CACTUS

STRENGTHENING CENTRAL AND EASTERN EUROPEAN CLIMATE TARGETS THROUGH ENERGY SUFFICIENCY

Analytical Brief on Energy Sufficiency in the National Context: Lithuania

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

European Climate Initiative EUKI

based on a decision of the German Bundestag

CACTUS

STRENGTHENING CENTRAL AND EASTERN EUROPEAN CLIMATE TARGETS THROUGH ENERGY SUFFICIENCY

Analytical Brief On Energy Sufficiency in the National Context: Lithuania

Analytical brief prepared as part of the EUKI 2020 project "Consolidating Ambitious Climate Targets with end-Use Sufficiency" (CACTUS)

Authors: Viktorija Bobinaite, Inga Konstantinaviciute, Ausra Pazeraite (LEI)

CACTUS is a project on energy sufficiency and its integration into climate and energy strategies in the Central and Eastern European context funded by the European Climate Initiative EUKI.
It sensitises key scenario builders, policy makers and wider EU and climate and energy stakeholders on energy sufficiency, and explores its integration in Hungarian and Lithuanian scenario models.
Since the Summer 2020, the négaWatt association has been coordinating the implementation of the Cactus project with its partners REKK, LEI and the Fraunhofer ISI, and with the financial support of the EUKI fund of the German Ministry of the Environment BMU.

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

based on a decision of the German Bundestag

European Climate Initiative EUKI

Table of contents

Introduction

The CACTUS project aims at strengthening climate mitigation actions in Central Eastern European countries (Lithuania and Hungary) by supporting the integration of energy sufficiency in national scenarios and policies.

Within the CACTUS, the energy sufficiency is understood as "a situation in which everyone has affordable access to the energy services they *need*, in which the energy services we *want* are equitably shared, and in which the environmental limits of the planet are respected"[1]. Energy sufficiency is about a fairer consumption and prioritizing energy uses which provide a genuine service, and dropping superfluous ones. Investigating ways to further reduce energy demand beyond energy efficiency options is key, considering energy consumption and greenhouse gas (GHG) emissions trends.

Responding the aim of the CACTUS project, this analytical brief on sufficiency in the national context of Lithuania represents the outcomes of activities (A I.2) "Analysis of existing national scenarios overview of demand related actions and identification of gaps in which sufficiency potentials are not yet tapped" and (A I.3) "Analysis of the national context: identifying socio-cultural barriers and specificities that may alter the way we apprehend sufficiency action". More specifically, it provides an analysis of the obstacles towards climate goals, a gap analysis on sufficiency related indicators not or partly covered in Lithuania, as well as a research analysis aiming at identifying key variables that may affect the way sufficiency assumptions have to be apprehended in target countries, e.g., social trends, policies, cultural habits, economic organisation, structure of the energy system etc. and integration in the two analytical briefs from A I.2.

Until today, energy policies have been mostly focusing on the reduction of energy prices to increase competitiveness and tackle energy poverty rather than structural changes towards more efficiency and the apprehension of the need for behavioral change to avoid rebound effects. Efforts on energy efficiency were not structural enough to counterbalance consumption trends which resulted in the rise of energy consumption.

In 2019, the building sector accounted about 40% in the final energy consumption (FEC) in Lithuania. The building sector as one of key emitting sectors has mitigation potential linked to actions on energy demand reduction.

Currently, the transport sector is the largest energy consuming sector in Lithuania. In 2019, transport sector accounted 40.9% in the total FEC. Due to a significant increase of fuel consumption the transport sector has become one of the most important sources of GHG emissions. Seeking to implement GHG reduction targets, transport will be the most challenging sector; therefore, it is necessary not only to increase the consumption of renewable and alternative fuels but also to investigate how to promote sustainable mobility.

Sufficiency can play an important role in this respect; therefore, it is necessary to analyze how sufficiency can go in hand with the alleviation of energy poverty and how behavioral changes can decrease energy consumption in Lithuania.

Thus, the first chapter of this analytical brief provides general information about Lithuania and its energy sector. The second chapter analyses the developments of energy use and its key drivers, the indicators providing insights on energy sufficiency potentials, the national energy and climate policy goals related to the building sector (household and tertiary) as well as regulatory aspects and behavioral, social and cultural drivers to energy sufficiency. The third chapter analyses the developments of energy use and its key drivers, the indicators providing insights on energy sufficiency potentials, the national energy and climate policy goals related to the transport sector consisting of passenger and freight, as well as the regulatory aspects and the behavioral, social and cultural drivers to energy sufficiency. Finally, conclusions are made.

[1] Progress within boundaries (energysufficiency.org)

1. Overview of Energy Sector

1.1. General Information on Lithuania

General information. The Republic of Lithuania is a central European country situated on the southeast cost of the Baltic Sea. Its area is 65,284 km^2. Capital is Vilnius. Country has borders with Latvia, Belarus, Poland and Kaliningrad region (Russia).

Climate. Climate is moderately warm as it is in mid-latitudes, transitioning from marine to continental. Continental climate is noticeable in the eastern part of the country. Lithuania is in a zone of mild temperature climate with moderately warm summers and moderately cold winters. The average temperature is about 17°C in July and about -5°C in winter. However, there are very hot summer days when weather warms up to 30°C, as well as very cold winter days when it cools down to -20°C and -30°C at night. Mostly precipitation falls in summer. The lowest rainfall is in spring, as anticyclones predominate.

Economic situation. Lithuania is a country with already high and still improving living standards. Its gross domestic product (GDP) per capita grew by 5% a year during 2005-2019, except, in 2009 when due to the global economic crisis it dropped by 17%. In 2019, GDP per capita was 17.5 thousand EUR and accounted to 82% of EU average level [1]. However, there is a gap of GDP per capita within the counties. The largest GDP per capita is in Vilnius and is 144% of the national average, while the smallest GDP per capita is in Taurage where it is only 56% of the national average [2]. Real GDP grows by 3.5% [3]. Inflation is moderate (2.5%). Unemployment rate was high in 2010 (17.8% of labour force) but shrinked to normal rate at 6.3% in 2019.

Demographic situation. The demographic situation deteriorates in Lithuania. In 2019, 2.8 million people lived in the country [4] compared to 3.4 million people in 2005. This is because of a negative net migration and a negative natural change of population. During 2005-2019, 0.64 million people emigrated from the country. In 2019, net migration got positive again for the first time since 1994 and accounted for 10.8 thousand people. Due to the natural change of population Lithuania lost 0.18 million people during 2005-2019 : the country suffers from an annual decrease of 3.4% in the number of births. Moreover, the population of the country gets older.

1.2. Overview of the Energy Sector in Lithuania

Responding to the structural transformations of the economy after 1990 and the cyclical development of the national economy, the dynamics of primary energy consumption (PEC) show significant reductions of consumption of all forms of fuels and energy after 1990, in 2000 and 2010. **During the last decade, the PEC grew about 1.2% a year.** In 2019, the PEC was 7.8 Mtoe. Oil and oil products have been the most important fuels in Lithuania over the last decades. Their share was of 39% in 2019. They are followed by natural gas, with a share of 24% in 2019, while the use of natural gas is reducing. **Contribution of renewable energy sources (RES) into the country's primary energy balance increases and accounts today for about 20%.** Since Ignalina nuclear power plant shutdown in 2009, Lithuania has been importing significant shares of its electricity (10.3% in 2019).

Until 2008, the FEC has increased by 3.9% per annum. In 2009, the FEC was 9.5% less than in the previous year. The most observable impact of the economic recession was in the construction sector where the FEC decreased by 34.9% and in the transport sector - by 18.5%. **Since 2010 the FEC has increased, mainly influenced by the increase in the energy demand in transport and industry sectors.** In 2019, the FEC was 5.6 Mtoe. The transport sector is the largest energy consuming sector (40.9% of FEC) while the residential and tertiary sectors accounted 25.9% and 11.2%, respectively.

The overall FEC increases slowlier than the final electricity consumption (FEIC). In 2019, FEC was 148% higher than in 2000, and FEIC was 170% higher (Fig. 1).

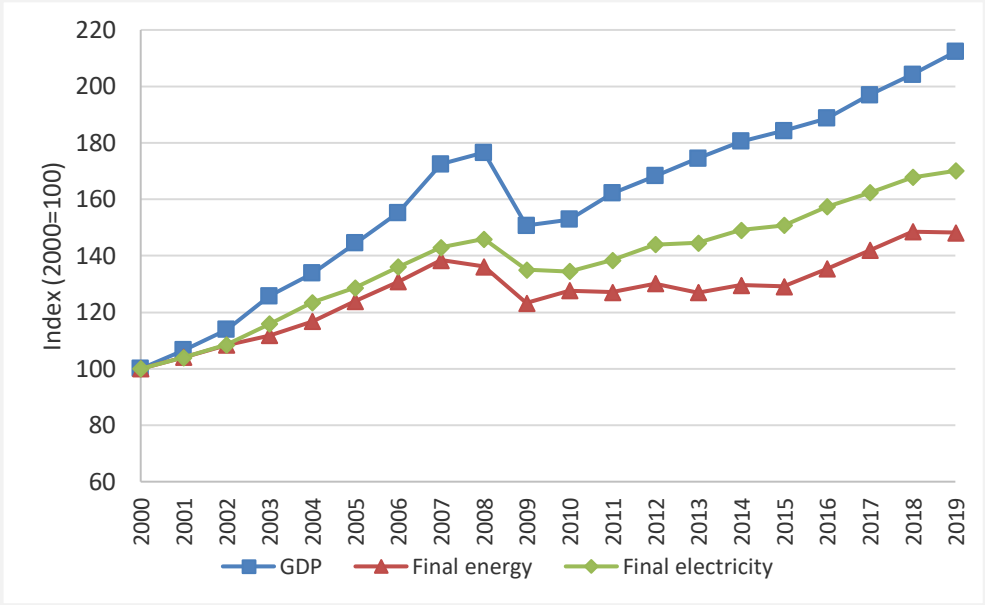


Figure 1. GDP, FEC and FEIC indexes (Source: Lithuanian Statistics database)

During the period 2000-2019, FEC and FEIC have been growing slowlier than GDP. Therefore, in 2019, GDP was 212% of the level in 2000.

1.3. Legislation on Climate and Energy Policy with a Focus on Energy Demand

Lithuania follows the goals and targets set in EU Climate & Energy Package 2020 and Climate and Energy Framework 2030 and responding them takes relevant obligations and supporting measures. Moreover, it takes into account the national circumstances. Therefore, the national climate and energy policy considers the country's dependence on fossil fuels imported from unreliable and volatile markets, poorly diversified energy supply, high and variable energy prices, increasing energy demand, unsustainable energy consumption, changing climate, rising emissions, untapped potential for competitiveness, growth and employment opportunities. Responding to them, the **National Energy Independence Strategy [5]** sets some short- to long-term goals that are summarized in Fig. 2.

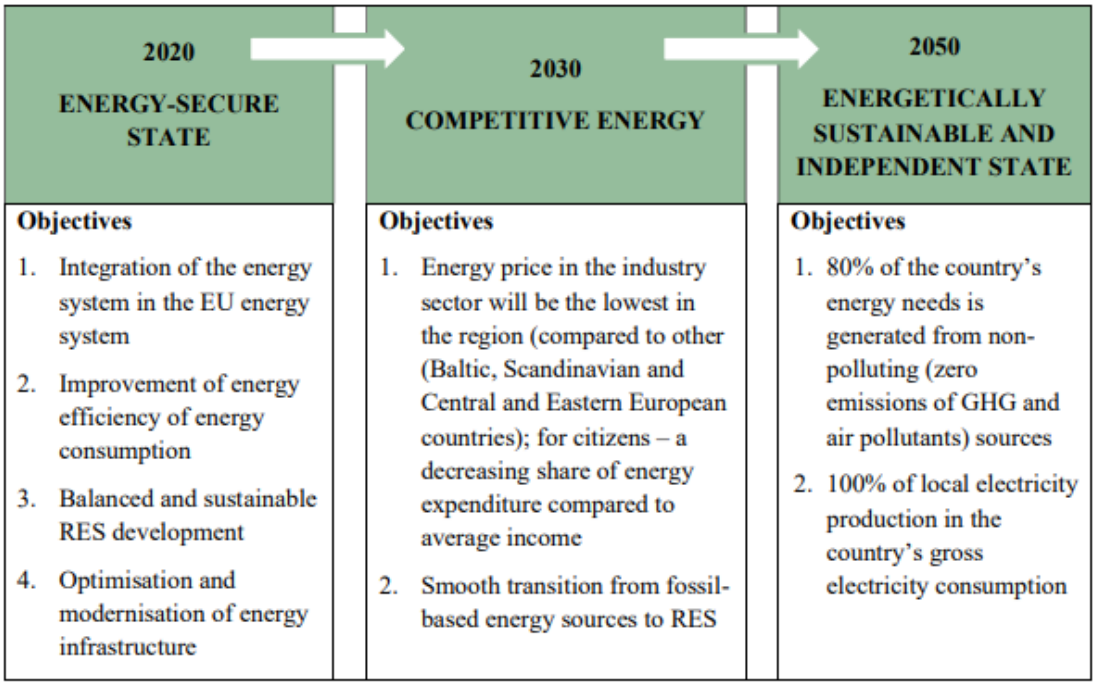


Figure 2. National energy policy goals till 2050 [5]

In response to the overall goals of the **National Strategy for the Development of Renewable Energy Sources [6]** to increase the share of RES in the total FEC to 23% and in the transport sector to 10% by 2020, the **Law on Renewable Energy Sources [7]** sets the following sectoral targets for the development of RES in the country:

- install 500 MW nominal capacity of new wind power plants (excluding those with a capacity not exceeding 30 kW), 355 MW nominal capacity of biomass-fired power plants, 141 MW nominal capacity of hydroelectric power plants and 10 MW nominal capacity solar power plants;
- increase the efficiency of heat production and transmission in order to achieve at least 70% of RES (biomass) in the district heating (DH) sector, and increase the share of RES in heating in households to at least 80% by 2020.

The updated **Law on Renewable Energy Sources [8]** aims at increasing the share of energy from RES in relation to the country's total FEC to at least 38%, and the share of electricity from RES in total electricity consumption to 38% by 2025. The law introduces sectoral measures to promote the production of energy from RES. The sector-specific RES development measures contributing to the achievement of RES targets are set out in the **National Renewable Energy Action Plan [9]**.

The **Law on Energy Efficiency [10]** confirms the goal of improvement of energy efficiency (EE) by 2020, 2030 and 2050. It requires the economic sectors to consume 1.5% less energy (taking into account the average FEC during 2010-2012) each year till 2020 and 0.8% less energy (taking into account the average FEC during 2016-2018) each year till 2030 and 2050. A top-down approach is applied when implementing the EE targets in practice. The Minister of Energy decides on the calculation and supervision of the mandatory energy savings, and then imposes these to the other Ministries involved. Therefore, the Ministry of Economy and Innovation, the Ministry of Environment, the Ministry of Transport and the Ministry of Agriculture are responsible for the implementation of EE measures in industry, service and household, transport and agriculture sectors for the purpose to achieve the mandatory energy savings of at least 5,456 GWh (469 ktoe), 10,366 GWh (891 ktoe), 10,912 GWh (938 ktoe) and 645 GWh (56 ktoe), respectively after 2020. Till 2018, Lithuania had made some progress to achieve its EE targets. The cumulative savings in 2014-2018 have been of 511 ktoe while the estimated annual savings required for 2014-2018 were 538 ktoe. This indicates a 95% rate of energy savings

achievement for 2014-2018. However, the total cumulative savings required by 2020 target is 1,004 ktoe; **therefore, the progress towards the cumulative savings required by 2020 was still 51%** [11].

The **Energy Efficiency Action Plan [12]** is a document required by the EU to all Member States every three years. It reports the national progress towards the EU overarching efficiency targets on an annual basis, and introduces a set of sectoral measures facilitating the reduction of energy consumption.

The **Long-term Strategy for the Renovation of the National Building Stock** (draft) envisages to upgrade 2.5 million m^2 of public and residential building until 2020, using EU structural funds and state budget funds. This should enable to save at least 43 ktoe (500 GWh) of thermal energy. The overall goal of the FEC savings is 287 ktoe (3,336 TWh) during 2015-2020. In order to achieve this goal, EE measures are implemented. It is plan to upgrade around 2,500-3,000 buildings during 2020-2030.

The **Programme for Renovation (Modernization) of Multifamily Houses [13]** (PoRM2H) and the **Programme for EE Improvements in Public Buildings [14]** (PoEEPB) are relevant instruments used for the improvement of EE in the building sector. The aim of PoRM2H is the renovation of multi-family houses built with reference to technical construction standards valid before 1993 and the reduction of thermal energy consumption by 86 ktoe (1,000 GWh) per year and GHG emissions by 230 kt CO_2eq per year by 2020. During the period 2013-2020 2,627 multifamily houses have been renovated. The PoEEPB aims at renovating at least 700,000 m^2 of public buildings, consisting of 470,000 m^2 of central government and 230,000 m^2 of municipal buildings, and thus saving 5 ktoe (60 GWh) of primary energy per year and reducing GHG emissions by 14 kt CO_2eq per year by 2020.

In response to the requirements of the EU and international agreements, Lithuania in the framework of the **Law on Financial Instruments for Climate Change Management [15]** approved the **National Climate Change Management Policy Strategy for the Period until 2020 [16]**. There it sets quantified annual GHG reduction targets for the economic sectors. The specific short-term climate change mitigation objective for the plants covered by the EU emission trading system (EU-ETS) is to achieve that GHG emissions would not exceed 8.53 Mt CO_2eq. by 2020. The GHG target should be achieved through the implementation of RES technologies and EE improving solutions. Therefore, economical and cost-effective emission reduction solutions are implemented in industrial enterprises, efforts are made to increase the share RES in DH sector by 60% and the share of RES-E to 21% of the country's total electricity consumption. Efforts are also made to to modernize the electricity generation, transmission and distribution infrastructures and to increase the possibilities to respond efficiently to demand changes. The specific short-term objectives for climate change mitigation in the non-ETS sectors are to ensure that GHG emissions do not exceed annual GHG targets and that total emissions would not increase by more than 15% in 2020 compared to 2005, and would not exceed 18.34 Mt CO_2eq.

In 2018, Lithuania has submitted to the European Commission the **National Energy and Climate Action Plan [17]** (NECP). The NECP sets out Lithuania's national goals for which the country will contribute to the implementation of the EU's energy and climate policy goals in 2030, as well as related policies and measures. Table 1 summarizes the national targets.

The **National Energy Independence Strategy [18]** (NEIS) formulated clearly descriptive goals and directions for the development of RES and EE improvement until 2050. Primary and final energy intensity should be 1.5 times lower in 2030 than in 2017 and by 2050 to about 2.4 times lower than in 2017. EE shall be further fostered in three directions:

- the renovation of multi-family houses and public buildings to save about 224-258 ktoe (2.6-3 TWh) of energy in renovated buildings by 2020 and about 430-516 ktoe (5-6 TWh) by 2030;
- the development of low-energy and energy efficient industries, with the latest and environmentally friendly technologies and equipment;

the improvement of EE in the transport sector by renewing the vehicle stock, to move to modern and efficient public transport, the optimization of transport and alternative fuel infrastructures and the electrification and use of alternative fuels.

Table 1. EU and National Energy and Climate Policy Targets [17]

Targets	EU		Lithuania	
	2020	2030	2020	2030
GHG emission target, %	20	40	EU level	
GHG emission target for EU-ETS, %	21	43	EU level	
GHG emission target for non EU-ETS, %	10	30	15	9
RES target, %	20	32	23	45
RES target for transport, %	10	14	10	15
EE target, %	20	32.5	EU level	
PEC, Mtoe	1474	1273	6.5	5.4
FEC, Mtoe	N/A	956	4.3	4.5
Final energy savings, TWh (EED, Article 7)			11.67	27

1.4. Dashboard to Characterize Demand and Identify Sufficiency Gap and Potential

The up-to-date climate and energy strategies (including the NECP and the NEIS) requesting for the economic sector specific achievement of targets, disclose a path towards them up to 2030 and 2050; but show a poor energy demand characterisation, as is highlighted in Table 2. Table 2 is the result of activity I.2 of the CACTUS project, through which the sufficiency gap is described in a table.

The information and data collected from the NECP and the NEIS show that little is known in the public strategies about key indicators of energy consumption and their expected developments till 2030 and 2050, especially when analysing the sector specific energy demand (i.e., in buildings and transport). Nonetheless, the assumptions on the developments of high-level indicators of energy consumption (including GDP and population) are clearer for medium-term (2030) but they are almost missed for long-term (2050). When describing the energy consumption, the NECP and the NEIS take into account that the number of population will reduce and the economy will grow up to 2050.

The table highlights that the concept of energy sufficiency is not included in the NECP and the NEIS; therefore, there is no data nor assumptions for energy sufficiency related indicators. A set of sector-specific energy consumption and sufficiency related indicators had been identified during CACTUS I.2 activity. It includes 10 energy sufficiency related input indicators for residential buildings, 3 – for tertiary buildings, 6 – for passenger transport, 3 – for freight transport and 11 energy consumption output indicators. Moreover 10 country level energy consumption, production and GHG emissions output indicators have been identified. The assumptions of energy sufficiency, its potential and gap are investigated in further sections of the analytical brief by analysing historical trends of indicators based on other sources of information.

Table 2. Dashboard to Characterise Demand and Identify Sufficiency Gap and Potential (results of CACTUS activity I.2)

	Indicator		Unit	Comments	Base year 2017	NECP 2030	NEIS 2050
	Population		persons		2828403 [1]	2727000 [1]	-
	GDP, constant prices (2005)		million EUR		28568.7 [1]	37996.4 [1]	58565.8 [1]
Energy consumption	PEC		Mtoe		6.5 [1]	5.5 [1]	-
	PE intensity		kgoe/EUR		0.27 [2]	0.14 [2]	-
	FEC		Mtoe		5.3 [1]	4.5 [2]	5.83 [1]
	FE intensity		kgoe/EUR		0.19 [1]	0.12 [1]	0.08 [1]
Buildings	Share of buildings in FEC		%		39.4 [2]	40.77 [2]	-
	Consumption in buildings	*Heat*	ktoe	only space heating	1322.2 [1]	1082.2 [3]	-
		Electricity	ktoe	household and tertiary sector	528.4 [5]	-	-
Residential	FEC		Mtoe		1.5 [1]	1.3 [1]	-
	FEC per capita		toe/person		0.5 [1]	0.5 [1]	-
	Average prices	*Heat*	EUR/MWh	heat price without VAT	47.5 [2]	-	-
		Electricity	EURct/kWh	average electricity price without VAT	9.088 [2]	-	-
	Monthly energy expenditure		%	on electricity, gas and other fuels as % of total	4.4 [2]	-	-
	Number of dwellings				1459405 [1]	-	-
	Consumption per dwelling	*Heat*	MWh/dw	with climatic corrections	8.72 [2]	-	-
		Electricity	kWh/dw	electrical appliances, lighting	1623.54 [2]	-	-
	Average household size		person/household		2.2 [1]	-	-
	Floor area per person		m2		35.42 [2]	-	-
	Population living in overcrowded /undercrowded buildings		%	2018 data due to change in methodology	23.7 [1]	-	-

		Indicator		Unit	Comments	Base year 2017	NECP 2030	NEIS 2050
	Tertiary	FEC		Mtoe		0.6 [1]	0.5 [1]	-
		Employees in tertiary		Mpersons		0.910187 [1]	-	-
		FEC per employee		toe/person		0.7 [1]	-	-
		Electricity per employee		kWh/person	total electricity per employee	3633.65 [2]	-	-
	Transport	Share of transport in FEC		%	excluding air transport	38 [1]	32.6 [1]	-
		Electric share of energy transports consumption		%		0 [2]	3.54 [2]	-
		Energy consumption	*Road*	ktoe		1856 [1]	-	-
			Air	ktoe		0.4 [1]	-	-
		Share in road FEC	*Passenger*	%		61 [4]	-	-
			Freight	%		39 [4]	-	-
	Passenger Mobility	No. of cars per person		No/1000 persons		483 [1]	-	-
		State of the car stock		%		-	-	-
		Passengers' traffic	*Cars*	Mp.km		31361 [1]	-	-
			Buses	Mp.km		2740 [1]	-	-
			Rail	Mp.km		424 [1]	-	-
			Rivers	Mp.km		3 [1]	-	-
	Freight Mobility	Freight traffic	*Road*	Mt.km		39099 [1]	-	-
			Trains	Mt.km		15414 [1]	-	-
			Rivers	Mt.km		1 [1]	-	-
Energy production		Domestic PE production		Mtoe		1.9 [1]	2.4 [1]	-
		Share of RES in FEC		%		26 [1]	45 [1]	80 [1]
		RES-E in FEC		%		18.3 [1]	59.2 [1]	100 [1]
GHG emissions		GHG emissions		%	% to 1990	57 [1]	67 [1]	69.8 [1]
		Share in GHG emissions	*Buildings*	%		7.2 [1]	6.1 [1]	6.5 [1]
			Transports	%		28 [1]	23 [1]	19 [1]

References: [1] Official data contained in the NECP / NEIS; [2] Data retrieved from the NECP; [3] Data calculated from the NECP; [4] Based on background calculation; [5] Data from Lithuanian Statistics database

2. Building Sector – Trends, Potentials and Strategies

2.1. Households

There were 1,357 thousand households in the country in 2017 and they consumed 1.46 Mtoe of energy. This is 0.6% less energy than in 2019. In 2019, the households accounted for 25.9% of FEC and emitted 4.4% of total GHG emissions (excluding LULUCF). There were 1,483,041 dwellings in 2019 and this is 14% more than in 2005. In 2019, dwellings of public ownership accounted to 2% and dwellings of private ownership – to 98% of total dwellings. The share of dwellings of municipal ownership made 92% in the structure of dwellings of public ownership. In that year the total floor area of dwellings was 102,430.8 thousand m^2. According to Lithuanian Statistics (2019), slightly more than half (59%) of the country's population lived in multi-apartment buildings and 41% in one-dwelling houses. 75% of dwellings were constructed before 1991 following Soviet-era building codes. All these buildings are in low EE classes (E and F).

This chapter analyses several indicators of the households that could be relevant to make insights on energy sufficiency potentials in the country. This includes the average floor area of dwelling and per capita over time, average household size and distribution of household by living mode, energy consumption by fuel, end use and per capita. This is followed by relative energy expenditure data and several indicators of energy poverty.

2.1.1. Average floor area of dwellings

The average floor area of dwellings has a tendency to increase in Lithuania (Fig. 3).

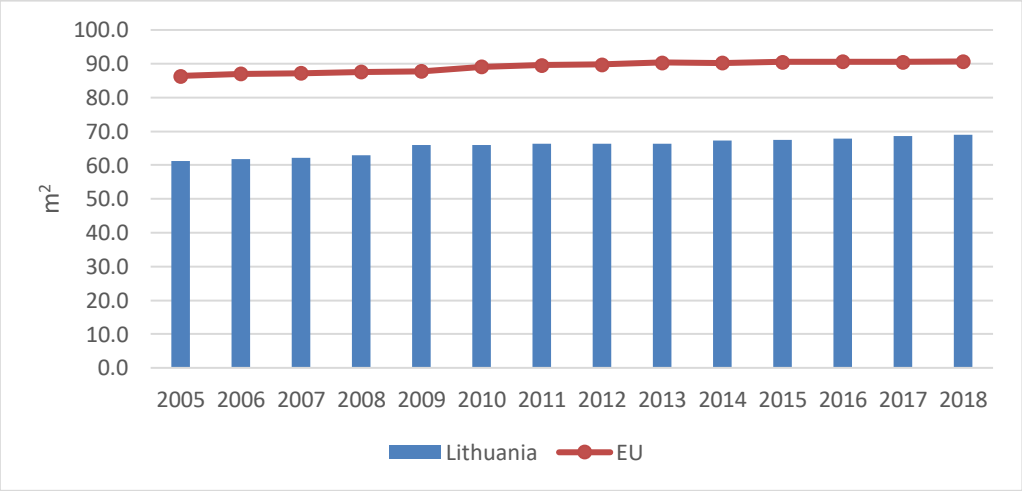


Figure 3. Average floor area of dwellings in Lithuania during 2005-2018 (Source: ODYSSEE database)

It was 61.3 m^2 in 2005 but 68.9 m^2 in 2018. **In Lithuania the average floor area of dwellings was by 24% lower than in EU.** However, it increased faster in Lithuania (0.9% a year) than EU (0.3% a year). Therefore, in the European context, the average floor area of dwellings in Lithuania was historically particularly in line with the trends that a sufficiency approach would entail. Following the linear upward trend of the average floor area of dwellings, we estimate that Lithuania could achieve the current EU level not earlier than in 2048 if the current dynamics were to go on. **Up to 2050 the average floor area of dwellings may increase in Lithuania with smaller EE potential in comparison to average EU where the downward trend of the indicator should be supported to exploit energy sufficiency potential. Nevertheless, it is the role of the CACTUS project to explore an acceptable limitation of this upward trend, in particular by looking into new build and readapting buildings when renovating.**

2.1.2. Average household size

The intergenerational living style predominated till 1990's has been outgoing; therefore, the households become smaller in Lithuania (Fig. 4).

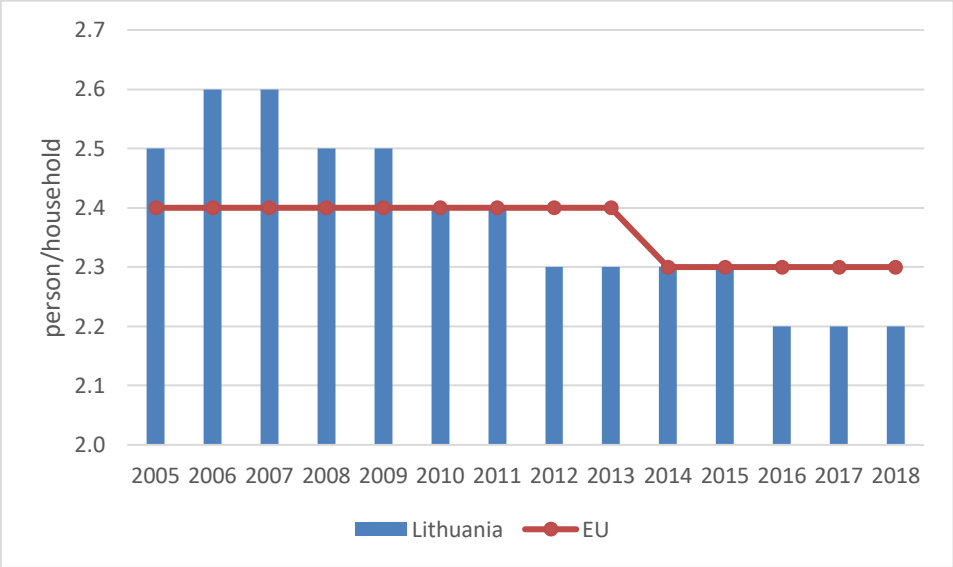


Figure 4. Average household size in Lithuania during 2005-2018 (Source: EUROSTAT database)

If a household consisted of 2.5 persons in 2005, **during a decade it reduced and today is made up of 2.2 persons and is slightly smaller than in EU (2.3)**. This is due to the fact that more often people choose to live single and families – without children and separately from their parents (Fig. 5).

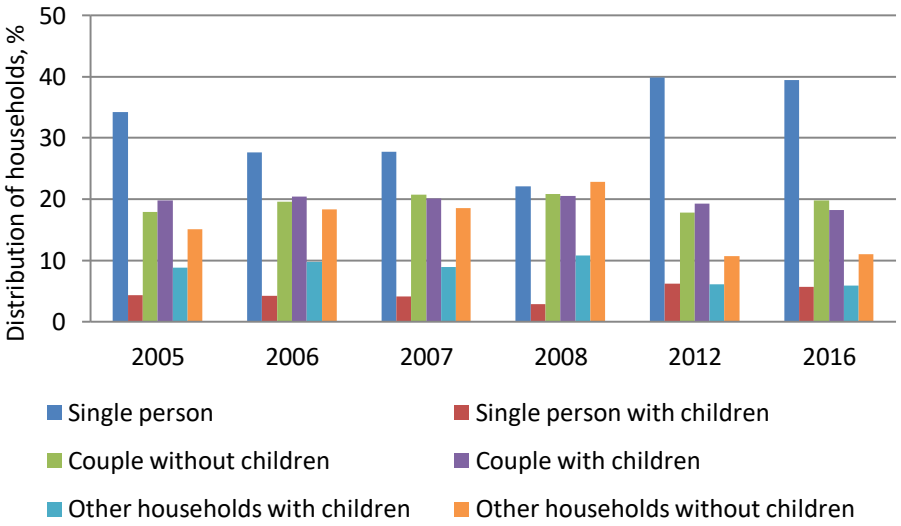


Figure 5. Distribution of households by living mode 2005-2016 (Source: Lithuanian Statistics database)

Over the period the share of households consisting of one person increased from 34.2% (2005) to 39.4% (2016) and the share of couples without children grew from 17.9% (2005) to 19.8% (2016). Moreover, the share of households consisting of a couple, children and other persons reduced from 23.9% (2005) to 16.9% (2016). Besides, the share of households consisting of a single person with children increases, i.e., from 4.3% (2005) to 5.7% (2016). Surely, this could be a sensitive part of society in terms of consumption of sufficient

amount of energy services, especially if this is a low-income (per capita) household, as that households may have difficulties to purchase and use enough appliances, as well as they may have difficulties when paying for energy services on time.

Thus, the figures demonstrate that historical developments of households size and living modes of Lithuanian households could be barriers for energy sufficiency; with present trends kept in future, it may be difficult to improve energy sufficiency level in the country. The CACTUS project should therefore explore, by comparing with sufficiency strategies in France or Germany, whether and how these trends could be tempered, or reversed.

2.1.3. Floor area per capita

Residential and non-residential buildings cover about 63% and 37% of the total building floor area in Lithuania, respectively [19]. In 2019, the total floor area of residential buildings accounted to 102,430.8 thousands m^2.

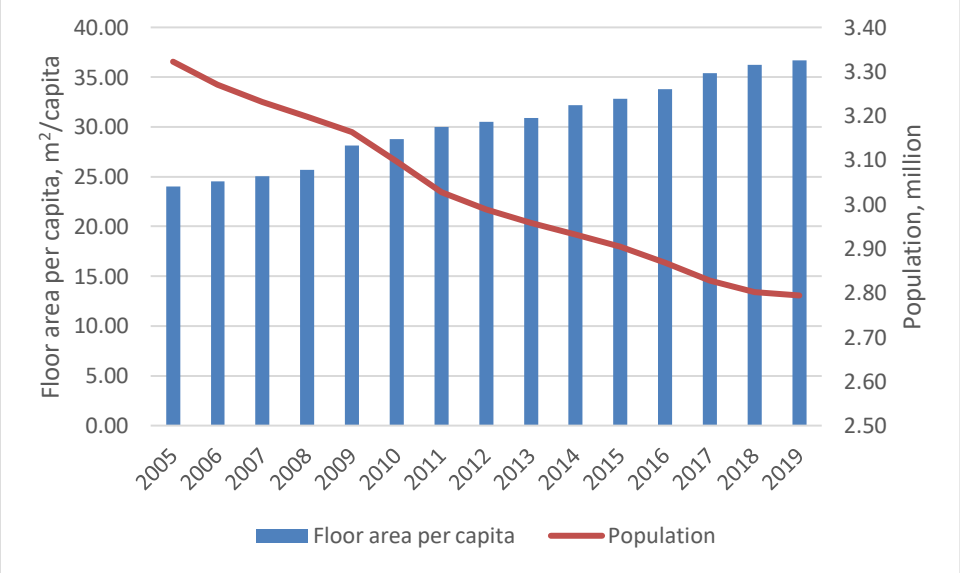


Figure 6. Floor area per capita and population in Lithuania during 2005-2019 (Source: Lithuanian Statistics database)

The floor area per capita increases by 2.4% a year and was of 36.66 m^2 in 2019 (Fig. 6), compared for example to 41 m^2 in France. The main factors of this change are the reducing population that leaves dwellings empty due to emigration or natural change of population, as well as households decisions to live in large and newly built dwellings. **The upward trend of the floor area per capita requests for stabilisation, otherwise, following its linear upward trend it could further increase and become a serious obstacle to energy sufficiency in future.**

2.1.4. Energy consumption by fuel and by end use

Despite the aforementioned developments, **the energy consumption of fuels reduces slowly (by 0.4% a year) in Lithuanian households** (Fig. 7). However, the reduction is interrupted by fuel consumption increases of 2.0% a year during 2007-2010 and of 3.0% a year during 2015-2018. Totally, 1.42 Mtoe of energy was consumed in households in 2019.

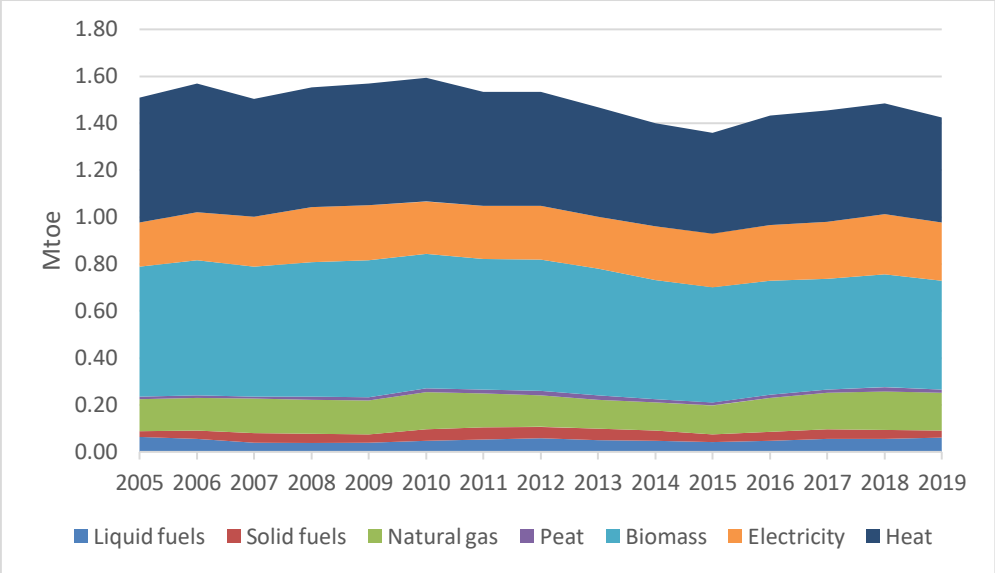


Figure 7. Energy consumption by fuel during 2005-2019 (Source: Lithuanian Statistics database)

Biomass and DH dominates in the energy consumption structure with the shares of 32.4% and 31.3%, respectively in 2019 (Fig. 8). However, consumption of biomass and DH reduces by 1.3% a year. Consumption of liquid fuels reduces too (by 0.5% a year). Electricity is the third important energy type with a clearly upward trend. 0.25 Mtoe of electricity was consumed in 2019. Natural gas has tendency to substitute biomass. Its consumption increases by 1.3% a year and totally 0.16 Mtoe was consumed in 2019. Consumption of solid fuels and peat is negligible, i.e., 0.03 Mtoe and 0.01 Mtoe, respectively in 2019.

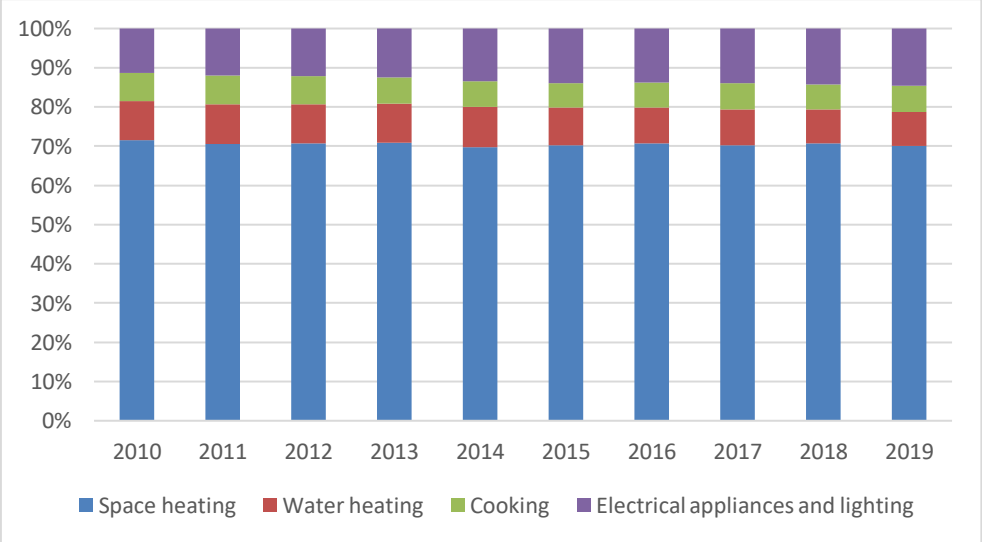


Figure 8. Energy consumption by end use in Lithuania during 2010-2019 (Source: Lithuanian Statistics database)

Historically, the households consumed about 70% of energy for space heating, 14% – in electrical appliances and for lightening, 9% – for water heating and 7% – for cooking. There is an increasing trend of energy consumption by electrical appliances and lighting (by 1.7% a year) and reducing trend – for hot water preparation (by 2.7% a year), cooking (1.7%) and space heating (1.3%).

2.1.5. Energy consumption per capita

On average households consumed about 0.493 toe per capita in Lithuania and about 0.581 toe per capita in EU during 2005-2018 (Fig. 9).

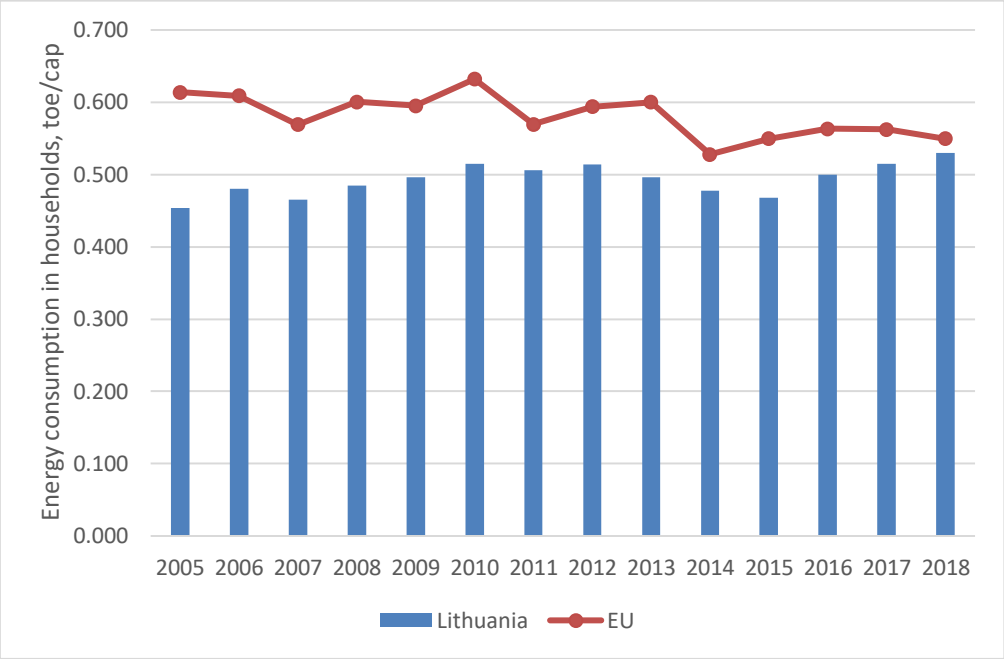


Figure 9. Energy consumption per capita during 2005-2018 (Source: ODYSSEE database)

While EU households demonstrate stabilization of energy consumption per capita, **Lithuanian households has started increasing energy consumption per capita by 4.2% since 2015 and almost reached EU level in 2018.**

Therefore, the latest developments of energy consumption per capita in Lithuania supports the relevance of energy sufficiency implementation in the country to stabilize energy consumption per capita to EU level and, later on, to transform the upward trend of the indicator.

2.1.6. Share of energy expenditure in total household expenditure

In 2019, household consumption expenditure of electricity, gas and other fuels made 4% in Lithuania in comparison to 3.8% in the EU (Fig. 10).

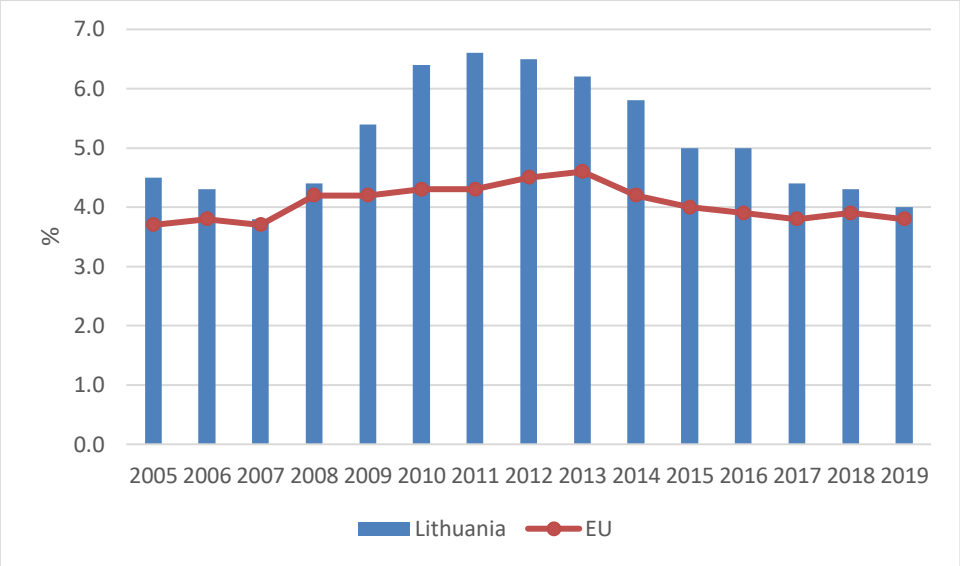


Figure 10. Share of energy expenditure in total household expenditure during 2005-2019 (Source: EUROSTAT database)

During a decade the share of energy expenditure in Lithuania and EU reduced by 2.6 and 0.5 percentage points, respectively. Seeking to keep the share of energy expenditure at current level, especially under the assumptions of increasing energy prices and taxes on energy, energy sufficiency could be important in combination to RES use and EE improvements.

2.1.7. Share of under-occupied and over-crowded dwellings

In EU every third dwelling is under-occupied and 25% of population live in under-occupied dwellings in Lithuania but this share tends to increase (Fig. 11). The upward trend of under-occupancy means that an increasing number of households live in dwellings which are too large (there is a surplus of rooms) for the needs of the households living in there. The main reasons of the under-occupation are older individuals or couples staying in their homes after their children have grown up and left, breakdowns of families as well as income situation of households. In reference to EUROSTAT data, in 2019, 34.2% of people of 65 years and over lived in under-occupied dwellings in Lithuania, but this share was 50.1% in EU. The under-occupancy rate of people at age of 18-64 was 24.6% in Lithuania but 33.4% in EU in 2019. In Lithuania the under-occupancy problem becomes evident both in rich and poor households. During 2010-2019, a share of people below 60% of median equivalised income but living in the under-occupied dwellings increased from 6.8% (2010) to 18.8% (2019), but this share was 22.8% in EU (2019); a share of people above 60% of median equivalised income and living in the under-occupied dwellings increased from 9.1% (2010) to 25.9% (2019), but this share was 38.3% in EU (2019) [20]. **Therefore, energy sufficiency potentials could be found in the households living in the under-occupied dwellings by solving the problems of under-occupancy in Lithuania. The energy sufficiency potential could be exploited for not reaching the EU level.**

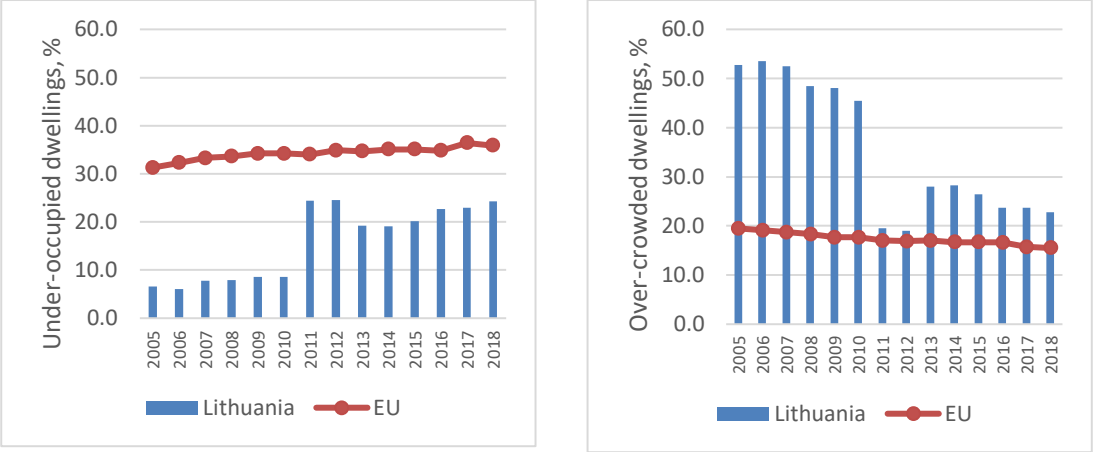


Figure 11. Share of under-occupied and over-crowded dwellings during 2005-2018 (Source: EUROSTAT, EU-SILC survey)

In contrast, there is a share of population who live in the over-crowded households that do not have at their disposal a minimum number of rooms (Fig. 11). This share is higher in Lithuania than EU average. The problem is common in households consisting of two adults with three and more children (50%) and poor households. The statistics shows that **in 2019 the over-crowding rate was 27.3% in Lithuanian and 26.7% in average EU household below 60% of median equivalised income. Therefore, it is expected that there is little or no possibilities to search for energy sufficiency solutions in this segment until EU levels are caught up, as people might live tight and even need better access to energy services here.**

2.1.8. Decomposition of energy consumption changes in households

The decomposition of energy consumption changes in Lithuanian households is provided in Fig. 12.

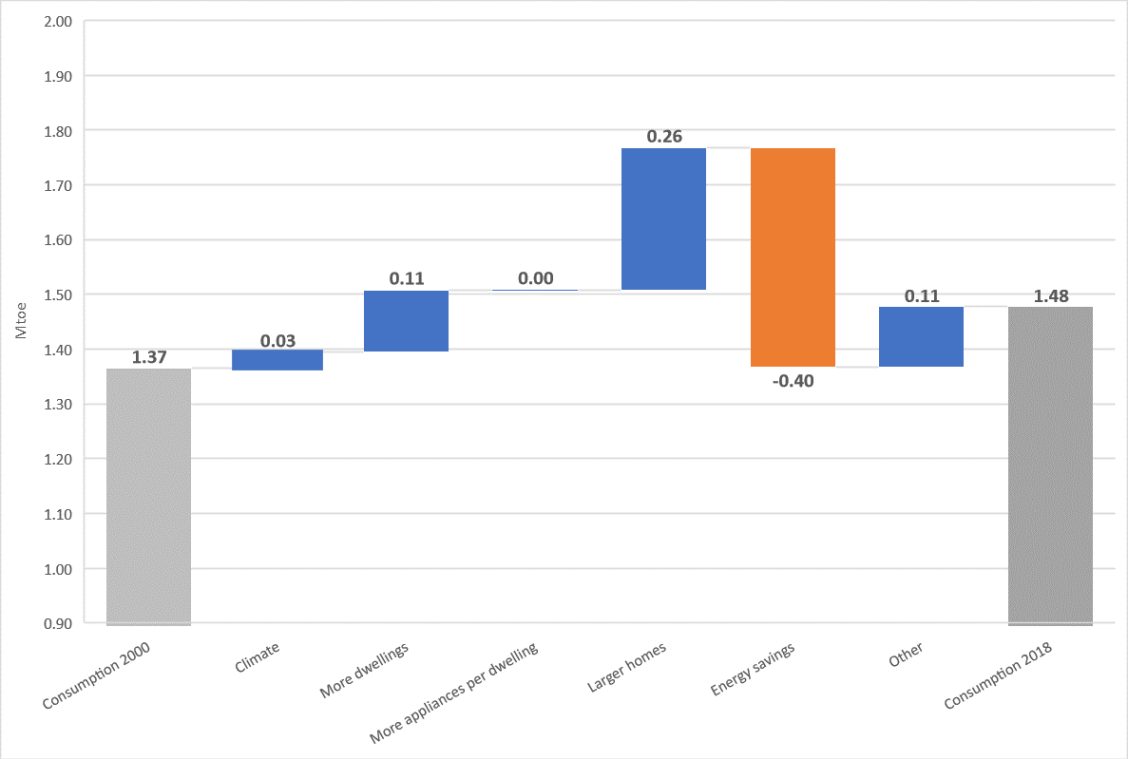
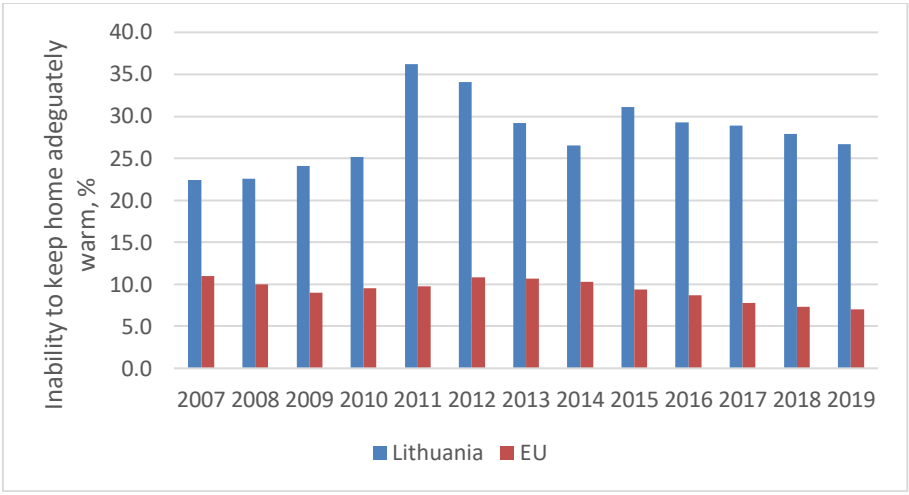


Figure 12. Main drivers of the energy consumption variation in households (Source: ODYSSEE database)

During 2000-2018 energy consumption in households increased by 0.11 Mtoe. **Larger homes, more dwellings, a request for assurance of comfort subject to climate change and household behaviour towards use of energy are identified as some of the main driversin the increasing residential energy consumption.** It is estimated that all together they increased energy consumption by 0.51 Mtoe in 2018 in comparison to 2000. The effect of more appliances used in households is estimated as negligible. Due to energy savings achieved from the implemented EE measures, the energy consumption reduced by 0.4 Mtoe.

2.1.9. Indicators of energy poverty

There is a share of population in the EU which is unable to keep home adequately warm (Fig. 13). In EU 7% of population was unable to keep home adequately warm on average, but in Lithuania this share was 26.7% in 2019. This value is nearly four times higher than EU average. However, these figures should be interpreted carefully because each EU Member State formulates the problem related question differently in the EU-SILC survey. In case of Lithuania, the indicator could be overestimated after 2011 in comparison to its values before that year, because the formulation of the question in the survey had been changed twice, i.e., in 2011 and 2015.



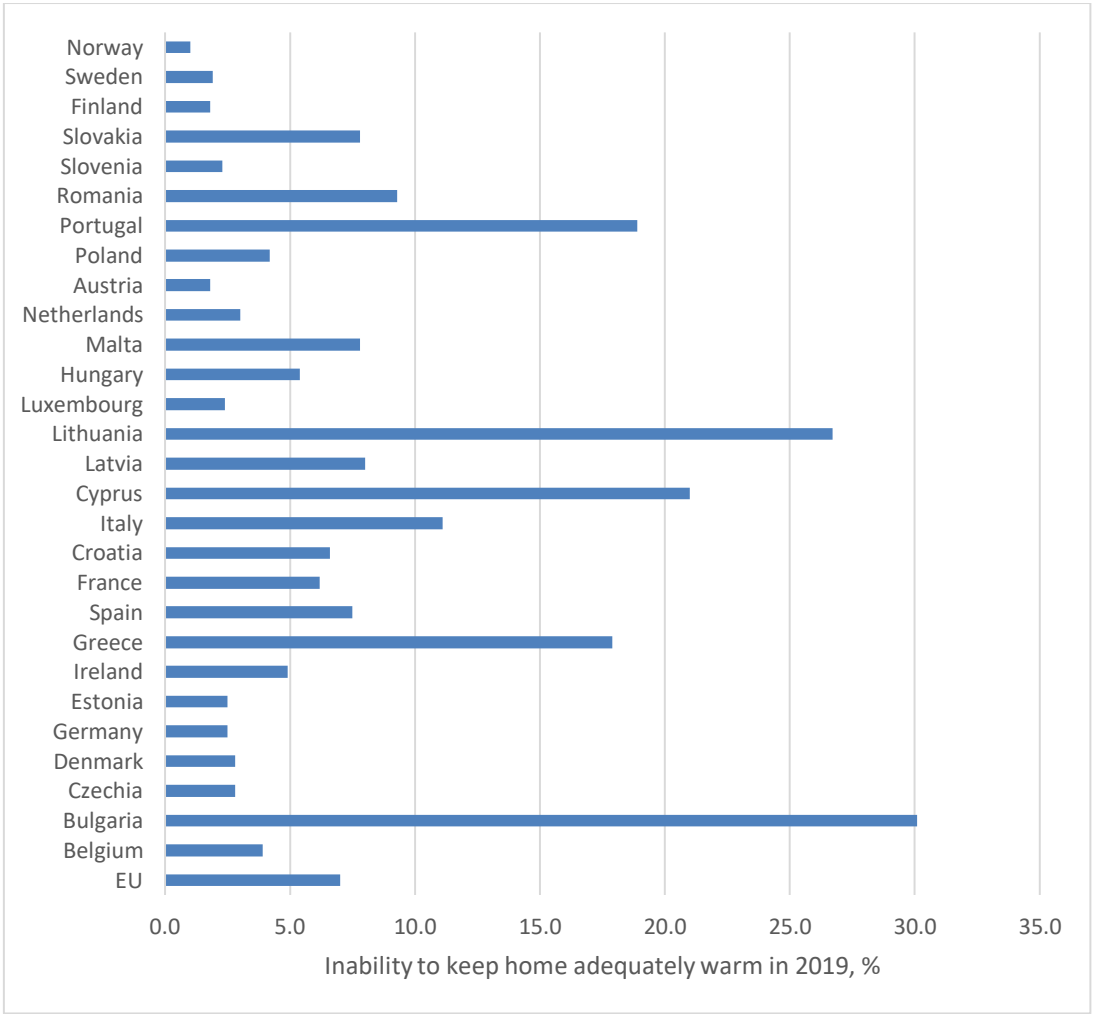


Figure 13. Inability to keep home adequately warm (Source: EUROSTAT, EU-SILC survey)

However, the share of population facing arrears on utility bills has been reducing in Lithuania and EU (Fig. 14).

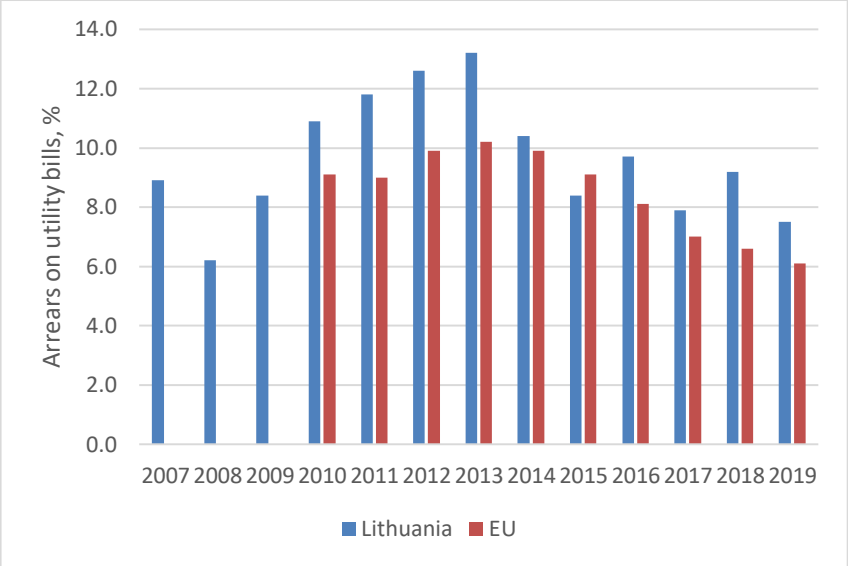


Figure 14. Arrears on utility bills during 2007-2019 (Source: EUROSTAT, EU-SILC survey)

There are still households in the EU that have difficulties in satisfaction of basic needs [21]. In 2019, almost 6.1% of households could not pay for heating, electricity, gas, water, etc. on time, due to financial difficulties. However, this share has fallen in the EU from 10.2% in 2013. **In 2019, 7.5% of households in Lithuania experienced problems paying their utility bills on time during the last 12 months and this share has been decreasing from 13.2% in 2013.**

An important instrument to address energy poverty in Lithuania is heating compensation, which provides financial assistance to households who cannot afford sufficient heating.

2.2. Tertiary Sector

In Lithuania the tertiary sector consists of wholesale and retail trade, maintenance of motor vehicles and motorbikes, repairing of household equipment, hotels and restaurants, financial intermediation, real estate management and rent, public management and defense, mandatory social security, education, health treatment and social work, other public, social and individual services, as well private households related activities. The tertiary sector creates more than half of the total value added. In 2019, the share of value added in tertiary sector accounted 68.3%. In addition, the tertiary sector employed 932,447 persons, consumed 0.63 Mtoe of energy (accounted 11.2% of the FEC) and emitted 1.6% of total GHG emissions (excluding LULUCF) in 2019. The following chapters present the tertiary sector -specific indicators that back relevant energy sufficiency assumptions and provide insights on energy sufficiency potentials.

2.2.1. Final energy consumption by fuel

Tertiary sector consumes about 0.6 Mtoe of energy a year but consumption increased by 0.2 Mtoe during 2015-2018 (Fig. 15).

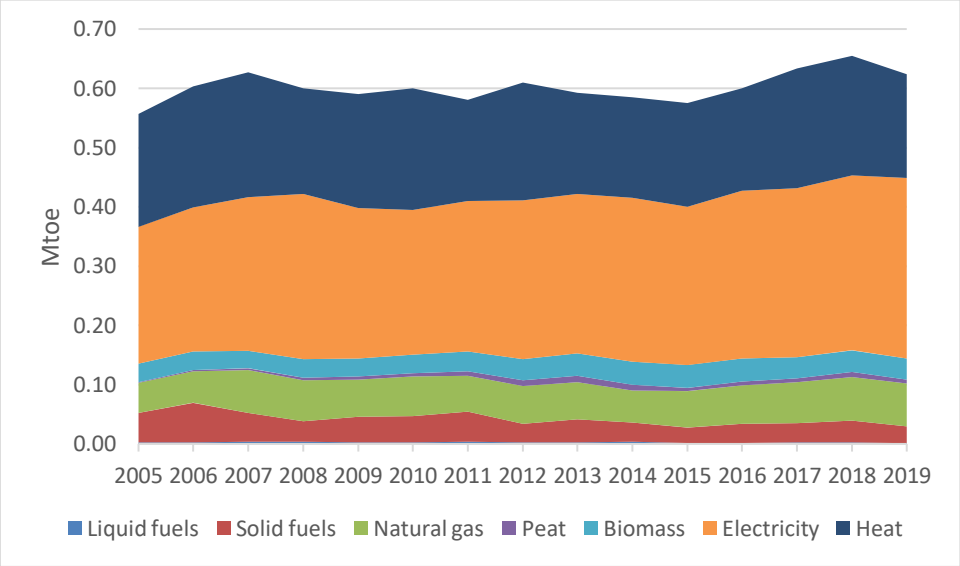


Figure 15. Energy consumption by fuel during 2005-2019 (Source: Lithuanian Statistics database)

Electricity and DH accounts for 76% of total energy consumption and mainly cause changes in it. Certainly, some small developments were caused by use of natural gas, the share of which increased from 9.1% in 2005 to 11.6% in 2019, and solid fuels, the share of which increased from 8.8% in 2005 to 4.5% in 2019.

2.2.2. Energy consumption per employee and per value added

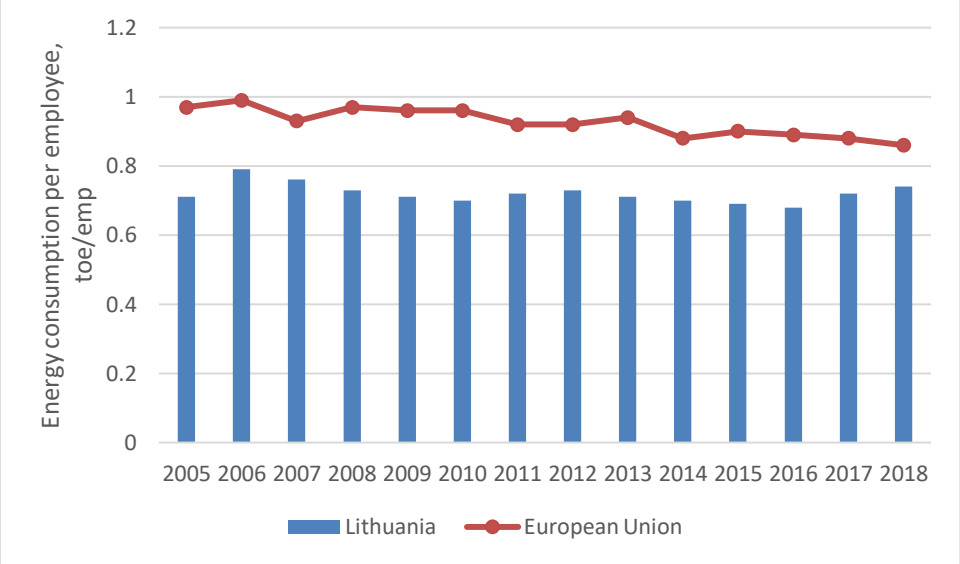


Figure 16. Energy consumption per employee during 2005-2018 (Source: ODYSSEE database)

On average, employee in tertiary sector consumes 0.72 toe of energy a year in Lithuania, while consumption of energy in EU is by 29% higher (Fig. 16). There is a downward tendency of energy consumption per employee in EU but no clear trend exists in Lithuania. In the last three years energy consumption increased by 0.2 Mtoe a year in Lithuania. From the point of view of energy consumption per employee, **Lithuania outperforms the average EU; yet, this emerging trend could be even more enhanced with the support of a sufficiency approach.**

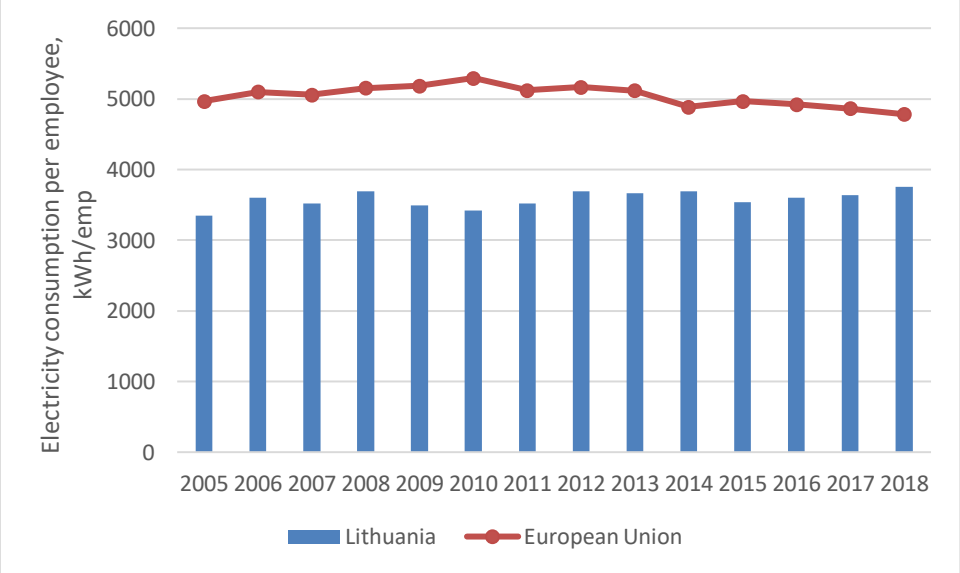


Figure 17. Electricity consumption per employee during 2005-2018 (Source: ODYSSEE database)

On average employees use about 3,584 kWh of electricity a year in Lithuania but by 40.6% more in the EU (Fig. 17). Since 2015, electricity consumption has been increasing by 2.0% in Lithuania. **The electricity**

consumption per employee in Lithuania is lower than the EU average, but tends now to stabilize. In this context, energy sufficiency potential could be searched and exploited in order to foster further decrease.

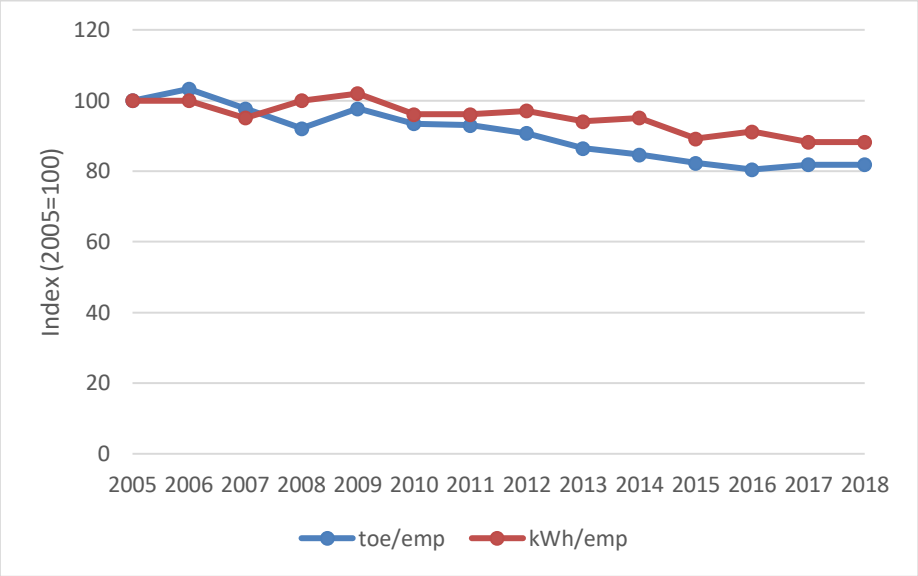


Figure 18. Indexes of electricity and energy consumption per employee during 2005-2018 (Source: own calculations based on Lithuanian Statistics data)

Energy consumption per employee reduces faster than electricity consumption per employee and in 2018 was 80% and 88% of 2005 level, respectively (Fig. 18). Therefore, energy sufficiency potentials could be key for specific (electricity) demand reductions.

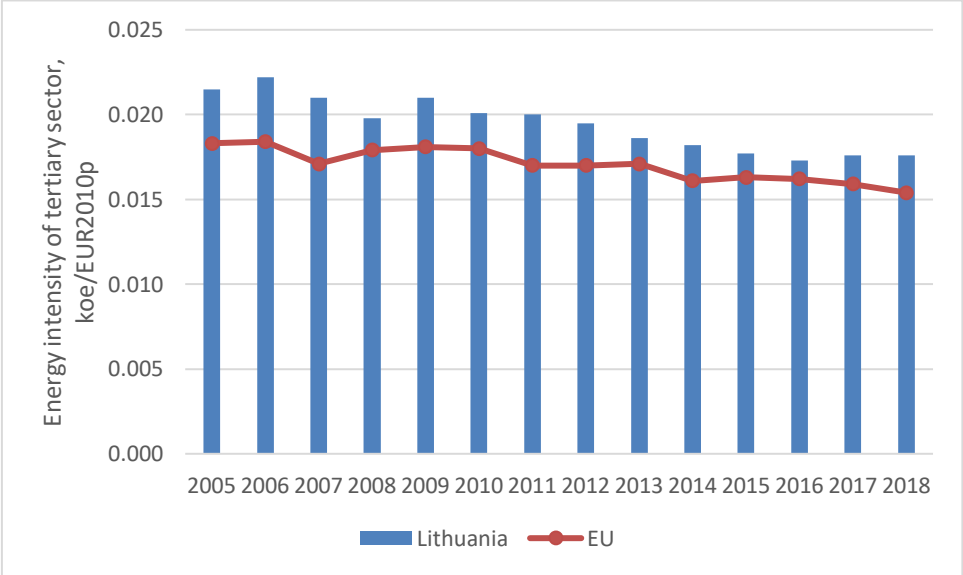


Figure 19. Energy intensity during 2005-2018 (Source: ODYSSEE database)

Energy consumption intensity improves faster in Lithuanian tertiary sector than in the EU, however, it remains worse in comparison to EU average (Fig. 19). The gap between intensities was 18% in 2005 and 14% in 2018; as made 0.018 koe/$EUR_{2010PPP}$ and 0.015 koe/$EUR_{2010PPP}$, respectively. **The energy sufficiency approach could be relevant when reducing energy intensities in Lithuanian tertiary sector and approaching the average EU levels.**

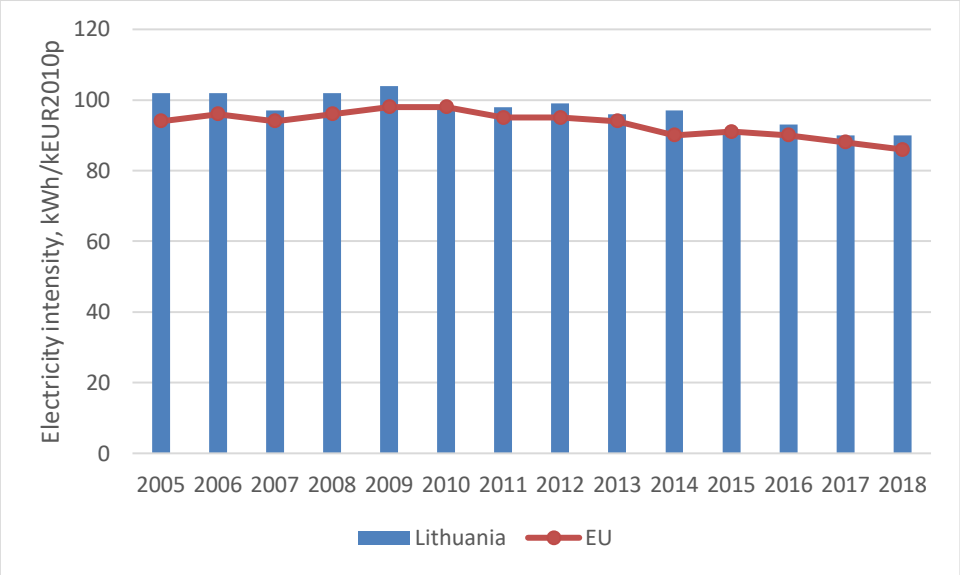


Figure 20. Electricity intensity in commercial sector during 2005-2018 (Source: ODYSSEE database)

Electricity intensities are similar in Lithuania and EU – 90 kWh/kEUR$_{2010PPP}$ and 86 kWh/kEUR$_{2010PPP}$ in 2018, respectively (Fig. 20). During the latter several years electricity intensities reduced.

2.2.3. Decomposition of energy consumption changes in tertiary sector

During 2000-2018 energy consumption in tertiary sector increased by 0.19 Mtoe, as it is showed in Fig. 21.

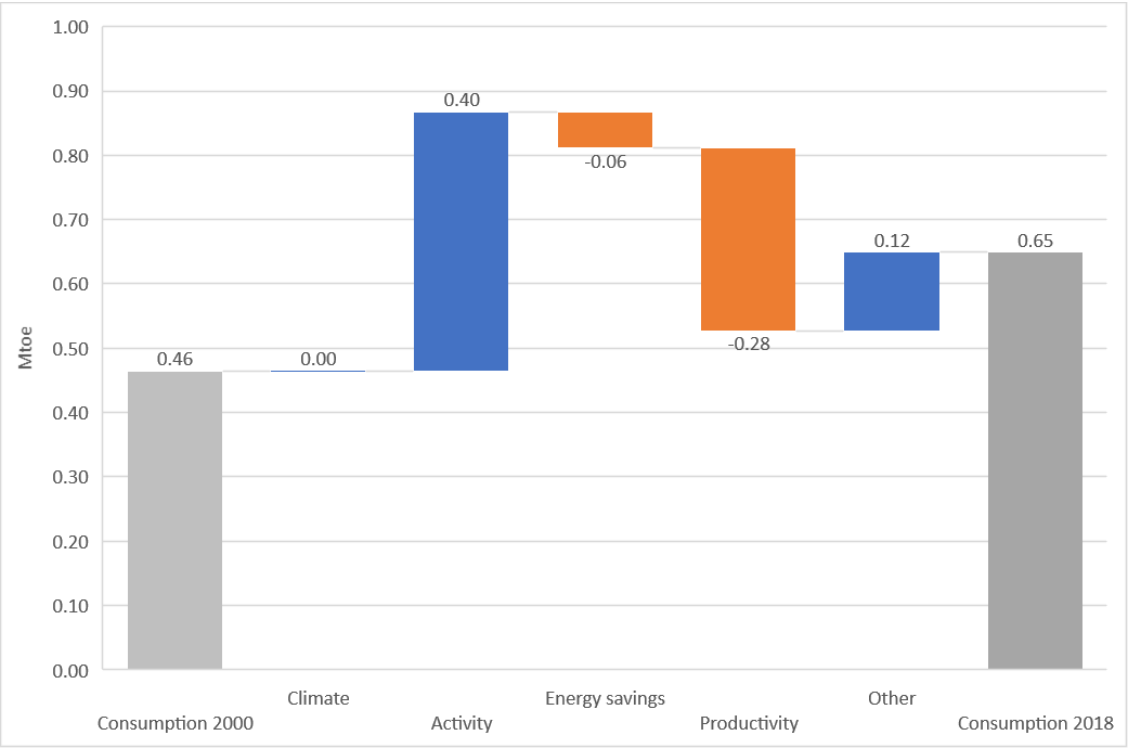


Figure 21. Main drivers of the energy consumption variation in tertiary sector (Source: ODYSSEE database)

The economic activity of the sector strongly supported by the consumerism approach viable in the economy when consuming goods and related services increased energy consumption the most, i.e. by 0.4 Mtoe; while inappropriate behaviour towards energy consumption put on additional 0.12 Mtoe. **Nonetheless, due to developments in labour productivity energy consumption reduced by 0.28 Mtoe. Implemented EE measures in service sector allowed reducing energy consumption by additional 0.06 Mtoe.**

2.3. Energy and Climate Policy Goals Related to Building Sector

2.3.1. NECP 2030

Seeking to follow the decarbonisation path of the national economy, **the NECP 2030 expects to reduce GHG by 25% (in comparison to 2017) in households and by 14% in service sector in 2030.** Energy consumption will reduce from 649.9 ktoe (2018) to 540.4 ktoe (2030) and 535.8 ktoe (2040) in service sector and from 1,486 ktoe (2018) to 1,307.5 (2030) and 1,209.6 (2040) in households. **The reductions in energy consumption will be achieved through the introduction of a list of existing and planned policy measures responding to the application of new and less energy-intensive technologies, the increase of consumer awareness and the change of behaviour (these are the agreements with energy suppliers on consumer education and consulting).** In particular, by the end of 2030, around 5,000 multi-apartment buildings will be renovated to meet energy class C[2] and to save 40% of energy. This means that nearly 500 multi-apartment buildings will be renovated each year. Therefore, energy savings will be 310 ktoe (3.6 TWh) during 2021-2030. In addition, 960,000 m^2 of public building area will be renovated to meet class C by 2030. This should increase energy savings to 31 ktoe (0.36 TWh) during 2021-2030. Furthermore, 50,000 domestic boilers will be replaced in households and other heat efficiency improvement measures will be implemented, resulting in savings of at least 17 ktoe (200 GWh) per year. Related energy savings shouldbe 946 ktoe (11 TWh) during 2021-2030. Moreover, the indoor heating and hot water systems in multi-apartment buildings will be modernised, with estimated energy savings of 47.3 ktoe (0.55 TWh) during 2021-2030. Besides this, financial incentive for private house owners will be provided for the renovation of their homes. Therefore, 1,000 private houses will be renewed, resulting again in energy savings of 1.2 ktoe (13.5 GWh) a year and 63.6 ktoe (0.74 TWh) during 2021-2030. Then, the energy suppliers will ensure the implementation of measures of consumer education and consulting provided for in agreements concluded between them or through other persons (including the introduction of smart metering). Energy savings shall be 258 ktoe (3 TWh) during 2021-2030. 50% of the savings will go to industrial end-users and the remainder to households. In terms of energy source, electricity will account for 40% of energy savings, heat for 40% and natural gas for the remaining 20%. Finally, energy companies will save energy according to the levels of energy specified in the energy savings agreements by applying cost-effective energy efficiency improvement measures at the final energy customers' installations, equipment and transport. Energy savings should be 473 ktoe (5.5 TWh) during 2021-2030. It is planned that this measure will apply to the services and industry sectors, assuming that the savings measures will generate 50% electricity and 50% heat savings. **The NECP proposes several measures to address energy poverty within the internal energy market. These are financial support and legal protections, as well as energy price related and consumer information, vulnerable people needs prioritizing measures**. However, their impacts on energy consumption in households suffering from energy poverty is not assessed separately.

[2] Technical regulation STR 2.01.09:2012 Energy performance of buildings. Energy performance certification

2.3.2. National Energy Independence Strategy till 2050

The NEIS is narrow in terms of disclosure of assumptions and display of annual developments of climate and energy policy related indicators representing the way the building sector is going to deal with energy consumption developments and contribute to achievement of EE targets. It is known that energy consumption in households shall reduce by 0.4% a year till 2050 and 1,340.2 ktoe shall be consumed in 2050, in comparison to 1,338.6 ktoe (2030) and 1,359.7 ktoe (2015). Controversially, energy consumption in service sector shall increase by 0.6% a year and 752.1 ktoe shall be consumed in 2050, in comparison to 651.4 ktoe (2030) and 575.4 ktoe (2015). **The NEIS sets that the comprehensive renovation of multi-apartment and public buildings (by providing the priority for the renovation of residential areas) is the core direction of EE improvement in buildings.**

2.4. Main Obstacles and Drivers to Energy Sufficiency

2.4.1. Regulatory aspects

The analysis of the aforementioned strategic documents showed that the concept of energy sufficiency was not directly introduced in the national energy and climate policy. Moreover, it did not necessarily refer to sustainable consumption. Controversially, the term had been used in context of development of sustainable energy production and grid capacities, as well as transport infrastructure to support fast economic growth and increasing energy consumption. However, some evidence of energy sufficiency could be observed in the NECP. Namely, the small insights on energy sufficiency could be found in the dimensions of decarbonization, energy efficiency and internal energy market of the **NECP**:

- **Within the dimension of energy efficiency**, energy sufficiency could be related to the renovation of multi-family and public buildings as well as purchase and use of environment friendly technologies. Renovation creates precondition for human to live comfortably in existing dwelling instead of searching alternative solutions living in new larger individual houses (cottages) that request for additional energy related services. The same is true when speaking about benefits of improved energy performance of renovated public buildings.
- **The internal market dimension** suggests that promotion of competitive energy price formation shall enable consumers to choose dynamic price contracts and to respond them to price signals and manage their energy consumption in the direction of reducing energy consumption, especially during peak hours.
- Moreover, **the hidden energy poverty** remains an issue in the country, as there are households who may spend too little and not acquire a sufficient number of services, including energy services. The **National Progress Programme 2021-2030** determines the target of "reducing energy poverty among the population", introducing two national indicators with targets for 2025 and 2030. The programme aims at reducing the share of the population unable to keep home adequately warm from 27.9% (2018) to 23% (2025) and 17% (2030) [22] and decreasing the share of households who spend large share of income to pay for energy from 17.1% (2016) to 15% (2025) and 8.6% (2030). Presently, energy poverty is addressed from several measures in the NECP, including reimbursement of heating, drinking water and hot water costs, reimbursement of payment of the loan taken out for the renovation/modernisation of multi-apartment buildings as well as interest on behalf of persons eligible for reimbursement of domestic heating costs.

2.4.2. Behavioural, social and cultural obstacles and drivers

After Lithuania regained its independence (1990), it was decided to allow the privatisation of the apartments. People living in the multi-family buildings and those who did not owned individual dwellings were offered the opportunity to become their owners. Since then, the 'one apartment – one owner' policy has been implemented. **At the same time, having a large number of apartment owners, in particular the multi-family buildings, makes lots of problems when trying to agree on home maintenance or renovation. That is perceived as an obstacle to achieve efficiency and further more sufficiency.** The main and the most important driver to renovate a building is a chance to use support schemes for financing renovation.

The current development in the COVID-19 situation discloses several behavioral directions. First one, households are tended to buy large individual houses, which hit energy sufficiency concept. Second one, construction of co-living dwellings (very small dwellings for rent) has been started that is better adjusted to energy sufficiency concept.

As for new buildings, the first priority is given to the location, the second to the price then number of bedrooms [23]. The latest trends show growing demand for bigger apartments and individual houses to be comfortable for working from home [24]. The same survey shows that, the acquisition of own housing has become a priority for Generation Y. 42% of Vilnius residents aged 26–35 have plans to acquire new housing. A large part of these young and usually mobile people got "grounded" by the pandemic in Lithuania and turned into rather sedentary citizens; therefore, it is natural that they are seriously interested in purchasing their own housing. The demand for so-called holiday housing also jumped upwards. About a fifth of the population (17%), who do not yet have such housing, have started to consider purchasing a second home for recreation on the Lithuanian seaside, in a resort or in another remote, picturesque place.

2.5. Possible Improvements in Building Sector

The analysis above disclosed the assumptions unfavourable to energy sufficiency driven energy consumption in Lithuanian households. These are:

- the reducing size of households pushed by increasingly common single person and couples without children constellations;
- high rates of under-occupancy of dwellings both in rich and poor households;
- the increasing floor area per capita strongly supported by the purchase of newly built, large dwellings;
- the deterioration of the demographic situation in the country,
- the increasing consumption of natural gas and electricity in appliances and for lightening purposes;
- and high demand for space heating.

The historical trends should undergo transformations to catch up at least EU levels and later on to improve in a way establishing opportunities for exploitation of energy sufficiency potential. Following the current trends of indicators facilitated by the existing State and regional policies, no significant opposite changes in values of indicators could be expected. Controversially, observing the upward trend of energy consumption in households (toe/cap), it is considered that in a few several years energy consumption (toe/cap) could exceed the average EU level and leave a room for energy sufficiency driven consumption at least to the average EU level. Therefore, seeking to achieve energy sufficiency driven reduction in energy consumption in the household sector, the **State Concept on Family Policy** [25] should be updated and implemented. In particular, the social and economical problems of families, as well as demographical and cultural problems, including changing values in society, children education and safety ensuring issues making a negative impact on family institute should be solved. Moreover, energy sufficiency oriented **Housing Support Policy** (based on Law on support for acquisition and rent of dwelling) should be implemented. The **RES & EE policy related**

programmes should be continued to be implemented. However, they should be updated taking into account the criteria of energy sufficiency. From this perspective EE & RES solutions could be implemented at building, group of buildings or residential area level instead of supplying a separate household with a technology / solution. Moreover, measures on education and information of households should be proposed. In addition, energy efficient appliances should be purchased and later on households should be motivated to use them in a shared manner.

Other suggestions might include:

- the establishment of absolute norms of consumption for building performances (e.g., kWh/cap) in addition to the „efficiency" related current norms (in kWh/m^2);
- the promotion of more diverse constellations of households to counteract the decreasing household size trends;
- the establishment of absolute norms of consumption for home appliances (e.g., kWh/refrigerator) in place of the current intensive ones (e.g., kWh/L) to counteract the growing size of these appliances.

The analysis of tertiary sector related indicators supports the relevance of energy sufficiency concept when transforming existing trends of energy and electricity consumption in the tertiary sector and reducing energy demand, as well as reducing energy intensities in a way approaching the average EU levels.

3. Transport Sector – Trends, Potential and Strategies

The fossil fuel consumption and GHG emissions has been growing in the transport sector over the last decade. In 2019, the transport sector accounted 40.9% of FEC and emitted 30.9% of total GHG emissions (excluding LULUCF) in Lithuania. The emissions from the transport sector increased from 4.2 Mt CO2eq in 2005 to 6.3 Mt CO2eq in 2019, 96.2% of which comes from road transportation [26].

3.1. Passenger Transport

Passenger transport can be classified into individual / public transport mode, road / non-road transport mode and motorized / non-motorized transport modes. Seeking to achieve sustainability, public transport and non-motorized modes should be much more widely used and replace non-efficient fossil fuel-based individual transports. This chapter is an analysis of the FEC for passenger transport, the change in demand for passenger transport, the evaluation of car ownership, modal split, the age of vehicle, the share of public transport and the decomposition of energy consumption variation in passenger transport.

3.1.1. Final energy consumption

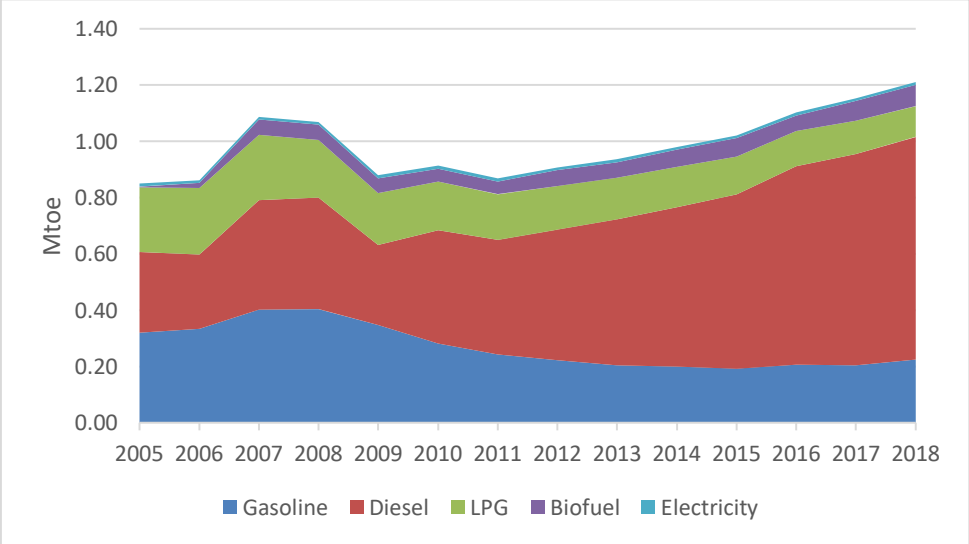


Figure 22. Final energy consumption in passenger transport by fuel during 2005-2018 (Source: Lithuanian Statistics database)

Energy consumption for passenger transport unequivocally decreased after global economic recession (Fig. 22). In 2009, 0.88 Mtoe were consumed in passenger transport. This is by 18% less than in 2008. During the following several years passenger transport consumed 0.90 Mtoe a year. **Since 2011 energy consumption in passenger transport started to increase at rapid rates – by 4.3% a year**; therefore, in 2018 there were consumed 1.21 Mtoe. During a period the consumption of diesel grew by 8.7% a year, use of biofuel – by 6.8%, while LPG and gasoline consumption decreased by 4.8% and 1.0% a year, respectively. Electricity consumption was stable and accounted about 0.01 Mtoe. Currently, diesel accounts of 65% of energy consumption in passenger transport, gasoline – 19%, LPG – 9%, biofuel – 6% and electricity 1%. The share of biofuel is low as relatively high investment in the renewal of the vehicle fleet is necessary.

3.1.2. Passenger km per capita

Energy consumption in passenger transport has been influenced by the distances travelled by passengers (Fig. 23).

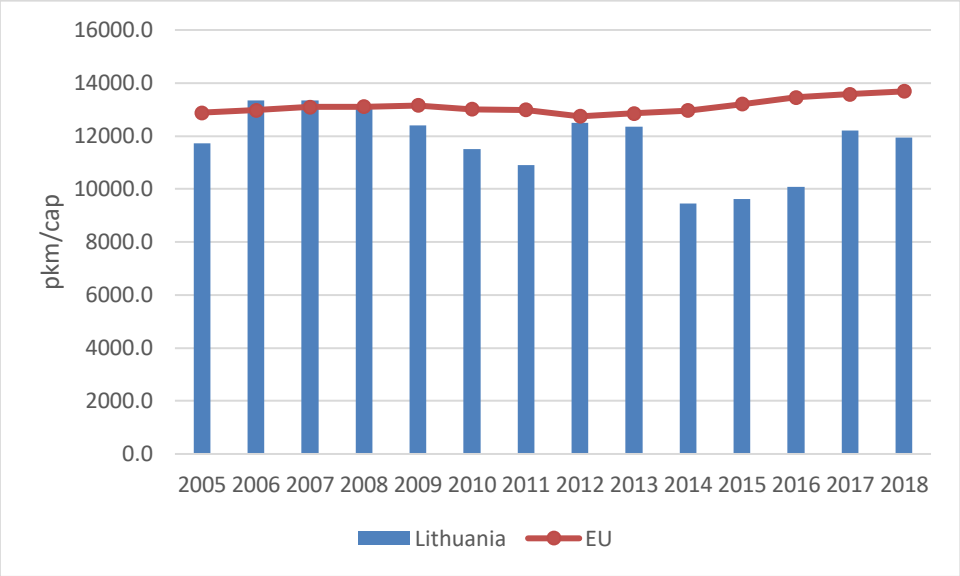


Figure 23. Passenger kilometres per capita during 2005-2018 (Source: ODYSSEE database)

In 2008, passenger transport represented 13,253 pkm/cap in Lithuania. Later on, travelled distances started decreasing by 5.8% a year; therefore, in 2011 the national average level of transport was of 10,913 pkm/cap. During the next several years passengers travelled more, and then in 2014 travelling distances reduced to 9,440 pkm/cap that is the lowest level during the period 2005-2018. After then passenger travelling distances started increasing by 6.0% a year but in 2019 only the 2010 level had been achieved**. On average Lithuanians travel less than the average EU where travelling distances has been constantly increasing since 2012**.

3.1.3. Number of passenger cars

The stock of passenger cars is a driver of energy consumption in passenger transport too (Fig. 24).

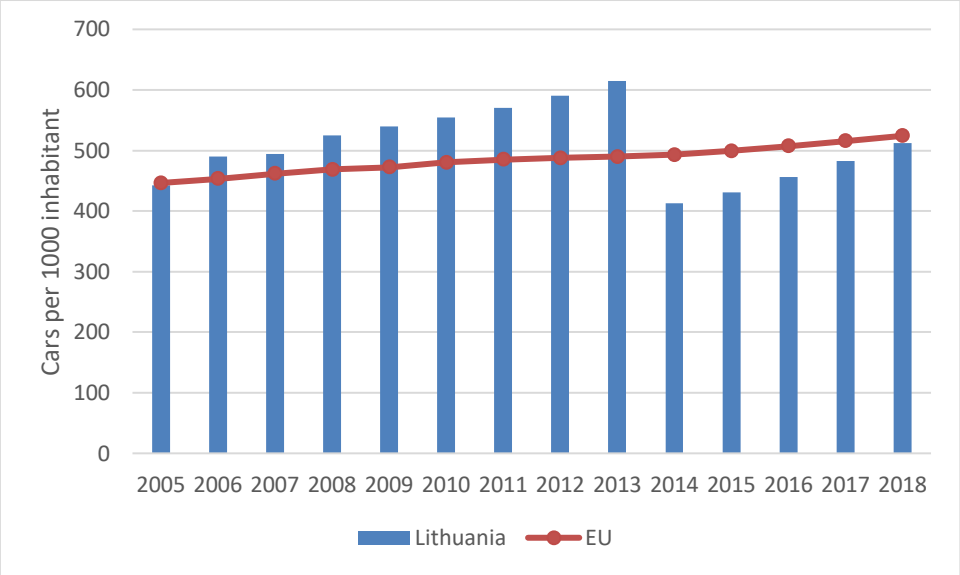


Figure 24. Passenger cars per 1000 inhabitants during 2005-2018 (Source: EUROSTAT, EU Transport in figures, statistical pocketbook 2020)

There is an upward trend of the number of passenger cars per 1,000 inhabitants. During 2005–2013 it increased by 40%, i.e., from 442 (2005) to 615 (2013). In 2014, old and not used passenger cars which owners could not provide evidence that cars were technically in order and insured, had been automatically registered out; therefore, the official number of passenger cars significantly reduced. About 900 thousand cars had been automatically registered out [27]. Since 2014 the number has been increaseing furthermore from 413 (2014) to 512 (2018). **In 2018, Lithuania achieved EU level which trend suggests a long-term growth in passenger cars per 1,000 inhabitants**.

3.1.4. Modal split in passenger transport

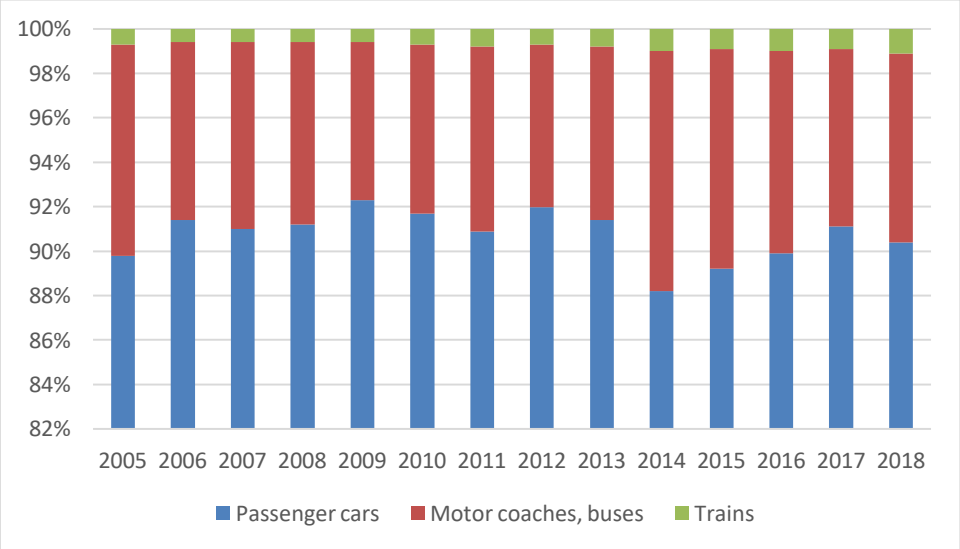
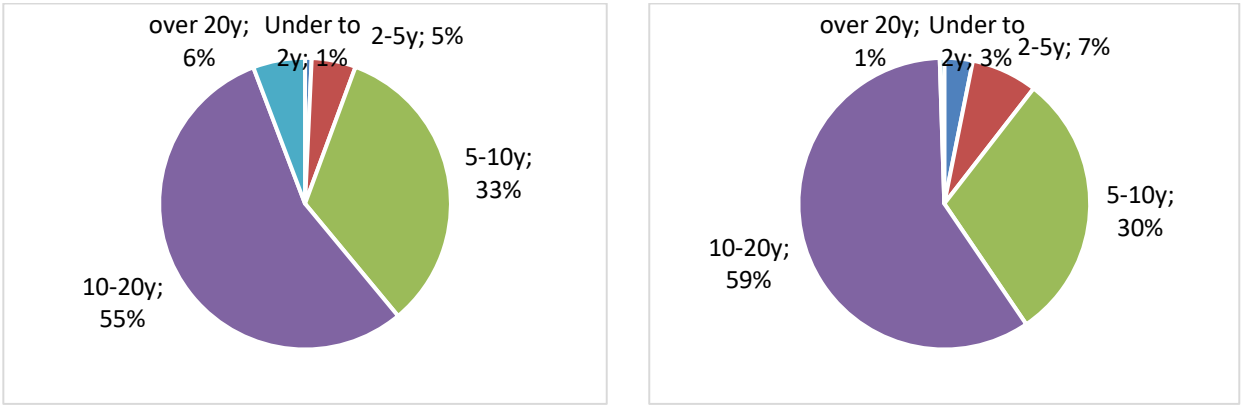


Figure 25. Modal split in passenger transport during 2005-2018 (Source: EUROSTAT database)

During economic growth **period Lithuanian inhabitants prefer passenger cars more than use of buses or trains** as the modal split in passenger transport till 2008 shows (Fig. 25). During 2005-2008 passenger cars accounted to 90.9% of passenger transport. Economic recession and slow recovery period slightly changed

the structure of passenger transport in a way that the share of buses and trains increased from 7.7% (2009) to 9.1% (2011). **The popularity of buses and trains was improving till 2014, as their share increased up to 11.8%. Today that means of transport accounts for 9.6% of passenger transport which is below the EU level of 16.7% in 2018.**

3.1.5. Composition of vehicles by age



a) Private cars b) Buses

Figure 26. Composition of vehicles by age in 2019 (Source: REGITRA data)

55% of private cars and 59% of buses are 10-20 years old (Fig. 26). **Thus, half of private cars with average age of 15 years and average CO_2 emissions of 160-170 g/km are in Lithuania**. One-third of the park is 5-10 years old. The status of park of buses is only slightly better than the status of the park of privates cars, there is a smaller share of very old vehicles (1%) and a larger share of vehicles under 2 years (3%). These shares are 6% and 1%, respectively in the park of private cars.

3.1.6. Share of public and private transport

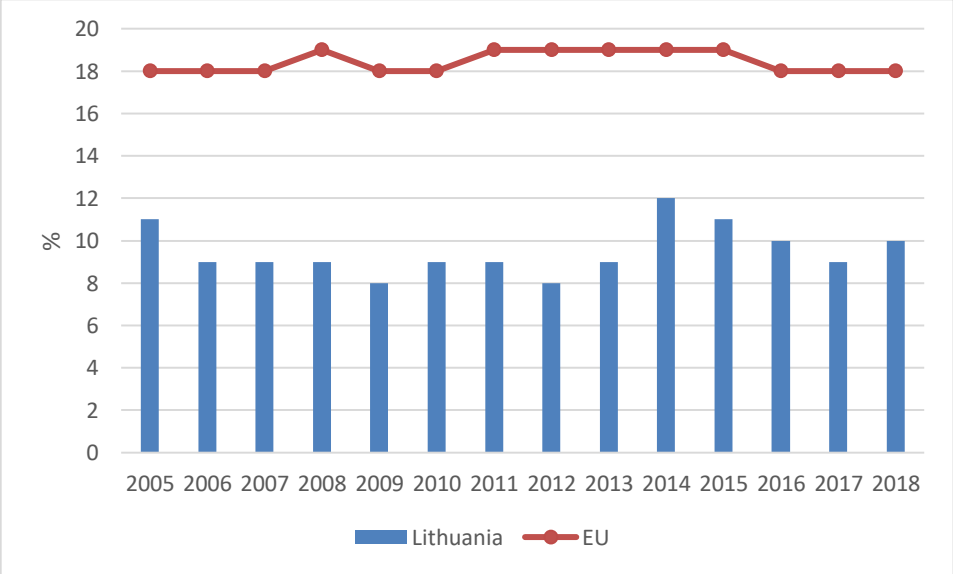


Figure 27. Share of public transport during 2005-2018 (Source: ODYSSEE database)

The attractiveness of public transport is considerably lower in Lithuania than in the EU as public transport accounted only to 9.5% of passenger transport in the country while in the EU it has been twice higher (Fig. 27). Moreover, over the last years this share has been even reducing in Lithuania.

3.1.7. Decomposition of energy consumption variation in passenger transport

During 2000-2018 energy consumption in passenger transport increased even by 0.52 Mtoe (Fig. 28). According to the analysis made in the Odysee-Mure database, **the behavioural effects increased energy consumption the most**, i.e. by 0.50 Mtoe; while the increase in passenger traffic (passenger-km) added additional 0.22 Mtoe. Modal shift from public transport to private transport increased energy consumption by 0.02 Mtoe. Nonetheless, due to switch to the more effective modes energy consumption reduced by 0.22 Mtoe.

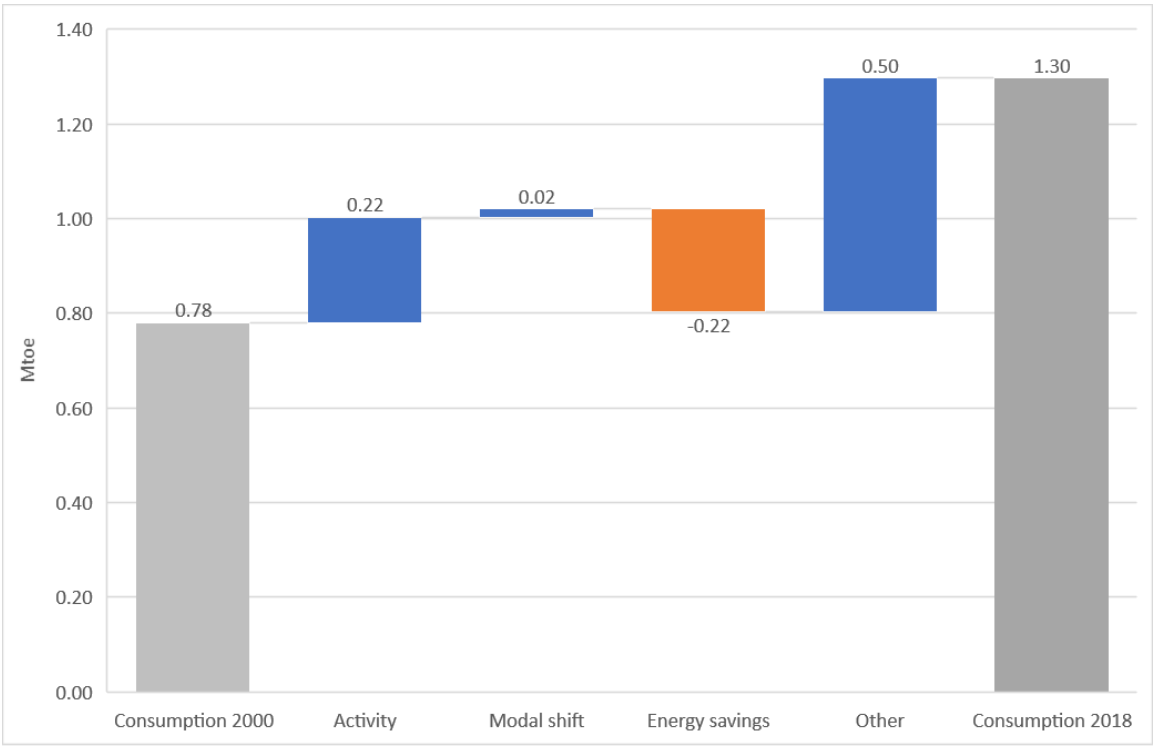


Figure 28. Main drivers of the energy consumption variation in passenger transport (Source: ODYSSEE database)

3.2. Freight transport

Historically, fuel consumption in freight transport has been highly dependent on GDP. Policies and measures are needed in order to improve efficiency of freight vehicles, to promote modal shift and to increase the use of renewable fuels. This subsection is an analysis of the FEC for freight transport, the change in freight transport intensity, the structure of freight transport, the composition of freight transport by age and the decomposition of energy consumption variation in freight transport.

3.2.1. Final energy consumption

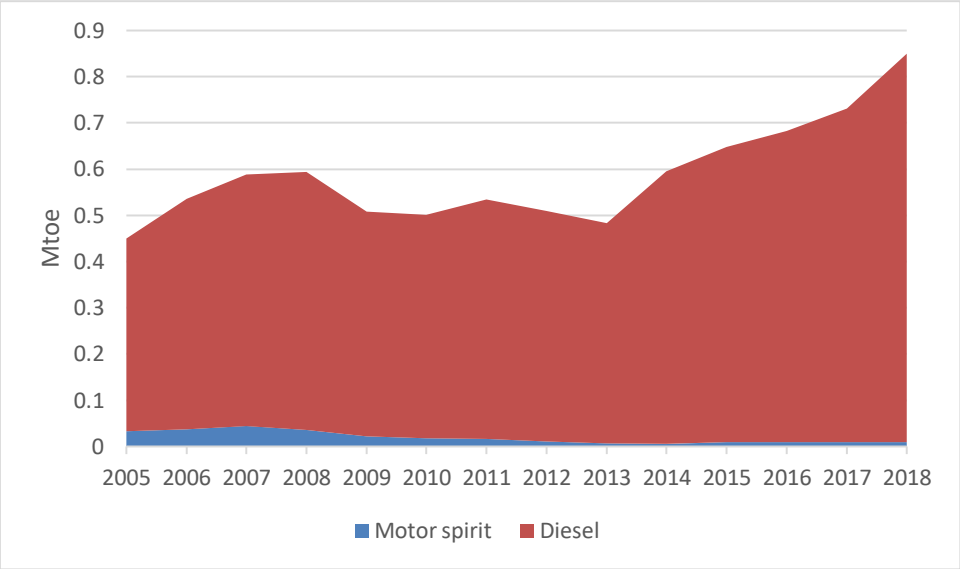


Figure 29. Final energy consumption in freight transport during 2005-2018 (Source: Lithuanian Statistics database)

Freight transport is mostly fueled with diesel (Fig. 29). Until 2008, energy consumption grew by 9.7% a year, but **since 2013 energy consumption growth rates are considerable, i.e., 12% a year**. 0.85 Mtoe of energy was consumed in 2018 and this is by 80% more than in 2013.

3.2.2. Energy consumption per tkm

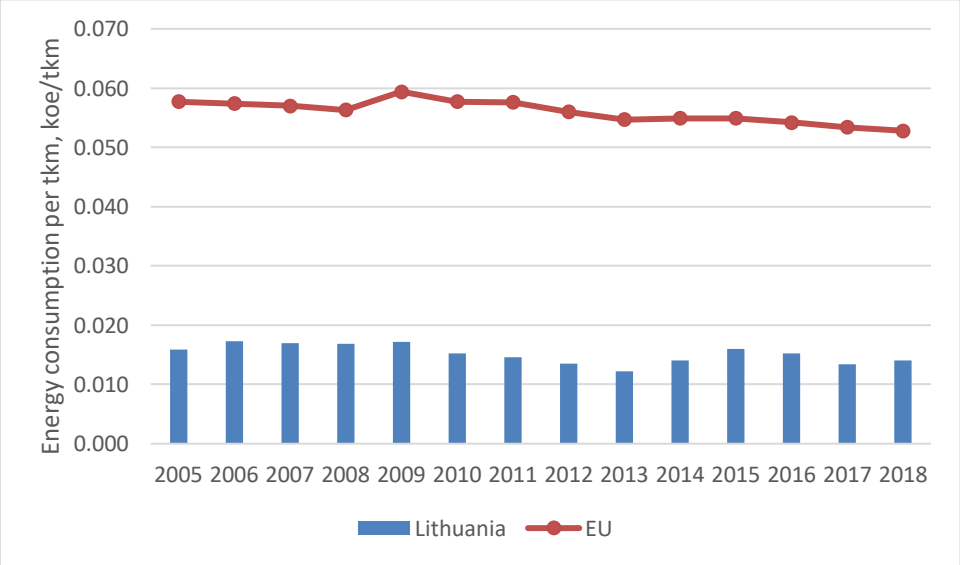


Figure 30. Energy consumption per tkm during 2005-2018 (Source: ODYSSEE database)

Historically, energy intensity in Lithuanian freight transportation was considerably lower than in EU (Fig. 30). On average, during 2005-2018, the intensity of cargo transportation 0.015 koe/tkm of energy while the requirements for energy were 0.056 koe/tkm in EU.

3.2.3. Structure of freight transport

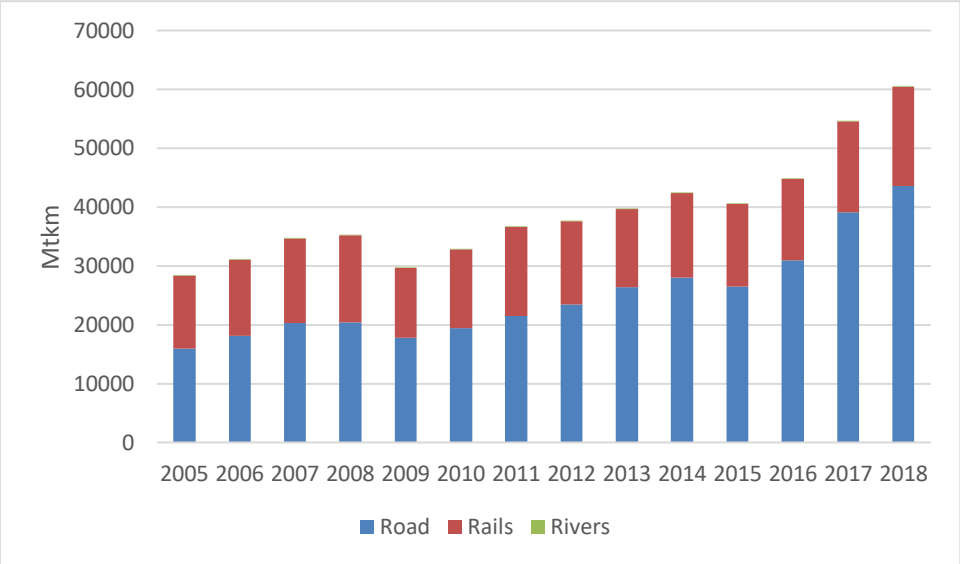


Figure 31. Traffic in tkm during 2005-2018 (Source: ODYSSEE database)

Since 2005, except in the economic recession period, the traffic in tkm intensified rapidly in Lithuania (Fig. 31). **In 2018, traffic in tkm was more than 2 times intense than in 2009 when it was 60,476 Mtkm.** Currently, two-third (72.1%) of cargo transportation is organized on the roads while this share was 56.1% in 2005. The load of rails for cargo transportation increases by 1.2% a year but the load improvement rates are lower in comparison to the rate of road load which is 8% a year. Historically, rivers have not been used much for cargo transportation.

3.2.4. Composition of freight transport by age

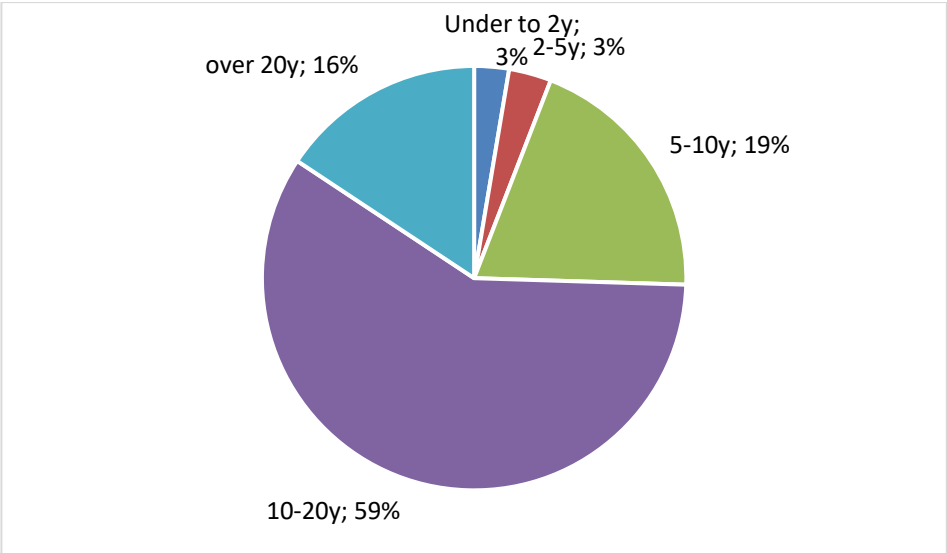


Figure 32. Stock of freight transport vehicles by age in 2019 (Source: REGITRA data)

The park of freight transport consists of 16% of heavy-duty trucks over 20 years and 59% – of age 10-20 years (Fig. 32). New heavy-duty trucks accounted only 3%. Therefore, the freight transport is older than the passenger transport in Lithuania.

3.2.5. Decomposition of energy consumption variation in freight transport

During 2000-2018 energy consumption in freight transportation increased by 0.50 Mtoe (Fig. 33). According to the analysis from the Odysee-Mure databse, the significant increase in **the total traffic goods in tkm increased energy consumption by 0.61 Mtoe**. Modal shift to road transport has contributed to rise of energy consumption by 0.16 Mtoe, while energy savings due to use of more effective trucks and behaviour effects have decreased consumption by 0.2 Mtoe and 0.07 Mtoe respectively.

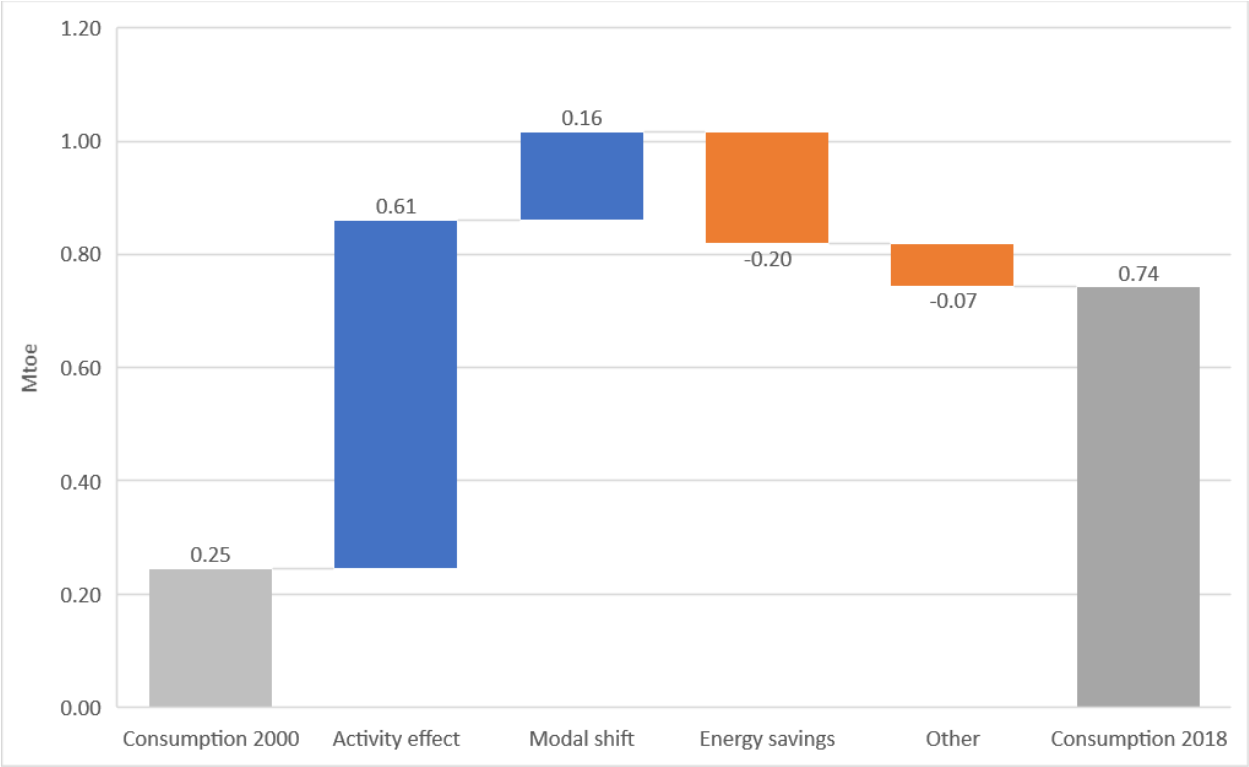


Figure 33. Main drivers of the energy consumption variation in freight transport (Source: ODYSSEE database)

3.3. Energy and Climate Policy Goals Related to Transport Sector

3.3.1. NECP 2030

The NECP 2030 expects to reduce GHG by 39% (in comparison to 2017) in transport sector in 2030 and 52% in 2040. Energy consumption will reduce from 2,215 ktoe (2018) to 1,606 ktoe (2030) and 1,440 ktoe (2040) in transport sector. The 35% reductions in energy consumption will be achieved through the implementation of 3 existing and 29 planned policy measures. The existing policy measures focus on the purchase of city and

suburban buses running on alternative fuels and electricity and the installation of infrastructure (GHG emission reduction effect is 4.9 kt CO_2 eq. by 2030); electrification of 814 km of railways which will enable 70% of freight traffic to be carried by electrified railways (GHG emission reduction effect is 1,115 kt CO_2 eq.) and implementation of Sustainable Urban Mobility Plan measures to reduce the use of fossil fuel-powered vehicles (GHG emission reduction effect is 1,524 kt CO_2 eq.). A wide array of planned policy measures focusing on the promotion of electric cars and other low-emission vehicles, on car pollution taxes and the efficiency of passenger and freight transport (public and combined transport, habit building) will allow reducing GHG emission significantly – by 10.5 Mt CO_2 eq during 2021-2030. Due to the mandatory blending of biofuel into mineral fuels, excise duty concession for biofuels, promotion of generation II biofuels, support for the purchase of public, utility or other commercial vehicles fuelled by compressed natural and/or biomethane gas, the RES share in transport shall increase to 4.33% (2020), 15% (2030) and 50% (2050). With the increase of the EU targets for 2030, more ambition will have to be sought, and sufficiency could have a key role to play in this regard.

3.3.2. National Energy Independence Strategy till 2050

The main goal of the NEIS in the field of fuels is to gradually move to less polluting fuels and electricity through the flexible and efficient use of existing oil and oil sector infrastructure and local renewable energy potential. The NEIS sets targets to increase the share of RES to 10% (2020), 15% (2030) and 50% (2050), as well as to ban gasoline- and diesel-based cars in cities by 2050. The NEIS forecasts that energy consumption in transport sector will increase by 1.6% a year till 2050 and 2948 ktoe will be consumed in 2050, in comparison to 2,309 ktoe in 2020 and 2,576 ktoe in 2030. Energy consumption in transport sector forecasts take into account that the use of electric vehicles shall be promoted, necessary infrastructure for electric vehicles will be developed, the railway transport will be electrified, public transport will be upgraded by successively replacing it with electricity or alternatives fuel-powered transport, the use of natural gas and other alternative fuels in freight transport and shipping will be promoted.

3.4. Main Bottlenecks and Drivers to Energy Sufficiency

3.4.1. Regulatory aspects

According to Lithuanian Ministry of Transport and Communications, 1.073 billion EUR of investments from EU funds have been allocated to the transport sector. Under Priority 4 “Promotion of Energy Efficiency and Renewable Energy Production and Use” of the EU Funds Investment Operational Program for 2014–2020, 8 measures are financed and under Priority 6 “Development of Sustainable Transport and Core Network Infrastructure” 11 measures are financed. In the transport sector, the largest investments will be made in the modernization of road and railway infrastructure: 47% for roads and 32% for railways. About 50% of all freight is transported by road. Road transport is by far the most popular mean of passenger transport. This mode of transport carries about 97% of all passengers. Lithuanian road transport occupies a significant place in the international market of transportation services. The basis for the development of this business was the conclusion of cross-border agreements in the field of road transport with 34 European and Asian countries. In 1993, there were only 88 carriers in Lithuania with licenses to transport passengers and cargo, which had only 960 licensed buses and trucks. In 2018, Lithuanian carriers had 5,742 licenses granting the right to transport passengers and cargo, and the vehicle fleet amounted to about 49 thousands vehicles, of which about 46 thousands were trucks [28].

As regarding other transport means, **Lithuania's strategic documents envisage continuous modernization of railway transport infrastructure by integrating the most important railway lines into the trans-European transport networks.** According to State railway company „Lietuvos geležinkeliai“ in the period January-October from 2020, the total volume of cargo reaches 43.8 million. tons and is 4.8% lower than last year (mainly, because of COVID-19) [29]. Significance of Klaipeda port for the state: 58 thousands induced jobs; 4.5% of the country's workforce; 6.13% of Lithuania's GDP generated. It is important to mention, that transport industry is first of all treated from an economic point of view and it is a very important part of Lithuanian state economy.

3.4.2. Behavioural, social and cultural drivers

Last year, the largest passenger transport railway company in the Baltic States, „Lietuvos geležinkeliai“, carried a record number of passengers, as many as 5.5 million. This is 6.7% better result compared to last year. The growth was observed on all routes, and the company’s transportation revenue rose by 5%, according to preliminary data. Nevertheless, the most popular transportation is observed on roads. Road traffic intensity is constantly growing from 2000 up till now [30]. Cars with diesel engines 67.1%, with petrol about 22.7%, 9.7% with gas and only 0.5% with electric (hybrid) engines. There has been a trend for the share of diesel engines to increase sharply over the last four years. Compared to 2012, their share increased from 53% to 67.1% [31]. As for cars, petrol engines are absolutely predominant. Public transport is well developed in Lithuania and its utilization is quite stable (Fig. 27). Young, average-income families prefer new houses in the suburbs. This fact raises new urbanistic challenges since these areas are usually not well developed in terms of services and infrastructure (public transport, kindergartens and schools etc.). It implies the use of passenger cars. On the other hand, short term rent (using apps) of cars, bikes, scooters are going more and more popular among young generation. In general, the use of bicycles is rapidly gaining popularity. The main contributors to this are the constantly renewing of the existing cycle path infrastructure and the building of new cycle paths, which are combined with pedestrian paths. In the financial period 2014–2020, a total of EUR 10.2 million of European Regional Development Fund investments were allocated for the construction and reconstruction of pedestrian and bicycle paths in Lithuania [32]. It is worth mentioning that large cities are planning to invest more than support from the funds in cycling and walking paths in order to achieve sustainable mobility. Kaunas, the second city in the country, plans to invest more than 19 million euros in these trails over the next three years [33]. Moreover, a primary goal is to be able to drive from the residence with a bicycle to the workplace.

3.5. Possible Improvements in Transport Sector

The upward trend in energy consumption for passenger and freight transport is planned to be managed by an array of RES & EE measures introduced in the NECP. It is unlikely that these measures alone could reduce the energy consumption to planned levels. The introduction of an energy sufficiency approach could significantly contribute to the implementation of goals set for the transport sector.

Thus far, the increasing distances travelled by the passengers, the growing number of cars, the old park and the low share of public transport push an increase in energy consumption. They are important obstacles to energy sufficiency driven reduction. In the future, the number of cars in Lithuania could follow the upward trend from other countries in the EU if it is not stabilized. Public transport should get more used, but there is a long way to go to achieve the average EU levels. Moreover, the park of private cars and buses will be upgraded to approach the average EU standards. At least in the short-term, the COVID-19 crisis stabilizes the passenger travelling distances.

Lithuania has rather an old park for freight transportation which is mainly achieved by road. Due to good load of cargo transport on roads, the country has low and slightly reducing rate of energy consumption per tkm in comparison to the EU average.

From the energy sufficiency perspective, improvements in pattern of energy consumption in transport sector is possible. These could be done in two directions. The first one is to change Lithuanians travelling behaviour by more efficiently using public transport and cycling. Therefore, investment in sustainable public transport and bicycle infrastructure should be made. Public transport and passenger cars should be renewed at faster rates. An energy sufficiency approach could also be applied when searching methods to reduce diesel and gasoline consumption as expected changes in consumption of biofuels and electricity is well addressed in RES & EE policies. The second one is to re-load the road freight transport but to increase intensity of freight transport in waters, by effectively using Lithuanian port.

Lithuania considers to a small extent to address energy sufficiency problems in its NECP through the implementation of several measures to decarbonize and reduce energy consumption. This includes developing and promoting economic and ecological driving skills, establishment of relevant tax system, promoting flexible working hours and remote work, and improving access to public transport. Seeking to go beyond, the energy sufficiency concept should be implemented at wider scale in passenger and in freight transport.

4. Conclusions

The review of the climatic, economic and demographic trends enabled to observe that the macro environment lays background for energy sufficiency, as it forms levels and changes of energy consumption by increasing or reducing it. For example, the analysis of the economic situation and developments in energy consumption showed that improvements in living standards in Lithuania is a driver of energy consumption, as well as a potential of energy sufficiency when it comes to a deliberate energy consumption that is supported and achieved through public interventions. The analysis of demographic situation disclosed that deteriorations in the situation creates barriers to energy sufficiency, since a share of building stock remains unoccupied or even left without a care due to emigration. This is especially relevant in villages, where part of the dwellings are getting empty due to emigration, deaths of old inhabitants and lack of energy services. Therefore, the energy sufficiency concept could be differentiated in the municipality policy context considering these existing differences at municipal (regional) level. The review of climate in Lithuania disclosed that energy sufficiency levels might be different in the east and west of the country, as well during different seasons. However, the CACTUS project will consider assumptions on average country.

The analysis of the legislation on climate and energy policy revealed that short- to long-run climate and energy policy has been mainly oriented towards the development and the adaptation of energy production facilities and infrastructure to growing energy demand, reduction of country's dependence upon fossil fuels, the diversification of energy supply, and high and fluctuating energy prices. Less has been done on the demand-side so far. Currently, energy sufficiency approach is not taken into account when formulating and implementing climate and energy policy, which are so far based on the principles of competitiveness, reliability, cost-efficiency, green energy and participation of business seeking to reach progress in energy. However, since the Programme for Renovation (Modernization) has been approved in 2005, efforts have been made to increase EE on the end-user's side which could be recognized as the relevant step towards energy sufficiency. Energy sufficiency approaches are introduced to some extent in the NECP 2030 (altough they are not named as such) but not in the NEIS. In particular, the NECP 2030 sets that seeking to achieve targets, the measures of promotion of economic and ecological driving skills, establishment of relevant tax system, promotion of flexible working hours and remote work, and improving access to public transport are important.

The analysis of trends of energy consumption in households in relation to drivers of variations in energy consumption in households showed some potential for energy sufficiency. It could be achieved through changing people’s attitudes and behaviours towards “sufficient” dwelling size and floor area per household member, higher household size with more diverse composition, the consumption of sufficient amount of sustainable fuels instead of fossil fuel, the improvement of EE in heating sector, the purchase and use of sufficient number of electric appliances and equipment. Following the decreasing share of energy expenditure (it is influenced by reducing energy prices) in total household expenditure it becomes challenging to exploit energy sufficiency potential. The analysis of poverty indicators disclosed that although the share of households unable to keep home adequately warm reduces, it remains high in comparison to EU average; therefore, actions should be taken to ease access of those households to sufficient energy services.

The analysis of indicators in tertiary sector in relation to the drivers of energy consumption in that sector showed that energy sufficiency approach could be important to reduce total and per employee energy consumption of various types of energies (electricity and DH) and fuels (natural gas) as well as energy intensities. Thus far, following the increasing demand for electricity, DH and natural gas total and per employee energy consumption in the tertiary sector increases. During several years being higher than on average EU, the energy intensities started increasing in Lithuanian tertiary sector.

The analysis of trends in passenger transport in relation to the drivers of energy consumption in that sector showed that when establishing assumptions of energy sufficiency driven consumption of energy in Lithuanian passenger transport, one could take into account that passenger transport is diesel and gasoline based, it is rather old and request to updating, passengers are tended to travel more and more. For the travelling purposes people mainly use passenger cars while popularity of buses and trains is rather low. The number of passenger cars increases and have already achieved the average EU levels. The share of public transport is very low in comparison to average EU. There is energy sufficiency potential in the passenger transport, which could be realised by stabilizing and transforming the present trends of drivers of energy consumption.

The analysis of trends of energy consumption in freight transport in relation to drivers of variations in energy consumption in that sector showed that freight transport is important for economy, as it contributes importantly to GDP. Freight transport vehicles are older than the passenger transport and need upgrading. Due to good load factors, the energy consumption per tkm is significantly below the average EU level and still has a tendency to decrease. Roads following rails are key for cargo transportation while rivers are currently not used. Lithuania has port that could be relevant for cargo transportation but it should be better loaded.

The CACTUS project will contribute to the development of effective national decarbonization policies by assessing the potential role of energy sufficiency in Lithuania through investigating different scenarios. Based on the results, policy recommendations will be formulated, and the project will provide a forum for discussing mitigation options.

5. Data table list

1. Lithuanian Statistics database. https://osp.stat.gov.lt/.
2. Eurostat database. https://ec.europa.eu/eurostat/web/regions/data/database
3. ODYSSEE database. https://www.odyssee-mure.eu/
4. EU-SILC survey. European Union Statistics on Income and Living Conditions. https://ec.europa.eu/eurostat/web/microdata/european-union-statistics-on-income-and-living-conditions
5. EU Transport in Figures. Statistical pocketbook 2019. Mobility and Transport. https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2019_en
6. REGITRA database. https://www.regitra.lt/

6. Bibliography

1. Eurostat (2020) GDP per capita, consumption per capita and price level indices. Statistics Explained (europa.eu), https://ec.europa.eu/eurostat/.
2. Lithuanian Statistics (2020) Gross domestic product by counties in 2019, News releases, https://osp.stat.gov.lt.
3. Eurostat (2020) Real GDP rate of change 2009-2019. Statistics Explained, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Real_GDP_rate_of_change,_2009-2019.png.
4. Lithuanian Statistics (2020) Population of Lithuania (Edition 2020): Population and Its composition, https://osp.stat.gov.lt/lietuvos-gyventojai-2020/salies-gyventojai/gyventoju-skaicius-ir-sudetis
5. Seimas of the Republic of Lithuania (2012) Resolution on the Approval of the National Energy Independence Strategy, No XI-2133, 26 June 2012, Vilnius, https://e-seimas.lts.lt
6. Government of Republic of Lithuania (2010) Resolution on the Approval of National Strategy for the Development of Renewable Energy Sources, No 789, 21 June 2010, Vilnius, https://e-seimas.lts.lt
7. Seimas of the Republic of Lithuania (2011) Resolution on the Approval of the Law on Renewable Energy Sources, No XI-1375, 12 May 2011, Vilnius, https://e-seimas.lts.lt
8. Seimas of the Republic of Lithuania (2021) Amendment of Resolution on the Approval of the Law on Renewable Energy Sources, No XI-1375, Vilnius (valid from 2021), https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.398874/asr
9. National Renewable Energy Action Plan of Lithuania (2010), Vilnius, 133 p., https://www.ena.lt/uploads/PDF-AEI/KITI-doc/5a-Veiksmu-planas-78.pdf
10. Seimas of the Republic of Lithuania (2016) Law on Energy Efficiency, No XII-2702, 3 November 2016, Vilnius, https://www.e-tar.lt/portal/lt/legalAct/946da260a67b11e69ad4c8713b612d0f/bSbluHOaEr
11. European Commission (2020) Assessment of the progress made by Member States towards the implementation of the Energy Efficiency Directive 2012/27/EU and towards the deployment of nearly zero-energy buildings and cost-optimal minimum energy performance requirements in the EU in accordance with the Energy Performance of Buildings Directive 2010/31/EU, progress_report_towards_the_implementation_of_the_energy_efficiency_directive_com2020954.pdf (europa.eu).
12. Ministry of Energy of Lithuania (2017) Order on Energy Efficiency Action Plan, No 12845, https://www.e-tar.lt/portal/lt/legalAct/0af002e075c811e7827cd63159af616c/asr.
13. Housing Energy Efficiency Agency (2020) Programme for renovation (modernization) of multi-family houses,http://www.betalt.lt/veiklos-sritys/programos/daugiabuciu-namu-atnaujinimo-modernizavimo-programa/102
14. Housing Energy Efficiency Agency (2020) Programme for EE Improvements in Public Buildings, http://www.betalt.lt/veiklos-sritys/programos/viesuju-pastatu-energinio-efektyvumo-didinimo-programa/12
15. Seimas of the Republic of Lithuania (2009) Law on Financial Instruments for Climate Change Management, No XI-329, 7 July 2009, https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.349514/asr
16. Seimas of the Republic of Lithuania (2012) National Climate Change Management Policy Strategy for the period until 2020, No XI-2375, https://www.e-tar.lt/portal/lt/legalAct/TAR.F1333EAD263B
17. Lithuanian National Energy and Climate Action Plan for 2021–2030, https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en

18. Seimas of the Republic of Lithuania (2012) Resolution on the Approval of the National Energy Independence Strategy, No XI-2133, 26 June 2012, Vilnius, https://e-seimas.lts.lt
19. European Commission (2020) EU Building Datamapper, Share of non-residential in total building floor area, https://ec.europa.eu/energy/eu-buildings-datamapper_en?redir=1
20. Eurostat (2020) Glassary: Under-occupied Dwelling. Statistics Explained, https://ec.europa.eu/eurostat
21. Eurostat (2020) Arrears on utility bills, https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20200120-1.
22. Government of Republic of Lithuania (2020) The list of strategic aims, tasks and impact indicators of National Progress Programme 2021-2030, https://epilietis.lrv.lt/uploads/epilietis/documents/files/NPP%20tiksl%C5%B3-uz%CC%8Cdaviniu%CC%A8-rodikliu%CC%A8%20medis(1).pdf
23. 15 min (2020) Lietuviams ir estams renkantis namus svarbiausia yra vieta, Latvijos jaunuoliams – kaina, https://www.15min.lt/verslas/naujiena/kvadratinis-metras/nekilnojamasis-turtas/lietuviams-ir-estams-renkantis-namus-svarbiausia-yra-vieta-latvijos-jaunuoliams-kaina-973-1419808
24. 15 min (2020) „Pandeminiai“ pirkėjai nori didesnių ir naujesnių būstų, www.15min.lt/verslas/naujiena/kvadratinis-metras/nekilnojamasis-turtas/pandeminiai-pirkejai-nori-didesniu-ir-naujesniu-bustu-973-1413644.
25. Seimas of the Republic of Lithuania (2008) Resolution on the Approval of the Sate Family Concept, No X-1569, Vilnius, https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.322152/asr
26. UNFCCC (2020) Lithuania’s national inventory report, Greenhouse gas emissions 1990-2019, https://unfccc.int/documents/226319
27. Lietuvos rytas (2014) Beveik pusė Lietuvos automobilių nebegalės riedėti į gatves, https://auto.lrytas.lt/naujienos/beveik-puse-lietuvos-automobiliu-nebegales-riedeti-i-gatves.htm.
28. Ministry of Finance of the Republic of Lithuania (2020), EU investments in 2014-2020 database, https://sumin.lrv.lt/lt/es-investicijos/es-investicijos-2014-2020-m.
29. Lithuanian Railways (2020), Data on railways transport, https://www.litrail.lt/en#.
30. State Enterprise Lithuanian Road Administration (2020) Eismo intensyvumas, https://lakd.lrv.lt/lt/veiklos-sritys/eismo-intensyvumas.
31. Lithuanian Association of Technical Inspection Companies (2020) Lietuvos automobilių parko lyderiai techninės apžiūros kontrolierių akimis, https://www.vta.lt/lietuvos-automobiliu-parko-lyderiai-technines-apziuros-kontrolieriu-akimis/
32. Made in Vilnius (2020) Savivaldybių pėsčiųjų ir dviračių takams – daugiau kaip milijonas eurų, https://madeinvilnius.lt/naujienos/transportas/vilniaus-gatves/savivaldybiu-pesciuju-ir-dviraciu-takams-daugiau-kaip-milijonas-euru/
33. NT naujienos (2020) Kaunas į pėsčiųjų ir dviračių takų atnaujinimą investuos iki 19,5 mln. Eurų, https://www.ntnaujienos.lt/kaunas-i-pesciuju-ir-dviraciu-taku-atnaujinima-investuos-iki-19-5-mln-euru