW	20.7	850
Solar power plants	MW	0[11]	174

Source: TYNDP

Based on the installed capacity, the TYNDP predicts the following electricity generation by technology, as shown in Figure 3-3.

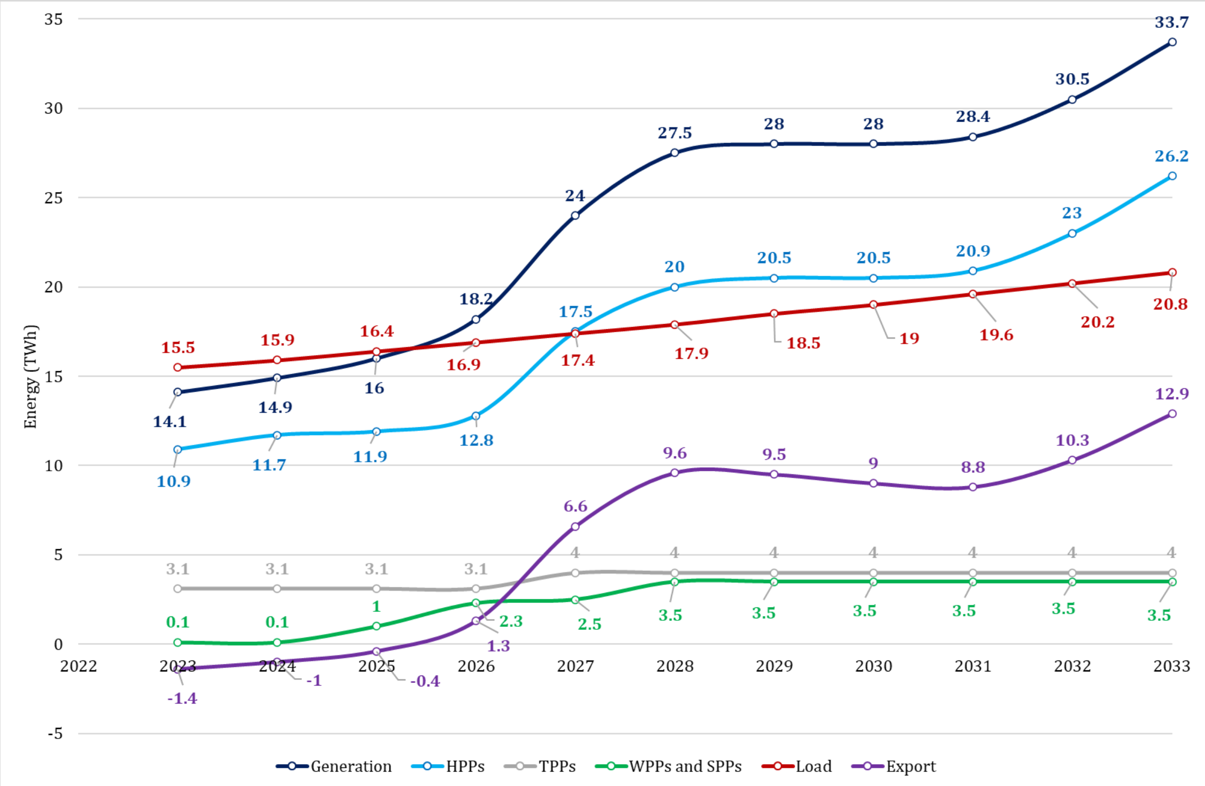


Figure 3-3 Georgian electricity generation, consumption, and exports

Source: TYNDP

Since the TYNDP only includes projections for the next ten years (until 2033), it was not possible to use it for projections of electricity generation until 2050.

[10] The total installed gas TPP capacities according to the official document TYNDP are: Mtkvari No. 9 (300 MW), Tbilsresi No. 3 and No. 4 (272 MW), Gardabani CCGT (230 MW), Gardabani CCGT 2 (255 MW). Coal TPPs, Tkibuli TPP (13 MW) and Rustavi Azoti TPP (9 MW), have been excluded from the capacities due to reasons described in the last paragraph of Page 46.

[11] The table does not include micro solar power plants, totaling 47 MW in capacity. These smaller solar projects are not integrated into the transmission network, so this is why they are not mentioned in TYNDP and consequently in this table, but we include them in this note to ensure their recognition.

3.2.2 National Energy and Climate Plan (NECP)

Table 3-3 and Table 3-4 show the historical values and projections taken from the NECP for both capacities and electricity generation. They are generally lower than the TYNDP's. The NECP TPP capacities tend to be in decline (except in 2035), while TPP generation is only slightly increasing, much less compared to the TYNDP. The NECP is more optimistic toward RES.

Table 3-3 NECP capacity by source – historical values and projections

Technology	Unit	2018	2019	2020	2025	2030	2035	2040	2045	2050
Coal-fired	MW	13	13	13	13	13	13	13	-	-
Gas-fired	MW	1,081	1,081	1,311	1,171	1,171	1,401	961	899	909
Hydro	MW	3,253	3,325	3,325	3,559	3,992	3,992	4,284	4,923	5,510
Solar	MW	-	-	4	102	547	1,068	1,345	1,383	1,383
Wind	MW	20	20	126	226	750	1,021	1,273	1,423	1,573

Source: NECP

Table 3-4 NECP electricity generation by source – historical values and projections

Technology	Unit	2018	2019	2020	2025	2030	2035	2040	2045	2050
Coal-fired	GWh	11	-	-	-	-	-	-	-	-
Gas-fired	GWh	2,009	2,717	2,966	2,384	2,444	2,572	2,539	2,618	2,657
Hydro	GWh	9,821	8,828	9,218	10,084	10,222	11,191	11,975	13,920	16,094
Solar	GWh	-	-	6	160	807	1,680	2,116	2,175	2,175
Wind	GWh	84	85	478	850	2,549	3,798	4,718	5,274	5,830

Source: NECP

3.2.3 GSE Delivered Data

GSE delivered an Excel file containing future projections of installed capacities and electricity generation. They are divided into five scenarios:

6. Scenario 1: High Load – High Generation
7. Scenario 2: High Load – Base Generation
8. Scenario 3: Base Load - Low Generation
9. Scenario 4: High Load – Low Generation
10. Scenario 5: NECP

The data is shown in the following tables. For Scenarios 1 to 4, GSE delivered monthly generations for referent years, which are shown in Annex 6.1.

Table 3-5. Projections of annual electricity generation from different sources

No.	Year	Unit	Generation[12] 1	Storage hydro power plants 2	Run-of-river hydro power plants 3	Wind power plants 4	Solar power plants 5	Thermal power plants+imports 6	Exports 7
Scenario 1: High Load – High Gen	**2025**	GWh	17,000	6,523	5,248	2,710	740	2,900	1,123
	2030	GWh	20,119	7,540	6,073	5,059	1,924	2,149	2,626
	2035	GWh	23,272	8,557	6,898	7,407	3,107	1,695	4,394
	2040	GWh	26,600	9,574	7,723	9,756	4,291	1,386	6,130
	2045	GWh	30,300	10,591	8,547	12,104	5,475	1,304	7,723
	2050	GWh	34,278	11,622	14,996	14,453	6,659	13	13,466
Scenario 2: High Load – Base Gen	**2025**	GWh	17,000	6,523	5,248	723	148	4,765	408
	2030	GWh	20,119	7,104	6,073	1,807	1,036	4,822	724
	2035	GWh	23,272	7,685	6,898	3,975	1,739	4,225	1,250
	2040	GWh	26,600	8,266	7,723	6,142	2,441	3,912	1,887
	2045	GWh	30,300	9,283	8,547	8,310	3,144	3,747	2,734
	2050	GWh	34,278	10,315	9,372	10,478	3,847	3,819	3,555
Scenario 3: Base Load - Low Gen	**2025**	GWh	17,000	6,523	5,248	723	74	4,812	381
	2030	GWh	19,111	6,915	5,329	1,807	444	5,072	457
	2035	GWh	21,477	7,104	5,450	2,168	740	6,264	251
	2040	GWh	23,907	7,685	5,531	2,529	1,036	7,297	172
	2045	GWh	26,410	8,702	5,571	2,891	1,332	8,101	189
	2050	GWh	29,071	8,717	5,652	3,613	1,628	9,483	24

[12] Load with included losses

No.	Year	Unit	Generation[12]	Storage hydro power plants	Run-of-river hydro power plants	Wind power plants	Solar power plants	Thermal power plants+imports	Exports
			1	2	3	4	5	6	7
Scenario 4: High Load – Low Gen	**2025**	GWh	17,000	6,523	5,248	723	74	4,812	381
	2030	GWh	20,119	6,915	5,329	1,807	444	5,879	256
	2035	GWh	23,272	7,104	5,450	2,168	740	7,827	18
	2040	GWh	26,600	7,685	5,531	2,529	1,036	9,817	0
	2045	GWh	30,300	8,702	5,571	2,891	1,332	11,802	0
	2050	GWh	34,278	8,717	5,652	3,613	1,628	14,667	0
Scenario 5: NECP	**2025**	GWh	13,690	10,084		850	160	3,023	428
	2030	GWh	16,334	11,191		2,792	860	2,586	1,096
	2035	GWh	18,050	11,191		3,798	1,680	2,572	1,191
	2040	GWh	20,001	11,975		4,718	2,116	2,539	1,347
	2045	GWh	20,120	11,975		4,718	2,116	2,539	1,228
	2050	GWh	24,778	16,094		5,830	2,175	2,657	1,978

Source: GSE

Table 3-6. Projections of installed capacities from different sources

No.	Year	Unit	Storage hydropower plants	Run-of-river hydropower plants	Wind power plants	Solar power plants	Thermal power plants
Scenario 1: High Load – High Gen	**2025**	MW	2,245	1,400	750	500	1,170
	2030	MW	2,595	1,620	1,400	1,300	1,600
	2035	MW	2,945	1,840	2,050	2,100	1,600
	2040	MW	3,295	2,060	2,700	2,900	1,330
	2045	MW	3,645	2,280	3,350	3,700	1,330
	2050	MW	4,000	4,000	4,000	4,500	0
Scenario 2: High Load – Base Gen	**2025**	MW	2,245	1,400	200	100	1,170
	2030	MW	2,445	1,620	500	700	1,600
	2035	MW	2,645	1,840	1,100	1,175	1,600
	2040	MW	2,845	2,060	1,700	1,650	1,330
	2045	MW	3,195	2,280	2,300	2,125	1,330
	2050	MW	3,550	2,500	2,900	2,600	1,330
Scenario 3: Base Load - Low Gen	**2025**	MW	2,245	1,300	200	50	1,170
	2030	MW	2,380	1,320	500	300	1,600
	2035	MW	2,445	1,350	600	500	1,600
	2040	MW	2,645	1,370	700	700	1,600
	2045	MW	2,995	1,380	800	900	1,700
	2050	MW	3,000	1,400	1,000	1,100	1,850
Scenario 4: High Load – Low Gen	**2025**	MW	2,245	1,300	200	50	1,170
	2030	MW	2,380	1,320	500	300	1,800
	2035	MW	2,445	1,350	600	500	2,000
	2040	MW	2,645	1,370	700	700	2,500
	2045	MW	2,995	1,380	800	900	2,700

No.	Year	Unit	Storage hydropower plants	Run-of-river hydropower plants	Wind power plants	Solar power plants	Thermal power plants
	2050	MW	3,000	1,400	1,000	1,100	3,000
Scenario 5: NECP	**2025**	MW	3,559		226	102	1,171
	2030	MW	3,992		750	547	1,171
	2035	MW	3,992		1,021	1,068	1,401
	2040	MW	4,284		1,273	1,345	961
	2045	MW	4,285		1,423	1,383	899
	2050	MW	5,510		1,573	1,383	909

Source: GSE

3.3 Establishing the Relevant Electricity Generation Scenarios

The Consultant used GSE supplied generation data to calculate gas consumption. Scenario 0 is a combination of the TYNDP and NECP data.

3.3.1 Description of Scenario 0

In this scenario, data from the NECP and TYNDP was combined to generate a single electricity generation scenario. The purpose of this scenario was to assess whether a realistic gas demand scenario could be created using publicly available data. For 2025 and 2030, TYNDP data was used, while from 2035 until 2050 NECP data was used. The resulting generation from TPPs is shown in the following table.

Table 3-7 TPP generation in Scenario 0

Year	Unit	Scenario 0
2025	GWh	3,100
2030	GWh	4,000
2035	GWh	2,572
2040	GWh	2,539
2045	GWh	2,618
2050	GWh	2,657

Source: TYNDP, NECP

Comparing 2025 and 2030 versus 2035 to 2050, there are differences in the data between the official document TYNDP and the unofficial NECP. This is a result of the two documents using different methodologies and assumptions. Due to the discrepancies, this scenario is deemed not appropriate for long-term modeling and it is therefore not included in further analysis.

3.3.2 Description of Scenarios 1 to 5

To summarize the data, Table 3-5 provides scenario descriptions:

1. Scenario 1: High Load – High Gen → Very optimistic scenario with high consumption and high generation from RES technologies, resulting in low TPP capacities (and no TPP generation in 2050).
2. Scenario 2: High Load – Base Gen → Optimistic scenario with high consumption and base generation from RES technologies, resulting in lower TPP capacities (and with TPP generation in 2050, as opposed to the previous scenario).
3. Scenario 3: Base Load – Low Gen → Pessimistic scenario with lower consumption and low generation from RES technologies, resulting in higher TPP generation.
4. Scenario 4: High Load – Low Gen → Very pessimistic scenario with high consumption and low generation from RES technologies, resulting in high TPP generation and low imports and exports.
5. Scenario 5: NECP → The data according to NECP.

Table 3-5 shows no distinction between the TPP generation and imports (column 6 in Table 3-5). Therefore, it is necessary to analyze the monthly generation data provided by GSE, which is visible in Table 6-1, Table 6-2, Table 6-3 and Table 6-4 of Annex 6.1 (columns 1 to 6 are provided by GSE, while columns 7 to 9 are the Consultant's calculations). According to that data, the total electricity generation (column 5) would be generated according to the merit order, starting first with HPPs (columns 1 and 2), followed by WPPs and SPPs (columns 3 and 4). The remaining difference is TPP generation, imports, and exports (column 6). The primary goal is to obtain TPP generation. Therefore, this difference needs to be distributed.

The negative difference represents net exports (shown as absolute values in column 9). For the months where that difference is positive, it represents the sum of TPP generation and imports. Therefore, the analysis must determine which part falls into the category of TPP generation versus which part refers to imports.

During the stakeholder meetings, the share of TPP generation was decided as 68% in the sum of TPP generation and imports. This information was derived from the historical yearly averages. For the last two scenarios, there are deviations in this assumption:

- In the scenario with the highest TPP generation, the stakeholders suggested increasing the share of TPP generation to cover the whole amount in the sum of TPP generation and imports. Therefore, in Scenario 4, the TPP generation share of 68% was increased linearly until 2050 to reach 100%, and imports were decreased accordingly so that they would reach 0% in 2050.
- Similarly, in Scenario 5 the Consultant (based on stakeholders' inputs) considered that in 2025 the share of TPP is expected to be 79%, while in all other years, the imports will amount to zero.

The resulting distribution of TPP generation and imports is shown in columns 7 and 8 of the tables in Annex 6.1. The summed yearly TPP generation is shown in the following table and figure. This represents inputs for further calculations of gas consumption.

Table 3-8 Electricity generation from gas thermal power plants - Scenarios 1 to 5

Year	Unit	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
2025	GWh	1,972	3,240	3,272	3,272	2,384
2030	GWh	1,461	3,279	3,449	4,374	2,586
2035	GWh	1,153	2,873	4,259	6,324	2,572
2040	GWh	942	2,660	4,962	8,561	2,539
2045	GWh	887	2,548	5,509	11,047	2,539
2050	GWh	0	2,597	6,448	14,667	2,657

Source: GSE

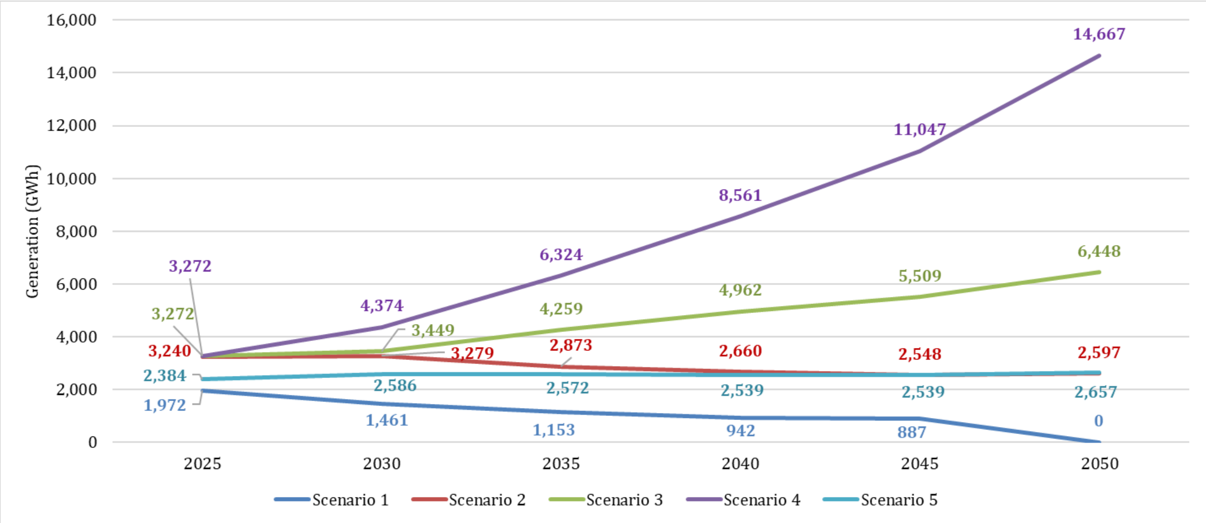


Figure 3-4 Scenarios 1 to 5 of electricity generation from gas thermal power plants

Source: GSE

3.3.3 Share of Technology Type in TPP generation

As mentioned in Chapter 3.1, other than the electricity generation from the TPPs which was described in the previous subchapter, an important input for gas consumption modeling is the heat rates (efficiencies). They are specific to each type of TPP, so it is important to distribute the generation accordingly. Given that the provided GSE data does not contain generation by technology type (gas turbine, steam turbine, CCGT), the Consultant made estimated projections of the share of a particular technology in the total TPP production. It is based primarily on the delivered installed capacities of TPPs provided by GSE which are visible in Table 3-9 as well as on historical data.

There are three types of gas-fired thermal power plants in Georgia: gas turbine, steam turbine, and CCGT. During the kick-off meeting held in June 2023, the group agreed that 2019 can be considered a year with representative values. However, the Consultant analyzed values from other years as well, primarily because the Gardabani CCGT 2 power plant started operating in 2020 and from the graph in Figure 3-2 shows that it holds a significant portion of production. Furthermore, 2022 was a unique year as it is assumed that the increased TPP generation occurred due to the new geopolitical situation resulting from the war in Ukraine.

The Consultant calculated the average of the 2019 and 2022 values for the TPPs. This resulted in an average of 2.49% of total generation being attributed to the gas turbine and 38.96% of total generation being attributed to steam turbines. The analysis assumed that the remaining percentage of 58.55% was assigned to CCGT production. This was applied to all scenarios in 2025, as the capacities are similar to those today.

For the years after 2024, the Consultant made assumptions that are shown in Table 3-10. In the first four scenarios, the gas turbine production of the existing 2.49% was maintained until 2045. This decision was confirmed with the stakeholders. The exception is Scenario 5 (NECP) for which the Consultant received information that it will not operate beyond 2036. This is seen in the decrease of capacities in 2040.

Following discussions with the stakeholders, it appears that steam turbines will continue operating longer than anticipated. It is important to note that Tbilsresi No. 3 and No. 4 have been in operation since 1963[13]. By 2050, they will have reached 87 years of continuous operation. Such a long period of operation is unlikely and therefore the decrease in percentages in Table 3-10 represents the decommissioning of those units. Mtkvari No. 9 steam turbine, which was commissioned in 1991[13] could potentially remain in operation until 2050, especially if compared to units No. 3 and No. 4.

Finally, the remaining difference between gas and steam turbine shares was assigned to CCGTs. The anticipated rise in CCGT production depends on the possibility that the new capacities specified in Table 3-9 will predominantly consist of CCGT capacities. CCGTs are frequently favored as the primary choice for new TPP capacities due to their notable advantages, including higher efficiency, reduced emissions, reliability, etc. As a result of these benefits, their prominence is expected to grow, as evident in the table where their share steadily becomes more dominant.

Table 3-9 Projections of thermal power plant capacities

Year	Unit	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
2025	MW	1,170	1,170	1,170	1,170	1,171
2030	MW	1,600	1,600	1,600	1,800	1,171
2035	MW	1,600	1,600	1,600	2,000	1,401
2040	MW	1,330	1,330	1,600	2,500	961
2045	MW	1,330	1,330	1,700	2,700	899
2050	MW	0	1,330	1,850	3,000	909

Source: GSE

To summarize, gas turbine generation is expected to remain at 2.49% of TPP generation until 2045, except in Scenario 5 where it drops to 0% in 2040. CCGT becomes more dominant and is calculated as the remaining difference of gas and steam turbine share in the total TPP generation. Finally, the steam turbine shares in the projections of TPP production beyond 2030 are allocated as follows:

- For Scenario 1 in 2025, steam turbines comprise 39% of the total generation mix, based on previously described historical data. This indicates a significant reliance on steam turbines for electricity generation. In 2030, the forecast indicates a decrease because of the new CCGT TPP. There is a reduction to 15%, but they still have a substantial presence in the generation mix. Based on projected installed capacities in Table 3-9, the same behavior is anticipated in 2035. In 2040, their share is expected to decrease to 10%. This is due to the evident reduction in installed capacities which indicates the decommissioning of Tbilsresi No. 3 and No. 4. This trend continues in 2045, where the remaining steam turbine Mtkvari No. 9 will comprise 5% of the generation mix. By 2050, steam turbines will phased out entirely, contributing 0% to the generation mix.

- Scenario 2 capacities indicate the same behavior as Scenario 1. Therefore, the same estimates were applied. A difference occurs in 2050 when the steam turbine share is left at 5%, an amount provided by Mtkvari No. 9.

- Scenarios 3 and 4 are more pessimistic as they have higher TPP generation. However, the same shares were attributed as in Scenario 2. Even though the TPP capacities will increase, and it can be anticipated that those will be CCGT units, the steam turbines (primarily Mtkvari No. 9) can cover a certain share of generation. In these two scenarios, TPP generation is quite high. Still, their share in the generation is expected to decrease.

[13] TYNDP

- Scenario 5 is based on NECP data, so the shares were distributed according to the provided capacities. Steam turbines begin with the same share as in previous scenarios, 39% in 2025. Since the capacities do not change, they remain at 39% in 2030 and it is assumed their contribution will remain on a similar level. However, in 2035 there is a decrease to 20%, due to the predicted addition of CCGT capacities (and in turn their contribution to the overall generation). These capacities are lower than in the first four scenarios, amounting to 230 MW as opposed to 430 MW. This is why they hold a slightly higher percentage in total generation. In 2040 and 2045 we see that the capacities of TPPs have been reduced, and it is to be expected that the CCGT will dominate the remaining generation. This explains the drop to 10% and 5%. We assume that the new 10 MW capacity will be CCGT, therefore, the steam turbine contribution in the generation mix is reduced to 0%. Although it is unclear which capacities will be excluded after 2040, NECP is generally more optimistic toward renewables and it is anticipated that steam turbine generation will not be favored.

The following table summarizes the assumed contribution of each TPP technology in the generation mix of TPP.

Table 3-10 Estimated share of technology type in TPP production (percentage of generation)

Year	Technology	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
2025	Gas turbine	2%	2%	2%	2%	2%
	Steam turbine	39%	39%	39%	39%	39%
	CCGT	59%	59%	59%	59%	59%
2030	Gas turbine	2%	2%	2%	2%	2%
	Steam turbine	15%	15%	15%	15%	39%
	CCGT	83%	83%	83%	83%	59%
2035	Gas turbine	2%	2%	2%	2%	2%
	Steam turbine	15%	15%	15%	15%	20%
	CCGT	83%	83%	83%	83%	78%
2040	Gas turbine	2%	2%	2%	2%	0%
	Steam turbine	10%	10%	10%	10%	10%
	CCGT	88%	88%	88%	88%	90%
2045	Gas turbine	2%	2%	2%	2%	0%
	Steam turbine	5%	5%	5%	5%	5%
	CCGT	93%	93%	93%	93%	95%
2050	Gas turbine	0%	0%	0%	0%	0%
	Steam turbine	0%	5%	5%	5%	0%
	CCGT	0%	95%	95%	95%	100%

Source: EIHP (based on GSE, TYNDP, NECP)

3.4 Results

The results are shown in the Table 3-11. The inputs for the consumption calculation include the calculated TPP generation based on the delivered data and heat rates per type of gas TPP. The gas consumption data for 2021 and 2022 has also been incorporated to allow for a comparison of behavior against the resulting scenarios. This data is presented in terajoules, while the conversion to cubic meters is shown in the following chapter.

Table 3-11 Historical gas consumption and its projections

Year	Unit	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
2021	TJ			16,268[14]		
2022	TJ			25,598[14]		
2025	TJ	16,958	27,856	28,135	28,135	20,497
2030	TJ	11,296	25,347	26,662	33,809	22,234
2035	TJ	8,912	22,207	32,925	48,883	20,347
2040	TJ	7,098	20,041	37,379	64,488	18,964
2045	TJ	6,518	18,730	40,502	81,216	18,504
2050	TJ	0	18,928	46,994	106,890	18,883

Source: EIHP (based on GSE)

Table 3-11 shows that in 2025, **Scenarios 2, 3, and 4 closely align with historical data**, whereas Scenarios 1 and 5 exhibit noticeably lower consumption. This disparity can be explained by analyzing the GSE provided scenarios. Scenario 1 leans toward high-RES capacities, resulting in lower TPP generation, and hence lower gas consumption. Scenario 5 relies on NECP data, which also tends to be more optimistic regarding RES utilization. Therefore, there is a slight decline in gas consumption in 2050 compared to 2025.

There is one discrepancy in Scenario 3. In 2030, there is a reduction in gas consumption even as the TPP generation increases. This decline is explained by examining the share of CCGT technology within the energy mix. **Increasing CCGT's share from 59% in 2025 to 83% in 2030 results in a decrease in TPP gas consumption,** as CCGT is considerably more efficient when compared to the expected decrease in steam turbine usage.

The visualization of the data in the table is shown in Figure 3-5.

[14] Energy balances of Georgia (2021-2022), https://www.geostat.ge/en/single-categories/118/energy-balance-of-georgia, Accessed: September 5th, 2023

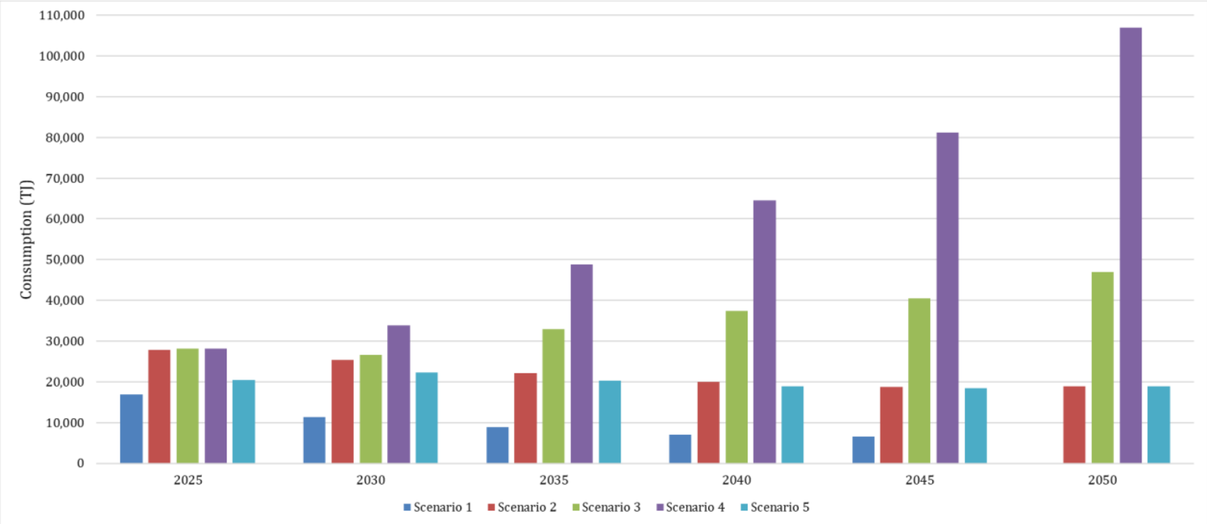


Figure 3-5 Projections of gas consumption

Source: EIHP (based on GSE)

The figure above indicates the gas consumption in the electricity sector for Scenarios 1 and 2 will decrease. This confirms that those scenarios are more optimistic, implying a larger share of RES. The more pessimistic Scenarios 3 and 4 predict an increase in gas consumption. As expected, Scenario 4 has significantly more consumption compared to Scenario 3 (and consequently other scenarios), because of the assumption that TPP share in the sum of TPP generation and imports will increase to 100% in 2050. Scenario 5, which is based on NECP data, does not show pronounced fluctuations, but rather a steady TPP generation.

The Consultant calculated if the TPP capacities can cover the calculated generations. The conclusion is that they can cover them, though in some scenarios TPPs would need to operate a higher number of hours at full capacity. Regarding the first two optimistic scenarios: the TPP capacities provided by GSE in Scenario 2 would need to operate at a higher number of hours to generate assumed electricity. This is to be expected as it predicts lower generation from RES compared to Scenario 1. In Scenario 5, the provided capacities do not need to operate for a large number of hours as this scenario is also more inclined towards RES. On the other hand, for the pessimistic Scenarios 3 and 4 there is not only a higher TPP generation to start with in 2025, but it also continues to rise until 2050. Consequently, the provided TPP capacities must operate for a longer amount of time to cover the demand. This is especially the case for Scenario 4 which generally predicts very high gas consumption compared to all the scenarios. For this scenario, the provided TPP capacities can cover the demand, but in 2050 they would need to operate at almost 90% of the maximum number of hours during the winter months (when the TPP generation is higher) at their full capacities. For TPPs this is technically viable, so the capacities in all scenarios satisfy the predicted needs.

Based on stakeholder feedback and the technical viability of the provided TPP capacities, Scenarios 2 and 3 emerge as the most realistic and likely outcomes. The realization of these scenarios depends on various factors including the implementation of renewable technology projects and their integration into the Georgian power system.

4. TOTAL ANNUAL GAS DEMAND AND PEAK GAS DEMAND

Based on the results in Chapters 2 and 3, this chapter presents the results for forecasted total annual gas demand and peak gas demand. The forecasted total annual gas demand consists of gas demand of final consumption in all sectors excluding electricity generation and gas demand for electricity generation.

The conversion of energy units to natural units considered the weighted average of the net calorific value[15] of natural gas in Georgia, provided by the Georgian Gas Transportation Company (GGTC).

4.1 Gas Demand of Final Consumption Sectors

4.1.1 BAU Scenario

In the business-as-usual scenario, forecasted gas demand in final consumption in all sectors excluding electricity generation in Georgia is projected to grow to 3.28 bcm in 2050. Forecasted gas demand by consumption sectors of final energy consumption is given below (Table 4-1 and Figure 4-1).

Table 4-1 Forecasted gas demand by consumption sector (mcm) - BAU Scenario

Consumption sector	2021	2022	2025	2030	2035	2040	2045	2050
Households	1,254	1,377	1,472	1,635	1,695	1,746	1,790	1,824
Services	268	299	305	316	326	335	344	351
Industry	237	267	314	399	487	590	712	834
Agriculture	10	11	12	15	17	20	22	25
Transport	129	158	150	130	106	85	68	56
Feedstocks	169	191	185	185	185	185	185	185
Total	**2,067**	**2,303**	**2,438**	**2,680**	**2,816**	**2,961**	**3,121**	**3,276**

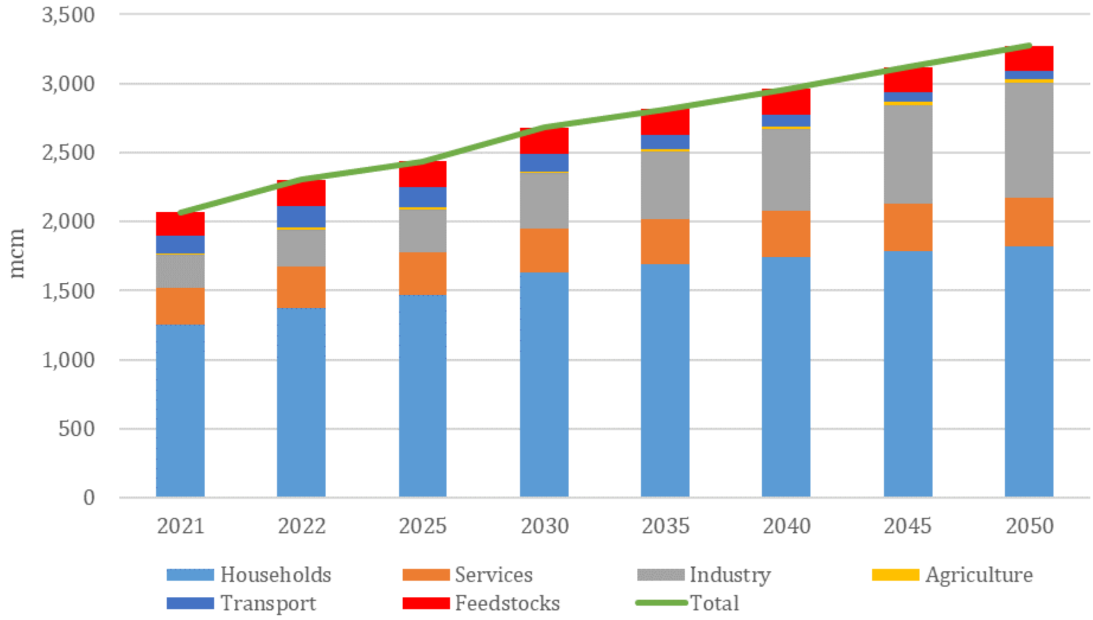


Figure 4-1 Forecasted gas demand by consumption sector - BAU Scenario

[15] NCV = 35.4 MJ/m³

4.1.2 Scenario with Measures

This scenario is shaped by three determinants: renovation of buildings to reduce the need for useful energy, increasing the energy efficiency of technology, and fuel switch from fossil fuels towards renewable energy sources (including electricity).

The objective of this scenario is to decrease both final energy demand and greenhouse gas emissions in comparison to the Business as Usual (BAU) scenario.

Therefore, the forecasted gas demand in final consumption in all sectors excluding electricity generation in Georgia is projected to increase until 2030, and then decrease to 2.16 bcm by 2050. The forecasted gas demand by consumption sectors of final energy consumption according to this scenario is given below (Table 4-2 and Figure 4-2).

Table 4-2 Forecasted gas demand by consumption sector (mcm) - Scenario with measures

Consumption sector	2021	2022	2025	2030	2035	2040	2045	2050
Households	1,254	1,377	1,406	1,420	1,325	1,213	1,086	946
Services	268	299	277	249	224	201	181	163
Industry	237	267	324	434	552	693	751	789
Agriculture	10	11	12	15	17	20	22	25
Transport	129	158	150	130	106	83	64	50
Feedstocks	169	191	185	185	185	185	185	185
Total	**2,067**	**2,303**	**2,355**	**2,433**	**2,409**	**2,395**	**2,290**	**2,157**

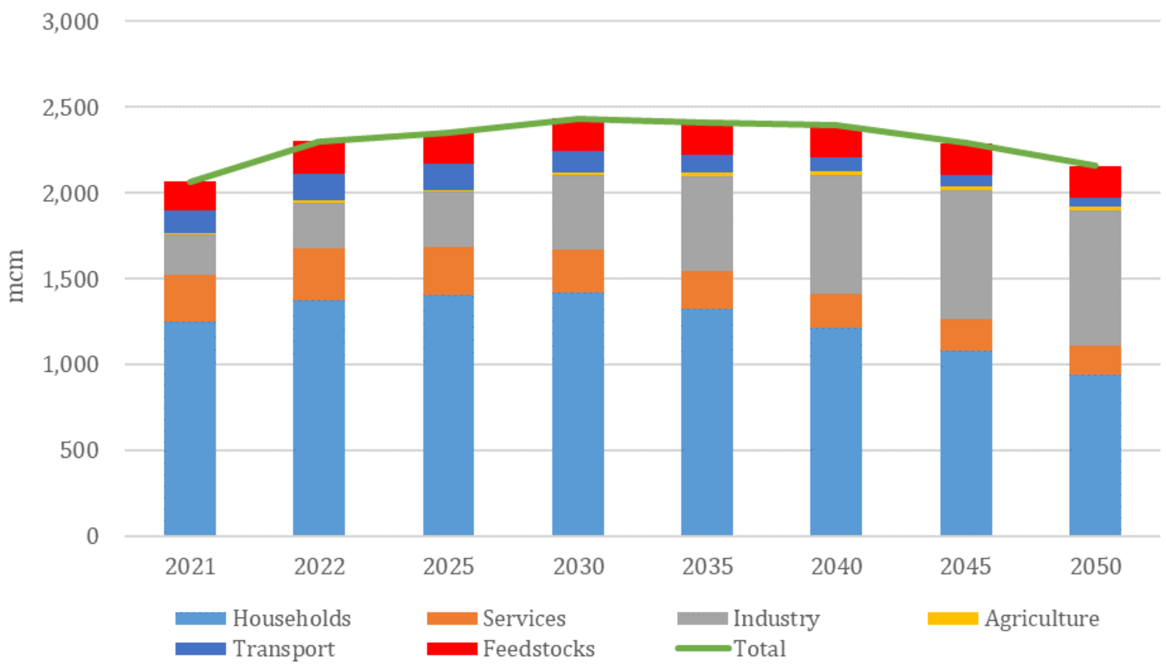


Figure 4-2 Forecasted gas demand by consumption sector - Scenario with measures

4.1.3 High Gas Consumption Scenario

The high gas consumption scenario is based on the BAU scenario where the projected useful energy demand is the same. However, the crucial difference between these scenarios is the shares of final energy sources that are used to satisfy thermal needs. Compared to the BAU scenario, a higher proportion of natural gas is assumed in meeting useful thermal energy demand in the high gas consumption scenario.

In the high gas consumption scenario, in all sectors forecasted gas demand in final consumption excluding electricity generation in Georgia is projected to grow to 4.21 bcm in 2050. Forecasted gas demand by consumption sectors in this scenario is given below (Table 4-3 and Figure 4-3).

Table 4-3 Forecasted gas demand by consumption sector (mcm) - High gas consumption Scenario

Consumption sector	2021	2022	2025	2030	2035	2040	2045	2050
Households	1,254	1,377	1,485	1,680	1,751	1,816	1,873	1,923
Services	268	299	312	333	355	378	401	425
Industry	237	267	342	489	655	858	1,107	1,373
Agriculture	10	11	12	15	17	20	22	25
Transport	129	158	159	165	164	154	141	130
Feedstocks	169	191	185	339	339	339	339	339
Total	**2,067**	**2,303**	**2,496**	**3,020**	**3,282**	**3,565**	**3,884**	**4,215**

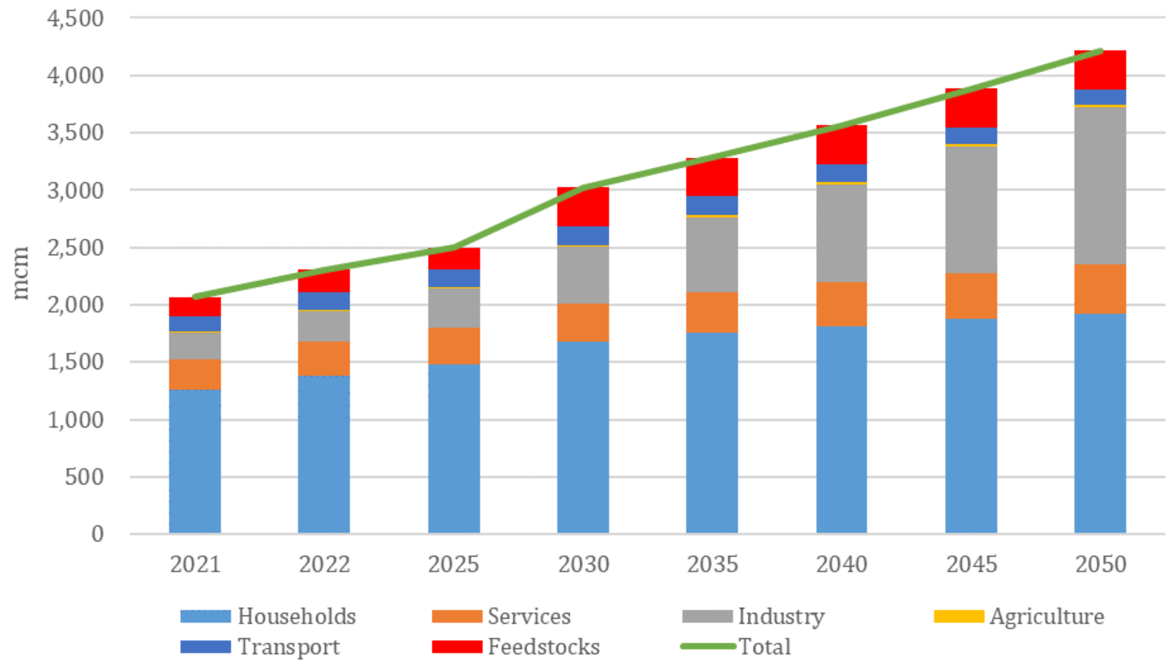


Figure 4-3 Forecasted gas demand by consumption sector - High gas consumption Scenario

Table 4-4 and Figure 4-4 show the comparison of the forecasted gas consumption in the final consumption sectors:

Table 4-4 Comparison of the forecasted gas consumption in final consumption sectors

	2021	2022	2025	2030	2035	2040	2045	2050
BAU Scenario	2,067	2,303	2,438	2,680	2,816	2,961	3,121	3,276
Scenario with measures			2,355	2,433	2,409	2,395	2,290	2,157
High gas consumption Scenario			2,496	3,020	3,282	3,565	3,884	4,215

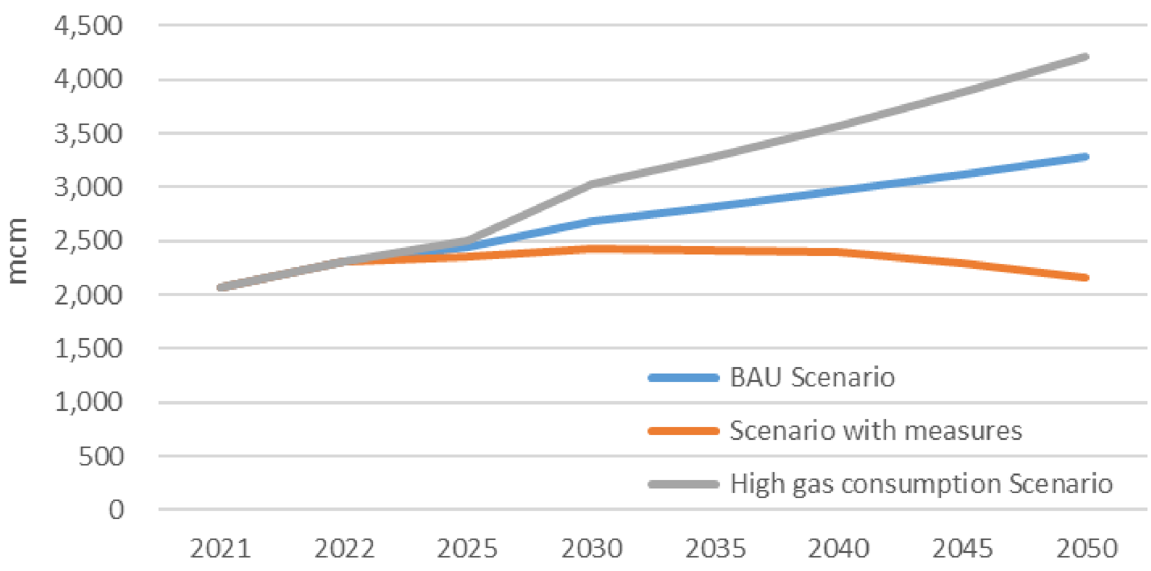


Figure 4-4 Comparison of the forecasted gas consumption in final consumption sectors

4.2 Gas Demand for Electricity Generation

The projected gas demand for electricity generation (for scenarios 1 to 5) as described in Chapter 3 is detailed in Table 4-5 and Figure 4-5 below:

Table 4-5 Forecasted gas demand for electricity generation (mcm)

Gas demand for electricity generation	2021	2022	2025	2030	2035	2040	2045	2050
Scenario 1	496	754	479	319	252	200	184	0
Scenario 2			787	716	627	566	529	535
Scenario 3			795	753	930	1,056	1,144	1,328
Scenario 4			795	955	1,381	1,822	2,294	3,019
Scenario 5			579	628	575	536	523	533

Scenarios 1 and 5 show noticeably lower consumption. Scenario 1 has higher installed RES capacities compared to the current state – HPPs increase by 269 MW, WPPs by 729 MW, and SPPs by 500 MW. While the TPP capacities stay the same, higher utilization of RES is probable leading to lower gas consumption in the electricity sector. Regarding Scenario 5, it relies on NECP data which tends to be more optimistic regarding RES utilization. Therefore, gas consumption is also lower.

Additionally, there is a discrepancy in the trendline of Scenario 3 in 2030. As was previously mentioned, this is attributed to predicted higher generation from CCGTs – an efficient technology that lowers gas consumption due to its higher efficiency.

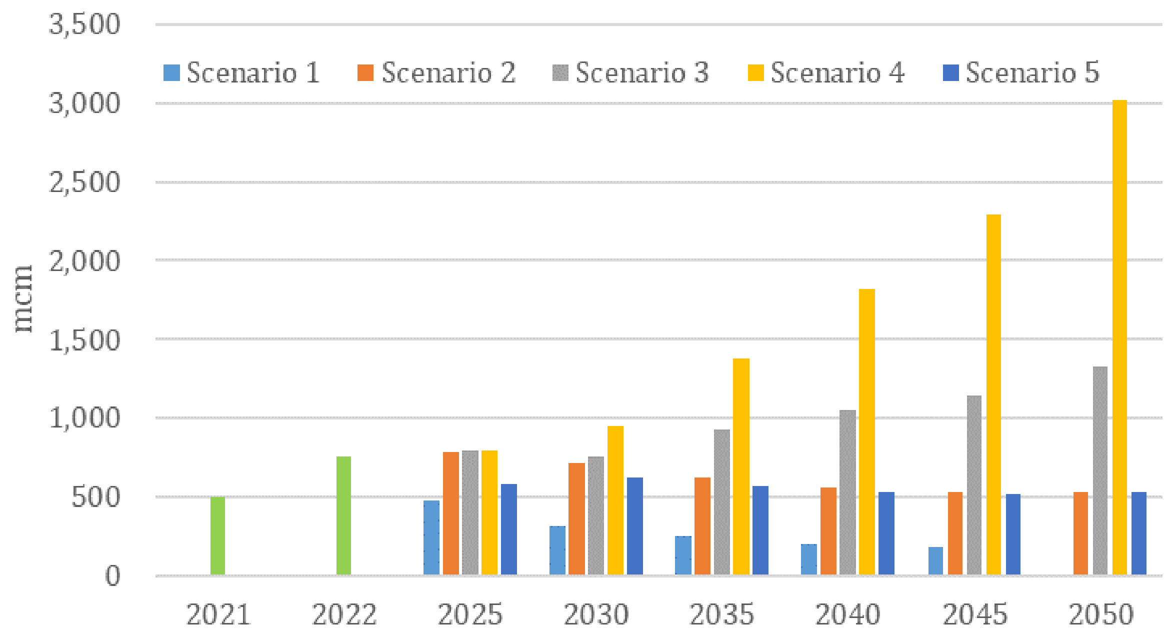


Figure 4-5 Forecasted gas demand for electricity generation

4.3 Total Gas Demand

Summing up the gas demand projections for the final consumption sectors and gas demand for electricity generation, we obtained the total projected gas demand in Georgia for the scenarios. The scenarios highly differ due to different assumptions of gas demand for electricity generation, as explained in the previous chapter.

4.3.1 BAU Scenario

According to BAU Scenario 1, the total projected gas demand in Georgia will grow to 3.3 bcm in 2050. As presented in Table 4-5 and Figure 4-5 in all other scenarios, higher gas demand for electricity generation is expected. Therefore, total projected gas demand will grow to 3.8 bcm in 2050 in Scenarios 2 and 5, up to 4.6 bcm in 2050 in Scenario 3, and up to 6.3 bcm in Scenario 4 (Table 4-6 and Figure 4-6).

Table 4-6 Total forecasted gas demand in Georgia (mcm) - BAU Scenario

	2021	2022	2025	2030	2035	2040	2045	2050
BAU Scenario 1	2,563	3,058	2,918	2,999	3,068	3,162	3,305	3,276
BAU Scenario 2	2,563	3,058	3,225	3,396	3,443	3,527	3,650	3,810
BAU Scenario 3	2,563	3,058	3,233	3,433	3,746	4,017	4,265	4,603
BAU Scenario 4	2,563	3,058	3,233	3,635	4,197	4,783	5,416	6,295
BAU Scenario 5	2,563	3,058	3,018	3,308	3,391	3,497	3,644	3,809

The total forecasted gas demand data shows what has already been concluded. Scenarios 1 and 5 assume significantly lower trends in gas consumption in the electricity sector, which of course impacts overall gas demand.

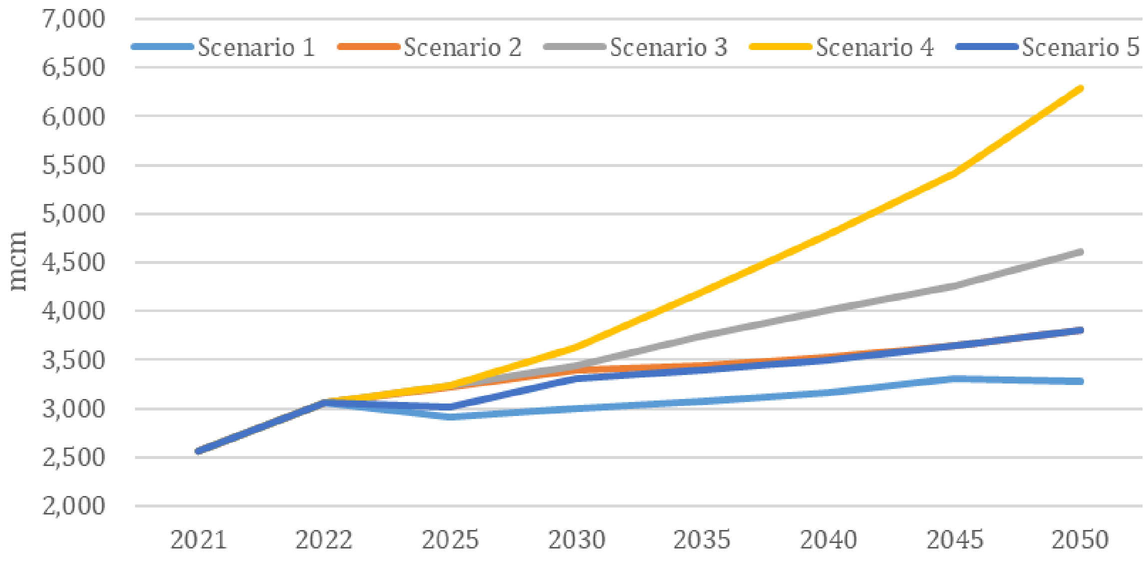


Figure 4-6 Total forecasted gas demand in Georgia (BAU Scenario 1-5)

4.3.2 Scenario with Measures

The goal of the Scenario with measures is to decrease final energy demand. Therefore, in Scenarios with measures, the total projected gas demand in Georgia is expected to increase by 2030, and then decline after until 2050, except in scenarios 3 and 4, in which higher gas consumption is assumed for gas-fired electricity generation. In this case, the difference is much more pronounced due to the lower projected gas consumption in the final consumption sectors so the total gas consumption in Scenario 4 is significantly higher than in other scenarios. The projected total gas consumption in Scenario with measures 1 in 2050 is 2.2 bcm, while in scenarios 2 and 5 is 2.7 bcm. In Scenarios with measures 3 and 4, the total projected gas demand is expected to grow to 3.5 bcm, and 5,2 bcm in 2050 (Table 4-7 and Figure 4-7).

Table 4-7 Total forecasted gas demand in Georgia (mcm) - Scenario with measures

	2021	2022	2025	2030	2035	2040	2045	2050
Scenario with measures 1	2,563	3,058	2,834	2,753	2,661	2,596	2,474	2,157
Scenario with measures 2	2,563	3,058	3,142	3,149	3,037	2,961	2,819	2,692
Scenario with measures 3	2,563	3,058	3,149	3,187	3,340	3,451	3,434	3,484
Scenario with measures 4	2,563	3,058	3,149	3,389	3,790	4,217	4,584	5,176
Scenario with measures 5	2,563	3,058	2,934	3,062	2,984	2,931	2,812	2,690

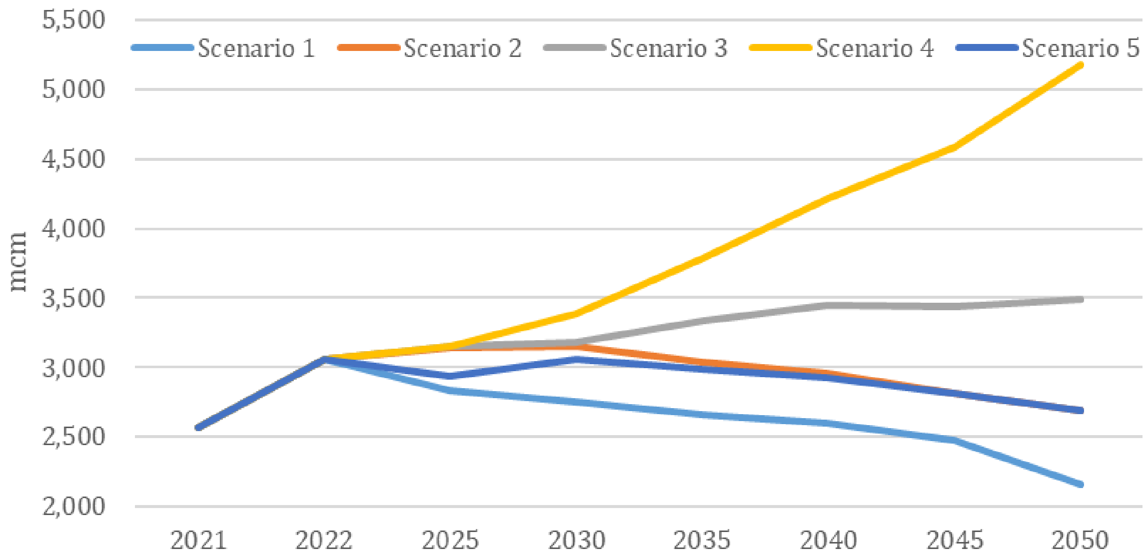


Figure 4-7 Total forecasted gas demand in Georgia (Scenario with measures 1-5)

4.3.3 High Gas Consumption Scenario

In the high gas consumption scenario, the total projected gas demand in Georgia will grow to 4.2 bcm by 2050 in Scenario 1, to 4.7 bcm in Scenarios 2 and 5, up to 5.5 bcm in 2050 in Scenario 3, and up to 7.2 bcm in Scenario 4 (Table 4-8 and Figure 4-8).

Table 4-8 Total forecasted gas demand in Georgia (mcm) - High gas consumption Scenario

	2021	2022	2025	2030	2035	2040	2045	2050
High gas consumption scenario 1	2,563	3,058	2,975	3,339	3,534	3,765	4,068	4,215
High gas consumption scenario 2	2,563	3,058	3,283	3,736	3,909	4,131	4,413	4,749
High gas consumption scenario 3	2,563	3,058	3,291	3,774	4,212	4,621	5,028	5,542
High gas consumption scenario 4	2,563	3,058	3,291	3,975	4,663	5,387	6,178	7,234
High gas consumption scenario 5	2,563	3,058	3,075	3,648	3,857	4,101	4,407	4,748

Again, Scenario 4 assumes a high level of gas-fired electricity generation which results in significantly higher gas consumption compared to other scenarios.

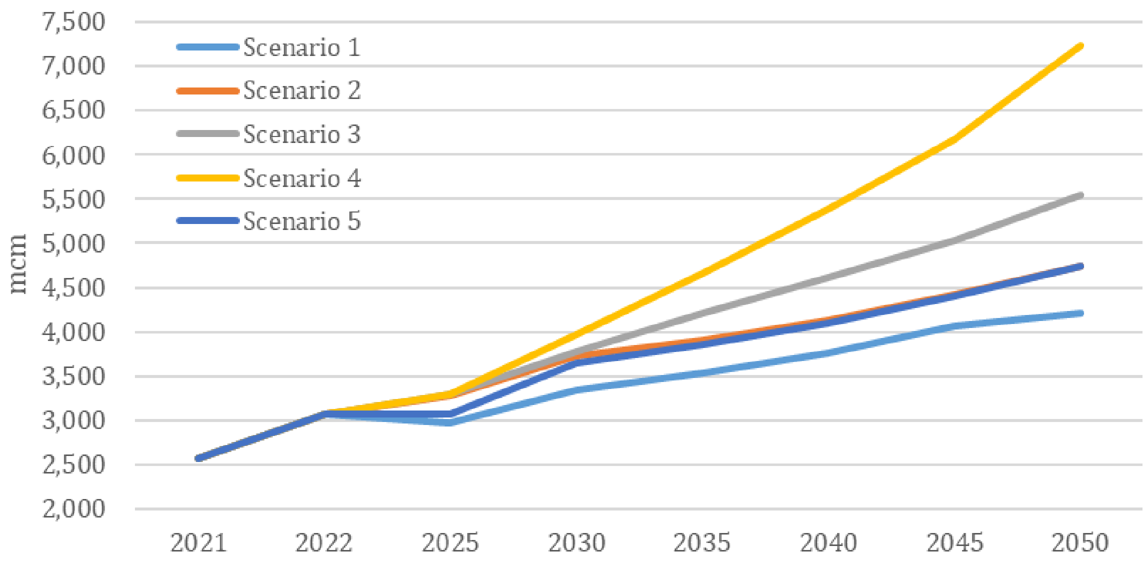


Figure 4-8 Total forecasted gas demand in Georgia (High gas consumption Scenario 1-5)

A comparison of all analyzed scenarios of the projections of gas demand in Georgia is shown in Figure 4-9.

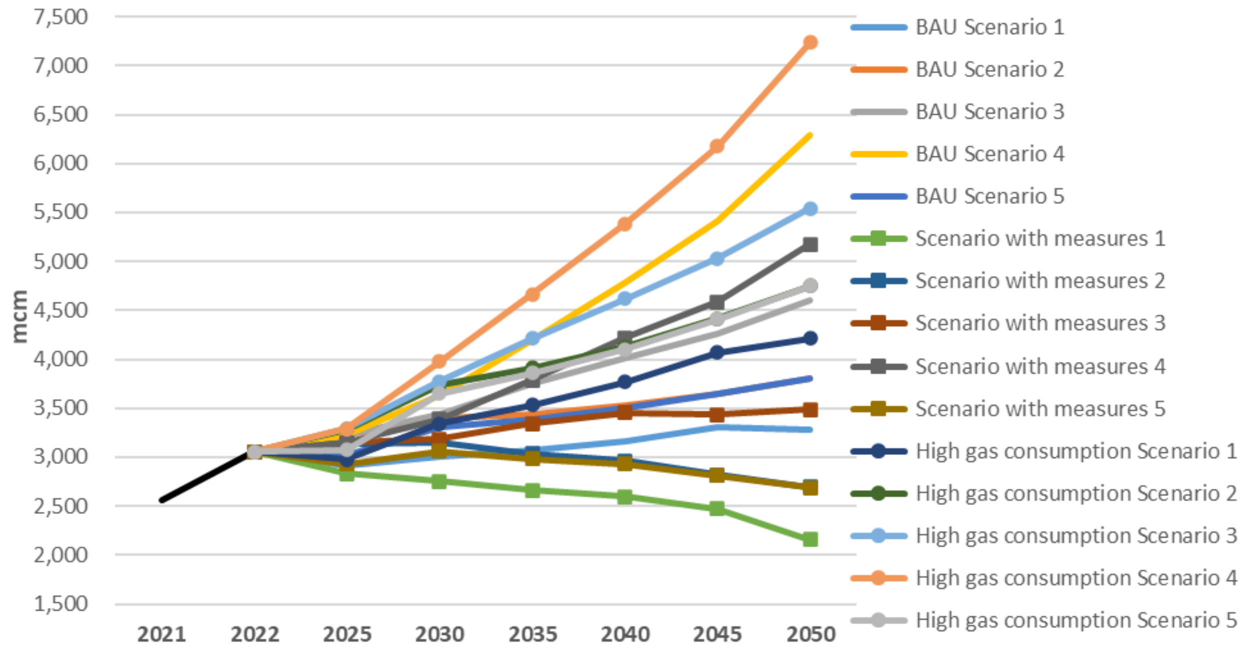


Figure 4-9 Comparison of the forecasted gas demand in Georgia (all scenarios)

4.4 Peak gas demand

Like other countries in which natural gas is largely used for heating purposes in households, Georgia has pronounced seasonality in gas consumption. Due to the increase in gas demand by temperature-dependent consumers, gas consumption in the winter months is much higher than average consumption. Additionally, gas consumption for electricity generation in Georgia is also realized mostly in the winter months, when the electricity generation from the hydropower plants is reduced due to low water flows. This is why Georgia has a relatively high peak gas demand compared with the average gas consumption.

The peak gas demand is calculated considering (1) the available historical data on annual and monthly gas consumption in Georgia as well as (2) the data regarding the maximum realized daily gas consumption per month in the 2019 to 2022 period, including the first seven months of 2023 (as provided by the Georgian Gas Transportation Company for the consumers on the distribution systems, and those connected directly to the gas transmission system, i.e. thermal power plants and large industry). According to the data, peak gas consumption in Georgia is realized in the winter months: December, January, or February. The average calculated peak gas demand factor in the observed period is 2.14, meaning that the realized daily gas consumption[16] is 2.14 times higher than the average gas consumption (annual consumption divided by the number of days in the year).

The additional information provided by GGTC enabled even better insight into the gas consumption profile and made it possible to conduct a more detailed analysis and calculate the peak demand factor separately for the industrial consumers, power plants, and the consumers connected to the distribution system. The analysis showed that the peak gas demand factor for industry is 2.04, and for consumers connected to the distribution system it is 2.02.

These factors are used for the calculation of the projected peak gas demand considering the projected sectoral annual gas demand in Georgia per different scenarios presented in Table 4-1, Table 4-2 and Table 4-3.

4.4.1 BAU Scenario

The projected peak daily gas demands per consumption sector in BAU Scenario are presented in Table 4-9 and Table 4-10.

Table 4-9 Projected peak gas demand in final consumption sectors in Georgia (mcm/day) - BAU Scenario

Consumption sector	2021	2022	2025	2030	2035	2040	2045	2050
Households	7.0	7.3	8.2	9.1	9.4	9.7	9.9	10.1
Services	1.5	1.6	1.7	1.8	1.8	1.9	1.9	1.9
Industry	1.3	1.5	1.8	2.2	2.7	3.3	4.0	4.7
Agriculture	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Transport	0.7	0.8	0.8	0.7	0.6	0.5	0.4	0.3
Feedstocks	0.9	1.1	1.0	1.0	1.0	1.0	1.0	1.0
Total	**11.6**	**12.3**	**13.5**	**14.9**	**15.6**	**16.4**	**17.3**	**18.2**

[16] Actual peak daily gas consumption measured in a given year (provided by GGTC), i.e., the highest factual daily peak gas consumption during the calendar year.

The same above-mentioned analysis showed that the peak gas demand factor for gas-powered electricity generation is 2.78[17]. However, this factor is highly dependent on the utilization of the power plants, i.e. total annual gas consumption for electricity generation. If the utilization rate of the gas-fired power plants is low (such as in Scenario 1), the average daily gas consumption is also low so the difference between the average and the peak gas consumption is higher. Vice versa, Scenario 4 assumes relatively high utilization of the gas-powered electricity generation capacity, meaning a high number of operating hours of power plants at almost full capacity. In such a case, the average gas consumption throughout the year will be higher, so the peak gas demand factor or the ratio between the average and the peak gas consumption will be lower.

Therefore, the peak demand factors for electricity generation are calculated considering the monthly gas-fired electricity generation for each generation scenario provided by GSE. Data on forecasted monthly gas-fired electricity generation were used to calculate annual and monthly gas consumption considering the heat rates for each power plant (provided by GSE). After that, the average daily gas consumption in a peak month was calculated.

Furthermore, to calculate peak daily gas consumption, the average daily consumption in a peak month was increased by 13%, which is calculated to be the difference between the peak daily and average daily consumption in a peak month, according to the GSE provided data on hourly electricity generation during the period 2020-2022. The calculated peak factors differ in range from 1.8 and 4.5, depending on the generation scenario.

Considering the calculated peak gas demand factors and the forecasted gas demand for electricity generation for each generation scenario (Table 4-5), the peak gas demand for electricity generation in Georgia was calculated and is shown in Table 4-10 below:

Table 4-10 Projected peak gas demand for electricity generation in Georgia (mcm/day)

	2021	2022	2025	2030	2035	2040	2045	2050
Scenario 1	4.0	6.1	3.6	2.9	2.6	2.3	2.3	0.0
Scenario 2			4.6	4.6	4.6	4.6	4.7	4.9
Scenario 3			4.7	4.6	5.5	6.2	6.7	7.6
Scenario 4			4.7	5.6	7.6	9.6	11.9	14.9
Scenario 5			3.4	4.0	4.2	4.4	4.6	4.9

Summarizing the projected peak gas demand for the final consumption sectors and electricity generation, the total projected peak gas demand in Georgia is obtained (Table 4-11 and Figure 4-10).

Table 4-11 Total projected peak gas demand in Georgia (mcm/day) - BAU Scenario

	2021	2022	2025	2030	2035	2040	2045	2050
BAU Scenario 1	15.6	16.7	17.1	17.8	18.2	18.8	19.6	18.2
BAU Scenario 2			18.2	19.5	20.3	21.1	22.0	23.1
BAU Scenario 3			18.2	19.5	21.1	22.6	24.1	25.8
BAU Scenario 4			18.2	20.5	23.3	26.1	29.2	33.1
BAU Scenario 5			17.0	18.9	19.9	20.8	22.0	23.1

[17] Average of peak gas demand factor in 2019-2022

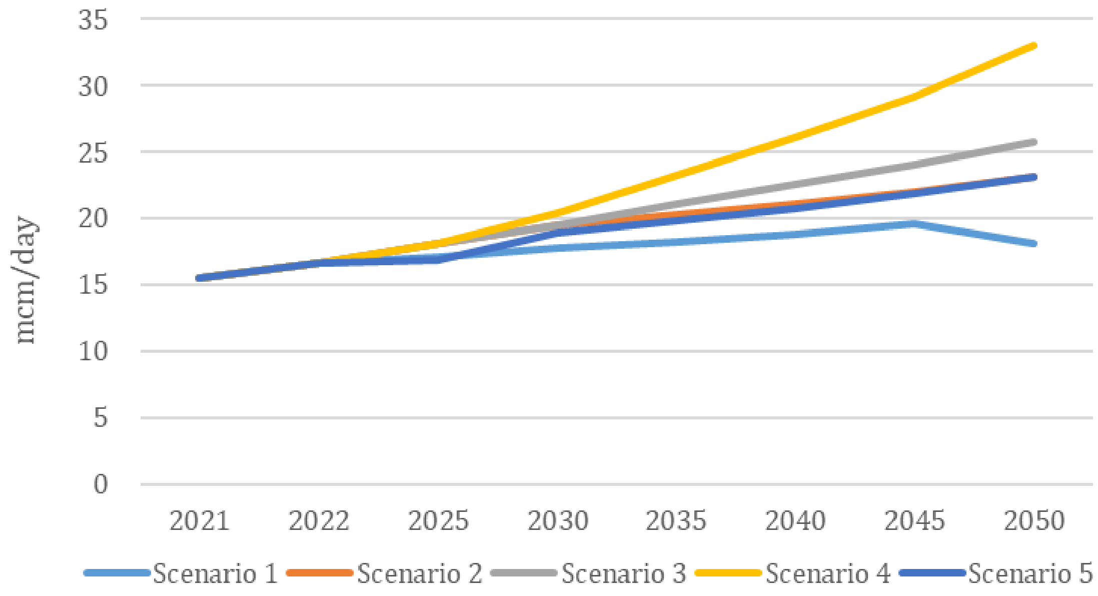


Figure 4-10 Total projected peak gas demand in Georgia (mcm/day) - BAU Scenario

Additionally, peak gas demand calculations were made considering the regression analysis provided by GOGC[18], showing the interdependence between annual gas consumption growth and the increase of the daily peak gas demand in Georgia in the period of 2016-2023. This analysis shows a very high correlation between peak gas consumption and the total annual gas consumption in Georgia (Figure 4-11).

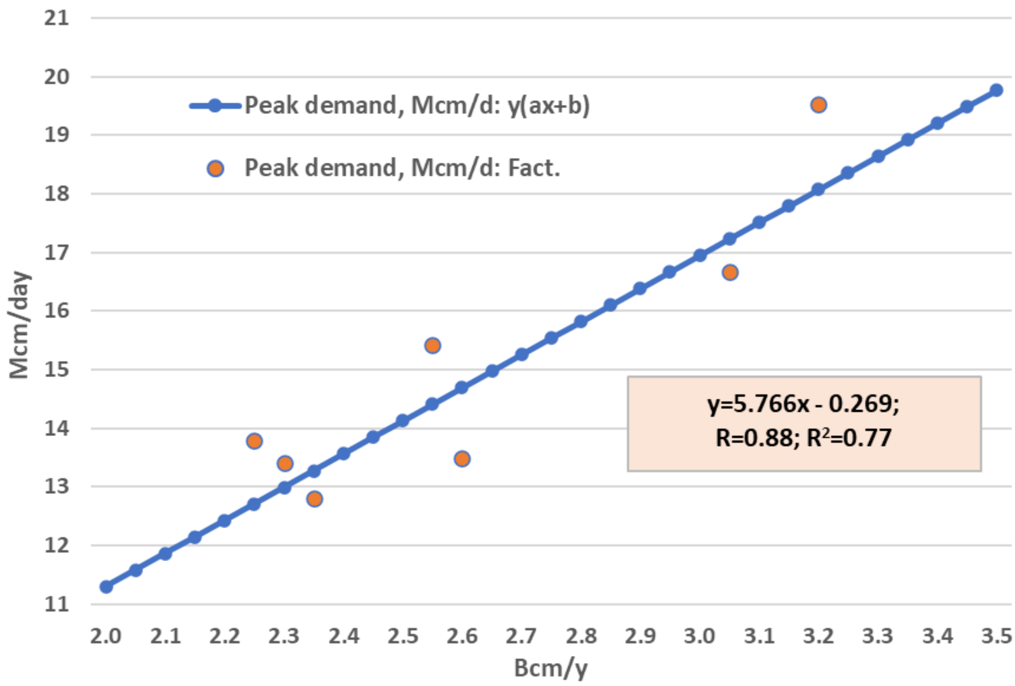


Figure 4-11 The results of the regression analysis on gas demand in Georgia

Source: GOGC

[18] Source: TYNDP (2021-2030), for Georgian natural gas transmission network, prepared by Department of strategic planning of GOGC, Tbilisi, 2021 (data for 2023 are operational, provided by GOGC).

The comparison of the results of the peak gas demand calculation by the two methods, and the actual (measured) peak gas consumption in the period from 2016 to 2023 shows that these two methods are suitable for the peak demand projection calculations (Table 4-12 and Figure 4-12).

Taking into consideration unpredicted high growth of peak gas consumption in February 2023 and the relevance of the EIHP method for the mid-term and long-term forecasting, it is more reasonable to use projection coming from GOGC method for the short-term (2025-2030 horizon) planning and preparedness and the EIHP method results for the 2040-2050 years strategy.

Table 4-12 Comparison of the results of the peak gas demand calculation and actual (measured) data of peak gas demand in Georgia (mcm/day)

	2016	2017	2018	2019	2020	2021	2022	2023	2025*	2030*	2035*	2040*	2045*	2050*
EIHP Method	13.5	13.7	13.5	14.6	15.4	15.3	17.7	19.5	18.2	19.5	21.1	22.6	24.1	25.8
GOGC Method	12.6	13.0	12.8	14.5	14.4	14.5	17.4	19.5	19.7	21.0	22.9	24.5	26.0	28.1
Actual measured data	13.8	12.8	13.4	13.0	15.4	15.6	16.7	19.5						

**Projected peak gas demand for BAU Scenario 3*

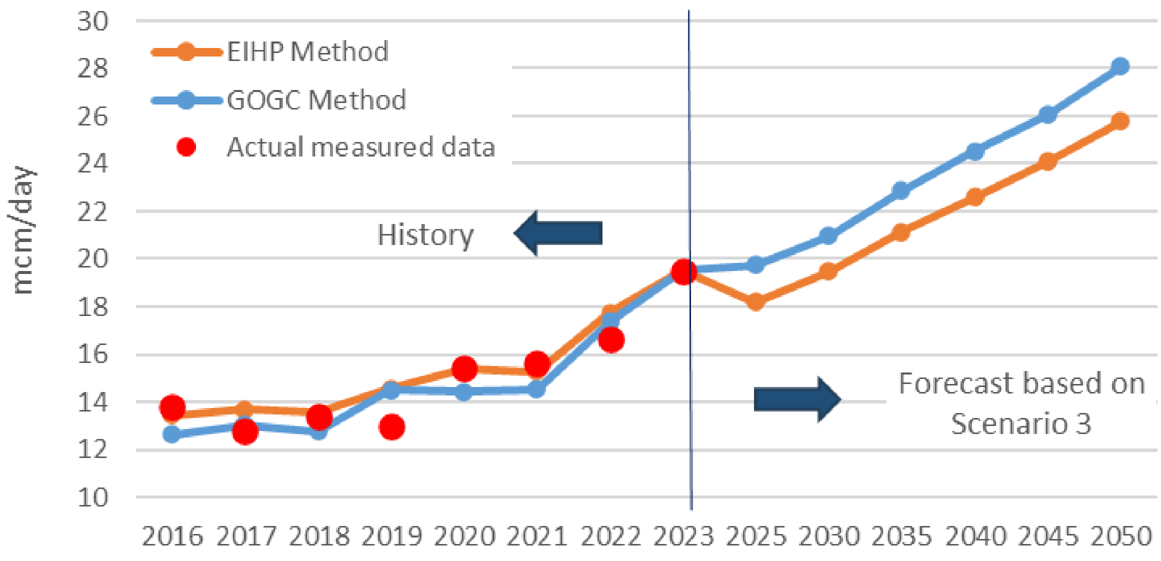


Figure 4-12 Comparison of the peak gas demand

Peak gas demand in Georgia calculated by using the GOGC method, and considering the projected annual gas demand is shown in Table 4-13 and Figure 4-13.

Table 4-13 Total projected peak gas demand in Georgia (mcm/day) - BAU Scenario (GOGC Method)

	2021	2022	2025	2030	2035	2040	2045	2050
BAU Scenario 1	15.6	16.7	17.8	18.3	18.7	19.3	20.2	20.0
BAU Scenario 2			19.7	20.7	21.0	21.5	22.3	23.3
BAU Scenario 3			19.7	21.0	22.9	24.5	26.0	28.1
BAU Scenario 4			19.7	22.2	25.6	29.2	33.1	38.4
BAU Scenario 5			18.4	20.2	20.7	21.3	22.2	23.2

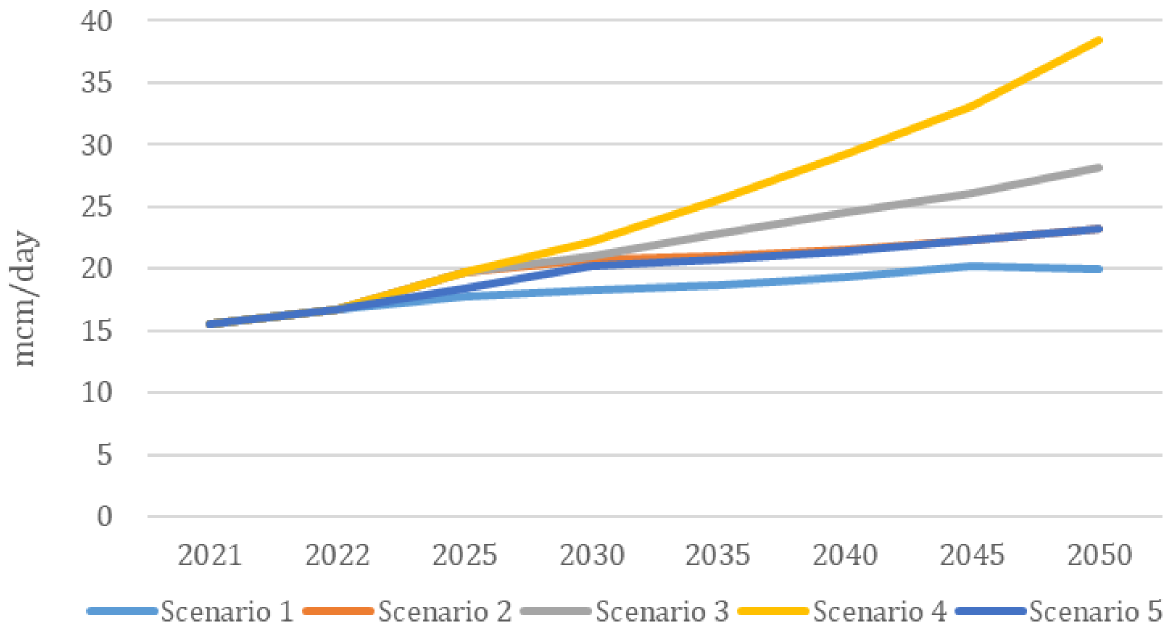


Figure 4-13 Total projected peak gas demand in Georgia (mcm/day) - BAU Scenario (GOGC Method)

The comparison of the resulting peak gas demand in Georgia shows that the differences in projected peak gas demand between the two methods used for the peak gas demand calculation are acceptable (Table 4-14 and Figure 4-14). The differences in projected peak gas demand are slightly higher in the Scenarios 1 and 4 (up to 13.9% difference in 2050).

Table 4-14 Differences in projected peak gas demand in Georgia calculated by two different methods

	2025	2030	2035	2040	2045	2050
BAU Scenario 1	-4.0%	-2.9%	-2.5%	-2.6%	-2.7%	-8.9%
BAU Scenario 2	-7.6%	-6.0%	-3.6%	-2.1%	-1.2%	-0.6%
BAU Scenario 3	-7.8%	-7.1%	-7.6%	-7.8%	-7.5%	-8.2%
BAU Scenario 4	-7.8%	-7.7%	-9.2%	-10.6%	-11.5%	-13.9%
BAU Scenario 5	-7.9%	-6.3%	-3.9%	-2.5%	-1.3%	-0.6%

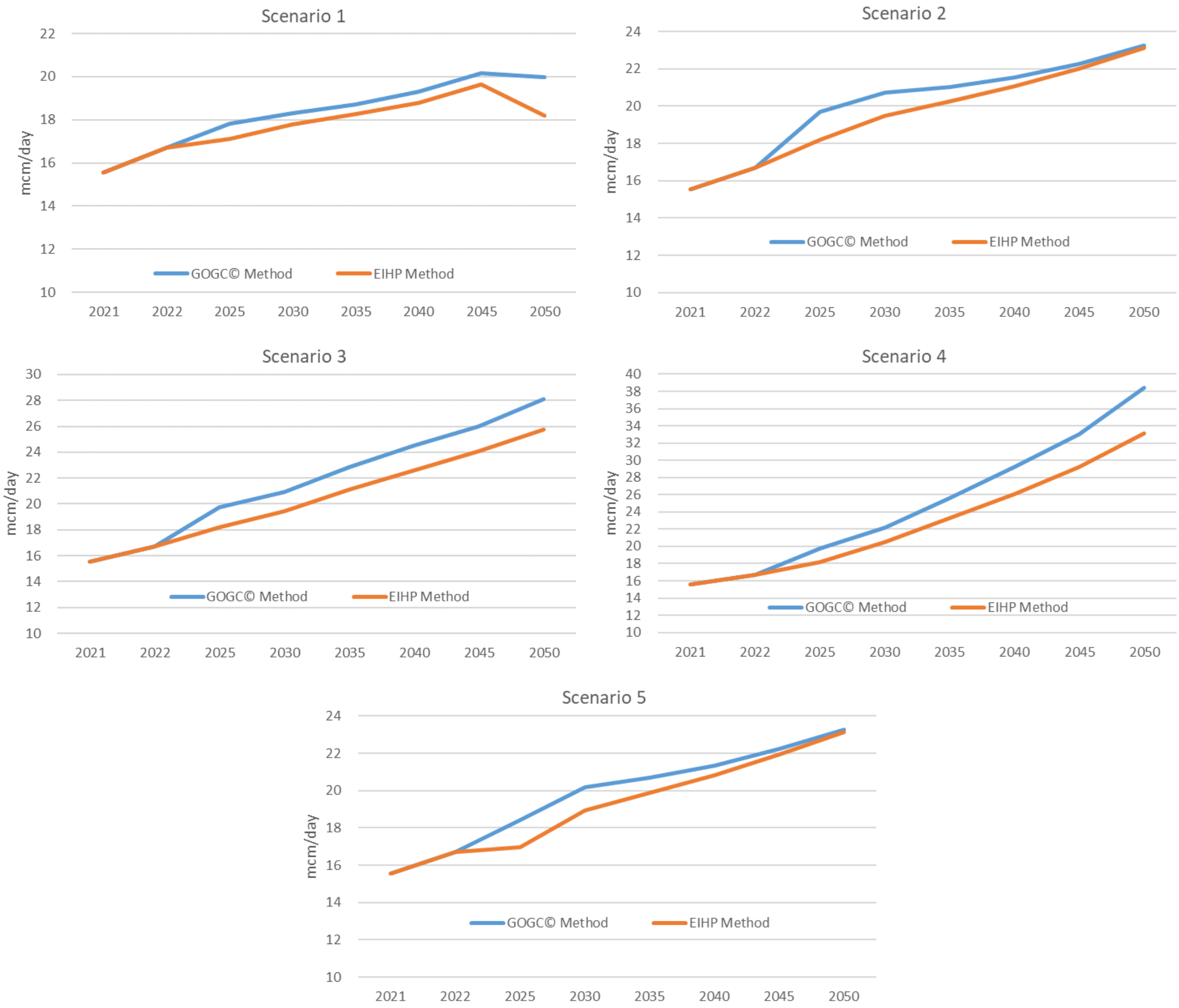


Figure 4-14 Comparison of the peak gas demand projections calculated by two methods - BAU Scenario

4.4.2 Scenario with Measures

The peak daily gas demands per consumption sector (considering the forecasted gas consumption in the Scenario with measures) are calculated using the same methodology as explained in Chapter 4.4. The resulting peak daily gas demands are presented in Table 4-15 and Table 4-16.

Table 4-15 Projected peak gas demand in final consumption sectors in Georgia (mcm/day) - Scenario with Measures

Consumption sector	2021	2022	2025	2030	2035	2040	2045	2050
Households	7.0	7.3	7.8	7.9	7.3	6.7	6.0	5.2
Services	1.5	1.6	1.5	1.4	1.2	1.1	1.0	0.9
Industry	1.3	1.5	1.8	2.4	3.1	3.9	4.2	4.4
Agriculture	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Transport	0.7	0.8	0.8	0.7	0.6	0.5	0.4	0.3
Feedstocks	0.9	1.1	1.0	1.0	1.0	1.0	1.0	1.0
Total	**11.6**	**12.3**	**13.1**	**13.5**	**13.4**	**13.3**	**12.7**	**12.0**

Summing up the projected peak gas demand for the final consumption sectors, and peak gas demand for electricity generation (Table 4-10), we obtain the total projected peak gas demand in Georgia considering the forecasted gas consumption according to the Scenario with Measures. The resulting peak daily gas demand projections are shown in Table 4-16 and Figure 4-15.

Table 4-16 Total projected peak gas demand in Georgia (mcm/day) - Scenario with Measures

	2021	2022	2025	2030	2035	2040	2045	2050
Scenario with measures 1			16.6	16.4	16.0	15.7	15.0	12.0
Scenario with measures 2			17.7	18.1	18.0	17.9	17.4	16.9
Scenario with measures 3	15.6	16.7	17.7	18.1	18.9	19.5	19.5	19.6
Scenario with measures 4			17.7	19.1	21.0	23.0	24.6	26.9
Scenario with measures 5			16.5	17.6	17.6	17.7	17.3	16.9

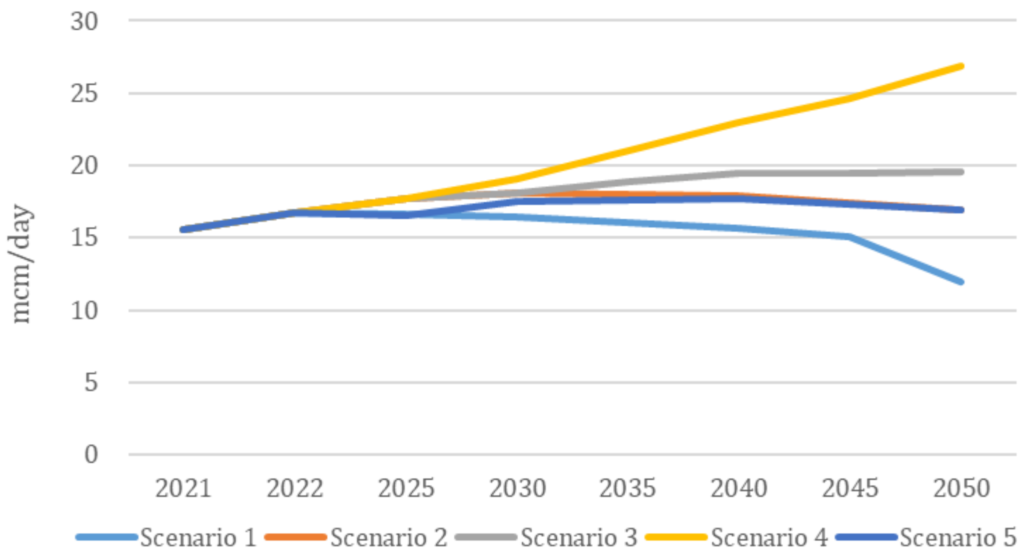


Figure 4-15 Total projected peak gas demand in Georgia (mcm/day) - Scenario with Measures

The following table and figures below describe the results of the peak daily gas consumption calculated by the GOGC method, and the comparison of the peak daily gas demand projections calculated by using the two methods previously explained.

Table 4-17 Total projected peak gas demand in Georgia (mcm/day) - Scenario with Measures - GOGC Method

	2021	2022	2025	2030	2035	2040	2045	2050
Scenario with measures 1			17.3	16.8	16.2	15.8	15.1	13.2
Scenario with measures 2			19.2	19.2	18.5	18.1	17.2	16.4
Scenario with measures 3	15.6	16.7	19.2	19.4	20.4	21.1	21.0	21.3
Scenario with measures 4			19.2	20.7	23.1	25.7	28.0	31.6
Scenario with measures 5			17.9	18.7	18.2	17.9	17.2	16.4

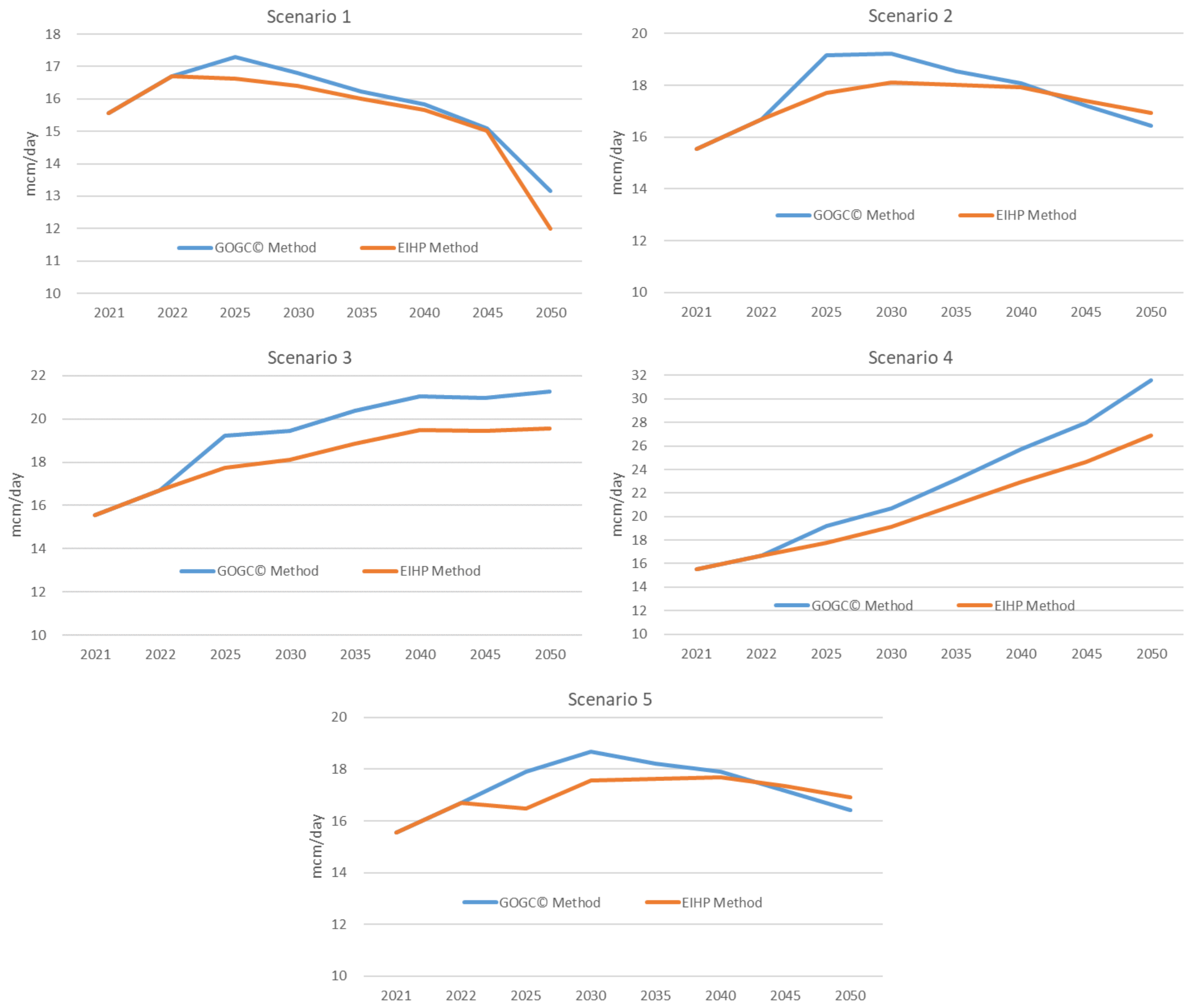


Figure 4-16 Comparison of the peak gas demand projections calculated by two methods - Scenario with Measures

4.4.3 High Gas Consumption Scenario

The peak daily gas demands per consumption sector (considering the forecasted gas consumption in the High gas consumption Scenario) are presented in Table 4-18.

Table 4-18 Projected peak gas demand in final consumption sectors in Georgia (mcm/day) - High Gas Consumption Scenario

Consumption sector	2021	2022	2025	2030	2035	2040	2045	2050
Households	7.0	7.3	8.2	9.3	9.7	10.1	10.4	10.7
Services	1.5	1.6	1.7	1.8	2.0	2.1	2.2	2.4
Industry	1.3	1.5	1.9	2.7	3.7	4.8	6.2	7.7
Agriculture	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Transport	0.7	0.8	0.9	0.9	0.9	0.9	0.8	0.7
Feedstocks	0.9	1.1	1.0	1.9	1.9	1.9	1.9	1.9
Total	**11.6**	**12.3**	**13.9**	**16.8**	**18.2**	**19.8**	**21.6**	**23.4**

Summing up the projected peak gas demand for the final consumption sectors, and peak gas demand for electricity generation (Table 4-10), we obtained the total projected peak gas demand in Georgia considering the forecasted gas consumption according to the High Gas Consumption Scenario. The resulting peak daily gas demand projections are shown in Table 4-19 and Figure 4-17.

Table 4-19 Total projected peak gas demand in Georgia (mcm/day) - High Gas Consumption Scenario

<table>
<tr><th></th><th>2021</th><th>2022</th><th>2025</th><th>2030</th><th>2035</th><th>2040</th><th>2045</th><th>2050</th></tr>
<tr><td>High gas consumption Scenario 1</td><td rowspan="5">15.6</td><td rowspan="5">16.7</td><td>17.4</td><td>19.7</td><td>20.8</td><td>22.2</td><td>23.9</td><td>23.4</td></tr>
<tr><td>High gas consumption Scenario 2</td><td>18.5</td><td>21.4</td><td>22.9</td><td>24.4</td><td>26.3</td><td>28.4</td></tr>
<tr><td>High gas consumption Scenario 3</td><td>18.5</td><td>21.4</td><td>23.7</td><td>26.0</td><td>28.3</td><td>31.0</td></tr>
<tr><td>High gas consumption Scenario 4</td><td>18.5</td><td>22.4</td><td>25.9</td><td>29.5</td><td>33.5</td><td>38.3</td></tr>
<tr><td>High gas consumption Scenario 5</td><td>17.3</td><td>20.8</td><td>22.5</td><td>24.2</td><td>26.2</td><td>28.3</td></tr>
</table>

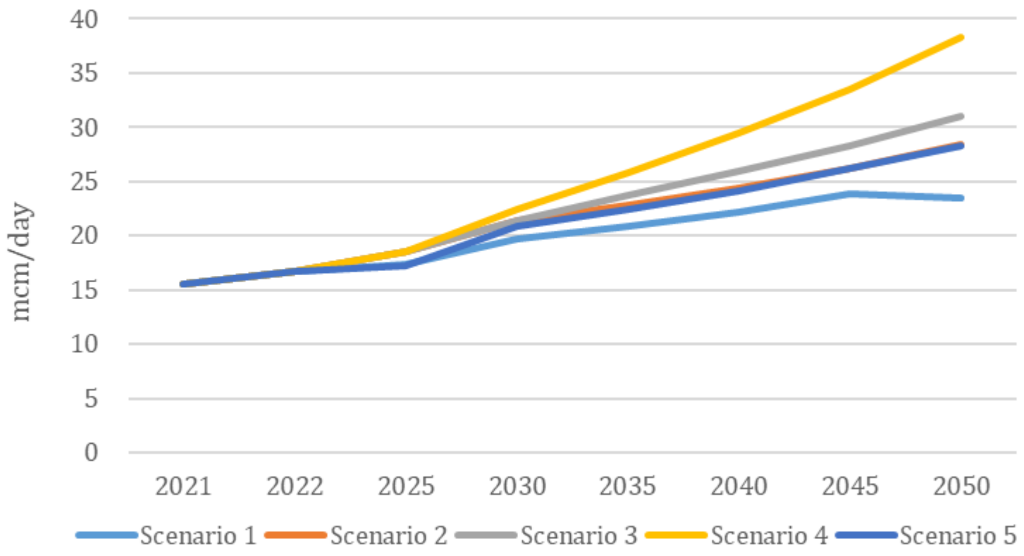


Figure 4-17 Total projected peak gas demand in Georgia (mcm/day) - High Gas Consumption Scenario

The results of the peak daily gas consumption calculated by the linear regression method, and the comparison of the peak daily gas demand projections (calculated by using the two methods explained earlier) are shown in the table and figures below.

Table 4-20 Total projected peak gas demand in Georgia (mcm/day) - High Gas Consumption Scenario - GOGC Method

	2021	2022	2025	2030	2035	2040	2045	2050
High gas consumption Scenario 1			18.2	20.4	21.6	23.0	24.8	25.7
High gas consumption Scenario 2			20.0	22.8	23.9	25.2	26.9	29.0
High gas consumption Scenario 3	15.6	16.7	20.1	23.0	25.7	28.2	30.7	33.8
High gas consumption Scenario 4			20.1	24.3	28.5	32.9	37.7	44.2
High gas consumption Scenario 5			18.8	22.3	23.5	25.0	26.9	29.0

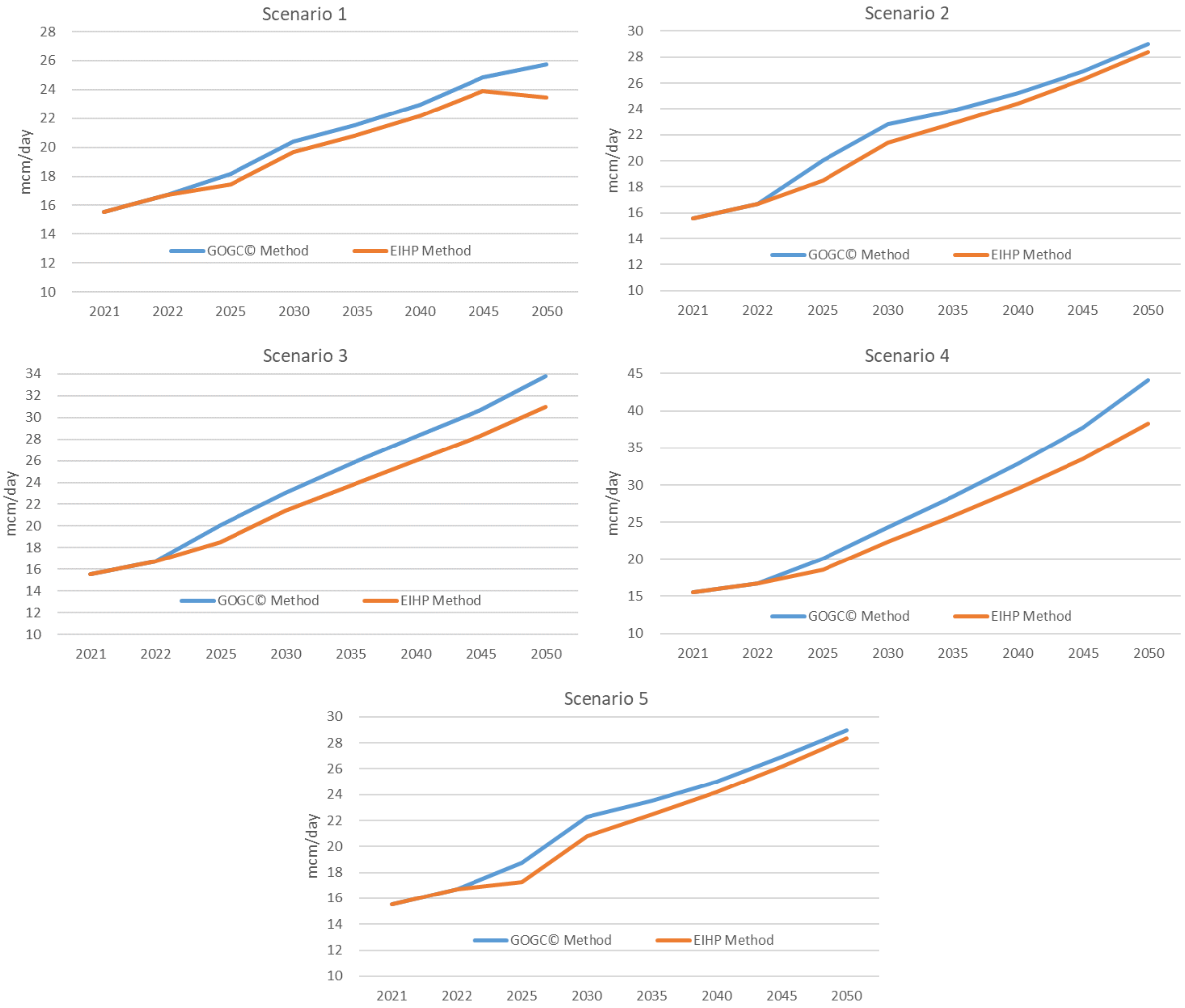


Figure 4-18 Comparison of the peak gas demand projections calculated by two methods - High Gas Consumption Scenario

5. CONCLUSION

This study analyzed the future total gas and peak gas demand in Georgia up to 2050. The future gas demand was assessed in two ways:

- Using LEAP software, the **final energy demand** for industry, transport, services, agriculture, and households was assessed (including an assessment of gas demand in the above sectors).
- In collaboration with Georgian State Electrosystem (GSE), the study analyzed the gas demand in the **electricity sector**.

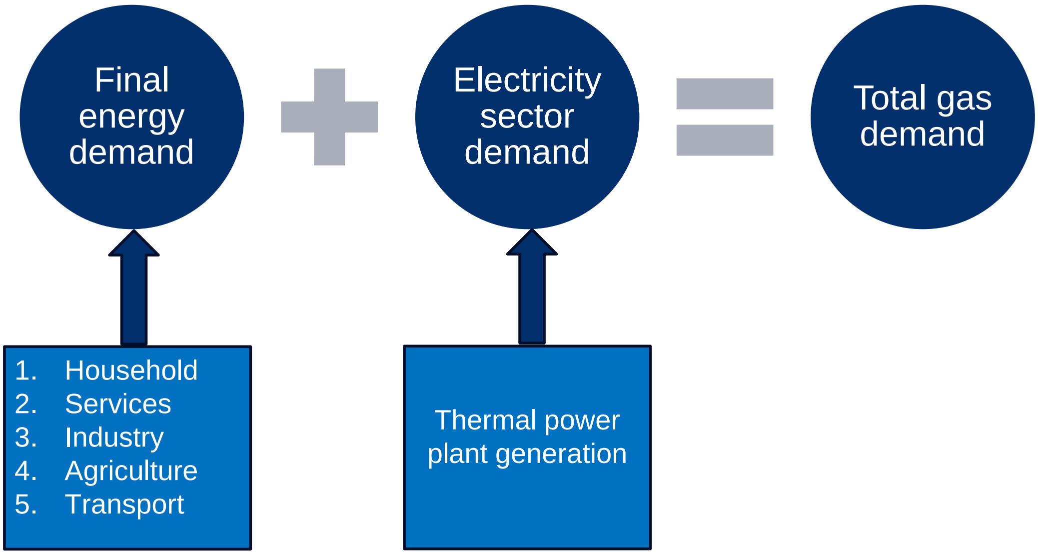


Figure 5-1. Modeling approach

To model final gas demand for the industry, transport, services, and household sectors, this study employed a comprehensive bottom-up modelling approach using the LEAP software to project natural gas demand until 2050. The projections were done under three scenarios: business-as-usual (BAU), Scenario with Measures, and High Gas Consumption Scenario. The results reveal substantial disparities in demand projections, highlighting the sensitivity of natural gas demand to factors such as economic growth, energy policies, and technological advancements. In summary, the results of this study on natural gas demand projections across three scenarios offer valuable insights into the potential future energy landscape.

For **electricity demand**, all scenarios show a consistent upward trajectory, indicating a continuous increase in consumption. Notably, the scenario with measures exhibits slightly higher electricity consumption, while the high gas scenario shows slightly lower consumption when compared to the business as usual (BAU) scenario. However, the relative differences in electricity demand among the scenarios remain within a range of +/- 3% by 2030 and +/- 7% by 2050, suggesting that the impacts of these scenarios on electricity usage are relatively moderate.

Conversely, **natural gas** demand projections display more pronounced disparities among the scenarios. The BAU scenario portrays a steady growth in natural gas demand, with slightly higher growth rates in the early period, particularly up to 2030. In contrast, the scenario with measures anticipates increased natural gas demand until 2030, followed by a noteworthy shift towards reduced usage. This transition underscores the influence of policy interventions and efficiency measures. The high gas scenario stands out with higher growth rates in natural gas demand compared to the BAU scenario, accentuated by a sharp spike in 2030. This surge is attributed to the assumption of doubling natural gas as a feedstock for mineral fertilizer production.

The Georgian economy and society are currently undergoing substantial transformations, evident in recent fluctuations in GDP growth rates and shifts in energy consumption patterns. Specifically, in the context of final energy consumption, there are notable dynamics at play.

One key factor is the growing pressure stemming from the limited availability of fuelwood resources. Simultaneously, there is an expansion of the gas distribution network, resulting in an increased reliance on natural gas to fulfill thermal energy needs. This shift underscores the significance of natural gas as a primary energy source in meeting heating requirements. Moreover, the affordability of natural gas plays a pivotal role in this transition, especially as living standards rise alongside increased economic growth rates. As people's economic well-being improves, the demand for more convenient and efficient energy sources, such as natural gas, tends to increase.

In order to make a general conclusion regarding the three FED scenarios taking into consideration stakeholder feedback, and due to the Association Agreement with the EU and Georgia's obligations in the fields of Green energy policy, decarbonization and state aid to the development of RES projects, it seems reasonable that the Scenario with Measures would be prioritized by the GoG and relevant utilities for the strategic planning purposes.

Regarding the demand for gas arising from the **electricity sector**, the Consultant analyzed the **five scenarios**. **Scenario 1** presents a highly optimistic outlook with reduced gas consumption, primarily driven by a notable reliance on renewable energy sources (RES). While this represents a positive outlook, it may require careful consideration of the feasibility of achieving such ambitious RES goals. **Scenario 4** shows notably higher thermal power plant generation leading to a high reliance on thermal power plants, which raises concerns about significantly higher gas consumption levels compared to other scenarios. **Scenario 5**, which is based on the National Energy and Climate Plan (NECP) data, shows stability but also an absence of pronounced fluctuations seen in other scenarios.

Based on stakeholder feedback and considering the technical viability of the provided thermal power plant capacities, **Scenarios 2 and 3 emerge as the most realistic and, therefore, more likely outcomes**. **Scenario 2** exhibits a steady decrease in thermal power plant consumption, in line with its optimistic forecasts of RES integration. On the other hand, **Scenario 3**, while on the pessimistic side in terms of RES deployment, still maintains a reasonable balance between RES and thermal power plant generation.

The realization of these scenarios remains dependent on various factors, primarily on the successful implementation of RES projects and their integration into the Georgian power system. These scenarios serve as valuable reference points for future energy planning by showing and emphasizing the importance of synergy between energy security and sustainability.

By summing up the gas demand projections for the final consumption sectors and gas demand for electricity generation, we obtained the total projected gas demand in Georgia for a total of **15 scenarios** (3 scenarios of gas consumption in final consumption sectors times 5 scenarios of gas-fired electricity generation).

		Gas demand in final consumption sectors[19]		
		BAU Scenario	Scenarios with Measures	High Gas Scenario
Electricity sector gas demand	Scenario 1	✓	✓	✓
	Scenario 2	✓	✓	✓
	Scenario 3	✓	✓	✓
	Scenario 4	✓	✓	✓
	Scenario 5	✓	✓	✓

Figure 5-2. Possible scenarios of gas demand analyzed in the report

[19] All consumption sectors excluding gas demand for electricity generation.

Scenarios differ in relatively high amounts due to the combination of the projected gas demand in final consumption sectors, and different assumptions of gas demand for electricity generation. Consequently, the resulting total projected gas demand in 2050 varies from 2.2 to 7.2 bcm.

Considering the projected annual gas consumption, peak gas demand projections calculations were made by two different methods, and projections are given for each of the 15 scenarios. Depending on the scenario, the peak gas demand varies from 12 mcm/day in the scenario with measures and scenario 1 to 44.2 mcm/day in the high gas consumption scenario and scenario 4.

As mentioned above, scenarios 2 and 3 are the most realistic outcomes, meaning that the total gas consumption in Georgia in 2050 would be in a range from 2.7 to 5.5 bcm, depending on the combination of the scenarios of gas consumption in final consumption sectors and electricity generation. At the same time, the peak daily gas consumption ranges from 16.4 to 33.8 mcm/day (in the High Gas Consumption Scenario).

The forecasting of future energy demand always carries a degree of uncertainty. Multiple variables, including economic developments, technological advancements, policy changes, and societal preferences, can influence energy consumption patterns. Therefore, as Georgia navigates these transformative changes, it's crucial for policymakers and energy planners to remain flexible and adaptable to evolving circumstances. This adaptability will be key in ensuring the country's energy supply remains sustainable and aligned with economic and societal developments.

6. ANNEX

6.1 Projections of Monthly Electricity Generation from Different Sources

Table 6-1. Projections of monthly electricity generation from different sources in GWh – Scenario 1

Year	Month	Storage HPPs	Run-of-river HPPs	WPP	SPP	Generation	TPP+Imports+Exports	TPP	Net Imports	Net Exports
		1	2	3	4	5	6	7	8	9
2025	January	296	424	221	28	1,533	563	383	180	0
	February	277	380	198	39	1,352	458	311	147	0
	March	490	551	266	56	1,445	82	56	26	0
	April	375	606	277	82	1,332	-8	0	0	8
	May	836	602	227	82	1,301	-446	0	0	446
	June	888	545	247	89	1,365	-404	0	0	404
	July	1,049	418	201	93	1,497	-264	0	0	264
	August	775	345	222	84	1,491	65	44	21	0
	September	487	300	198	74	1,278	219	149	70	0
	October	366	304	243	45	1,337	379	258	121	0
	November	318	347	194	39	1,442	543	369	174	0
	December	366	426	215	28	1,627	592	402	189	0
2030	January	342	491	413	73	1,815	495	337	158	0
	February	320	440	369	102	1,600	369	251	118	0
	March	566	637	497	146	1,710	-137	0	0	137
	April	434	701	517	214	1,576	-289	0	0	289
	May	966	696	423	214	1,540	-760	0	0	760
	June	1,026	631	462	230	1,615	-734	0	0	734
	July	1,213	484	376	242	1,772	-543	0	0	543
	August	896	399	414	219	1,764	-164	0	0	164
	September	563	348	369	191	1,512	41	28	13	0

Year/Month		Storage HPPs	Run-of-river HPPs	WPP	SPP	Generation	TPP+Imports+Exports	TPP	Net Imports	Net Exports
		1	2	3	4	5	6	7	8	9
	October	423	351	454	117	1,582	237	161	76	0
	November	368	401	363	102	1,706	472	321	151	0
	December	423	494	401	73	1,926	535	364	171	0
2035	January	388	558	605	118	2,099	430	292	137	0
	February	363	500	541	165	1,851	282	192	90	0
	March	643	724	728	236	1,978	-352	0	0	352
	April	492	796	757	345	1,823	-567	0	0	567
	May	1,097	791	620	345	1,781	-1,072	0	0	1,072
	June	1,165	717	676	372	1,868	-1,061	0	0	1,061
	July	1,376	550	551	391	2,050	-818	0	0	818
	August	1,017	453	607	354	2,041	-390	0	0	390
	September	639	395	541	309	1,749	-134	0	0	134
	October	480	399	665	188	1,830	98	66	31	0
	November	418	456	531	165	1,974	404	275	129	0
	December	481	561	587	118	2,227	482	328	154	0
2040	January	434	625	797	163	2,399	380	258	122	0
	February	406	560	712	229	2,115	209	142	67	0
	March	719	810	959	326	2,261	-553	0	0	553
	April	551	892	997	476	2,084	-831	0	0	831
	May	1,227	885	817	477	2,036	-1,370	0	0	1,370
	June	1,303	802	890	514	2,135	-1,374	0	0	1,374
	July	1,540	616	725	540	2,343	-1,077	0	0	1,077
	August	1,137	507	799	489	2,332	-600	0	0	600
	September	715	442	712	427	1,999	-297	0	0	297
	October	537	447	875	260	2,091	-28	0	0	28
	November	467	510	700	228	2,256	351	238	112	0
	December	538	628	773	163	2,546	445	303	143	0

Year/Month		Storage HPPs	Run-of-river HPPs	WPP	SPP	Generation	TPP+Imports+Exports	TPP	Net Imports	Net Exports
		1	2	3	4	5	6	7	8	9
2045	January	480	691	989	208	2,733	364	247	116	0
	February	449	619	883	292	2,410	166	113	53	0
	March	796	897	1,190	415	2,575	-722	0	0	722
	April	609	987	1,237	608	2,374	-1,067	0	0	1,067
	May	1,357	980	1,013	608	2,319	-1,640	0	0	1,640
	June	1,442	888	1,105	656	2,432	-1,657	0	0	1,657
	July	1,703	681	900	689	2,669	-1,304	0	0	1,304
	August	1,258	561	991	624	2,657	-778	0	0	778
	September	791	489	884	544	2,277	-431	0	0	431
	October	594	495	1,086	332	2,382	-124	0	0	124
	November	517	565	868	291	2,570	329	224	105	0
	December	595	695	959	207	2,900	445	302	142	0
2050	January	527	1,213	1,181	253	3,092	-82	0	0	82
	February	493	1,087	1,055	355	2,726	-263	0	0	263
	March	873	1,573	1,420	505	2,914	-1,459	0	0	1,459
	April	669	1,731	1,476	739	2,685	-1,930	0	0	1,930
	May	1,489	1,719	1,210	740	2,623	-2,535	0	0	2,535
	June	1,582	1,558	1,319	798	2,752	-2,504	0	0	2,504
	July	1,869	1,195	1,074	838	3,019	-1,957	0	0	1,957
	August	1,381	984	1,184	759	3,006	-1,302	0	0	1,302
	September	868	858	1,055	662	2,576	-867	0	0	867
	October	652	868	1,297	403	2,695	-525	0	0	525
	November	567	990	1,037	354	2,907	-41	0	0	41
	December	653	1,219	1,145	252	3,281	13	0	13	0

Table 6-2. Projections of monthly electricity generation from different sources in GWh – Scenario 2

Year	Month	Storage HPPs 1	Run-of-river HPPs 2	WPP 3	SPP 4	Generation 5	TPP+Imports+Exports 6	TPP 7	Net Imports 8	Net Exports 9
2025	January	296	424	59	6	1,533	748	509	239	0
	February	277	380	53	8	1,352	634	431	203	0
	March	490	551	71	11	1,445	322	219	103	0
	April	375	606	74	16	1,332	260	177	83	0
	May	836	602	60	16	1,301	-214	0	0	214
	June	888	545	66	18	1,365	-152	0	0	152
	July	1,049	418	54	19	1,497	-42	0	0	42
	August	775	345	59	17	1,491	295	201	94	0
	September	487	300	53	15	1,278	423	287	135	0
	October	366	304	65	9	1,337	593	403	190	0
	November	318	347	52	8	1,442	717	488	230	0
	December	366	426	57	6	1,627	771	525	247	0
2030	January	322	491	148	39	1,815	814	554	261	0
	February	301	440	132	55	1,600	672	457	215	0
	March	534	637	178	79	1,710	283	192	91	0
	April	409	701	185	115	1,576	167	113	53	0
	May	910	696	151	115	1,540	-333	0	0	333
	June	967	631	165	124	1,615	-272	0	0	272
	July	1,142	484	134	130	1,772	-119	0	0	119
	August	844	399	148	118	1,764	255	174	82	0
	September	530	348	132	103	1,512	399	271	128	0
	October	399	351	162	63	1,582	607	413	194	0
	November	347	401	130	55	1,706	774	526	248	0
	December	399	494	143	39	1,926	851	579	272	0
2035	January	348	558	325	66	2,099	802	545	257	0
	February	326	500	290	93	1,851	642	437	206	0

Year/Month		Storage HPPs	Run-of-river HPPs	WPP	SPP	Generation	TPP+Imports+Exports	TPP	Net Imports	Net Exports
		1	2	3	4	5	6	7	8	9
	March	577	724	391	132	1,978	155	105	49	0
	April	442	796	406	193	1,823	-14	0	0	14
	May	985	791	333	193	1,781	-520	0	0	520
	June	1,046	717	363	208	1,868	-465	0	0	465
	July	1,236	550	295	219	2,050	-250	0	0	250
	August	913	453	326	198	2,041	151	103	48	0
	September	574	395	290	173	1,749	317	216	102	0
	October	431	399	357	105	1,830	537	365	172	0
	November	375	456	285	92	1,974	766	521	245	0
	December	432	561	315	66	2,227	855	581	273	0
2040	**January**	375	625	502	93	2,399	805	547	258	0
	February	350	560	448	130	2,115	627	426	201	0
	March	621	810	604	185	2,261	41	28	13	0
	April	476	892	627	271	2,084	-182	0	0	182
	May	1,059	885	514	271	2,036	-694	0	0	694
	June	1,125	802	561	292	2,135	-645	0	0	645
	July	1,329	616	457	307	2,343	-366	0	0	366
	August	982	507	503	278	2,332	62	42	20	0
	September	617	442	448	243	1,999	249	169	80	0
	October	464	447	551	148	2,091	482	328	154	0
	November	403	510	441	130	2,256	772	525	247	0
	December	464	628	486	93	2,546	875	595	280	0
2045	**January**	421	691	679	120	2,733	822	559	263	0
	February	394	619	607	167	2,410	623	423	199	0
	March	697	897	817	239	2,575	-74	0	0	74
	April	534	987	849	349	2,374	-345	0	0	345
	May	1,190	980	696	349	2,319	-896	0	0	896

Year/Month		Storage HPPs 1	Run-of-river HPPs 2	WPP 3	SPP 4	Generation 5	TPP+Imports+Exports 6	TPP 7	Net Imports 8	Net Exports 9
	June	1,264	888	758	377	2,432	-854	0	0	854
	July	1,493	681	618	396	2,669	-519	0	0	519
	August	1,103	561	681	358	2,657	-46	0	0	46
	September	693	489	607	313	2,277	176	119	56	0
	October	521	495	746	190	2,382	431	293	138	0
	November	453	565	596	167	2,570	789	536	252	0
	December	521	695	658	119	2,900	907	617	290	0
2050	**January**	468	758	856	146	3,092	863	587	276	0
	February	437	679	765	205	2,726	640	435	205	0
	March	775	983	1,030	292	2,914	-166	0	0	166
	April	594	1,082	1,070	427	2,685	-488	0	0	488
	May	1,322	1,074	877	427	2,623	-1,077	0	0	1,077
	June	1,404	974	956	461	2,752	-1,043	0	0	1,043
	July	1,659	747	779	484	3,019	-649	0	0	649
	August	1,226	615	858	438	3,006	-132	0	0	132
	September	770	536	765	383	2,576	122	83	39	0
	October	579	542	940	233	2,695	401	273	128	0
	November	503	619	752	205	2,907	829	563	265	0
	December	579	762	830	146	3,281	964	656	309	0

Table 6-3. Projections of monthly electricity generation from different sources in GWh – Scenario 3

Year	Month	Storage HPPs	Run-of-river HPPs	WPP	SPP	Generation	TPP+Imports+Exports	TPP	Net Imports	Net Exports
		1	2	3	4	5	6	7	8	9
2025	January	296	424	59	3	1,533	751	511	240	0
	February	277	380	53	4	1,352	638	434	204	0
	March	490	551	71	6	1,445	328	223	105	0
	April	375	606	74	8	1,332	268	183	86	0
	May	836	602	60	8	1,301	-205	0	0	205
	June	888	545	66	9	1,365	-143	0	0	143
	July	1,049	418	54	9	1,497	-33	0	0	33
	August	775	345	59	8	1,491	303	206	97	0
	September	487	300	53	7	1,278	430	292	138	0
	October	366	304	65	4	1,337	598	406	191	0
	November	318	347	52	4	1,442	721	490	231	0
	December	366	426	57	3	1,627	774	527	248	0
2030	January	313	431	148	17	1,724	815	554	261	0
	February	293	386	132	24	1,520	685	466	219	0
	March	519	559	178	34	1,624	335	228	107	0
	April	398	615	185	49	1,497	250	170	80	0
	May	886	611	151	49	1,463	-235	0	0	235
	June	941	554	165	53	1,534	-179	0	0	179
	July	1,112	425	134	56	1,683	-44	0	0	44
	August	822	350	148	51	1,676	306	208	98	0
	September	516	305	132	44	1,436	439	298	140	0
	October	388	308	162	27	1,503	617	420	198	0
	November	337	352	130	24	1,621	778	529	249	0
	December	388	433	143	17	1,829	848	577	271	0
2035	January	322	441	177	28	1,937	969	659	310	0
	February	301	395	158	39	1,708	814	554	261	0

Year/Month		Storage HPPs 1	Run-of-river HPPs 2	WPP 3	SPP 4	Generation 5	TPP+Imports+Exports 6	TPP 7	Net Imports 8	Net Exports 9
	March	534	572	213	56	1,825	451	307	144	0
	April	409	629	221	82	1,683	341	232	109	0
	May	910	625	181	82	1,644	-155	0	0	155
	June	967	566	198	89	1,724	-95	0	0	95
	July	1,142	434	161	93	1,892	61	41	19	0
	August	844	358	178	84	1,883	419	285	134	0
	September	530	312	158	74	1,614	540	367	173	0
	October	399	315	195	45	1,689	735	500	235	0
	November	347	360	156	39	1,822	920	626	294	0
	December	399	443	172	28	2,056	1,014	690	324	0
2040	January	348	447	207	39	2,156	1,114	758	357	0
	February	326	401	185	55	1,901	935	636	299	0
	March	577	580	249	79	2,032	547	372	175	0
	April	442	639	258	115	1,873	419	285	134	0
	May	985	634	212	115	1,830	-116	0	0	116
	June	1,046	575	231	124	1,919	-56	0	0	56
	July	1,236	441	188	130	2,106	111	75	35	0
	August	913	363	207	118	2,096	495	336	158	0
	September	574	317	185	103	1,797	619	421	198	0
	October	431	320	227	63	1,880	839	570	268	0
	November	375	365	181	55	2,028	1,051	715	336	0
	December	432	449	200	39	2,288	1,168	794	374	0
2045	January	394	451	236	51	2,382	1,250	850	400	0
	February	369	404	211	71	2,100	1,046	711	335	0
	March	654	585	284	101	2,245	621	423	199	0
	April	501	643	295	148	2,069	482	328	154	0
	May	1,115	639	242	148	2,021	-123	0	0	123

Year/Month		Storage HPPs	Run-of-river HPPs	WPP	SPP	Generation	TPP+Imports+Exports	TPP	Net Imports	Net Exports
		1	2	3	4	5	6	7	8	9
	June	1,184	579	264	160	2,120	-66	0	0	66
	July	1,399	444	215	168	2,326	100	68	32	0
	August	1,034	366	237	152	2,316	527	359	169	0
	September	650	319	211	132	1,985	673	458	215	0
	October	488	322	259	81	2,076	926	630	296	0
	November	425	368	207	71	2,240	1,169	795	374	0
	December	489	453	229	50	2,528	1,307	889	418	0
2050	**January**	395	457	295	62	2,622	1,412	960	452	0
	February	369	410	264	87	2,312	1,182	804	378	0
	March	655	593	355	124	2,471	745	506	238	0
	April	502	653	369	181	2,277	574	390	184	0
	May	1,117	648	302	181	2,225	-24	0	0	24
	June	1,186	587	330	195	2,334	35	24	11	0
	July	1,402	451	269	205	2,561	235	160	75	0
	August	1,036	371	296	186	2,549	661	449	211	0
	September	651	324	264	162	2,185	785	534	251	0
	October	489	327	324	99	2,286	1,047	712	335	0
	November	425	373	259	87	2,466	1,321	898	423	0
	December	489	459	286	62	2,782	1,486	1,010	475	0

Table 6-4. Projections of monthly electricity generation from different sources in GWh – Scenario 4

Year	Month	Storage HPPs	Run-of-river HPPs	WPP	SPP	Generation	TPP+Imports+Exports	TPP	Net Imports	Net Exports
		1	2	3	4	5	6	7	8	9
2025	January	296	424	59	3	1,533	243	511	240	0
	February	277	380	53	4	1,352	194	434	204	0
	March	490	551	71	6	1,445	-171	223	105	0
	April	375	606	74	8	1,332	233	183	86	0
	May	836	602	60	8	1,301	-205	0	0	205
	June	888	545	66	9	1,365	-147	0	0	143
	July	1,049	418	54	9	1,497	-36	0	0	33
	August	775	345	59	8	1,491	211	206	97	0
	September	487	300	53	7	1,278	204	292	138	0
	October	366	304	65	4	1,337	444	406	191	0
	November	318	347	52	4	1,442	225	490	231	0
	December	366	426	57	3	1,627	83	527	248	0
2030	January	313	431	148	17	1,815	411	674	232	0
	February	293	386	132	24	1,600	397	569	196	0
	March	519	559	178	34	1,710	420	313	108	0
	April	398	615	185	49	1,576	329	245	84	0
	May	886	611	151	49	1,540	-159	0	0	158
	June	941	554	165	53	1,615	-100	0	0	98
	July	1,112	425	134	56	1,772	42	34	12	0
	August	822	350	148	51	1,764	392	293	101	0
	September	516	305	132	44	1,512	474	383	132	0
	October	388	308	162	27	1,582	459	518	178	0
	November	337	352	130	24	1,706	392	643	221	0
	December	388	433	143	17	1,926	409	703	242	0
2035	January	322	441	177	28	2,099	701	914	217	0
	February	301	395	158	39	1,851	675	773	184	0

Year/Month		Storage HPPs 1	Run-of-river HPPs 2	WPP 3	SPP 4	Generation 5	TPP+Imports+Exports 6	TPP 7	Net Imports 8	Net Exports 9
	March	534	572	213	56	1,978	603	488	116	0
	April	409	629	221	82	1,823	480	389	92	0
	May	910	625	181	82	1,781	-21	0	0	18
	June	967	566	198	89	1,868	47	39	9	0
	July	1,142	434	161	93	2,050	217	177	42	0
	August	844	358	178	84	2,041	574	466	111	0
	September	530	312	158	74	1,749	673	545	130	0
	October	399	315	195	45	1,830	779	708	168	0
	November	347	360	156	39	1,974	668	866	206	0
	December	399	443	172	28	2,227	704	958	228	0
2040	January	348	447	207	39	2,399	972	1,184	174	0
	February	326	401	185	55	2,115	935	1,002	147	0
	March	577	580	249	79	2,261	774	677	99	0
	April	442	639	258	115	2,084	628	549	81	0
	May	985	634	212	115	2,036	90	78	12	0
	June	1,046	575	231	124	2,135	158	139	20	0
	July	1,236	441	188	130	2,343	345	303	45	0
	August	913	363	207	118	2,332	731	637	94	0
	September	574	317	185	103	1,999	819	716	105	0
	October	431	320	227	63	2,091	1,048	916	134	0
	November	375	365	181	55	2,256	923	1,116	164	0
	December	432	449	200	39	2,546	974	1,243	182	0
2045	January	394	451	236	51	2,733	1,237	1,498	102	0
	February	369	404	211	71	2,410	1,189	1,268	87	0
	March	654	585	284	101	2,575	952	891	61	0
	April	501	643	295	148	2,374	785	736	50	0
	May	1,115	639	242	148	2,319	175	164	11	0

Year/Month		Storage HPPs	Run-of-river HPPs	WPP	SPP	Generation	TPP+Imports+Exports	TPP	Net Imports	Net Exports
		1	2	3	4	5	6	7	8	9
	June	1,184	579	264	160	2,432	238	230	16	0
	July	1,399	444	215	168	2,669	437	415	28	0
	August	1,034	366	237	152	2,657	867	813	56	0
	September	650	319	211	132	2,277	962	903	62	0
	October	488	322	259	81	2,382	1,232	1,153	79	0
	November	425	368	207	71	2,570	1,170	1,403	96	0
	December	489	453	229	50	2,900	1,235	1,572	107	0
2050	**January**	395	457	295	62	3,092	1,510	1,882	0	0
	February	369	410	264	87	2,726	1,452	1,597	0	0
	March	655	593	355	124	2,914	1,187	1,187	0	0
	April	502	653	369	181	2,685	980	982	0	0
	May	1,117	648	302	181	2,623	375	375	0	0
	June	1,186	587	330	195	2,752	451	454	0	0
	July	1,402	451	269	205	3,019	692	694	0	0
	August	1,036	371	296	186	3,006	1,115	1,117	0	0
	September	651	324	264	162	2,576	1,176	1,176	0	0
	October	489	327	324	99	2,695	1,454	1,456	0	0
	November	425	373	259	87	2,907	1,433	1,763	0	0
	December	489	459	286	62	3,281	1,515	1,984	0	0

6.2 LEAP software

This annex provides descriptions of the LEAP software and the background of certain calculations within the software. The mentioned materials are mostly taken from the official LEAP training materials as well as the "Help for LEAP" manual built into the tool itself.

6.2.1 General

The Low Emissions Analysis Platform (LEAP) is a widely-used software tool for energy policy, climate change mitigation and air pollution abatement planning developed at the Stockholm Environment Institute (SEI). LEAP has been adopted by thousands of organizations in more than 190 countries worldwide. Its users include government agencies, academics, non-governmental organizations, consulting companies, and energy utilities, and it has been used at scales ranging from cities and states to national, regional and global applications.

Integrated Planning

LEAP is an integrated modeling tool that can be used to track energy consumption, production and resource extraction in all sectors of an economy. It can be used to account for both energy sector and non-energy sector greenhouse gas (GHG) emission sources and sinks. In addition to tracking GHGs, LEAP can also be used to analyze emissions of local and regional air pollutants, making it well-suited to studies of the climate co-benefits of local air pollution reduction.

Flexibility and Ease-Of Use

LEAP has developed a reputation among its users for presenting complex energy analysis concepts in a transparent and intuitive way. At the same time, LEAP is flexible enough for users with a wide range of expertise: from leading global experts who wish to design polices and demonstrate their benefits to decision makers to trainers who want to build capacity among young analysts who are embarking on the challenge of understanding the complexity of energy systems.

Modeling Methodologies

LEAP is not a model of a particular energy system, but rather a tool that can be used to create models of different energy systems, where each requires its own unique data structures. LEAP supports a wide range of different modeling methodologies: on the demand side these range from bottom-up, end-use accounting techniques to top-down macroeconomic modeling. LEAP also includes a range of optional specialized methodologies including stock-turnover modeling for areas such as transport planning. On the supply side, LEAP provides a range of accounting, simulation and optimization methodologies that are powerful enough for modeling electric sector generation and capacity expansion planning, but which are also sufficiently flexible and transparent to allow LEAP to easily incorporate data and results from other more specialized models.

LEAP's modeling capabilities operate at two basic conceptual levels. At one level, LEAP's built-in calculations handle all of the "non controversial" energy, emissions and cost-benefit accounting calculations. At the second level, users enter spreadsheet-like expressions that can be used to specify time-varying data or to create a wide variety of sophisticated multi-variable models, thus enabling econometric and simulation approaches to be embedded within LEAP's overall accounting and optimization frameworks.

Time Frame

LEAP is intended as a medium to long-term modeling tool. Most of its calculations occur on an annual time-step, and the time horizon can extend for an unlimited number of years. Studies typically include both a historical period known as the Current Accounts, in which the model is run to test its ability to replicate known statistical data, as well as multiple forward looking scenarios. Typically, most studies use a forecast period of between 20 and 50 years. Some results are calculated with a finer level of temporal detail. For example, for electric sector calculations the year can be split into different user-defined "time slices" to represent seasons, types of days or even representative times of the day. These slices can be used to examine how loads vary within the year and how electric power plants are dispatched differently in different seasons.

Scenario Analysis

LEAP is designed around the concept of long-range scenario analysis. Scenarios are self-consistent story lines of how an energy system might evolve over time. Using LEAP, policy analysts can create and then evaluate alternative scenarios by comparing their energy requirements, their social costs and benefits and their environmental impacts. The LEAP Scenario Manager, shown right, can be used to describe individual policy measures which can then be combined in different combinations and permutations into alternative integrated scenarios. This approach allows policy makers to assess the marginal impact of an individual policy as well as the interactions that occur when multiple policies and measures are combined. For example, the benefits of appliance efficiency standards combined with a renewable portfolio standard might be less than the sum of the benefits of the two measures considered separately. In the screen shown right, individual measures are combined into an overall GHG Mitigation scenario containing various measures for reducing greenhouse gas emissions.

Low Initial Data Requirements

A key benefit of LEAP is its low initial data requirements. Modeling tools that rely on optimization tend to have high initial data requirements because they require that all technologies are fully defined both in terms of both their operating characteristics and their costs. They also require that the market penetration rates of those technologies have been reasonably constrained to prevent implausible knife-edge solutions. Developing the data for such models is a time-consuming task, requiring relatively high levels of expertise. By contrast, because LEAP relies on simpler accounting principles, and because many aspects of LEAP are optional, its initial data requirements are thus relatively low. Energy and environmental forecasts can be prepared before any cost data have been entered. Moreover, LEAP's adaptable and transparent data structures are well suited to an iterative analytical approach: one in which the user starts by rapidly creating an initial analysis that is as simple as possible. In later iterations the user adds complexity only where data is available and where the added detail provides further useful insights into the questions being addressed in the analysis.

6.2.2 LEAP Data Requirements

Introduction

Because LEAP is a general purpose software tool, which can be used to build a wide variety of different models of energy and environmental systems, it is impossible to definitively describe its data requirements.

Many parts of LEAP are optional such as the Transformation (energy supply) analysis, pollution and GHG emissions analysis, costing analysis, and non-energy sector GHG accounting. Compared to other energy modeling approaches, LEAP's initial data requirements are relatively simple. Nevertheless, they can still be quite daunting.

Equally as important, data requirements, especially in a demand analysis, depend on whether you develop an aggregate, top-down data set, which describes total consumption of the fuels in each major sector, or a disaggregated, bottom-up data set that examines how fuels are consumed in the various devices and end-uses in each different sub sector of the economy.

The following list is an attempt to describe some of the basic data you will require to help develop an initial national-level LEAP data set. In most cases it is very valuable to have current data and historical data (to help you establish trends) and projections for the future. Early-on in your work, it is important to choose the year you will use as your study base year. In general, you should choose the most recent year for which data is widely available.

It is also highly unlikely that all of the data you need will be available in-country. You will probably need to supplement available data by looking at international sources of data or by utilizing data from neighboring countries with similar energy infrastructures. The LEAP web site has a library page that is a good place to start looking for relevant international sources of publicly available data. Finally, you will inevitably need to supplement data with your own estimates. It is vital that you talk with colleagues and establish good working contacts and data exchange arrangements with relevant institutions including statistical agencies, governmental ministries (energy, environment, transport, finance, etc.), utilities, and academic organizations.

Demographic Data

National population data (historical and official government projections)

Rates of urbanization (historical and official government projections)

Average household sizes (historical and official government projections)

Macroeconomic Data

GDP data (historical and projections)

You may wish to link your LEAP energy sector analysis to a broader macro-economic analysis or macroeconomic model.

General Energy Data

Current and past national energy balances with data on energy consumption and production by sector or sub sector. NB: Energy balance data is the single most important data requested here! If possible, energy balances should include sections describing energy consumption (by sector and hopefully by sub sector), energy conversion, statistical differences (between demand and supply) and a summary of primary energy production, imports, exports and stock changes.

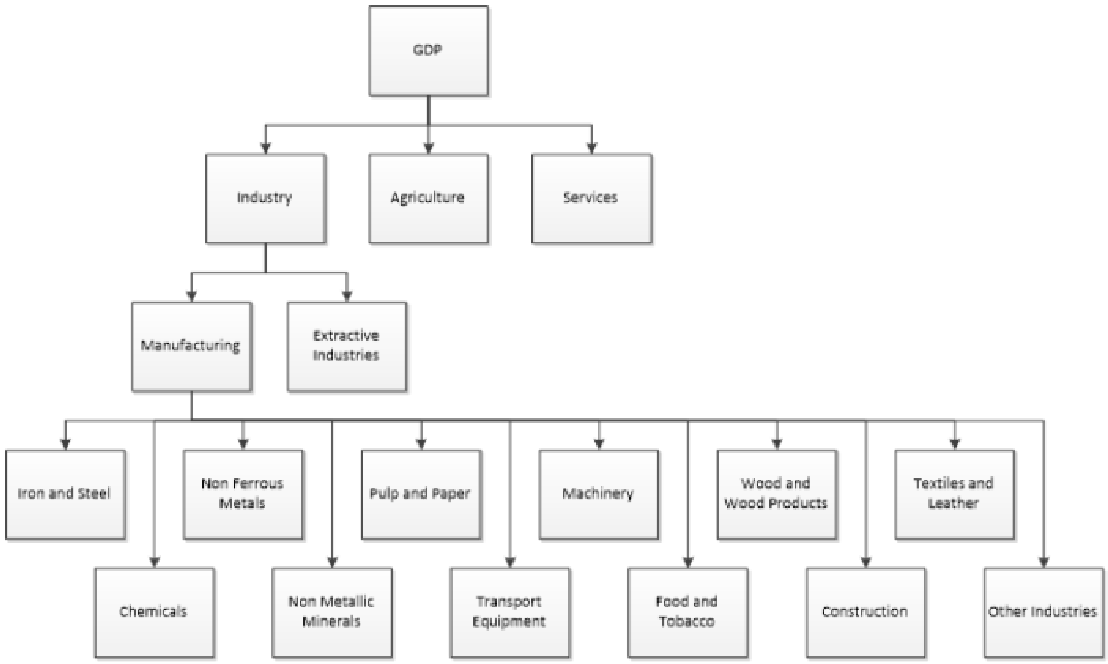
Energy Price Data

Available data describing current and historical national energy prices for major fuels (coal, natural gas and major oil products) as well as for electricity. If possible, please distinguish the prices charged to major sectors (households, industry, commercial sales).

Elasticities: Any studies that have examined the elasticity of energy demand with respect to prices and/or income levels.

Demand Forecasting

Activity Levels: Energy forecasts rely on projections both of energy intensities (energy per unit activity) and overall activity levels. Activity data varies from sector to sector. One approach for forecasting energy relies on using economic value added by sector and subsector as the activity level data. If possible, provide current and historical breakdowns of total GDP by describing how value added by sector and sub sector has changed over time. This data may be available from Planning or Finance ministries. A type breakdown of GDP is as follows:



Alternatively, for large energy intensive industries producing reasonably homogenous products (such as iron and steel, cement aluminum, etc.) measures of physical production may be a better measure of activity level. If possible, provide current and historical measures of physical production from any major industries (e.g. tonnes of cement).

Also, if possible, provide any information about likely major changes in the outlook for these sectors. For example, are major new plants planned or are large scale facilities likely to be started up or shut down?

For forecasting transportation energy use, a typical approach is to consider the overall demand for passenger transport (measured in passenger-kms) and Freight transport (measured in tonne-kms), bearing in minds how the total of each is split between different modes (road, rail, air, water) and different technologies (buses, cars, taxis, motorcycles, etc.). If possible, provide any national data describing the current, historical and future projections of tonne-kms and passenger-kms and where possible their breakdown by mode and technology. Such data may be available in national statistical reports or by contacting Ministries of Transport or academic organizations working in specific sectors.

Energy intensity data is often very hard to come by. Most likely it will need to be calculated initially by combining data on total energy use by fuel (see above) with data on activity levels (also see above). However, if any data on energy intensities in different sectors has been collected, please do collect and send it. Such information may be available from recent social or energy consumption surveys or reports from utilities.

Forecasting household energy consumption. This sector is one of the most difficult and complex to forecast because data availability is often very poor while energy use patterns vary dramatically between high and low income households; between urban and rural households; and among different housing types (single family, multi-family, etc.). If possible, please provide the results of any recent household energy surveys or studies. Particularly useful are data that describe how energy consumption varies by income level or between urban and rural households. Also useful are data describing household energy use for different end-uses (e.g., cooking, lighting, heating, cooling, refrigeration, electronics, etc.) as well as data describing the levels of ownership and types of technologies (fuels used, efficiencies, market penetrations) employed within each end-use.

6.2.3 Demand Analysis

Demand analysis is a disaggregated, end-use based approach for modeling the requirements for final energy consumption in an Area (the energy system being studied). You can apply economic, demographic and energy-use information to construct alternative scenarios that examine how total and disaggregated consumption of final fuels evolve over time in all sectors of the economy. You can also examine the costs and environmental implications of each scenario. Energy demand analysis is also the starting point for conducting integrated energy analysis, since all Transformation and Resource calculations are driven by the levels of final demand calculated in your demand analysis.

LEAP provides a lot of flexibility in how you structure your demand data. These can range from highly disaggregated end-use oriented structures to highly aggregated analyses. Typically, a structure would consist of sectors including households, industry, transport, commerce and agriculture, each of which might be broken down into different subsectors, end-uses and fuel-using devices. You can adapt the structure of the data to your purposes, based on the availability of data, the types of analyses you want to conduct, and your unit preferences. Note also that you can create different levels of disaggregation in each sector.

Similarly, you also have choices in the methodologies you can apply for energy demand analysis. The following methodologies are available:

Activity Level Analysis, which itself consists of either Final Energy Demand Analysis, or Useful Energy Demand Analysis in which energy consumption is calculated as the product of an activity level and an annual energy intensity (energy use per unit of activity).

Stock Analysis, in which energy consumption is calculated by analyzing the current and projected future stocks of energy-using devices, and the annual energy intensity of each device (defined as energy per device).

Transport Analysis, in which energy consumption is calculated as the product of the number of vehicles, the annual average mileage (i.e. distance traveled per vehicle) and the fuel economy of the vehicles (e.g. liters per km or 1/MPG).

You can mix and match these different methodologies within a single data set: for example, applying useful energy analysis for the analysis of industrial and commercial heating and employing final energy analysis for all other sectors.

In each case, demand calculations are based on a disaggregated accounting for various measures of social and economic activity (number of households, vehicle-km of travel, tonnes of industrial production, commercial value added, etc.). These "activity levels" are multiplied by the energy intensities of each activity (energy per unit of activity). Each activity level and energy intensity can be individually projected into the future using a variety of techniques, ranging from applying simple exponential growth rates and interpolation functions, to using sophisticated modeling techniques that take advantage of LEAP's powerful built-in modeling capabilities.

6.2.3.1 Activity Analysis

In this, the default methodology, energy consumption is calculated as the product of an activity level and an annual energy intensity (energy use per unit of activity). Overall activities are defined as the products of the individual activities entered along a complete branch of the Demand tree. Typically, activities are specified as a single absolute value (e.g. number of households) multiplied by a series of shares or saturations/penetrations (e.g. the percent share of urban households, the penetration of an end-use such as air conditioning), and the penetration of each technology that meets the end-use.

Total energy consumption is thus calculated by the equation:

energy consumption = activity level x energy intensity

There are two basic variations to this methodology: in a Final Energy Demand Analysis you specify energy intensities at the device level as the amount of fuel used per unit of activity; in a Useful Energy Demand Analysis you specify useful energy intensities at the next highest branch level (typically the end-use level), and then specify the efficiencies of each device.

Note: this method can also be used to project energy consumption directly (i.e. not per unit of activity). To do this, simply enter "No data" for the units in the Activity Level variable.

Activity Levels

Activity Levels are used in LEAP's Demand analysis as a measure of the social or economic activity for which energy is consumed.

In creating a demand analysis structure, you typically create a hierarchy of branches, in which activity levels are described in absolute terms (e.g., number of households) at one level of the hierarchy, and in proportionate terms (e.g. percentage share or percentage saturation) terms in the other levels of the hierarchy. The product of these terms yields the overall level of activity for a given device: one of the leaf branches in a Demand tree. Energy consumption in the device is then calculated by multiplying the overall level of activity for the device by its energy intensity (the average energy consumption of some device or end-use per unit of activity).

Notice that in some cases energy intensities can be defined at the end-use level, rather than the device level. Nevertheless, the general principle holds that LEAP calculates energy consumption as the product of activity levels and energy intensities.

For an **activity analysis**, calculations differ depending on whether you are conducting a **final** or **useful** energy demand analysis.

Final Energy Demand Analysis

In a final energy demand analysis, energy demand is calculated as the product of the total activity level (a measure of social and economic activity) and energy intensity (the average energy consumption of some device or end-use per unit of activity) at each given technology branch.

Energy demand is calculated for the Current Accounts year and for each future year in each scenario. In other words:

$$D_{b,s,t} = TA_{b,s,t} \times EI_{b,s,t}$$

Where D is energy demand, TA is total activity, EI is energy intensity, b is the branch, s is scenario and t is year (ranging from the base year to the end year). Note that all scenarios evolve from the same Current Accounts data, so that when t=0, the above equation can be written as:

$$D_{b,0} = TA_{b,0} \times EI_{b,0}$$

The energy demand calculated for each technology branch is uniquely identified with a particular fuel. Thus, in calculating all technology branches, LEAP also calculates the total final energy demand from each fuel.

The total activity level for a technology is the product of the activity levels in all branches from the technology branch back up to the original Demand branch. In other words:

$$TA_{b,s,t} = A_{b',s,t} \times A_{b'',s,t} \times A_{b''',s,t} \times \ldots$$

Where A_b is the activity level in a particular branch b, b' is the parent of branch b, b'' is the grandparent, etc. Note that those branches marked as having "No data" as well as the top level "Demand" branch are treated as having an activity level of 1. The activity level values of other branches with percentage units (e.g. percent shares or percent saturations) are always divided by 100 to yield a fractional value from zero to one in the calculations.

Useful Energy Demand Analysis

In a useful energy demand analysis, energy intensities are specified, not for a technology, but at one level up, at the **category with aggregate energy intensity** branch type.

In Current Accounts you specify final energy intensities for the **category with aggregate energy intensity** branch type, and fuel shares and efficiencies for each technology branch below. These data are used calculate the overall useful energy intensity for the aggregate energy intensity branch and the activity shares for each technology as follows:

For each technology branch:

$$UE_{b,0} = EI_{AG,0} \times FS_{b,0} \times EFF_{b,0}$$

Where b = 1..B

Where $EI_{AG,0}$ is the final energy intensity in aggregate energy intensity branch, UE is the useful energy intensity in a technology branch b, FS is its fuel share, EFF is its efficiency, and b is one of B technology branches.

The useful intensity of the aggregate energy intensity branch is the sum of the useful intensities for each technology branch:

$$UE_{AGG,0} = Sum_{b=1..B}(UE_{b,0})$$

The activity share (i.e. the share of the number of technologies, rather than the fuel share) is the product of the fuel share and efficiency of each technology b:

$$AS_{b,0} = UE_{b,0} / UE_{AGG,0}$$

Where AS is activity share.

In scenarios, you enter expressions to independently project the Current Accounts values calculated above for the useful energy intensity of the aggregate energy intensity branch, the technology activity shares and their efficiencies. The final energy intensity for each technology is given by:

$$EI_{b,s,t} = UI_{AGG,s,t} \times AS_{b,s,t} / EFF_{b,s,t}$$

Overall energy demand for each technology is calculated in the same way as for a final energy demand. In other words:

$$D_{b,s,t} = TA_{b,s,t} \times EI_{b,s,t}$$

Note: when specifying aggregate energy intensities, but not conducting useful energy analysis, the above equations still hold and all efficiencies are set equal to 100%.

6.2.3.2 Stock Turnover Analysis

Use the Demand Branch Properties screen to set-up a stock turnover analysis. There are two variations of this approach. One for conducting transportation sector stock turnover modeling and another suitable for any other type of energy-using technology. A stock turnover approach is most suitable when energy-using devices have fairly long lifetimes so that any changes to the marginal energy intensities and emission factors of newly introduced devices will thus take some time to affect the average energy intensities and emission factors of the total installed stock of devices. The stock turnover method is also useful if the operating characteristics of energy-using devices are subject change over the lifetime of those devices. For example, older vehicles may be driven less (have lower mileage) than newer vehicles or their emission factors may increase (for example as the pollution control equipment starts to fail). LEAP allows you to specify Lifecycle Profiles for variables that describe how such relevant variables change as devices get older.

When conducting a Transport stock turnover analysis, create branches with transport icon. For non-transport stock turnover analyses, choose the green stock icon.

Transport models:

With this methodology, energy consumption is calculated as the product of the number of vehicles, the annual average mileage (i.e. distance traveled) and fuel economy (e.g. liters per km or 1/MPG). The base year stock of vehicles is either entered directly or calculated from historical vehicle sales data and a lifecycle profile describing survival rates as vehicles age. In scenarios, you can enter projections for future sales of vehicles, and for future levels of fuel economy, vehicle mileage and environmental loadings of newly added vehicles. You can also specify scrappage policies. Other lifecycle profiles are used to describe how mileage, fuel economy and environmental loadings change as vehicles age. LEAP calculates the stock average values for fuel economy, mileage and environmental loadings across all vintages and hence, ultimately, the overall level of energy consumption and environmental loadings.

Total energy consumption is calculated by the equation:

energy consumption = stock of vehicles x annual vehicle mileage x fuel economy

Note: Unlike with other demand analysis methods, which only allow emission factors to be specified per unit of energy consumed (e.g., kg/TJ), a Transport stock turnover analysis also allows you to specify emission factors per unit of distance traveled by a vehicle (e.g. grammes/veh-mile), which is often more appropriate for regulated transport sector pollutant emissions. For more information, please refer to Transport Analysis Calculations.

Stock Turnover for Other Energy Using Equipment

With this methodology, energy consumption is calculated by analyzing the current and projected future stocks of energy-using devices, and the annual energy intensity of each device. In Current Accounts, you specify the current stock of devices and the current stock-average energy intensity and environmental loadings. In scenarios, you project future additions (sales) of devices and the energy intensity and environmental loadings associated with those newly added devices. LEAP then calculates the stock average energy intensity and environmental loadings across all vintages and hence, ultimately, the overall level of energy consumption and environmental loadings.

Total energy consumption is calculated by the equation:

energy consumption = stock of devices x energy intensity per device

6.3 Terms of reference

6.3.1 Overview

Georgian authorities must determine a cost-effective approach to meeting peak demand and ensuring the security of gas supply. According to information received from GOGC, Russian gas equals approximately 40%-45% of gas consumption in periods of peak demand, creating a security of supply risk.

To assist in determining the most cost-effective approach, it is proposed to carry out the following activities:

- Activity 1: Project the annual gas demand and peak gas demand for each year through the year 2050.

This proposal provides a terms of reference for Activity 1. A deliverable of Activity 1 will be a draft terms of reference for Activity 2. With concurrence of the GOGC, the results of the gas demand projections will be shared with the USAID Connect for Growth Project to provide context for transactional support.

6.3.2 Methodology

JSET will project the demand for natural gas in Georgia through 2050. Although the focus of the study is on the demand for natural gas, to create projections of future gas demand it is necessary to create a comprehensive (end use) energy model that includes the demand for all energy sources (e.g., gas, oil, electricity, biomass) in all sectors (households, services, industry, and transport) that could potentially be serviced by natural gas.

The activity will be conducted in two phases. In the first phase, a baseline energy demand will be established considering the connection between energy demand and its drivers (GDP, population growth, specific energy needs, energy efficiency, fuel penetration, etc.). In the second phase, projections of future energy demand will be estimated by modelling the evolution of the drivers to provide an annual energy demand forecast through 2050.

Recognizing the importance of natural gas electricity generation, an analysis of gas demand for the electricity sector will be conducted considering the current generation mix and its possible evolution through 2050.

The result will include projections of total gas demand including peak demand for all sectors of the economy through 2050. The gas demand projection will be calculated and presented using the LEAP end use calculation software.

6.3.3 Tasks

Tasks will include:

1. Analyze policy and regulatory framework, strategic and other documents governing the use of natural gas to determine policy commitments that will affect the future use of natural gas. These may include, but are not limited to:
    - International binding commitments, i.e. Energy Community Commitments
    - National Energy Strategy
    - National Energy and Climate Plan
    - Other documents, policies suggested by GOGC
2. Calculate annual and peak gas demand projections for electricity generation through the year 2050.
3. Calculate annual and peak gas demand projections by sectors (industry, services, household, transport) through the year 2050.
4. Calculate total annual and peak gas demand for the Georgian economy through 2050.

Deliverables:

1) The Final Report includes overview of the used study methodology and PowerPoint presentation of the annual and peak gas demand time series projections calculated above.
2) The LEAP model of annual and peak gas demand through 2050.