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NATIONAL REPORTS ON ENERGY EFFICIENCY POLICY SCENARIO ANALYSIS FOR THE RESIDENTIAL AND TRANSPORT SECTORS

D.4.1

PART OF WORK PACKAGE 4: FORWARD-LOOKING SCENARIO ANALYSIS, FOCUSING ON MACROECONOMIC AND MICROECONOMIC IMPACTS OF ENERGY EFFICIENCY POLICY OPTIONS

NATIONAL REPORT FOR ESTONIA

DATE: 31 DECEMBER 2016, UPDATED 5 MAY 2017

HERON project

"Forward-looking socio-economic research on Energy Efficiency in EU countries"

Contract no: 649690

Institution: *Stockholm Environment Institute Tallinn Centre*

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HERON: Forward – looking socio-economic research on Energy Efficiency in EU countries

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 649690. The content of this document reflects only the authors' views and the EASME is not responsible for any use that may be made of the information it contains.

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ACKNOWLEDGEMENTS

SEI Tallinn thanks our colleague Johannes Thema from Wuppertal Institute who provided expertise and comments that greatly assisted the research and manuscript of the report, and Dr Popi Konidari from KEPA for providing assistance with DST tool and LEAP integration.

We would also like to acknowledge Dr Kalle Kuusk who with his expertise and support provided great assistance to develop the buildings sector model.

And lastly yet most importantly our greatest thanks go to Dr Charlie Heaps from SEI US whose expertise and guidance on LEAP software made the implementation of the tasks of this project possible.

ACRONYMS

AAU	Assigned Amount Units under UN FCCC
BAU	Business as Usual
CNG	Compressed Natural Gas
DH	District heating
EE scenario	Energy efficiency scenario
ELMO	- Estonian Electro-Mobility Programme
ENMAK	Estonian National Energy Sector Development Plan 2030+ [Eesti Energiamajanduse Arengukava aastani 2030+]
EPBD	Energy Performance of Buildings
EPC	Energy Performance Certificates
ESD	Effort Sharing Decision
EU ETS	EU Emissions Trading Scheme
EV	Electric Vehicle
FCEV	Fuel cell electric vehicle
GHG	Greenhouse gases
HGV	Heavy Goods Vehicle
IEA	International Energy Agency
JI	Joint Implementation
KIK	Estonian Environmental Investment Fund (Keskkonnainvesteeringute Keskus)
KredEx	Credit and Export Guarantee Fund
LEAP	Long-range Energy Alternatives Planning System
LEB	Low-Energy Building
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MEAC	Ministry of Economic Affairs and Communications
NEEAP	National Energy Efficiency Action Plan
Non-ETS	sectors not covered by the EU Emissions Trading System
nZEB	nearly Zero-Energy Buildings
ODEX	Energy efficiency index of industry
PH Petrol/PEHV	Plug-in Hybrid Petrol car
PT	Public Transport
RKAS	State Real Estate Company Ltd (Riigi Kinnisvara AS)
SEAP	Sustainable Energy Action Plan
UNFCCC -	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

The aim of this report is to summarize the results of WP4 to evaluate whether and how Estonia would achieve its European Union energy efficiency targets by 2030 in buildings (residential, public and commercial buildings) and transport sector, in case the energy consumption would continue with the current regulations (baseline or so- called business-as-usual (BAU) scenario. The aim then was to analyse the missing reduction figures and develop energy efficiency scenarios until 2030 which would take additional measures needed to better ensure the success of the EU 2030 targets. The scenarios were developed with LEAP software. In both buildings and transport sector, firstly BAU scenario and energy efficiency (EE) scenarios were created. The energy efficiency scenarios under the buildings sector were split between 3 sub-scenarios: 1) Building shell improvement; 2) Efficient lighting; and 3) Efficient appliances. Under the transport sector, efficiency scenario was split into 5 sub-scenarios: 1) Fuel efficient vehicles; 2) Eco-driving; 3) Urban Planning; 4) Passenger Transport Modal Shift; and 5) Freight demand management. Three additional scenarios were created with the Decision Support Tool (DST) to evaluate the effect of each of the sub-scenarios or combinations of these on policy. In summary, 6 energy efficiency scenarios were developed for buildings and transport sector respectively, as follows:

Buildings sector scenarios	**Transport sector scenarios**
1. HERON BAU – Business-as-usual scenario	1. HERON BAU – Business-as-usual scenario
2.EE – B0: EE scenario with zero DST impact (energy efficiency scenario which does not include the impact of barriers)	2.EE – T0: EE scenario including 5 sub-scenarios with zero DST impact (energy efficiency scenario which does not include the impact of barriers)
3. EE - B1: EE DST scenario which considers the current barriers across all the sub-scenarios (based on EE-B0 scenario)	3. EE – T1 DST scenario which considers the current barriers across all the sub-scenarios (based on EE-T0 scenario and DST outputs)
4.EE - B2: EE DST scenario with the minimization of barriers within the building shell improvement sub-scenario	4. EE – T2 DST scenario first combination of three sub-scenarios with least barriers (electric and hybrid vehicles, eco-driving, more efficient vehicles)
5. EE – B3: EE DST scenario with the minimization of barriers within efficient lighting sub-scenario	5. EE – T3 DST scenario second combination of three sub-scenarios with least barriers (electric and hybrid vehicles, modal shift, more efficient vehicles)
6. EE – B4: EE DST scenario with the minimization of barriers within efficient appliances sub-scenario (combination of: EE-B4 (residential) and EE-B1 (tertiary))	6. EE – T4 DST scenario third combination of three sub-scenarios with least barriers (electric and hybrid vehicles, eco-driving, more efficient vehicles)

In buildings sector, the results show that compared to the business-as-usual (BAU) scenario, 19% reduction in the energy consumption needs to be further achieved in order to meet the EU target by 2030. After the implementation of additional measures under the EE-B0 scenario, the EU target both in terms of the energy consumption (1.23 Mtoe by 2030) and GHG emissions (0.37 $MtCO_2$ by 2030 which would be 5 % even lower from the target) would be achieved. The targets of 2020 would be achieved as well, as the energy consumption does not exceed the 2010 level (national policy) and the GHG emissions do not exceed more than 11% compared to 2005, according to the Estonian 2020 non-ETS target. The most effective scenario built with the DST tool is EE-B2 scenario since the building shell improvement sub-scenario includes the highest number of barriers and therefore minimizing the barriers under this sub-scenario gives the highest effects.

In transport sector, the BAU scenario (representing current policies already in place) projects a further growth in energy demand in the Estonian transport sector, growing by 18% from 2010 until 2030, failing to deliver the national and EU policy targets. The growth is driven by increased motorization, higher purchasing power, road freight and only slow improvement in fuel efficiency of the vehicles. As to the national and EU energy efficiency targets for Estonia Heron Transport EE-T0 scenario almost delivers the national energy efficiency target by 2020, and reduces transport energy demand to a level of 13%

below the EU 2030 target. Compared to the EU non-ETS targets for 2020 and 2030 the transport sector with five EE T-0 measures combined would meet the 2020 targets (-10% lower than target) and closely meets the 2030 targets (-0,1% lower than target). So when applying the EE scenario, transport energy consumption will be reduced by 7.3% by 2030 compared to 2010, and the national and EU targets are reached. EE-T1 scenario showed that with all barriers in place the EE-T0 scenario energy efficiency improvements are not delivered and the energy demand will be 8% higher than the EU target. The DST tool also showed that scenario EE-T3 of modal shift in passenger transport and fuel efficient vehicles both with minimization of barriers have highest positive effect on reaching the energy efficiency gains and GHG reduction targets.

Key barriers

The top three barriers in the **buildings sector** which impede the energy efficiency of the buildings sector in Estonia are 1) lack of any type of financial support; 2) High costs and risks; and 3) Misleading prices (energy/fuel/tariffs).

The highest barriers in the **transport sector** are lack of limited finance and fiscal incentives, the negative role of current investment schemes that prioritize new investment into car based solutions, perverse incentives related to employee benefits related to car use, limited infrastructure investment for public transport and lack of integrated governance in the field of transport, mobility and urban planning in Estonia.

Combination of technologies that would facilitate the meeting of the policy target

The highest effect on the energy efficiency of the residential and tertiary buildings sector would have the **building shell improvement**. This includes both reconstruction and improvement of heating systems. In transport sector, the highest impact on the success of reaching the EU 2030 policy targets is delivered by policies encouraging the **take-up of fuel efficient vehicles,** including electric and hybrid vehicles. The second priority should be given to managing the demand for personal mobility through integrated urban planning, the third priority to managing the demand of freight transport and the fourth priority should be given to encouraging the modal shift in passenger transport and the fifth priority should be given to eco-driving. While combining the scenarios with least barriers and minimizing the barriers, the DST tool showed that energy efficiency gains with more fuel efficient vehicles and eco-driving have least barriers and the scenario of modal shift in passenger transport and electric vehicles have barriers with highest positive effect on reaching the energy efficiency gains and GHG reduction targets.

Policy measures to overcome the barriers and implement technologies

In the buildings sector, the policy instruments should be as ambitious as to insure large scale building renovations: 40% reconstruction of single-family dwellings by 2030 and 50% reconstruction of multi-family dwellings by 2030 to take place. This is also proved by the EE-B2 scenario that has the highest positive impact on the energy efficiency, when barriers of the building shell improvement have been minimized. Such a measure would however mean a **large governmental investment** (at least 35% of renovation support). Additional measures such as improving the lighting and the use of appliances are also needed in order to fully assure the achievement of the EU energy efficiency and GHG target. One of the measures that would support the implementation of these targets is raising public awareness. Other measures, such as improvement of land usage and land use planning, the development of relevant regulatory environment and showcasing public sector pilot projects would also enhance more energy efficient environment and minimize the socio-economic barriers.

Regarding the trends and barriers in the transport sector, the main policy implications include, firstly, carefully planned fiscal incentives like **CO_2 based car registration and annual circulation taxes** need to be implemented. Secondly, the demand for personal mobility through integrated urban planning need to be managed, thirdly, the demand of freight transport need to be managed also and fourthly, by encouraging the modal shift in passenger transport through providing better public transport services and cycling infrastructure and fifthly - a priority should be given to the measures that facilitate eco-driving.

CHAPTER 1: NATIONAL ENERGY EFFICIENCY AND GHG REDUCTION TARGETS IN ESTONIA

In this chapter, the energy efficiency targets, energy saving policy measures/instruments, trends on energy use and changes in final energy consumption due to attempts to overcome barriers and improve the effectiveness of energy efficiency policy mixtures in Estonia have been described. The aim is to understand how Estonia as an EU member State can contribute in achieving the EU set EE targets for 2020 and 2030.

1.1 NATIONAL ENERGY EFFICIENCY AND GHG REDUCTION TARGETS FOR BUILDINGS

Energy efficiency

Estonia has adopted the new **Building Code** on 18.01.2016 (RT I, 30.12.2015, 11, https://www.riigiteataja.ee/akt/130122015011#para65lg3), which has been elaborated in line with the EU Energy Efficiency Directive 2010/31 (DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings).

The new Building Code includes the following EU 2020 targets:

- The share of renewable energy resources in the final energy consumption must be 25%
- Final energy consumption in 2020 may not exceed the final energy consumption in 2010 (2.818 Mtoe)

Under the new Building Code, there are various regulations. The most important one with regards to the energy efficiency in buildings, is the regulations set for the **Minimum Energy Performance Requirements of Buildings** (RT I, 05.06.2015, 15, https://www.riigiteataja.ee/akt/105062015015). This determines primary energy requirements (Kwh/m²) for all new buildings, buildings with major re-construction, low-energy buildings and nearly zero-energy buildings[1]. According to the EU Directive 2010/31 all the new public buildings to be built or substantially reconstructed from the first of January 2019 onward and all the rest of the buildings to be built or substantially reconstructed from the first of January 2021 onward must comply with the zero-energy performance requirements.

According to §3 of the Minimum Energy Performance Requirements of Buildings, the requirements for energy efficiency for different building types are set as follow (Table 1):

Table 1 Energy Performance Requirements of Buildings to be constructed (primary energy)

Building type	Kwh/(m²/y)
1) Single-family building	160
2) Multi-family building	150
3) Office building, library and academic building	160
4) Commercial/Business related building	210
5) Public building	200
6) Shopping related building and terminal	230
7) Educational building	160

[1] Buildings with zero net-energy consumption. The annual energy consumption within the building is roughly equal to the amount of renewable energy created on the site or by the renewable energy source elsewhere.

8) Pre-school institution	190
9) Health-care related building	380

The energy performance requirements of buildings substantially to be re-constructed may not exceed the following (Table 2):

Table 2 Energy Performance Requirements of Buildings substantially to be re-constructed (primary energy)

Building type	Kwh/(m²/y)
1) Single-Family dwelling	210
2) Multi-family building	180
3) Office building, library and Science building	210
4) Commercial/Business related building	270
5) Public building	250
6) Shopping related building and terminal	280
7) Educational building	200
8) Pre-school institution	240
9) Health-care related building	460

The energy performance requirements of nearly zero energy buildings may not exceed the following (Table 3):

Table 3 Energy Performance Requirements of Nearly Zero Energy Buildings (primary energy)

Building type	Kwh/(m²/y)
1) Single-Family Dwellings	50
2) Multi-family dwellings	100
3) Office building, library and Science building	100
4) Commercial/Business related building	130
5) Public building	120
6) Shopping related building and terminal	130
7) Educational building	90
8) Pre-school institution	100
9) Health-care related building	270

The energy performance requirements of low energy buildings may not exceed the following (Table 4):

Table 4 Energy Performance Requirements of Low Energy Buildings (primary energy)

Building type	Kwh/(m²/y)
1) Single-Family Dwellings	120
2) Multi-family dwellings	120
3) Office building, library and Science building	130
4) Commercial/Business related building	160
5) Public building	150
6) Shopping related building and terminal	160
7) Educational building	120
8) Pre-school institution	140
9) Health-care related building	300

Considering the targets set for 2030 only a general EU target exists in Estonia for the buildings sector - raising energy efficiency by 30% compared to 2007 (compared to the prognosis made by using the PRIMES model in 2007 for the year 2030) (EU Commission, 2007). The results modelled in 2007 have still been given by different sectors, but separate sector-specific targets have not yet been set for neither the household nor tertiary sector. Yet, PRIMES BAU model developed in 2007, gives a comparative moment to the scenarios developed for this paper. The PRIMES BAU takes into account measures and assumptions, which are less ambitious, compared to the ones developed in this project (i.e. non-existence of nearly zero-energy and minimum energy performance requirements), therefore resulting to a higher energy use within PRIMES BAU compared to BAU developed within HERON project (EU Commission, 2007).

In addition, an important document for Estonia regarding the energy sector, is **the Estonian National Development Plan of the Energy Sector until 2030** (ENMAK 2030+) with the vision until 2050. This is one of the central strategic documents fixing the pathways for the development of many other programmes. It has already been approved by the Government and is currently pending the approval of the Parliament. ENMAK 2030+ draws the main concept lines of the energy sector development until 2030, but also the vision for development until 2050. The programme is the most updated document describing the vision of possible development paths of all sectors including buildings. A detailed description of the existing and evolving building stock is given based on the formulation of further development paths. The technical energy saving potential forms around 80% (9.3 TWh/y) of present energy consumption of buildings and it comprises roughly 1/3 of total final energy consumption (33-34 TWh/y) in Estonia (Housing, 2015). The development plan has been prepared by the Ministry of Economic Affairs and Communications (MEAC) in close cooperation with other ministries, governmental institutions, universities and research institutes who took part in the preparatory seminars and brainstorms on a voluntary basis. In addition, the whole preparatory process was organised web-based, to allow experts and the wider public to participate in the specialised discussions and propose their comments and opinions on further development options of the energy sector (Energiatalgud, 2015).

The scenarios developed within this project for the Estonian building sector relied on the scenario prognosis already developed within ENMAK, yet with a slightly different structure and with some additional assumptions.

Emissions

Regarding the targets set for GHG and other emissions, the main source document was the European Environmental Agency report about the trends and projections in Europe published in 2015 (EEA 2015).

The report highlights the new emissions reduction targets for 2030, which is a 40% reduction target in GHG emissions compared to 1990. The target will be delivered through reduction of 43 % in the sectors covered by the EU-Emissions Trading Scheme (ETS) and a 30% reduction in sectors not included in the trading scheme, the so-called non-ETS sectors by 2030, compared to 2005 (EEA, 2015).

The national GHG emission target for the Estonian non-ETS sector is -10% compared to 2005 by 2020 and -11% to -14% compared to 2005 by 2030 (Ministry of the Environment, 2016).

The emissions studied within this project scenarios which were developed with the help of LEAP tool, were compared with the general non-emissions target, as the non-ETS sectors beside the inter alia, road transport, agriculture and waste, include the buildings sector particularly.

1.2 NATIONAL ENERGY EFFICIENCY AND GHG REDUCTION TARGETS FOR TRANSPORT

National GHG reduction targets follow the non-ETS targets and related Effort Sharing Decision

- By 2020 max 11% growth GHG from transport compared to 2005 levels (non-ETS, ESD)
- By 2030 -13% reduction compared to 2005 levels (final reduction target will be decided in 2018).
- Energy efficiency target by 2020: total transport energy consumption does not exceed the 2012 level. The energy efficiency target for the transport sector is set in the Estonian Transport Development Plan 2014‒2020; “Transpordi arengukava 2014-2020[2]” (approved by the Parliament on 19.2.2014): to retain the transport sector’s energy consumption by the year 2020 on the level of the year 2012 and to create a basis for reducing energy consumption after the year 2020.
- 10% renewable energy in transport by 2020

In Table 5 the national targets and reference values are presented for GHG emissions and energy efficiency.

Table 5 Overview of Estonian GHG emission reduction and energy efficiency targets in transport sector

	1990	**2005**	**2020**	**2030**
GHG targets and base year			max +11% (2005) Estonian non-ETS target	-13% (2005) Estonian non-ETS target
GHG emissions ton CO_2eq/a	2 479 000	2 152 000	2 372 000	1872000
Energy Efficiency targets			2020 final consumption in transport does not exceed 2012 level	EU wide target: -30% compared to 2007 EU baseline scenario

[2] https://www.riigiteataja.ee/aktilisa/3210/2201/4001/arengukava.pdf

Final demand in transport, targets, ktoe/a			Target: 788 ktoe	1084 ktoe (PRIMES, BAU scenario) Target: 801 ktoe

CHAPTER 2: COMMON KEY ASSUMPTIONS FOR SCENARIO-BUILDING AND METHODOLOGICAL APPROACH TO SCENARIO ANALYSIS

2.1 POPULATION

Population – Population forecast based on Estonian National Board of Statistics and extended until 2050 by the average population decrease within 2031...2040

	2010	2015	2020	2025	2030
Population (1000 persons)	1333.3	1 336.0	1 329.0	1 312.5	1 296.0

2.2 GDP

GDP – Forecast based on the economic forecast prepared by the Ministry of Finance in 2015 and extended until 2050 according to Ageing Report 2015 (European Commission 2015).

	2010	2015	2020	2025	2030
GDP (Billion €)	14.7	17.6	20.5	22.8	24.6

2.3 NUMBER OF HOUSEHOLDS

Number of Households – based on population forecast and average household size forecast (2.3 persons per household) (Household Size – Eurostat (http://ec.europa.eu/eurostat), table: Average household size (source: SILC) [ilc_lvph01])

	2010	2015	2020	2025	2030
Households (1000)	582.7	580.9	577.8	570.7	563.5

2.4 BUILDING STOCK PROFILE

The total number of dwellings has been split between all the household types considered in this assignment. For this, historical data was taken from the Estonian National Board of Statistics under the reference numbers of RL702 (The Residential Buildings, Dwellings and Surface Areas, 31 of March 2000) and RL0202 (Dwellings, 31 of December 2011).

The dwellings were split to two main classes (multi-family and single-family) each of them to four classes:

Single-family dwellings	Multi-family dwellings
1. Existing single-family not to be reconstructed by 2030 2. Existing single-family to be reconstructed by 2030	1. Existing multi-family not to be reconstructed by 2030 2. Existing multi-family to be reconstructed by 2030

3. New single-family dwellings to be built between 2015-2025 according to the minimum energy performance requirements	3. New multi-family dwellings to be built between 2015-2025 according to the minimum energy performance requirements
4. New single-family dwellings to be built 2025-2030 according to the zero-energy standards	4. New multi-family dwellings to be built 2025-2030 according to the zero-energy standards

The assumptions of the new building stock have been made by following the building trend of 2000-2010. Assumptions made for the reconstruction have been described in table 4 within the next Chapter.

Also, it is important to note that whilst by law, from 2021 onward, all new buildings must be nearly zero-energy buildings; it was considered in this work that nearly zero-energy buildings start to appear from 2025 onward. Building permits are to be provided, yet within the first 5 years it is unlikely that the permits get approved and therefore the real existence of buildings having a zero-energy performance, start approximately 5 years later. Therefore, it is considered in this work, that the buildings to be built between 2021-2025 have still the same energy performance requirements as the buildings to be built between 2011-2020.

2.5 TRANSPORT PROFILE

Transport profile in the LEAP software has been structures as follows:

1. Passenger demand, total travel demand (passenger-km) split between motorized travel modes, fuel technologies and energy efficiency parameters (MJ/passenger-km of "Existing" and "Ideal" figures):

Vehicle	Cars	Buses	Motorcycles	Rail	Water	Air
Fuel/Technology split	Petrol	Diesel	Petrol	Diesel	Fuel	Jet Kerosine
	Ethanol	Biodiesel	Electric	Electric	LNG	AV Gas
	Diesel	Hybrid		Biodiesel		
	Biodiesel	Electric				
	Hybrid Petrol	CNG				
	Plugin Hybrid Petrol	Biomethane				
	Electric					
	CNG					
	LPG					
	Biomethane					

2. Freight demand: total freight demand (ton-km) split between freight modes, fuel technologies and energy efficiency parameters (MJ/passenger-km of "Existing" and "Ideal" figures)

Transport method	Road	Rail	Water	Air
Fuel/Technology split	Diesel	Diesel	Diesel	Yet Kerosine
	Biodiesel	Electric	Biofuels	AV Gas
	Hybrid	Biodiesel		
	Electric			

	CNG			
	Biomethane			

2.6 CALIBRATION FACTORS APPLIED

Calculated as a last thing after the insertion of all the other data. The calculation factors have been calculated by dividing the last historical year fuel data with the first BAU year fuel data (Excel sheet from the Results window of LEAP).

In the buildings sector, in order to match the historical data with the projections data, calibration factors within the residential building sector were given to all fuels. It is important to notify though that the calibration factor “household biomass” includes the average of both peat and wood and the calibration factor “household other” includes the average of coal and LPG. Within the tertiary sector buildings, calibration factors were given only to heat and electricity as these were the main fuel types under this sector.

To match the historical reported and first projection years of calculations a calibration factor of 0.85 for petrol and 0.95 of diesel was used in the transport sector as the LEAP calculated first projections were respectively higher than the last actual national accounts.

CHAPTER 3: FORWARD LOOKING SCENARIOS FOR BUILDINGS

3.1. HISTORIC DATA AND TRENDS

Residential

The historical data regarding the different fuel types consumed in the Estonian household sector was derived from The Estonian National Board of Statistics for years 1990, 1995 and 2000-2014. This was done under the reference number KE023 (Energy Balance, Final Consumption of Households). In order to eliminate the influence of different outdoor temperatures in different years, the consumption data was converted to normal year with heating degree days (annual heating degree days at t_i17^{o}C: 4160^{o}Cd).

Hereof: *Electricity and household LPG have not been transformed to "normal year" figures as it was assumed that those fuels are not primarily used for heating.

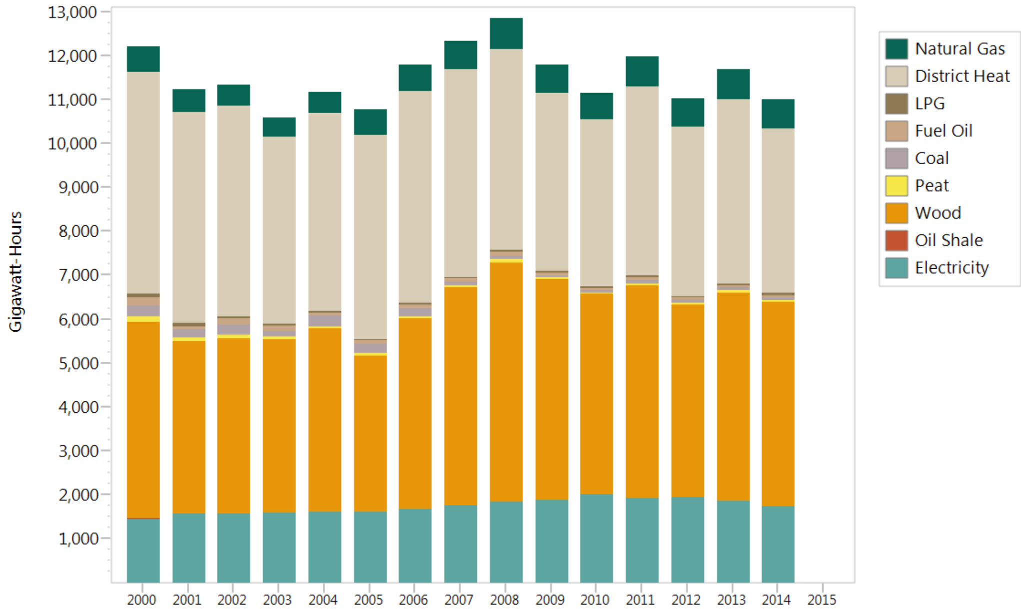

Figure 1 Household Historical Fuel Data 1990-2014

Tertiary

The historical data regarding the tertiary sector was derived from the Estonian Board of Statistics under the table code of KE024. It is important to mention that the historical data regarding the tertiary sector was not possible to separate between different tertiary building types (such as schools, offices etc). Therefore, the entire data regarding the fuel consumption within the tertiary sector in Estonia is given all together without any distinction made between sub-sectors. Similarly to the residential data, in order to eliminate the influence of different outdoor temperatures in different years, the consumption data was converted to normal year with heating degree days (annual heating degree days at t_i17^{o}C: 4160^{o}Cd).

The historical data regarding the tertiary sector in Estonia was available for the years 2000-2014.

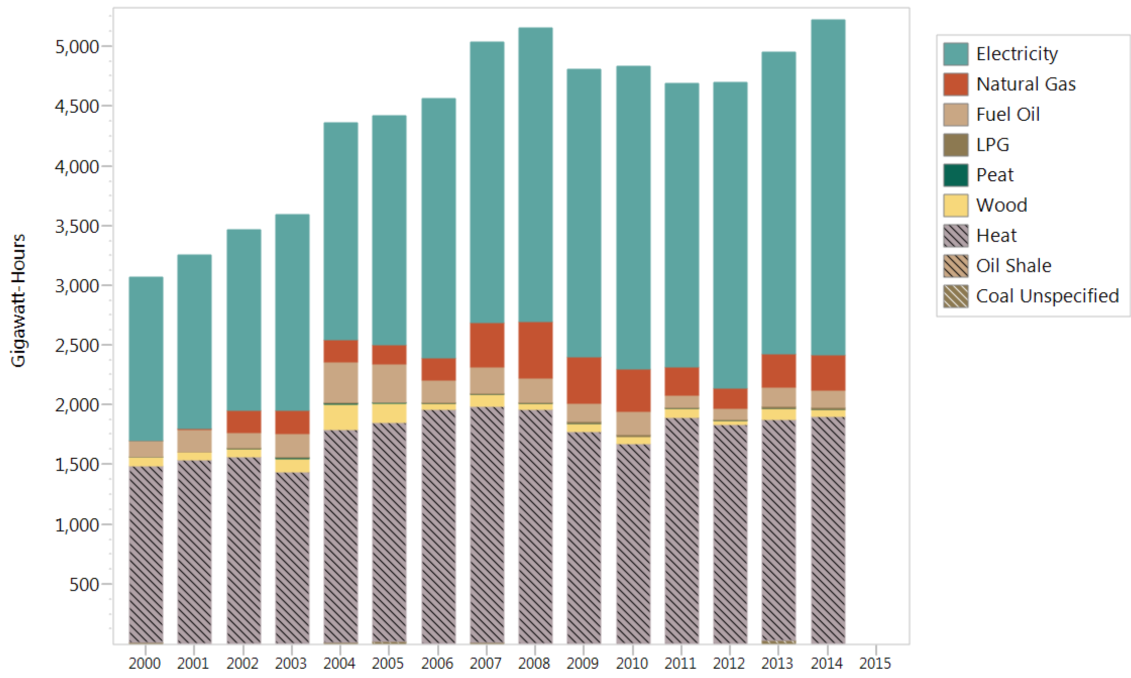

Figure 2 Tertiary Historical Fuel Data 2000-2014

3.2. BAU SCENARIO UP TO 2030

BAU looks into current possible trends with policy measures/instruments already implemented.

3.2.1. Key assumptions and parameters

Residential

Scenarios were structured according to the activities such as:

- Space Heating
- Domestic hot water heating
- Lighting
- Appliances

From the above-mentioned activities, only the space heating sector was analysed in more detail by different household types. The household types were already listed in the previous chapter regarding Key Assumptions. Other activities such as water heating, lighting and appliances were analysed in a more aggregated way, analysing the consumption of fuel types available by each category.

Assumptions and parameters made under space heating are as follows:

<u>Dwellings</u>

Additional dwelling stock assumptions were made for the Business as Usual Scenario (BAU) years in line with the prognosis established for the Estonian National Development Plan of the Energy Sector until 2030 (ENMAK 2030+).

Dwelling space - Hereby defined as the amount of floor space of rooms and auxiliary rooms (kitchen, hallway, cloakroom, hall, toilets, dwelling bath, pantry, space, bathroom, storage room, porch, built-in cupboards). Cellars, garages (including in residential), boiler rooms, lofts (if they are permanently not liveable) and public spaces (such as stairwells, hallways, saunas, etc.), are not included within the floor areas of multi-dwelling buildings.

The following assumptions for the dwelling stock were made:

Table 6 Dwelling stock assumptions made for BAU scenario

Assumption	**% Until 2020**	**% 2020-2030**	
Yearly demolition of building stock, %/y	0.3	0.3	
Annual reconstruction rate of apartment buildings, %/y	0.7		
Annual reconstruction rate of dwellings in apartment buildings, %/y	1.3		
Annual reconstruction rate of net floor area of apartment buildings, %/y	1.3		
Annual reconstruction rate of apartment buildings, %/y		0.2	*Less or no funding
The number of dwellings in apartment buildings to be reconstructed, %/y	0.4		* Less or no funding
The net floor area of apartment buildings to be reconstructed, %/y		0.4	* Less or no funding
Average reduction of heating energy use of reconstructed apartment buildings, %/y	45.0		
The net floor area of single-family houses to be reconstructed, %/y	0.5		
Average reduction of heating energy use of reconstructed single-family houses, %/y	25.0		

In the Estonian case it was complex to separate efficient heating from building shell improvement because the retrofit rate (%) in Estonia takes into account the houses undergoing the full retrofit process (walls, roof, windows, heating system). The renovation of apartment buildings in Estonia depend on the funding and this requires full renovation together with the heating system. It is not possible to only do building shell improvement or only change the heating system. In private houses, the situation is even more complex as there is no funding and house owners just do what they like. So in private houses, building shell improvement and change of heating system *is* done separately, but the separate works done in these houses are not being tracked and monitored and thus data is not available. Therefore, the assumptions hereof (and full retrofit rate) are based on a prognosis made for The Estonian National Development Plan of the Energy Sector until 2030 (ENMAK 2030+), coordinated by the Estonian Ministry of Economic Affairs and Communications, by and relying on a research called "An overview of apartment building renovations the impact analysis of the Apartment Building Renovation Grants for the period 2010-2014 (Margit Lauri together with Foundation KredEx, August 2014).

<u>Fuel shares</u>

The assumptions of fuel shares (%) under each eight household type are based on the total fuel consumptions (GWh/y) within each of the household types. It is assumed that in existing buildings, the heating technologies (thus also the fuel shares) do not change, and the heating technologies of the new building stock and buildings to be re-constructed is based on expert assumptions.

The choice of the heating system for the new buildings was made based on the heating systems of the buildings built between 2000-2010. It was assumed that the heating systems do not change within the next 15 years. Whilst district heating is more sustainable compared to the natural gas, the fuel share of natural gas in new buildings is higher than old buildings. That is because many of the new built areas are located out of the city where district-heating system does not exist. The district heating system exists in built up urban areas where no space is left for the assumed new buildings. If gas exists in the new development areas, then it is significantly cheaper for the developer to extend the existing gas pipeline than to extend the district heating network.

Table 7 Fuel shares in different buildings types

Multi-family dwellings in 2010

Fuel type	2010 Fuel share
Wood	15%
Natural Gas	6%
Fuel Oil	1%
District Heat	76%
Electricity	3%
Total	100%

Multi-family dwellings not to be re-constructed by 2030

Fuel type	2020 Fuel share	2030 Fuel share
Wood	15%	15%
Natural Gas	6%	6%
Fuel Oil	1%	1%
District Heat	76%	76%
Electricity	3%	3%
Total	100%	100%

Multi-family dwellings to be re-constructed by 2030

Fuel type	2020 Fuel share	2030 Fuel share
Wood	15%	15%
Natural Gas	6%	6%
Fuel Oil	0%	0%
District Heat	75%	75%
Electricity	4%	4%
Total	100%	100%

New multi-family dwellings to be constructed between 2015-2030

Fuel type	2020 Fuel share	2030 Fuel share
Wood	0%	0%
Natural Gas	25%	25%
Fuel Oil	0%	0%
District Heat	65%	65%
Electricity	10%	10%
Total	100%	100%

Single-family dwellings in 2010

Fuel Type	2010 Fuel share
Coal	1%
Oil Shale	0%
Peat	1%

Wood	78%
Natural Gas	8%
Fuel Oil	1%
District Heat	2%
Electricity	8%
Total	100%

Single-family dwellings not to be re-constructed by 2030

Fuel type	2020 Fuel share	2030 Fuel share
Coal	1%	1%
Oil Shale	0%	0%
Peat	1%	1%
Wood	78%	78%
Natural Gas	8%	8%
Fuel Oil	1%	1%
District Heat	2%	2%
Electricity	8%	8%
Total	100%	100%

Single-family dwellings to be re-constructed by 2030

Fuel type	2020 Fuel share	2030 Fuel share
Wood	80%	80%
Natural Gas	8%	8%
Fuel Oil	0%	0%
District Heat	2%	2%
Electricity	10%	10%
Total	100%	100%

New single-family dwellings to be constructed between 2015-2030

Fuel type	2020 Fuel share	2030 Fuel share
Wood	15%	15%
Natural Gas	40%	40%
Fuel Oil	0%	0%
District Heat	1%	1%
Electricity	44%	44%
Total	100%	100%

Floor Areas

The average m^2/dwelling per each household type is based on the calculations (total floor area of each dwelling type/total number of dwellings under each dwelling type) made relying on the data used within ENMAK 2030+ and its additional dwelling stock assumptions shown above (table 6). As a result, the average floor areas assumed for each dwellings type worked out with the buildings expert, can be seen below:

Table 8 Floor areas in different building types

Building type	**Average floor area m^2**

Multi-family dwellings	
Multi-family dwellings in 2010	51
Multi-family dwellings not to be re-constructed by 2030	51
Multi-family dwellings to be re-constructed by 2030	51
New multi-family dwellings to be constructed between 2015-2025	56
New multi-family dwellings to be constructed between 2025-2030	57
Single-family dwellings	
Single-family dwellings in 2010	108
Single-family dwellings not to be re-constructed by 2030	108
Single-family dwellings to be re-constructed by 2030	108
New single-family dwellings to be constructed between 2015-2025	118
New single-family dwellings to be constructed between 2025-2030	119

Energy Intensity (Kwh/m^2)

The energy intensities of each building types used for energy modelling were calculated as: Total energy consumption of each household type divided by total floor area of each household type. All of the energy related figures in LEAP are supplied not primary energy figures.

Table 9 Energy Intensities in different building types

Building type	**Energy Intensity Kwh/m^2**
Multi-family dwellings	
Multi-family dwellings in 2010	154
Multi-family dwellings not to be re-constructed by 2030	154
Multi-family dwellings to be re-constructed by 2030	85
New multi-family dwellings to be constructed between 2015-2025	60
New multi-family dwellings to be constructed between 2025-2030	30
Single-family dwellings	
Single-family dwellings in 2010	216
Single-family dwellings not to be re-constructed by 2030	216
Single-family dwellings to be re-constructed by 2030	162
New single-family dwellings to be constructed between 2015-2025	85
New single-family dwellings to be constructed between 2025-2030	20

For all the **new building stock**, the energy intensity values (Kwh/m^2) have been considered by the national energy performance standards, such as:

2015-2025 - Buildings meet the applicable minimum energy performance requirements. Within Minimum Energy Performance Requirements of Buildings (RT I, 05.06.2015, 15), the primary energy consumption figures are given. The maximum energy performance requirements were calculated based on the data of primary energy performance figures, wherein the requirements are still met.

2025-2030 – Buildings comply with the requirements of nearly zero-energy buildings. Within the Minimum Energy Performance Requirements of Buildings (RT I, 05.06.2015, 15), the primary energy consumption figures are given. The maximum energy performance requirements were calculated based on the data of primary energy performance figures, wherein the requirements are still met.

Efficiency
The efficiency data for converting useful heat energy demand to total building heat demand and, multiplied by heat appliance efficiencies converting this to energy carrier demand, has not been used in the Estonian case, because all energy figures have already been considered as primary energy data, meaning that the efficiency factor has already been considered in all the energy data.

Assumptions made under activities "Other":

Water heating
Percent share of dwellings – Percentage of households consuming respective fuel type. Assumptions based tables A1-6 and A3-4.1, within the final report of Household Energy Consumption Research carried out in 2012.
Energy Intensity (Kwh/dwelling) – Total amount of fuel consumed (each fuel type separately) divided with total number of dwellings.

Table 10 Energy consumed within residential buildings for water heating

Water heating			
Fuel type	% Share from total dwellings	Kwh/dwelling in 2010	Kwh/dwelling in 2030
District Heat	52.6	986	998
Electricity	40.4	758	767
Natural Gas	3.5	66	66
Wood	3.5	66	66

Lighting
Percent share of dwellings – Percentage of households consuming respective fuel type. Assumptions based tables A1-6 and A3-4.1, within the final report of Household Energy Consumption Research carried out in 2012.

Energy Intensity (Kwh/dwelling) - Total amount of fuel consumed (each fuel type separately) divided with total number of dwellings.

Table 11 Energy consumed for lighting within residential buildings

Lighting			
Fuel type	% Share of dwellings	Kwh/dwelling in 2010	Kwh/dwelling in 2030

Electricity	100	404	409

Appliances

Percent share of dwellings – Percentage of households consuming respective fuel type. Assumptions based tables A1-6 and A3-4.1, within the final report of Household Energy Consumption Research carried out in 2012.

Energy Intensity (Kwh/dwelling) - Total amount of fuel consumed (each fuel type separately) divided with total number of dwellings.

Table 12 Energy consumed for appliances within residential buildings

Appliances			
Fuel type	% Share of dwellings	Kwh/dwelling in 2010	Kwh/dwelling in 2030
Electricity	100	944	1026
LPG for cooking	5.2	1200	1200

*In Estonian case, the cooking sector was not considered in this work as only the amount of LPG used for cooking was known and that would have given wrong results within that sector. Therefore, the consumption of LPG has been included under the activity "Appliances". LPG in general is one of the less researched fuel types and therefore some separate rough assumptions had to be made. As such, the average consumption of the last five historical year data was taken. This in turn was divided between dwellings assumed for each future years (in order to get Kwh/dwelling).

Tertiary

Due to the lack of data regarding the tertiary buildings sector in Estonia, it was difficult to model very detailed energy efficiency scenarios. The historical data was not possible to separate between different tertiary building types (e.g. schools, hospitals etc) and due to lack of data about the existing situation, it was also hard to make any assumptions for the future scenarios for tertiary buildings other than schools and offices. Therefore, the historical data does not match with the future projections and the schools and offices are only given as an example for two tertiary building types in Estonia.

All the parameters and assumptions have been taken from the Estonian National Energy Development Plan 2030+. This was the only available source regarding the possible future trends in Estonia. The data under schools and offices was separated between heating and electricity (any other than heating).

Similarly to the residential buildings, all the new building stock is assumed to be built according to the existing legislations which are already in force for the new building stock, such as:

- Buildings to be built between 2015-2025 according to the minimum energy performance requirements
- Buildings to be built 2025-2030 according to the zero-energy standards

Again, the key to the efficient housing stock relies therefore within the renovation.

The structure of the data and the main data itself within the LEAP file for the tertiary sector was organized as follows:

Table 13 Tertiary building stock assumptions

Schools Kwh/(m^2/y)		
	Electricity	Heating

Existing Schools	90	150
Fuel share		Natural gas (6%); District Heat (78%); Fuel Oil (5%); Electricity (2%); Wood (9%)
Assumptions for the renovation	Efficient Lighting	Insulation of external walls
Renovated Schools	-6	-90
Fuel share		Natural gas (6%); District Heat (78%); Fuel Oil (5%); Electricity (2%); Wood (9%)
New Schools 2015-2021	45	78
Fuel share		Natural gas (30%); District Heat (65%); Electricity (5%);
New Schools 2021-2030	32	27
Fuel share		Natural gas (30%); District Heat (65%); Electricity (5%);
Offices Kwh/(m²/y)		
	Electricity	Heating
Existing Offices	30	140
Fuel share		Natural gas (21%); District Heat (60%); Fuel Oil (5%); Electricity (7%); Wood (7%)
Assumptions for the renovation	Efficient Lighting	Insulation of external walls
Renovated Offices	-7	-75
Fuel share		Natural gas (21%); District Heat (60%); Fuel Oil (5%); Electricity (7%); Wood (7%)
New Offices 2015-2021	56	53
Fuel share		Natural gas (20%); District Heat (70%); Electricity (10%);
New Offices 2021-2030	32	40
Fuel share		Natural gas (20%); District Heat (70%); Electricity (10%);

The building stock data was also derived from the Estonian National Energy Development Plan 2030+. The floor area of the existing offices in 2014 was 5608500 m^2 and the floor area of the existing schools in 2014 was 3021600 m^2. The main assumptions for all the new and to be renovated buildings are:

- Yearly outflow of building stock -0.3%

- Yearly renovation rate +0.5%
- Yearly inflow of new building stock +1.5%

3.2.2. Analysis and results of BAU scenario

Residential sector

As a result, the energy consumption within the BAU scenario until 2030, was calculated to arise 2% (Figure 1) from the consumption of the last historical year (2014). As the number of dwellings is growing whereas the energy consumption is declining thanks to the renovation and energy performance requirements of the new building stock, the growth in total energy consumption is not that significant.

The energy demand in the last historical year (2014) and the first BAU year, can be seen from the below provided table:

Table 14 BAU Energy Demand Final Units Residential Sector
Units: $MtCO_{2eq}$

Fuels	2000	2010	2014	2030
Electricity	0.13	0.17	0.15	0.17
Natural Gas	0.05	0.05	0.06	0.06
Fuel Oil	0.02	0.00	0.00	0.00
LPG	0.01	0.00	0.00	0.00
Peat	0.01	0.00	0.00	0.00
Wood	0.38	0.39	0.40	0.42
Heat	0.44	0.33	0.32	0.33
Oil Shale	0.00	-	-	-
Coal Unspecified	0.02	0.00	0.00	0.00
Total	1.05	0.96	0.95	1.01

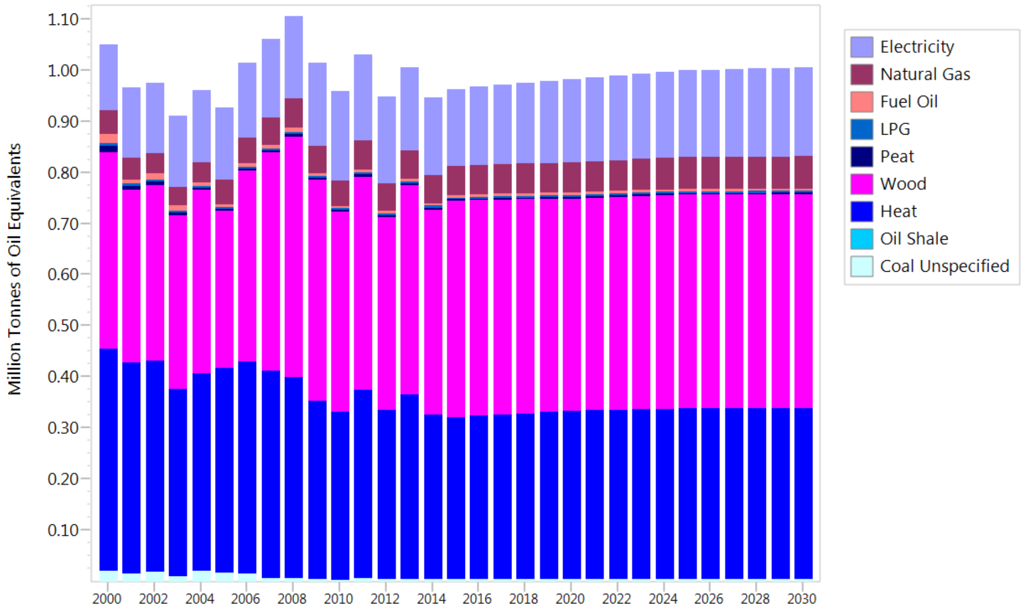

Figure 3 Energy Demand Baseline Scenario residential sector ($MtCO_{2eq}$)

Figure 3 describes the energy consumption results of BAU scenario as calculated by LEAP until 2030. It shows the estimated prognoses of fuel consumption with current trends. However, the pitfall of the scenario making in this work is the socio-economic trends what have not been considered in this work and therefore the consumption of fuels compared to the historical values can only be shown as smooth as shown on the graph, whilst historical data has more fluctuations.

Together with the data on fuel types, emissions data can as well be looked at in this work (Figure 4). However, as forming the transformation folder (transformation folder consists of energy production data according to what indirect emissions can be calculated) was not considered as a task doable within the frames of this project, only direct emissions can be analysed hereof.

Below the results of direct emissions based on the last historical year versus BAU 2030.

Table 15 BAU Direct (At Point) Emissions Residential

Emission type	2000	2014	2020	2030
GHGs ($MtCO_{2eq}$)	0.44	0.32	0.32	0.33
NO_x (1000tons)	1.94	1.87	1.93	1.95

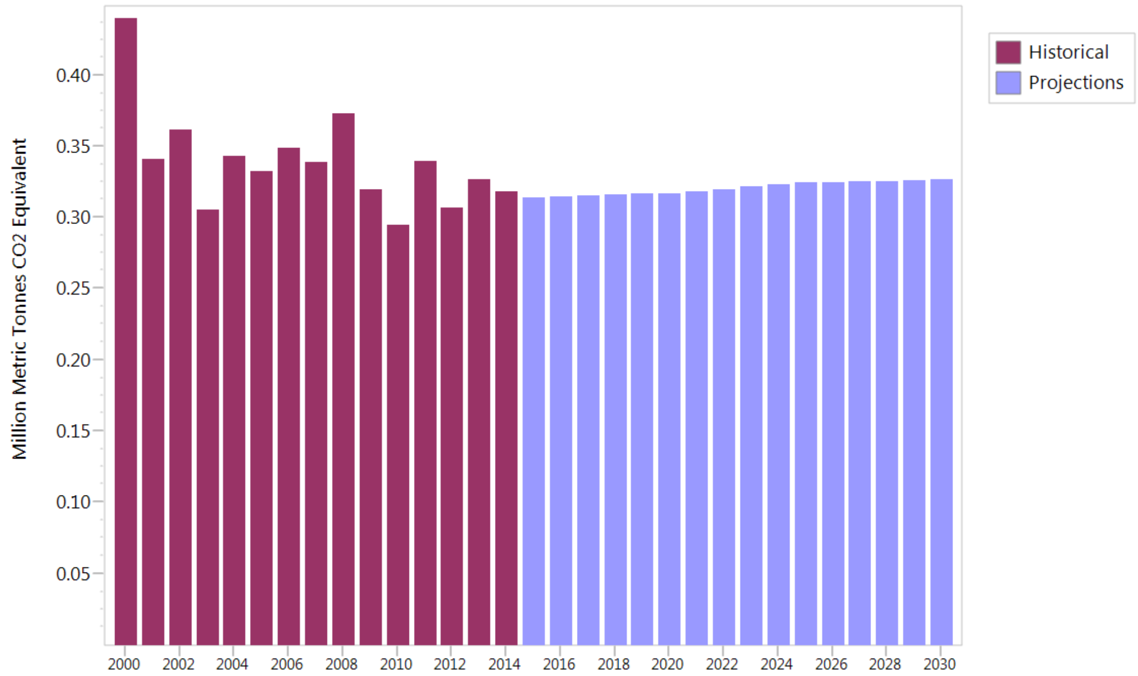

Figure 4 Direct (at point) emissions (GHGs) of BAU scenario for residential ($MtCO_{2eq}$) (100-year GWP)

Figure 4 describes the emissions results of BAU scenario as calculated by LEAP until 2030.

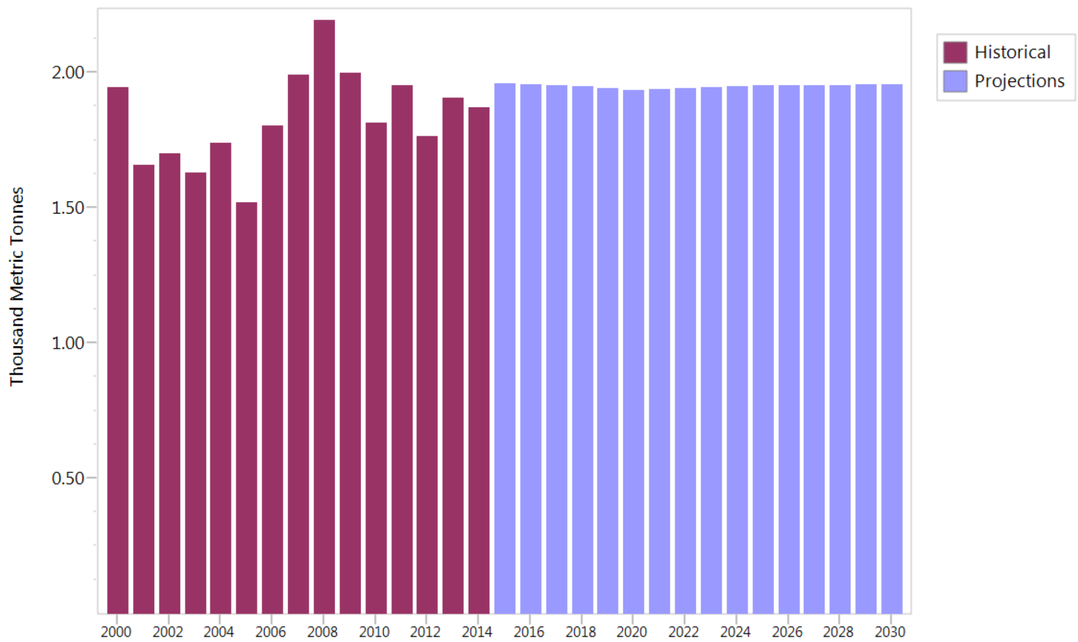

Figure 5 Nitrogen Oxides (NOx) of residential BAU scenario (1000tons)

Tertiary

As it was only possible to make projections for the office and school buildings under the tertiary sector, whilst the historical data was only available for the entire tertiary sector, we added the rest of the data under the projections by simply recalculating the first year of offices and schools projection data from the last historical year data. This resulted to the remainder what we called as “Other”. As it was not possible to make energy efficiency projections for the data under folder “Other”, the focus in this report is mainly on the offices and schools in order to give more precise example of future energy consumption within the Estonian tertiary sector according to those two tertiary building types.

The final energy consumption according to the current schools and offices energy consumption trends would increase about 3% by 2030 compared to 2015 (first scenario year).

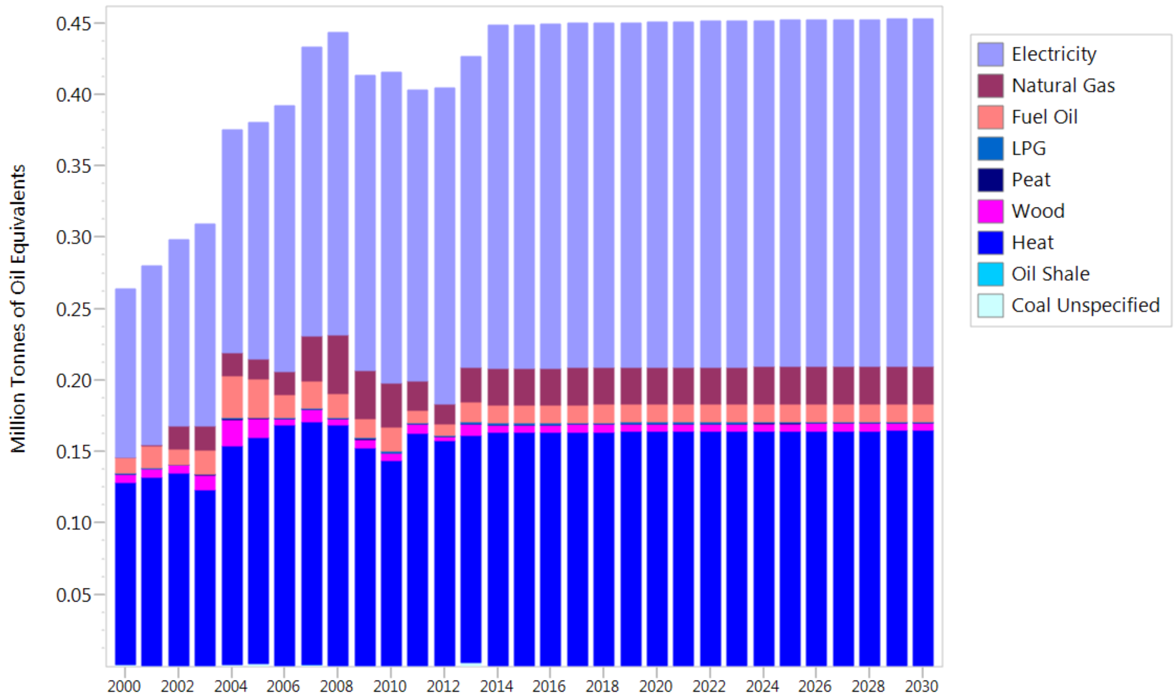

Figure 6 Energy Demand Baseline Scenario tertiary sector ($MtCO_{2eq}$)

Table 16 BAU Energy Demand Final Units Tertiary Sector

Units: $MtCO_{2eq}$

Schools			
Fuels	2015	2020	2030
Electricity	0.0009	0.0009	0.0010
Natural Gas	0.0002	0.0002	0.0003
Fuel Oil	0.0002	0.0002	0.0002
Wood	0.0003	0.0003	0.0003
Heat	0.0028	0.0029	0.0029
Total	0.0044	0.0045	0.0047
Offices			
Fuels	2015	2020	2030
Electricity	0.05	0.05	0.05
Natural Gas	0.02	0.02	0.02
Fuel Oil	0.00	0.00	0.00
Wood	0.01	0.01	0.00
Heat	0.04	0.04	0.04
Total	0.12	0.12	0.12

Schools + Offices	0.12	0.12	0.12
Difference 2015 vs. 2030			0.03
Other			
Fuels	2015	2020	2030
Electricity	0.19	0.19	0.19
Natural Gas	0.01	0.01	0.01
Fuel Oil	0.01	0.01	0.01
LPG	0.00	0.00	0.00
Peat	0.00	0.00	0.00
Wood	0.00	0.00	0.00
Heat	0.12	0.12	0.12
Oil Shale	-	-	-
Coal Unspecified	-	-	-
Total	0.33	0.33	0.33
Total	**0.45**	**0.45**	**0.45**

Table 17 gives an overview of the possible evolution of direct emissions in the tertiary sector buildings in Estonia, first scenario year compared to last scenario years.

Table 17 BAU Direct (At Point of Emissions) Emissions Tertiary

GHGs ($MtCO_{2eq}$)			
Schools			
Year	2015	2020	2030
Total	0.0012	0.0012	0.0013
Offices			
Year	2015	2020	2030
Total	0.0483	0.0486	0.0483
Other			
Year	2015	2020	2030
Total	0.0546	0.0546	0.0546
NO_x (1000tons)			
Schools			
Year	2015	2020	2030
Total	0.0026	0.0026	0.0026
Offices			
Year	2015	2020	2030
Total	0.0682	0.0682	0.0671
Other			
Year	2015	2020	2030
Total	0.0635	0.0635	0.0635

Figures 7 and 8 below show the emissions data of the tertiary sector (schools+offices+other) on respective graphs.

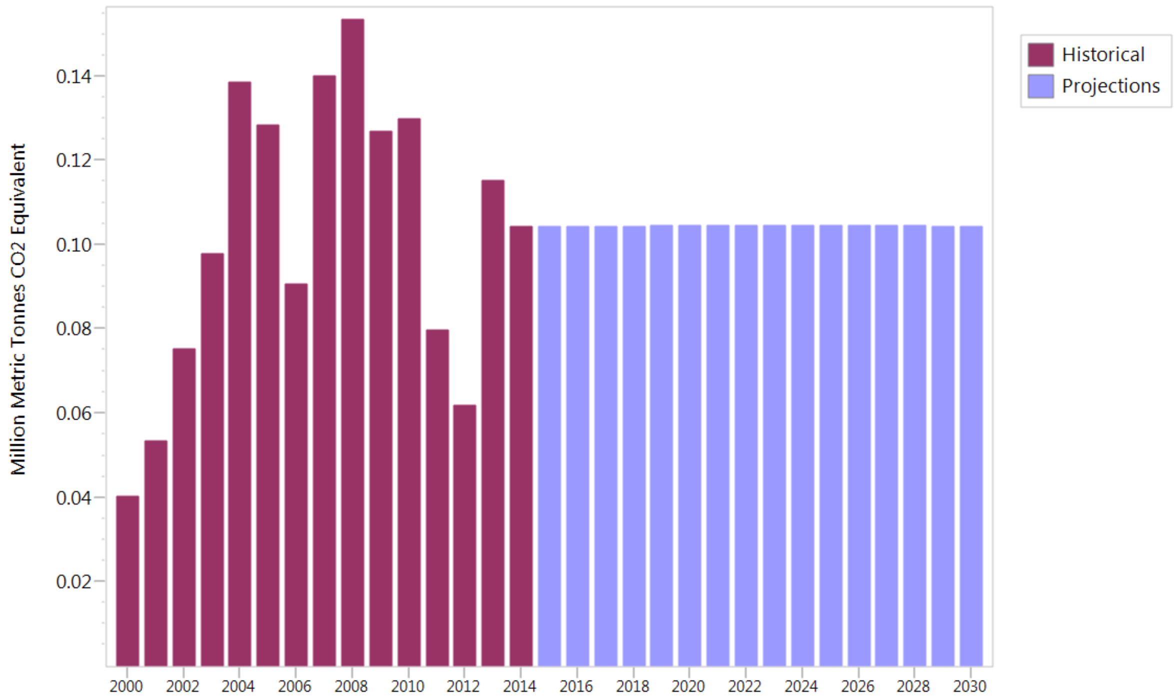

Figure 7 Direct (at point) emissions (GHGs) of BAU scenario for tertiary ($MtCO_{2eq}$) (100-year GWP)

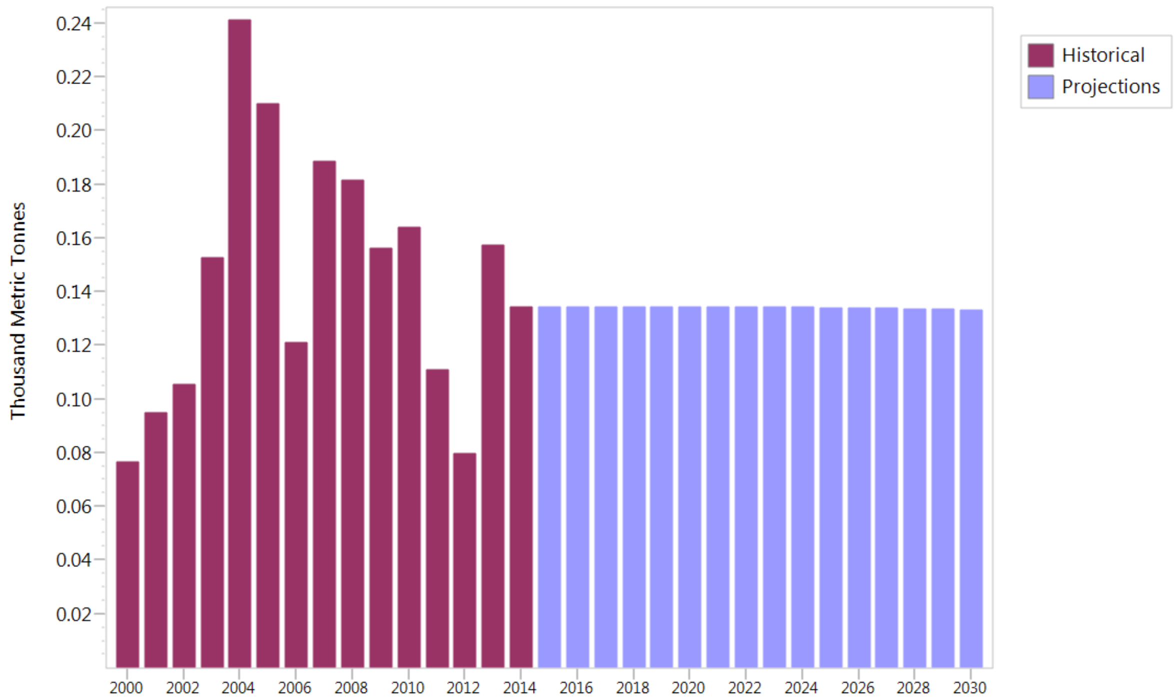

Figure 8 Nitrogen Oxides (NOx) of tertiary BAU scenario (1000tons)

3.3. ENERGY EFFICIENCY SCENARIOS UP TO 2030

The main assumptions of scenarios, for buildings and transport sectors, concern the penetration of technologies, the adoption of measures and the implementation of the respective policy instruments that support the exploitation of technologies and the achievement of measures. The choice of these measures and technologies for the HERON scenarios is based on the HERON questionnaire survey.

Six (6) sub-scenarios[3] for buildings (residential and tertiary) were proposed for all the HERON partners, each one assuming a specific level of penetration for one technology/measure that was included in the WP2 survey (please see below description for each one of these sub-scenarios) in LEAP.

For the residential buildings sector in Estonia, three sub-scenarios were built:

1. Building shell improvement: Efficient heating + building shell improvement* - In Estonian case it was complex to separate efficient heating from building shell improvement because the retrofit rate (%) in Estonia takes into account the houses what go through the full retrofit process (walls, roof, windows, heating system). The renovation of apartment buildings in Estonia depend on the funding and this requires full renovation together with the heating system. It is not possible to only do building shell improvement or only change the heating system. In private houses the situation is even more complex as there is no funding and the house owners just do what they like because the renovation depends on their own funding. So in private houses building shell improvement and change of heating system is done separately. However, as the works done in these houses are not being tracked, it is impossible to have relevant data. Therefore the assumptions hereof (and full retrofit rate) are based on prognosis which were made for The Estonian National Development Plan of the Energy Sector until 2030 (ENMAK 2030+), coordinated by the Estonian Ministry of Economic Affairs and Communications, by and relying on a research called "An overview of apartment building renovations the impact analysis of the Apartment Building Renovation Grants for the period 2010-2014 (Margit Lauri together with Foundation KredEx, August 2014)
2. Efficient lighting: This scenario focuses only on the penetration of LED in existing buildings (single-family, multi-family, tertiary). There is no national assumptions made in Estonia regarding appliances. The report prepared by McKinsey&Company in 2011 „Lighting the way: Perspectives on the global lighting market" was used. According to this, the proportion of LED lighting in residential buildings will be 70% by 2020. As LED- lighting is about 5 times more effective, we assumed together with the Estonian building sector expert, that in Estonia the entire electricity usage in lighting will decrease about 2.5 times.
3. Efficient appliances: No national assumptions in Estonia have been made under appliances on how to decrease the electricity consumption. Therefore we used the report prepared by Odyssee-Mure (2015) "Energy Efficiency Trends and Policies in the EU". According to the analyses made there, we relied on the same assumption hereof that electricity consumption in the household appliances has decreased 1.3% per year from 2000 onward. We assumed the same trend in HERON EE-B0 scenario up to 2030.

The developed sub-scenarios are combined and form an Energy Efficiency Scenario, which is named EE-B0, and run in LEAP. This is a zero DST scenario based on national energy efficiency assumptions taken in order to achieve the EU energy efficiency targets.

[3] The six sub-scenarios are: 1) Efficient Lighting; 2) Building shell improvement; 3) Efficient Appliances; 4) Efficient Lighting; 5) Efficient Cooling; 6) Application of BEMS. If the sub-scenarios that are applicable for a country are not at least three but less, eg. two, then the scenarios that should be developed are BAU, EE B0, EE B1 and EE B2.

After the implementation of the DST (Decision Support Tool) tool, which was developed by the Energy Policy and Development Centre (KEPA)[4], 5 additional Energy Efficiency (EE) scenarios were created. EE-B2 scenario takes into account the currently existing barriers and scenarios EE B2 - EE B4 minimize the barriers under each specific policy assumptions accordingly.

In total, there are 5 different energy efficiency scenarios created with the DST under the buildings sector of Estonia. It should be mentioned though, that within the EE B4 scenario it was not possible to minimize the barriers under the "efficient appliances" branch of the tertiary sector due to the lack of data. Therefore it is the only DST scenario that is a combination of two sectors where barriers under the tertiary have not been minimized (EE B1 was used instead where the barriers do exist).

The barriers that were minimized per each scenario are presented in Annex 8 and Annex 9 of this report.

Scenarios	**Residential buildings**	**Tertiary buildings**
1.EE – B0: EE scenario with zero DST impact	x	x
2. EE - B1: EE DST scenario which considers the current barriers across all the sub-scenarios	x	x
3.EE - B2: EE DST scenario with the minimization of barriers within the building shell improvement sub-scenario	x	x
4. EE – B3: EE DST scenario with the minimization of barriers within efficient lighting sub-scenario	x	x
5. EE – B4: (EE B4 (R) + EE B1 (T)) EE DST scenario with the minimization of barriers within efficient appliances sub-scenario	x	x (EE B1 scenario was considered due to the unavailability of EE B4 scenario under the tertiary buildings sector)

3.3.1. Sub-scenarios for buildings - key assumptions - proposed policy measures and their respective policy instruments

In Estonia, as for the new buildings to be built between 2014-2030, the energy performance requirements have already quite a high technical performance set by the requirements, the EE scenario could only focus on the renovation rates of the already existing building stock. Another assumptions made were for the efficient lighting and efficient appliances.

The assumptions made for the energy efficiency scenario built based on renovation rates within the Estonian National Energy Development Plan 2030 +, were as follows:

3.3.1.1. EE-B0 scenario for buildings

Table 18 Assumptions of EE-B0 scenario (residential)

Sub-scenarios	**Policy assumptions**	**Policy instrument(s) that focus on achieving the policy assumption**
Building Shell Improvement	Average energy consumption of reconstructed dwellings, 62	(Residential and tertiary) Awareness raising campaigns:

[4] Further explanation about the DST and the barriers is given in the Work Package 3 report of this project.

(renovation including efficient heating)	Kwh/(m^2a) single family houses with the re-constructed surface area of 13, 274, 407 m^2 and 128 Kwh/(m^2a) multi-family houses with the re-constructed surface area of 8, 691, 860 m^2 (Estonian National Energy Development Plan 2030 +).*	potential of energy savings due to improvement of insulation in existing buildings (windows, doors) (for households and hotels); (Residential and tertiary) Financial incentives: Financial support from the government (in the range of 35% for both multi- and single family houses) for the home owners and the apartment building cooperatives, in order to reach the renovation targets of 2030; (Residential and tertiary) Government demolition programmes: demolition fund for the abandoned buildings; (Residential and tertiary) Clear and user friendly renovation packages for homeowners and apartment block associations with different levels of renovation opportunities (i.e renovation of ventilation systems, lofts, renovation of main entrances) and prices, in order to minimize risks; (Residential and tertiary) Development of governmental think tanks and change makers teams: In order to improve and push for the development of regulatory system (modernization); make improvements in land use planning (i.e. compulsory CO2 evaluation for the buildings); (Residential and tertiary) Pilot projects (of zero-energy buildings for instance, application of new technologies).
Efficient lighting	2.5 times lower by 2030 compared to current	(Residential and tertiary) Information Campaigns about energy efficient light bulbs, LED lamps, movement detectors etc.; (Residential and tertiary) Financial support for low-

		income population to purchase LED (e.g. vouchers); (Residential and tertiary) Regulatory restrictions and taxation for incandescent lighting.
Efficient appliances	1.3% decline each year up to 2030	(Residential) Information Campaigns about the new technologies (i.e smart gadgets) and new regulations (requirements of solar panels to new buildings to be built from 2021 onward, to reach NZB); (Residential) Financial incentives (loan and grant); (Residential) Trainings for tenants.

* It should be noted that the Estonian National Energy Development Plan 2030 + created two energy efficiency scenarios and in Table 18 only the most efficient scenario assumptions have been given. This according to ENMAK 2030 + is the knowledge based national scenario. However in HERON we also implemented the assumptions of less efficient scenario, called minimally intervening state EE scenario. The descriptions and more specific assumptions of those two have been given below:

a) Minimally intervening state EE scenario (residential)

Within scenario "minimally intervening state EE scenario" it is assumed that the existing resources will be used in economically most efficient way in order to achieve the socio-economic goals.

- Relevant assumptions made for minimally intervening state EE scenario:

EE I - Minimally intervening state EE scenario	**Multi-family houses**	**Single-family houses**
Fraction of dwellings to be reconstructed by 2030	30%	20%
Energy savings	50%	30%
Re-constructed surface area m^2	7.964.644	4.345.930
Average energy consumption of reconstructed dwellings, Kwh/(m^2a)	78	150

b) Knowledge based national scenario (residential)

This is a scenario with relatively high expectations where a wide range of risks and investments have been assumed in order to achieve economic benefits from energy efficiency and contribute to a high level of living.

- Relevant assumptions made for knowledge based national scenario:

EE II - Knowledge based national scenario	**Multi-family houses**	**Single-family houses**

Fraction of dwellings to be reconstructed by 2030	50%	40%
Energy savings	60%	40%
Re-constructed surface area m^2	13.274.407	8.691.860
Average energy consumption of reconstructed dwellings, Kwh/(m^2a)	62	128

Table 19 Assumptions of EE-B0 scenario (tertiary)

Sub-scenarios	**Policy assumptions**
Stock of renovated buildings out of the entire tertiary building stock by 2030: 13 % schools & 13% offices*	
Building Shell Improvement	Schools: 90 Kwh/(m^2/y) Offices: 75 Kwh/(m^2/y)
Efficient lighting	Schools: 6 Kwh/(m^2/y) Offices: 7 Kwh/(m^2/y)

*Similarly to the residential buildings sector, the EE-B0 scenario presented hereof is made with the maximum assumptions which were worked out for ENMAK 2030+, that is the so called knowledge based national scenario which was already described under the residential buildings sector. However, the modeller also implemented another less ambitious scenario – minimally intervening state energy efficiency scenario, which (the only difference being) assumed the renovation percentage out of the entire building stock in 2030 to be 6% instead of 13%.

3.3.1.2. EE-B1-EEB4 scenarios for buildings

After the implementation of the DST, EE-B1 scenario was developed which takes into account the existing barriers within the residential and tertiary sectors of Estonia and recalculates the policy assumptions accordingly. As a result, each of the policy assumptions made under the EE-B0 scenario, decreased after taking into account the existing barriers in the respective sectors. The outcome of the DST shows that the EE-B0 scenario has to be modified, since it did not incorporate the end-users behaviour. Therefore, the DST outcome shows how much the scenario has declined from the assumed policy target. At the end of this report, Annexes 6 and 7 give an overview of the calculated weight coefficients for all the existing barriers in both tertiary and residential sectors.
Tables 20 and 21 describe the decrease (less efficient assumptions) of each of the policy assumptions within the residential and tertiary sector EE-B1 scenarios, after taking into account the weight coefficients of the existing barriers.

Tabel 20 EE-B1 scenario assumptions (DST buildings)

Sub-scenarios	**Policy assumption(s) in EE-B0 scenario**	**DST outcome (after considering impact of barriers)**

Building shell improvement (+ efficient heating)	Residential: 40% increase of the total single-family buildings floor area by 2030 and 58% increase of the total multi-family buildings floor area by 2030. Schools: a) Heating: 50 Kwh/m^2 of future energy consumption; Offices: a) Heating: 75 Kwh/m^2 of future energy consumption;	Residential: 18.70% increase of the total single-family buildings floor area by 2030 and 27% increase of the total multi-family buildings floor area by 2030. Schools: a) Heating: 76.6 Kwh/m^2 of future energy consumption; Offices: a) Heating: 114.9 Kwh/m^2 of future energy consumption;
Efficient lighting	Residential: 161.6 Kwh/dwelling per year by 2030. Schools: 24 Kwh/m^2 of future energy consumption Offices: 83 Kwh/m^2 of future energy consumption	Residential: 198.7 Kwh/dwelling per year by 2030. Schools: 29.5 Kwh/m^2 of future energy consumption Offices: 102 Kwh/m^2 of future energy consumption
Efficient appliances	Residential: 765.7 Kwh/dwelling per year by 2030. For the tertiary sector efficient appliances were not considered in this project.	Residential: 855 Kwh/dwelling per year by 2030. For the tertiary sector efficient appliances were not considered in this project.

Table 21 EE-B2 scenario assumptions (DST buildings)

Sub-scenarios	**Policy assumption(s) in EE-B0 scenario**	**DST outcome (after considering impact of barriers)**	**Minimized barriers** **(priority on building shell improvement)**	**Policy instrument(s) that focus on achieving the policy assumption**

Building shell improvement (+ efficient heating)	Residential: 40% increase of the total single-family buildings floor area by 2030 and 58% increase of the total multi-family buildings floor area by 2030. Schools: a) Heating: 50 Kwh/m^2 of future energy consumption; Offices: a) Heating: 75 Kwh/m^2 of future energy consumption;	Residential: 33% increase of the total single-family buildings floor area by 2030 and 48% increase of the total multi-family buildings floor area by 2030. Schools: a) Heating: 58.3 Kwh/m^2 of future energy consumption; Offices: a) Heating: 87.5 Kwh/m^2 of future energy consumption;	**<u>Institutional:</u>** Split incentives Building stock characteristics and special issues Disruption/Hassie factor Problematic implementation network/governance framework **<u>Social:</u>** Inertia Socio-economic status of building owners Strong dependency on neighbours (multi-family housing) **<u>Educational:</u>** Lack of awareness on savings potential, technologies Lack of experienced professionals, trusted information **<u>Economic:</u>** Unexpected costs High costs and risks **<u>Cultural:</u>** Custom – habits – relevant behavioural aspects Missing credibility – mistrust in technologies/constructors Lack of any type of financial support	Awareness raising campaigns: potential of energy savings due to improvement of insulation in existing buildings (windows, doors) (for households and hotels); Financial incentives: Financial support from the government (in the range of 35% for both multi- and single family houses) for the home owners and the apartment building cooperatives, in order to reach the renovation targets of 2030; Pilot projects (of zero-energy buildings for instance, application of new technologies); Policy instruments that support professionals in acquiring additional skills and knowledge on energy efficient technologies and practices. Trainings for engineers/architects and local municipalities on how to consider building stock characteristics/ give technical and regulatory advice; Policies for more transparent and user-friendly loan/financial support system schemes. Regulation of owner-tenant relationship in case of renovation; Clear and user friendly renovation packages for homeowners and apartment block associations with different levels of renovation opportunities (i.e renovation of ventilation systems, lofts, renovation of main entrances) and prices, in order to minimize risks.
Efficient lighting	Residential: 161.6 Kwh/dwelling per year by 2030. Schools: 24 Kwh/m^2 of future energy consumption	Residential: 170.5 Kwh/dwelling per year by 2030. Schools:		Information Campaigns about energy efficient light bulbs, LED lamps, movement detectors etc; Financial support for low-income population to purchase LED (e.g. vouchers).

	Offices: 83 Kwh/m^2 of future energy consumption	25 Kwh/m^2 of future energy consumption Offices: 86.8 Kwh/m^2 of future energy consumption		
Efficient appliances	Residential: 765.7 Kwh/dwelling per year by 2030. For the tertiary sector efficient appliances were not considered in this project.	Residential: 784.6 Kwh/dwelling per year by 2030. For the tertiary sector efficient appliances were not considered in this project.		Financial incentives, (loan and grant); Information Campaigns about the new technologies (i.e smart gadgets) and new regulations (requirements of solar panels to new buildings to be built from 2021 onward, to reach NZB).

Table 22 EE-B3 scenario assumptions (DST buildings)

Sub-scenarios	Policy assumption(s)	DST outcome (after considering impact of barriers)	Minimized barriers (priority on efficient lighting)	Policy instrument(s) that focus on achieving the policy assumption
Building shell improvement (including efficient appliances)	Residential: 40% increase of the total single-family buildings floor area by 2030 and 58% increase of the total multi-family buildings floor area by 2030. Schools: a) Heating: 50 Kwh/m^2 of future energy consumption; Offices: a) Heating: 75 Kwh/m^2 of future energy consumption;	Residential: 26% increase of the total single-family buildings floor area by 2030 and 37% increase of the total multi-family buildings floor area by 2030. Schools: a) Heating: 58.3 Kwh/m^2 of future energy consumption; Offices: a) Heating: 87.5 Kwh/m^2 of future	**<u>Economic:</u>** Lack of any type of financial support High costs and risks	Government demolition programmes: demolition fund for the abandoned buildings; Improvements in land use and planning (i.e. compulsory CO_2 evaluation for the buildings); development of regulatory system (modernization); Awareness raising campaigns: potential of energy savings due to improvement of insulation in existing buildings (windows, doors) (for households and hotels); Financial incentives: Financial support from the government (in the range of 35% for both multi- and single family houses) for the home owners and the apartment building cooperatives, in order to reach the renovation targets of 2030; Development of governmental think tanks and change makers

		energy consumption;		teams: In order to improve and push for the development of regulatory system (modernization); make improvements in land use planning (i.e. compulsory CO2 evaluation for the buildings); Pilot projects (of zero-energy buildings for instance, application of new technologies).
Efficient lighting	Residential: 161.6 Kwh/dwelling per year by 2030. Schools: 24 Kwh/m^2 of future energy consumption Offices: 83 Kwh/m^2 of future energy consumption	Residential: 170.5 Kwh/dwelling per year by 2030. Schools: 25 Kwh/m^2 of future energy consumption Offices: 86.8 Kwh/m^2 of future energy consumption		Information Campaigns about energy efficient light bulbs, LED lamps, movement detectors etc. Financial support for low-income population to purchase LED (e.g. vouchers). Regulatory restrictions and taxation for incandescent lighting; Trainings on new technologies (i.e semi-conductive materials based LED lamps).
Efficient appliances	Residential: 765.7 Kwh/dwelling per year by 2030. For the tertiary sector efficient appliances were not considered in this project.	Residential: 795.7 Kwh/dwelling per year by 2030. For the tertiary sector efficient appliances were not considered in this project.		Information Campaigns about the new technologies (i.e smart gadgets) and new regulations (requirements of solar panels to new buildings to be built from 2021 onward, to reach NZB); Financial incentives (loan and grant.

Table 23 EE-B4 scenario assumptions (DST buildings)

Sub-scenarios	**Policy assumption(s)**	**DST outcome (after considering impact of barriers)**	**Minimized barriers** **(priority on efficient appliances)**	**Policy instrument(s) that focus on achieving the policy assumption**

Building shell improvement (including efficient appliances)	Residential: 40% increase of the total single-family buildings floor area by 2030 and 58% increase of the total multi-family buildings floor area by 2030. Schools: a) Heating: 50 Kwh/m^2 of future energy consumption; Offices: a) Heating: 75 Kwh/m^2 of future energy consumption;	Residential: 22.40% increase of the total single-family buildings floor area by 2030 and 32.50% increase of the total multi-family buildings floor area by 2030. Schools: a) Heating: 67.4 Kwh/m^2 of future energy consumption; Offices: a) Heating: 101 Kwh/m^2 of future energy consumption;	**Economic:** Lack of any type of financial support **Social:** Inertia Socio-economic status of building users	Reconstruction of the existing housing stock with 35% of reconstruction fund both for the multi and single family homes; Government demolition programmes: demolition fund for the abandoned buildings; Improvements in land use and planning (i.e. compulsory CO_2 evaluation for the buildings); Development of regulatory system (modernization); Awareness raising campaigns: potential of energy savings due to improvement of insulation in existing buildings (windows, doors) (for households and hotels); Financial incentives: Financial support from the government (in the range of 35% for both multi- and single family houses) for the home owners and the apartment building cooperatives, in order to reach the renovation targets of 2030; Development of governmental think tanks and change makers teams: In order to improve and push for the development of regulatory system (modernization); make improvements in land use planning (i.e. compulsory CO2 evaluation for the buildings); Pilot projects (of zero-energy buildings for instance, application of new technologies).
Efficient lighting	Residential: 161.6 Kwh/dwelling per year by 2030. Schools: 24 Kwh/m^2 of future energy consumption Offices:	Residential: 186.2 Kwh/dwelling per year by 2030. Schools: 25 Kwh/m^2 of future energy consumption Offices: 86.8 Kwh/m^2 of future energy consumption		Information Campaigns about energy efficient light bulbs, LED lamps, movement detectors etc. Financial support for low-income population to purchase LED (e.g. vouchers).

	83 Kwh/m^2 of future energy consumption			
Efficient appliances	Residential: 765.7 Kwh/dwelling per year by 2030. For the tertiary sector efficient appliances were not considered in this project.	Residential: 784.6 Kwh/dwelling per year by 2030. For the tertiary sector efficient appliances were not considered in this project.		Information Campaigns about the new technologies (i.e smart gadgets) and new regulations (requirements of solar panels to new buildings to be built from 2021 onward, to reach NZB); Financial incentives, (loan and grant); Fiscal incentives for purchasing A++ or better appliances. Training for tenants about the new household devices. Eco-labeling with more information (for energy savings that can be achieved, environmental benefits, contribution in mitigating climate change); Economic incentives need to be targeted to low and middle income households; these may include tax reliefs or deductions from electricity bills for a certain time period.

After the implementation of the DST the changing variables in LEAP model under each of the listed scenarios can be concluded as follows:

Table 24 Changing variables in buildings sector across different EE scenarios

Scenario:	**EE B0**	**EE B1**	**EE B2**	**EE B3**	**EE B4**
Building Shell Imrpovement Single-family dwellings	40%	18.70%	33%	26%	22.40%
Building Shell Imrpovement Multi-family dwellings	58%	27%	48%	37%	32.50%
Kwh/dwelling					
Efficient Lighting	161.6	198.7	170.5	170.5	186.2
Efficient Appliances	765.7	855	784.6	795.7	784.6
Scenario:	**EE B0**	**EE B1**	**EE B2**	**EE B3**	**EE B4**
Kwh/m^2 of energy consumption					

Schools	24	29.5	25	25	25
Offices	83	102	86.8	86.8	86.8
Building shell improvement					
Schools	50	76.6	58.3	58.3	67.4
Offices	75	114.9	87.5	87.5	101

1.3.2 Analysis and results of EE scenarios compared with BAU and policy targets

A. First group of outcomes

Table 23 underlines the differences between the energy consumption target derived from EU PRIMES Baseline scenario modelled in 2007 with HERON Baseline scenario and the rest of the energy efficiency scenarios modelled for this project. It should be noted though that whilst two baseline scenarios were created, different parameters and assumptions were implemented. As such HERON baseline scenario takes into account also the new efficiency legislations such as EU 2020 zero energy legislative, being probably a reason why the energy consumption in the residential buildings sector according to EU PRIMES (2007) 2030 is higher (1.109 Mtoe Residential) compared to HERON BAU (1.0055 Mtoe Residential). The latest EU target sets that 30% reduction is needed from the result modelled in 2030 with the PRIMES model in 2007. As the PRIMES model does not separate agriculture from the services sector, Statistics Estonia was used in order to find out the proportion of agriculture. According to this, agriculture makes about 23% of the entire services and agriculture sector (Statistics Estonia, 2016). The Table number 23 below calculates the target hence based on that assumption.

It should be noted that under the tertiary buildings sector, the modeller made future projections under schools and offices only. The results in HERON tertiary sector assume the same energy consumption for all the rest of the service sectors (except schools and offices) to be the same as on the last historical year. Therefore only very aggregated results of the tertiary sector could be modelled. Also, differently from the residential buildings sector, the tertiary buildings sector does not take efficient appliances into account under the EE B4 scenario which means that EE B4 scenario does not minimize barriers under the tertiary buildings sector.

The three outcome tables below show and compare the results of tertiary and residential sectors as one overall “Buildings” sector.

Table 25 Comparisons among scenarios for final energy consumption (or energy savings) in Mtoe/Buildings (R+T) sector

	2005	2010	2020	2030
EU Policy target	n.a.	n.a.		-30% compared to EU BAU baseline scenario, 2007
National policy target	n.a.	n.a.	2020 max 2010 level (according to ENMAK) *(set for all sectors together)	
EU BAU PRIMES 2007 baseline scenario				EU data: 1.109 (2007 Residential) + 0.847 (Services/agriculture) = 1.956 Calculated: 1.109 (2007 Residential) + 0.652 (0.847 - 23% agriculture) = 1.761 Target: 1.23
HERON BAU	**1.31**	**1.37**	**1.43**	**1.46**

% difference between EU BAU 2007 target	Exceeds 2010 level	19 % higher
HERON EE B0 (without running DST)	**1.36**	**1.23**
% difference between EU BAU 2007 target	Does not exceed the 2010 level	0 %
% change compared to HERON BAU	4.9 % lower	16 % lower
HERON EE B1	**1.42**	**1.37**
% difference between EU BAU 2007 target	Exceeds 2010 level	11.4 % higher
% change compared to HERON BAU scenario	0.7 % lower	6 % lower
HERON EE B2	**1.38**	**1.27**
% difference between EU BAU 2007 target	Exceeds 2010 level (yet rather equal)	3.3 % higher
% change compared to HERON BAU scenario	3.5 % lower	13 % lower
HERON EE B3	**1.39**	**1.32**
% difference between EU BAU 2007 target	Exceeds 2010 level	7.3 % higher
% change compared to HERON BAU scenario	2.8 % lower	9.6 % lower
HERON EE B4 (EE B4(R) + EE B1(T))	**1.40**	**1.34**
% difference between EU BAU 2007 target	Exceeds 2010 level	8.9 % higher
% change compared to HERON BAU scenario	2 % lower	8.2 % lower

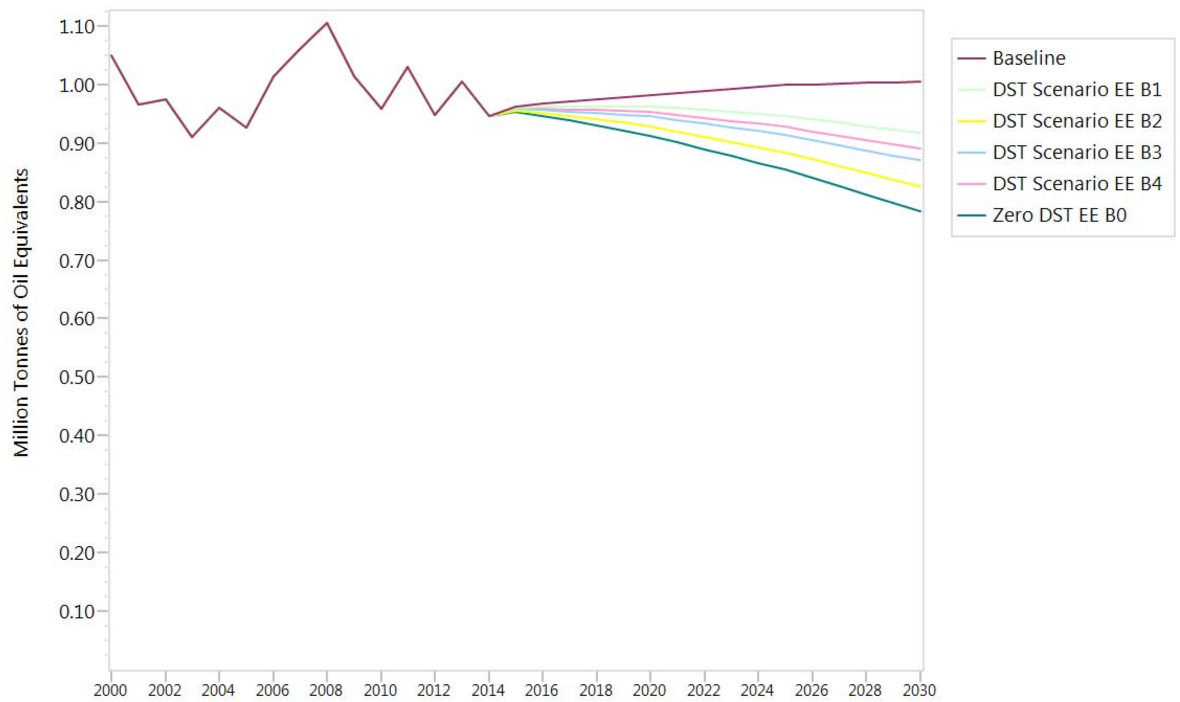

Figure 9 Residential: Energy consumption under baseline scenario, energy efficiency (EE-B0) scenario (and its sub-scenarios) and different DST scenarios (EE B1- EE B4)

Table 26 Energy Demand Final Units Residential buildings sector

Units: Million Tonnes of Oil Equivalents			
Scenarios	**2010**	**2020**	**2030**
Baseline	0.9586	0.9813	1.0055
DST Scenario EE B1	0.9586	0.9626	0.9179
DST Scenario EE B2	0.9586	0.9289	0.8261
DST Scenario EE B3	0.9586	0.9452	0.8704
DST Scenario EE B4	0.9586	0.9525	0.8901
Zero DST EE B0	0.9586	0.9128	0.7833
Total	**5.7518**	**5.6833**	**5.2933**

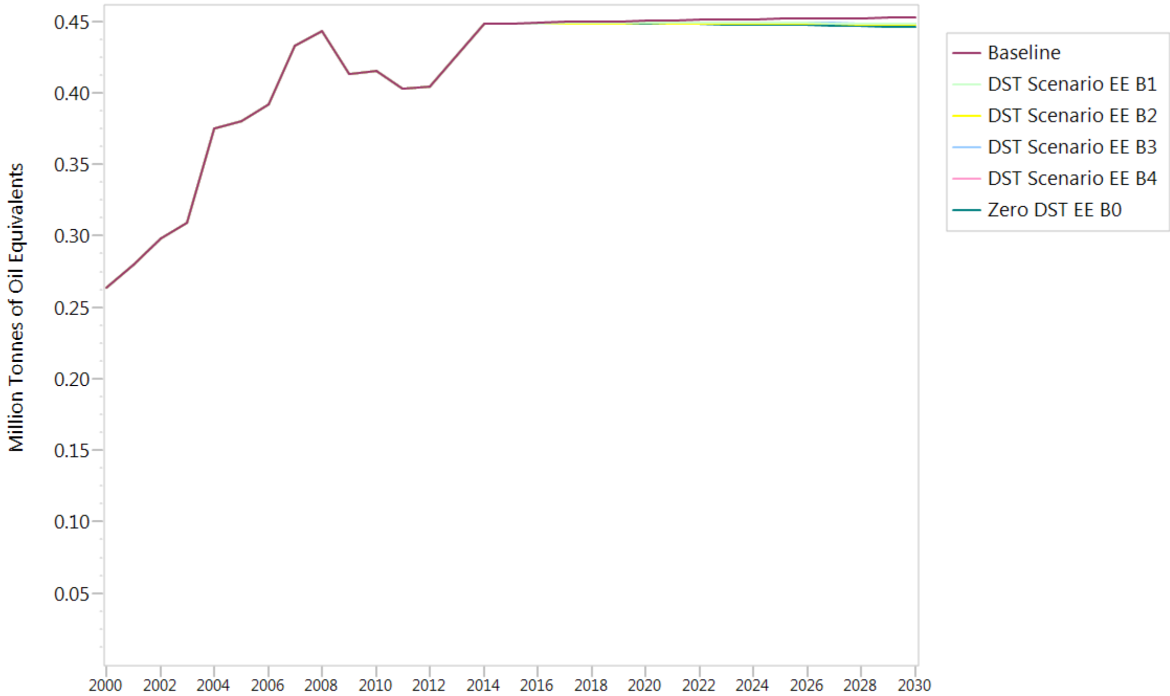

Figure 10 Tertiary: Energy consumption under baseline scenario, energy efficiency (EE-B0) scenario (and its sub-scenarios) and different DST scenarios (EE B1 – EE B3)

Table 25 Energy Demand Final Units Tertiary Buildings Sector

Units: Million Tonnes of Oil Equivalents			
Scenarios	2010	2020	2030
Baseline	0.4156	0.4504	0.4524
DST Scenario EE B1	0.4156	0.4490	0.4481
DST Scenario EE B2	0.4156	0.4487	0.4472
DST Scenario EE B3	0.4156	0.4490	0.4483
Zero DST EE B0	0.4156	0.4483	0.4460
Total	2.4934	2.6943	2.6902

B. Second group of outcomes – GHG and NOx (direct emissions)Reductions of direct (at point of) emissions - GHG in $MtCO_2$

Table 27 EE scenario outcomes – reduction of GHG direct (at point of) emissions ($MtCO_2$)/ Buildings (T+R) sector

	2005	2020	2030
National policy targets		max +11% (2005) Estonian non-ETS target	
EU Policy targets		**Reference target: 0.51**	-13% (2005) Estonian non-ETS target **Reference target: 0.39**
HERON BAU scenario	**0.46**	**0.42**	**0.43**
% difference compared to non-ETS target		Does not exceed max 11% compared to 2005	9% higher
HERON EE B0		**0.40**	**0.37**
% difference compared to non-ETS		Does not exceed max 11% compared to 2005	5 % lower
% difference compared to HERON BAU		4.8 % lower	14 % lower
HERON EE B1		**0.42**	**0.41**
% difference compared to non-ETS		Does not exceed max 11% compared to 2005	5% higher
% difference compared to HERON BAU		0 %	4.7 % lower
HERON EE B2		**0.41**	**0.38**
% difference compared to non-ETS		Does not exceed max 11% compared to 2005	3% lower
% difference compared to HERON BAU		2.4 % lower	11.6 % lower
HERON EE B3		**0.41**	**0.39**
% difference compared to non-ETS		Does not exceed max 11% compared to 2005	0%
% difference compared to HERON BAU		2.4 % lower	9 % lower
HERON EE B4 (EE B4(R) + EE B1(T))		**0.41**	**0.40**
% difference compared to non-ETS		Does not exceed max 11% compared to 2005	3% higher
% difference compared to HERON BAU		2.4 % lower	7 % lower

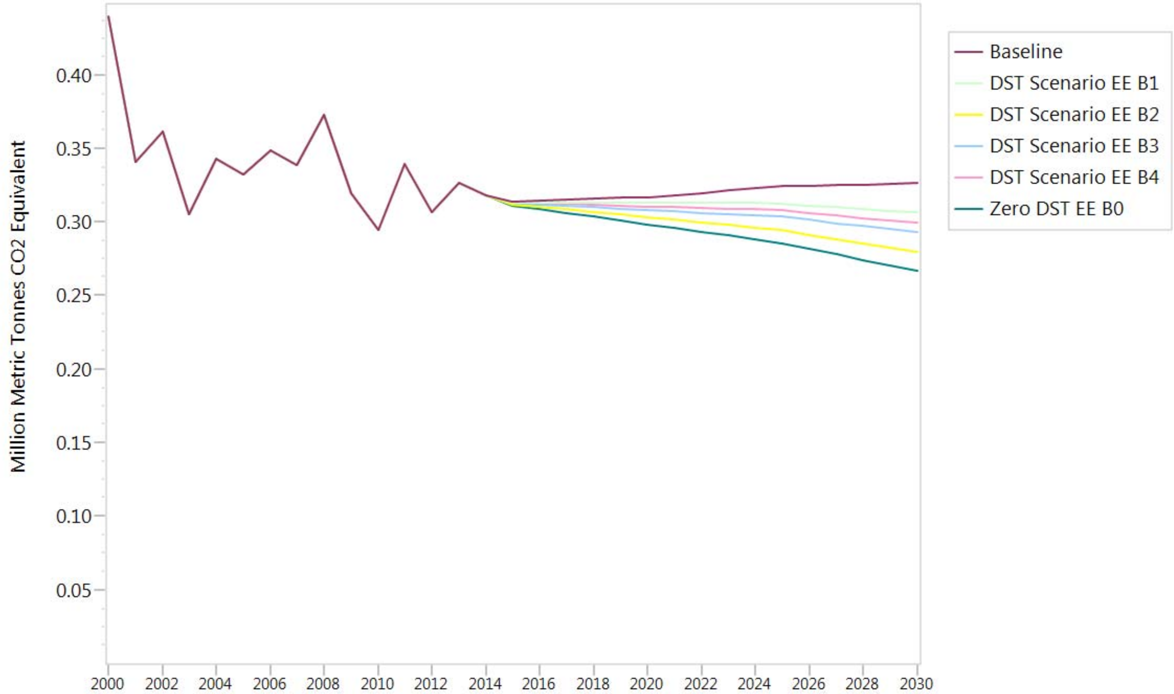

Figure 11 Residential: Reduction of GHGs between Baseline scenario, EE B0 scenario (+ different sub-scenarios under it) and scenario with DST

Tabel 28 GHG Emission Final Units Residential

Units: Million Metric Tonnes CO_2 Equivalent			
Scenarios	**2010**	**2020**	**2030**
Baseline	0.2947	0.3165	0.3262
DST Scenario EE B1	0.2947	0.3127	0.3064
DST Scenario EE B2	0.2947	0.3029	0.2797
DST Scenario EE B3	0.2947	0.3078	0.2931
DST Scenario EE B4	0.2947	0.3102	0.2995
Zero DST EE B0	0.2947	0.2982	0.2668
Total	**1.7682**	**1.8484**	**1.7717**

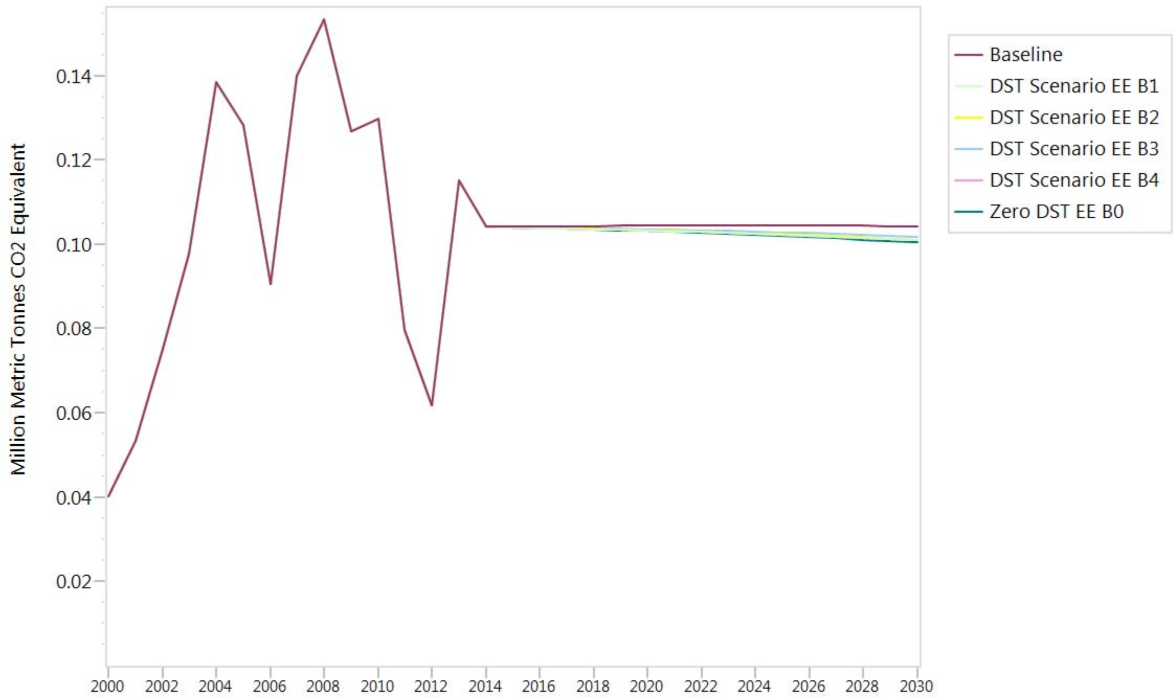

Figure 12 Tertiary: Reduction of GHGs between Baseline scenario, EE B0 scenario (+ different sub-scenarios under it) and scenario with DST

Tabel 29 GHG Emission Final Units Tertiary

Units: Million Metric Tonnes CO_2 Equivalent			
Scenarios	**2010**	**2020**	**2030**
Baseline	0.1298	0.1044	0.1042
DST Scenario EE B1	0.1298	0.1032	0.1008
DST Scenario EE B2	0.1298	0.1033	0.1010
DST Scenario EE B3	0.1298	0.1035	0.1017
DST Scenario EE B4	0.1298	0.1032	0.1008
Zero DST EE B0	0.1298	0.1031	0.1004
Total	**0.7786**	**0.6207**	**0.6090**

Table 30 Comparisons among scenarios for NOx emissions in 1000ton/ Buildings (R+T) sector

Scenarios	**2020**	**2030**
HERON BAU scenario NO_x	**2.07**	**2.08**
HERON EE B0	**1.95**	**1.72**
Reduction compared to HERON BAU	*5.8 %*	*17.3 %*
HERON EE B1	**2.04**	**1.96**

Reduction compared to HERON BAU	*1.45 %*	*5.8 %*
HERON EE B2	**1.98**	**1.78**
Reduction compared to HERON BAU	*4.3 %*	*14 %*
HERON EE B3	**2.00**	**1.88**
Reduction compared to HERON BAU	*3.4 %*	*9.6 %*
HERON EE B4 (EE B4(R) + EE B1(T))	**2.02**	**1.92**
Reduction compared to HERON BAU	*2.4 %*	*7.7 %*

Annex 5 at the end of this report show also the NOx data of the less ambitious, the so called minimally intervening state energy efficiency scenario what was described above.

C. *Third group of* outcomes

Reference year vs. target year

"-" refers to the growth of energy consumption but not decline

Table 31 EE scenario outcomes – total energy savings/capita in 2030

RESIDENTIAL			
	Unit	2020	2030
Population		1329000	1296000
HERON BAU			
Total energy savings (compared to 2014 reference year)	Mtoe	-0.037	-0.064
EE-B0			
Total energy savings (compared to 2014 reference year)	Mtoe	0.033	0.165
Savings vs. BAU	%	4.9 %	15.7 %
Per-capita savings	toe	0.026	0.127
EE-B1			
Total energy savings (compared to 2014 reference year)	Mtoe	-0.017	0.028
Savings vs. BAU	%	1.4 %	6.3%
Per-capita savings	toe	0.019	0.019
EE-B2			
Total energy savings (compared to 2014 reference year)	Mtoe	0.017	0.121
Savings vs. BAU	%	3.8 %	12.7 %
Per-capita savings	toe	0.0105	0.096
EE-B3			
Total energy savings (compared to 2014 reference year)	Mtoe	0	0.076
Savings vs. BAU	%	2.6 %	9.6 %
Per-capita savings	toe	0	0.057

HERON EE B4 (EE B4(R) + EE B1(T))			
Total energy savings (compared to 2014 reference year)	Mtoe	-1.006	0.056
Savings vs. BAU	%	2.1 %	8.2 %
Per-capita savings	toe	0.005	0.04

3.4 KEY FINDINGS

The results showed that the maximum energy efficiency scenario (EE B0) achieves the EU target both in terms of the energy consumption (1.23 Mtoe target exactly achieved) and GHG emissions (0.37 $MtCO_2$ 5 % even lower from the target). The highest impact to the energy efficiency of the residential and tertiary buildings sector will be mainly achieved through the building shell improvement. That is mainly thanks to the policies what assume large scale building renovations (single-family dwellings 40% and multi-family dwellings 58%) to happen. This can also be proved by the EE B2 scenario what has the highest impact in terms of the energy efficiency when barriers under the building shell improvement are to be minimized.

When considering the barriers through the DST tool, the level of energy consumption goes back towards the level of energy consumption in BAU scenario. Yet, energy consumption is still more efficient than within BAU scenario due to the energy efficiency policies what were included within the zero DST energy efficiency scenario. The scenario where barriers which block the building shell improvements (renovation including efficient heating) are to be minimized – is the most effective one in terms of the energy efficiency. Efficient lighting and efficient appliances technologies have rather a marginal impact to the energy efficiency of the buildings sector and therefore even when minimizing the barriers what block the implementation of the policies under these two sub-scenarios, is not that visible.

CHAPTER 4: FORWARD LOOKING SCENARIOS FOR TRANSPORT

4.1. HISTORIC DATA AND TRENDS

Transport energy demand has been growing in Estonia during the last 20 years. The growth in demand has been highly coupled with the economic growth of the country. The main drivers of this growth have been increasing car use, increasing purchasing power, suburbanization, relocation of jobs and services. The fuel economy of the car fleet has not improved as quickly as the European average and Estonian new car sales stand out as one of the least fuel-efficient. Increasing commuting distances have decreased the shares of public transport and walking (Jüssi et al 2010).

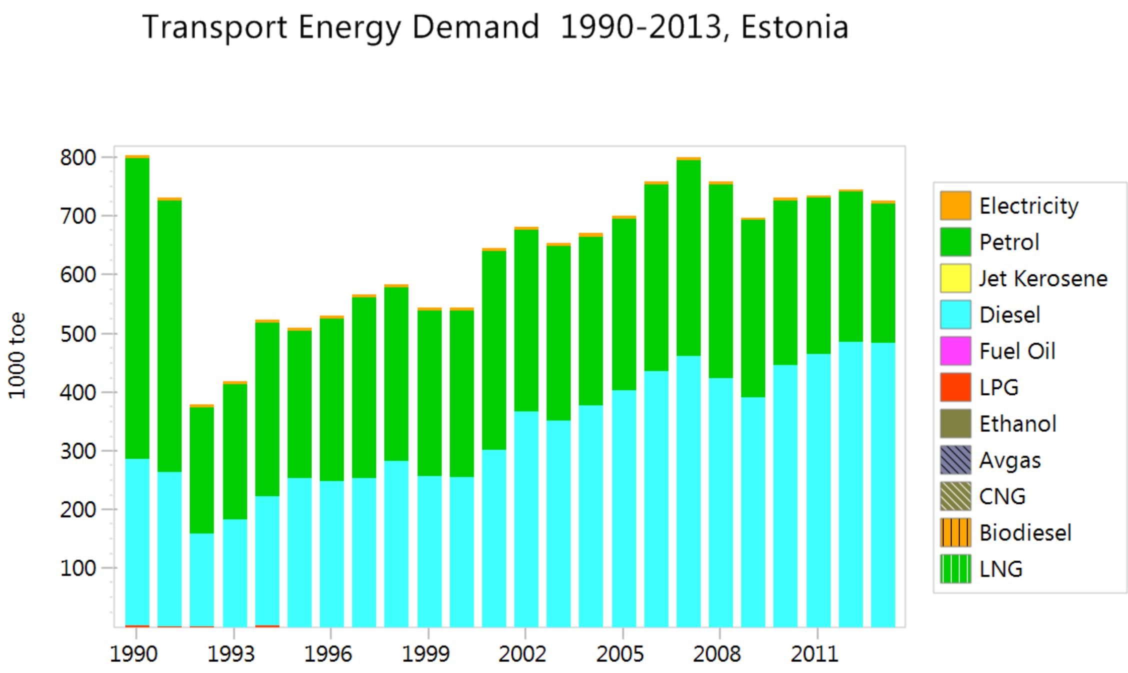

Figure 13 Transport energy demand trends in Estonia 1990-2013, 1000 toe

4.2. BAU SCENARIO UP TO 2030

BAU looks into current possible trends with policy measures already decided or in place

4.2.1. Key assumptions and parameters

Key assumptions in BAU scenario follow the assumptions selected during national climate policy roadmap and national energy strategy preparation processes (Jüssi & Rannala 2014; EKUK 2016).

The Business as usual scenario takes into account the current policies in place that the Estonian government has envisaged until 2020 and the energy efficiency trends of vehicle fleet renewal. As no concrete action plans are in place for 2030 and the current government has declared that no vehicle taxation will be implemented, only a modest trend in fuel efficiency improvement is envisaged. The national and local policies, having an effect on transport energy demand 2010-2020 are the following:

- Reconstruction of railway network and renewal of passenger train fleet, increasing the frequency of rail service
- Electric vehicle support scheme and quick charging network (see Deliverables 1.1-1.4)
- Reconstruction of tram lines and renewal of tram fleet in Tallinn (see D 1.1.-1.4)
- Increasing fuel excise duty 2016-2018
- Supporting the production and take up of bio-methane in transport
- Energy labelling of new cars (2016)

The assumptions used in BAU scenario are described in the following tables.
Passenger transport demand: average 1.17% annual growth rate in per capita passenger-km

Table 32 References for vehicle fuel efficiency assumptions used in BAU and EE scenarios

Technology/ Vehicle type	Unit	2013 values	2020		2030		Source
			Change in fuel cons. % vs 2015	"Ideal" Value	Change in fuel cons. % vs 2015	"Ideal" Value	
Passenger							
Car, diesel, biodiesel	MJ/vkm	2.66		1.97		1.73	2050 values based on Schmied et al 2015, p 25
Car, gasoline, ethanol	MJ/vkm	2.88		1.99		1.74	2050 values based on Schmied et al 2015, p 25
Car, CNG	MJ/vkm	2.88		1.99		1.74	2050 values based on Schmied et al 2015, p 25
Car, electric BEV	MJ/vkm	0.8		0.80		0.70	2050 values based on Schmied et al 2015, p 25
Car, hybrid, PEHV	MJ/vkm	1.44		1.14		1.00	2050 values based on Schmied et al 2015, p 25
Bus, diesel, biodiesel, urban	MJ/vkm	**15.16**	-7%	14.10	-14.80%	12.92	Dünnebeil et al 2015, p 93
Bus, CNG, urban	MJ/vkm		15%	17.42	5%	15.92	Dünnebeil et al 2015, p 93
Bus, hybrid, urban	MJ/vkm		-21%	11.97	-29.50%	10.69	Dünnebeil et al 2015, p 93
Bus, electric, urban	MJ/vkm		-72.1%	4.23	-75.20%	3.76	Dünnebeil et al 2015, p 93

Bus, diesel, biodiesel, interurban	MJ/vkm	**14.7**	-7.00%	13.67	-13%	12.789	2010 value from Schmied et al 2015, p 25
Bus, CNG, interurban	MJ/vkm		10%	16.17	3%	15.141	
Bus, hybrid, interurban	MJ/vkm		-16%	12.35	-23%	11.319	
Freight							
Road							
Road HGV diesel, biodiesel	MJ/vkm						
long haul, 40t	MJ/vkm	**12.4**	-11%	11.04	-21%	9.80	Dünnebeil et al 2015, p 38
natural gas, 40 t	MJ/vkm		7%	13.27	-2%	12.15	Dünnebeil et al 2015, p 38
Electr. Parallel hybrid, long haul40 t	MJ/vkm		-16%	10.42	-24%	9.42	Dünnebeil et al 2015, p 38
regional delivery, 40 t	MJ/vkm	**14.6**	-7%	13.58	-13%	12.70	Dünnebeil et al 2015, p 38
natural gas, regional del 40 t	MJ/vkm		10%	16.06	3%	15.04	Dünnebeil et al 2015, p 38
Electr. Parallel hybrid, regional 40 t	MJ/vkm		-16%	12.26	-23%	11.24	Dünnebeil et al 2015, p 38
Diesel, 12 t, local	MJ/vkm	**7.5**	-7.5%	6.94	-17.4%	6.20	Dünnebeil et al 2015, p 91
CNG, 12 t, local	MJ/vkm		8.6%	8.15	-2.6%	7.31	Dünnebeil et al 2015, p 91
Electr. Parallel hybrid, local, 12 t	MJ/vkm		-14.9%	6.38	-24.8%	5.64	Dünnebeil et al 2015, p 91
Electric, local, 12t	MJ/vkm		-66.6%	2.51	-71.0%	2.18	Dünnebeil et al 2015, p 91

Table 33 Modal shares of transport modes, BAU scenario

Branches	1990	1995	2000	2005	2010	2015	2020	2025	2030
Air	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Water	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Rail	14.4	6.8	3.8	2.5	2.6	3.0	3.0	3.0	3.0
Motorcycles	0.9	0.9	0.9	0.9	0.5	0.5	0.5	0.5	0.5
Buses	20.0	20.0	20.0	20.0	20.0	20.0	17.0	16.0	15.0
Cars	63.7	71.3	74.3	75.6	75.5	75.5	78.5	79.5	80.5

Table 34 Load factors for cars used in BAU scenario (vehicle-km per passenger-km)

Branches	2010	2015	2020	2025	2030
Cars, Load Factor	0.66	0.68	0.69	0.70	0.71

Table 35 Share of fuel efficient vehicle mileage (cars), %, share of vehicle-kms

Fuel Type	2010	2015	2020	2025	2030
BioMethane	0.00	0.00	0.00	1.50	3.00
LPG	0.00	0.00	0.00	0.00	0.00
CNG	0.00	0.46	3.00	4.00	5.00
Electric	0.00	0.25	0.30	0.65	1.00
PH Petrol	0.00	0.00	1.00	3.00	5.00
Hybrid Petrol	0.00	3.00	5.00	10.00	15.00
Biodiesel	0.00	0.00	1.50	1.50	1.50
Diesel	33.00	30.00	30.00	30.00	30.00
Ethanol	0.00	0.00	3.00	3.00	3.00
Petrol	67.00	66.29	56.20	46.35	36.50

Table 36 Fuel and technological split, buses, % share of vehicle-kms, BAU scenario

Branches	2010	2015	2020	2025	2030
BioMethane	0.0	1.3	1.5	3.3	5.0
CNG	0.0	0.5	3.5	4.3	5.0
Electric	1.0	1.0	1.0	1.0	1.0
Hybrid	0.0	0.3	3.0	5.0	7.0
Biodiesel	0.0	2.5	3.0	3.0	3.0
Diesel	99.0	94.5	88.0	83.5	79.0

Table 37 Share of fuel-efficient vehicle mileage, %, share of vehicle-kms (cars, buses)

Branches	2010	2015	2020	2025	2030
Ideal	0	3	5	13	20
Existing	100	97	95	87	80

Freight transport demand: The forecasts for train freight ton-km are varied and depend not directly from the economic activity in Estonia, but geopolitical factors related to Russia. The per capita ton-km average growth is assumed 0.889%/year based on Climate Policy Roadmap BAU scenario (EKUK 2016).

Table 38 Modal shares of freight transport modes, BAU scenario

Branches	2010	2015	2020	2025	2030
Air	0	0	0	0	0
Water	1	1	1	1	1
Rail	54	33	31	30	29
Road	45	66	68	69	70

Table 39 Fuel and technological split of road freight, % share of ton-km, BAU scenario

Branches	2010	2015	2020	2025	2030
BioMethane	0	0	1	2	3
CNG	0	0	1	2	3
Electric	0	0	0	0	1
Hybrid	0	0	0	1	2
Biodiesel	0	0	3	3	3
Diesel	100	100	95	92	90

Table 40 Fuel efficiency shares in road freight, % share of ton-km

Branches	2010	2015	2020	2025	2030
Ideal	0	3	5	10	15
Existing	100	97	95	90	85

4.2.2. Analysis and results of BAU scenario

BAU scenario will continue the growth in energy demand in Estonian transport sector, growing 18% from 2010 until 2030. The growth is derived by increased motorization, higher purchasing power, road freight and slow improvement in fuel efficiency of the vehicles.

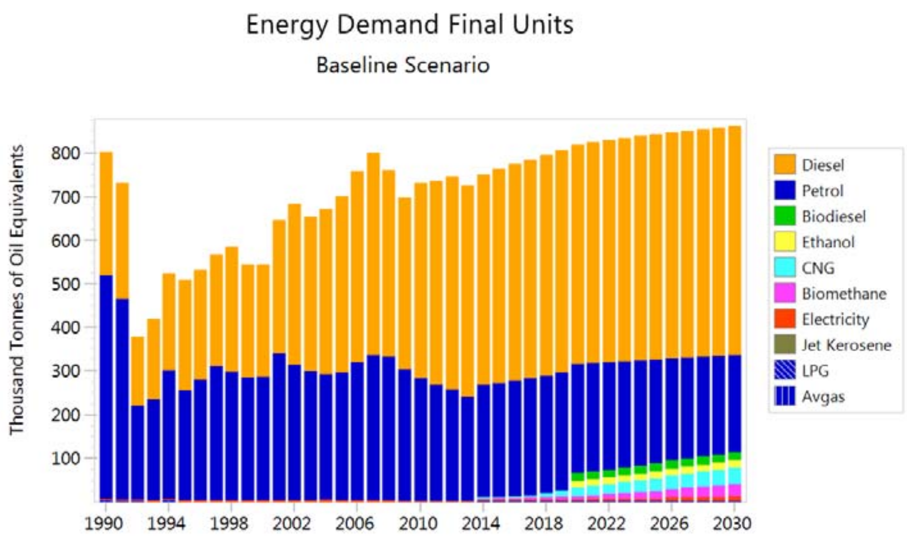

Figure 1. Transport final energy demand until 2030, BAU scenario, 1000 toe

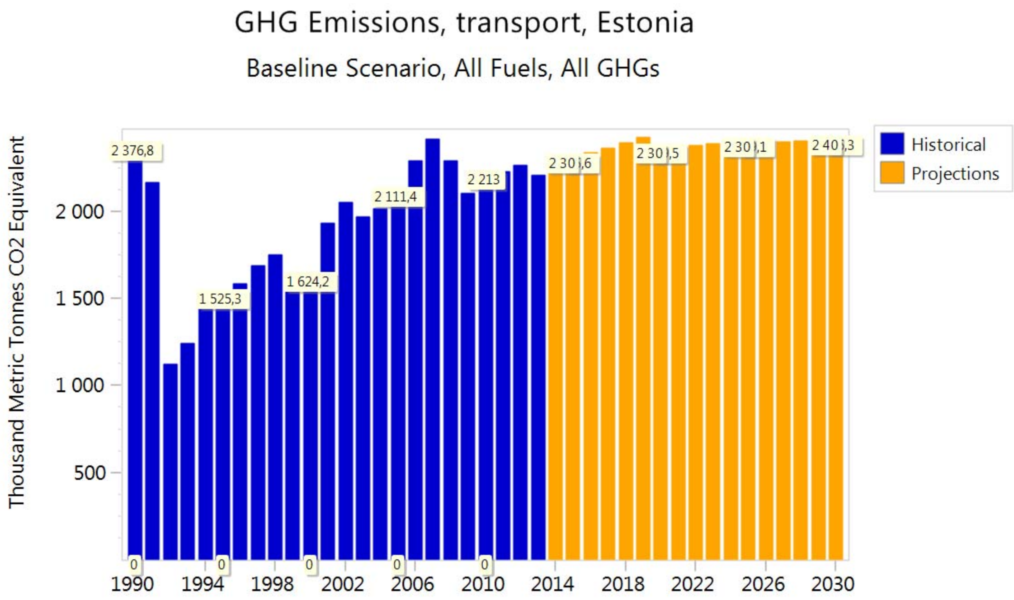

Figure 2. Transport GHG emissions in Estonia until 2030, 1000 t CO_2eqv

4.3. ENERGY EFFICIENCY SCENARIOS UP TO 2030

For the Estonian analyses first five sub-scenarios representing policy areas were modelled based on previous national research in the field. The sub-scenarios are the following:

- Fuel efficient vehicles
- Eco-driving
- Urban Planning
- Passenger Transport Modal Shift
- Freight demand management

These five sub-scenarios combined formed a combined, EE (EE T0) scenario aiming to reach the main policy targets of energy efficiency and GHG emission reductions.

In the second step the EE sub-scenarios were analysed and barriers weighed with the Decision Support tool and new values for assumptions in the LEAP model, forming another set of 4 scenarios:

EE T1 scenario – analysing the impact of barriers on EE combined scenario based on DST outputs to LEAP (no specific barriers minimized).
EE T2-4 scenarios – analysing combination of sub-scenarios with minimized barriers based on DST outputs to LEAP.

4.3.1. Sub-scenarios for transport – key assumptions – proposed policy measures and their respective policy instruments

The assumptions of impacts of policy measures on transport demand, mode choice and fuel efficiency are based on literature review and evidence from previous projects. References are listed in **Error! Reference source not found.**39.

Table 41 References to quantified policy measure impacts used in sub-scenario assumptions

Policy measure	Car	LDV	Bus	HGV	Train	Impact assumption basis
Fuel Efficient/Eco Driving	3%	3%	3%	3%		Jüssi and Poltimäe. 2011. Kommunaalteenustega seotud veokite keskkonnamõju vähendamine Tallinnas. Uuringuaruanne Tallinna Keskkonnaametile. Säästva Eesti Instituut, Tallinn.
Increasing public transport service by 20%	6%		-10%			CENTAR 2008. Uute rongide soetamise tulu-kulu analüüs. Eesti Rakendusuuringute Keskus CentAR OÜ. Tallinn.
Mobility management	1.9%		-1%			Travel plans for companies -1.6%, schools -0.3% (WSP Sweden 2007). Effekter av Mobility Management åtgärder – en analys baserad på internationell litteratur.
CO_2 based car taxation	14%					Based on Finnish climate Policy scenarios and EEA 2010
Freight management, road charging of HGV				3%		EEA TERM-scenarios 2050 (EEA 2010).
Parking management	12%					Whitelegg *et al*. 2010, impact is shown for urban traffic
Urban planning, transport demand management	25%	10%	10%	10%		Impact on urban traffic. Skinner *et al*. 2010. Towards the decarbonisation of EU's transport sector by 2050. Final report produced under the contract ENV.C.3/SER/2008/0053 between European Commission Directorate-General Environment and AEA Technology plc.
Developing cycling and walking	1%					Based on Finnish climate Policy scenarios (LVM 2009).
Redesigning urban streets	10%					Reduces 10% urban car mileage (Cairns *et al*., 1998, ref Whitelegg 2010).

4.3.1.1. EE-T0 scenario for transport

The main assumptions used in EE T0 scenario compared to BAU scenario are described in Tables 40-41.

Table 42. Assumptions of EE-T0 scenarios

Sub-scenarios	Policy assumptions for effects in 2030
Fuel efficient vehicles	Hybrid Petrol share 2.5 times higher than in BAU Plugin Hybrid – 2.5 times higher share than in BAU Petrol, Diesel, CNG, Ethanol, Biodiesel Ideal Share will reach 40% by

	2030 vs 20% in BAU Trucks – share of Hybrid and Electric 2 times higher by 2030
Eco-driving	2.5% better fuel efficiency for petrol and diesel cars, 2.5% for diesel, CNG trucks and buses (Parameter changed under VKM intensity)
Urban Planning	5% lower transport demand compared to BAU: 1.11% growth rate Car load factor unchanged from BAU Rail share increases from 3% to 5% Bus remains 20% Freight demand change reduced by 2%
Passenger Transport Modal Shift	Reallocation of space on major urban streets (reduces 10% car use in urban areas, assumed – 33% traffic evaporation, 33% shift to cycling-walking, 33% shift to PT) Investment into Cycling and Pedestrian Infrastructure – 1% less car use, shifted to walking and cycling Increased Public transport service (rail and bus): 20% increased rail and bus service; 6% less car mileage Parking management in urban areas: -12% of less car use in major urban areas 33% traffic evaporation, 33% shift to cycling-walking, 33% shift to PT Mobility Management: 1.9% less car mileage, 80% shift to PT, 20% walking and cycling All measures combined: Passenger transport demand growth rate: 0.8% compared to BAU 1.17%.
Freight demand management	Includes introduction of distance-based HGV charging system in Estonia - 3% less ton-km 2020 onwards - Share of rail does not drop 2020 onwards and remains 31%

Table 43 Modal shares in combined EE-T0 scenario

Branches	**2010**	**2015**	**2020**	**2025**	**2030**
Air	0.3	0.3	0.3	0.3	0.3
Water	0.7	0.7	0.7	0.7	0.7
Rail	2.6	2.5	4.0	5.5	7.0
Motorcycles	0.9	0.5	0.5	0.5	0.5
Buses	20.0	20.0	20.0	19.3	18.5
Cars	75.5	76.0	74.5	73.8	73.0

After building the EE sub-scenarios a combined EE T0 scenario was formed in LEAP. As a next step the policy assumptions were analysed with the DST tool, where the barriers are weighed and the impact of barriers to policy targets and assumptions assessed. The DST outcomes of weighing the barriers based on analytical hierarchy method are shown in Annex 10. The input values for DST for calculating the impact of barriers are shown in Table 42. As the transport model structure in LEAP requires input across all different sub-sectors (passenger, rail, car, bus, lorries etc) and different fuel technologies, involving tens or hundreds of figures to be inserted, a factor approach was applied and the DST outcome was used as reduction factor for certain technology and policy assumptions.

Table 44 Assumptions of EE-T0 scenario used in the DST tool (input values)

Sub-scenarios	Policy assumptions until 2030	Policy Instruments
TMODE: Modal shift	Passengers: Bus share: 18,5% Rail share: 7% 25,5% vs BAU 18% 2,17% difference with BAU for car share 5% lower travel demand by 2030 3% less freight demand Rail share 30%	Integrated zoning and priority to rail-based, multifunctional, walkable developments; maximum parking standards Investment into public transport service quality, developing interoperability of different modes, road redesign to give priority to PT and walking and cycling. Revising employee benefits related to mobility to encourage PT use, walking and cycling. Investment into cycling infrastructure, traffic calming, walking. Cycle to work schemes. Road pricing for HGV-s, developing rail and intermodality
TEFF: Fuel efficient vehicles	Ideal tech share by 2030 15-40% depending on subcategory (using factor 1 in DST)	CO_2 based vehicle taxation (annual, registration) and/or road charging system; Differentiated taxation system for company cars based on CO_2 Road pricing for HGV-s, developing rail and intermodality
TDRIVE: Eco-Driving and Speed limits	2,5 % energy saving per vehicle-km and ton-km across all road transport modes	Training, awareness raising, traffic calming, reduced speed limits, speed limit enforcement
Electric, Hybrid and Plugin vehicles	Passenger cars Hybrid Petrol vehicles 30% in 2030 Plugin Hybrid vehicles 15% in 2030 Electric vehicles 3% in 2030 **Buses** Hybrid vehicles 30% in 2030 Electric vehicles 5% in 2030 **Freight** Hybrid 5% Electric vehicles 1,75% in 2030 Using factor 1 in DST tool	CO_2 based vehicle taxation (annual, registration) and/or road charging system; Differentiated taxation system for company cars based on CO_2 Road pricing
Biofuels	Biodiesel, bioethanol and Biomethane, 3%-7% share in 2030, using factor 1	Blending obligation, investment into CNG and biomethane infrastructure

4.3.1.2 EE-T1- EE-T4 scenarios for transport

As a next step the assumptions of EE T0 were inserted into the DST tool to find the total impact of existing barriers – forming scenario EE T1 (Table 45). In order to analyse the impact of minimization of barriers three additional scenarios were built with DST output values, involving a combination of three sub-scenarios (see Tables 46-48). The parameters that were not changed in the different combination of sub-scenarios kept the values of EE T1 DST outputs.

Table 45 EE-T1 scenario assumptions used in the DST tool and outputs to LEAP

Sub-scenarios	Policy assumptions until 2030	DST outcome (after considering impact of barriers)	Policy Instruments
TMODE: Modal shift	Passengers: Bus share: 18,5% Rail share: 7% Public transport share 25,5% vs BAU 18% 2,17% difference with BAU for car share 5% lower travel demand by 2030 3% less freight demand Rail share 31%	Passengers: Bus share: 18 Rail share: 4% Public transport share 22,1% 1,187% difference with BAU for car share 2,5% lower travel demand by 2030 1,61% less freight demand Rail share 30%	Integrated zoning and priority to rail-based, multifunctional, walkable developments; maximum parking standards Investment into public transport service quality, developing interoperability of different modes, road redesign to give priority to PT and walking and cycling. Revising employee benefits related to mobility to encourage PT use, walking and cycling. Investment into cycling infrastructure, traffic calming, walking. Cycle to work schemes. Road pricing for HGV-s, developing rail and intermodality
TEFF: Fuel efficient vehicles	Ideal tech share by 2030 15-40% depending on subcategory (using factor 1 in DST)	Reduction factor 0,958	CO_2 based vehicle taxation (annual, registration) and/or road charging system; Differentiated taxation system for company cars based on CO_2
			Road pricing for HGV-s, developing rail and intermodality
TDRIVE: Eco-Driving and Speed limits	2,5 % energy saving per vehicle-km and ton-km across all road transport modes	2,485% energy saving per vehicle-km and ton-km across all road transport modes	Training, awareness raising, traffic calming, reduced speed limits, speed limit enforcement

Electric, Hybrid and Plugin vehicles	Passenger cars Hybrid Petrol vehicles 30% in 2030 Plugin Hybrid vehicles 15% in 2030 Electric vehicles 3% in 2030 **Buses** Hybrid vehicles 30% in 2030 Electric vehicles 5% in 2030 **Freight** Hybrid 5% Electric vehicles 1,75% in 2030 Using factor 1 in DST tool	Reduction factor 0,687	CO_2 based vehicle taxation (annual, registration) and/or road charging system; Differentiated taxation system for company cars based on CO_2 Road pricing
Biofuels	Biodiesel, bioethanol and Biomethane, 3%-7% share in 2030, using factor 1 in DST tool	Reduction factor 0,991	Blending obligation, investment into CNG and biomethane infrastructure

Table 46 EE-T2 scenario assumptions used in the DST tool and outputs to LEAP

Sub-scenarios	Policy assumptions until 2030	DST outcome (after considering impact of barriers)	Minimized barrier(s)	Policy instrument(s) that focus on addressing barriers so as to be minimized and allow the achievement of the policy target
TMODE: Modal shift	Passengers: Bus share: 18,5% Rail share: 7% Public transport share 25,5% vs BAU 18% 2,17% difference with BAU for car share 5% lower travel demand by 2030 3% less freight demand Rail share 31%	Not in best combination	-	Integrated zoning and priority to rail-based, multifunctional, walkable developments; maximum parking standards Investment into public transport service quality, developing interoperability of different modes, road redesign to give priority to PT and walking and cycling. Revising employee benefits related to mobility to encourage PT use, walking and cycling. Investment into cycling infrastructure, traffic calming, walking. Cycle to work schemes. Road pricing for HGV-s, developing rail and intermodality
TEFF: Fuel efficient vehicles	Ideal tech share by 2030 15-40% depending on subcategory (using factor 1 in DST)	Reduction factor: 2020 0,961 2030 0,966	I3. Problems with infrastructure / public transport services Ed4. Lack of certified and experience staff	Road pricing for HGV-s, developing rail and intermodality CO_2 based vehicle taxation (annual, registration) and/or road charging system; Differentiated taxation system for company cars based on CO_2

			C2. Habit / social norm of driving - car ownership & use C1. Car - symbol status & group influence	
TDRIVE: Eco-Driving and Speed limits	2,5 % energy saving per vehicle-km and ton-km across all road transport modes	Not changed		Training, awareness raising, traffic calming, reduced speed limits, speed limit enforcement
Electric, Hybrid and Plugin vehicles	Passenger cars Hybrid Petrol vehicles 30% in 2030 Plugin Hybrid vehicles 15% in 2030 Electric vehicles 3% in 2030 **Buses** Hybrid vehicles 30% in 2030 Electric vehicles 5% in 2030 **Freight** Hybrid 5% Electric vehicles 1,75% in 2030 Using factor 1 in DST tool	Not changed		CO_2 based vehicle taxation (annual, registration) and/or road charging system; Differentiated taxation system for company cars based on CO_2 Road pricing
Biofuels	Biodiesel, bioethanol and Biomethane, 3%-7% share in 2030, using factor 1 in DST tool	Not used		Blending obligation, investment into CNG and biomethane infrastructure, supporting biomethane production.

Table 47 EE-T3 scenario assumptions used in the DST tool and outputs to LEAP

Sub-scenarios	Policy assumptions until 2030	DST outcome (after considering impact of barriers)	Minimized barrier(s)	Policy instrument(s) that focus on addressing barriers so as to be minimized and allow the achievement of the policy target

TMODE: Modal shift	Passengers: Bus share: 18,5% Rail share: 7% Public transport share 25,5% vs BAU 18% 2,17% difference with BAU for car share 5% lower travel demand by 2030 3% less freight demand Rail share 31%	Change in PT compared to BAU 2020 +4,383% 22,383 2030 +4,829% 22,829 Passenger shares: Bus 2020 18,383 2030 18,5 Rail 2020 2% Rail 2030 4,329% Lower travel demand 2020 2,922 2030 3,219 Lower Freight demand 2020 1,753%; 2030 1,931% Rail share 30,5%	I3. Problems with infrastructure / public transport services C3. Cycling is marginalized I1. Lack of integrated governance / entities - fragmentation / bureaucracy I7. Contradicting policy goals Ec6. Negative role of Investment schemes / employee benefits S1. Low satisfaction / lack of trust for public transport Ec2. Limited infrastructure investment for public transport Available technologies that benefit from minimization: Efficient Vehicles	Integrated zoning and priority to rail-based, multifunctional, walkable developments; maximum parking standards Investment into public transport service quality, developing interoperability of different modes, road redesign to give priority to PT and walking and cycling. Revising employee benefits related to mobility to encourage PT use, walking and cycling. Investment into cycling infrastructure, traffic calming, walking. Cycle to work schemes. Road pricing for HGV-s, developing rail and intermodality
TEFF: Fuel efficient vehicles	Ideal tech share by 2030 15-40% depending on subcategory (using factor 1 in DST)	2020 0,966 2030 0,967		Road pricing for HGV-s, developing rail and intermodality CO_2 based vehicle taxation (annual, registration) and/or road charging system; Differentiated taxation system for company cars based on CO_2
TDRIVE: Eco-Driving and Speed limits	2,5 % energy saving per vehicle-km and ton-km across all road transport modes		Not changed	Training, awareness raising, traffic calming, reduced speed limits, speed limit enforcement

Electric, Hybrid and Plugin vehicles	Passenger cars Hybrid Petrol vehicles 30% in 2030 Plugin Hybrid vehicles 15% in 2030 Electric vehicles 3% in 2030 **Buses** Hybrid vehicles 30% in 2030 Electric vehicles 5% in 2030 **Freight** Hybrid 5% Electric vehicles 1,75% in 2030 Using factor 1 in DST tool		Not used	CO_2 based vehicle taxation (annual, registration) and/or road charging system; Differentiated taxation system for company cars based on CO_2 Road pricing
Biofuels	Biodiesel, bioethanol and Biomethane, 3%-7% share in 2030, using factor 1 in DST tool		Not used	Blending obligation, investment into CNG and biomethane infrastructure

Table 48 EE-T4 scenario assumptions used in the DST tool and outputs to LEAP

Sub-scenarios	Policy assumptions until 2030	DST outcome (after considering impact of barriers)	Minimized barrier(s)	Policy instrument(s) that focus on addressing barriers so as to be minimized and allow the achievement of the policy target
TMODE: Modal shift	Passengers: Bus share: 18,5% Rail share: 7% Public transport share 25,5% vs BAU 18% 2,17% difference with BAU for car share 5% lower travel demand by 2030 3% less freight demand Rail share 31%		Not used	Integrated zoning and priority to rail-based, multifunctional, walkable developments; maximum parking standards Investment into public transport service quality, developing interoperability of different modes, road redesign to give priority to PT and walking and cycling. Revising employee benefits related to mobility to encourage PT use, walking and cycling. Investment into cycling infrastructure, traffic calming, walking. Cycle to work schemes. Road pricing for HGV-s, developing rail and intermodality

TEFF: Fuel efficient vehicles	Ideal tech share by 2030 15-40% depending on subcategory (using factor 1 in DST)		Not changed	Road pricing for HGV-s, developing rail and intermodality CO_2 based vehicle taxation (annual, registration) and/or road charging system; Differentiated taxation system for company cars based on CO_2
TDRIVE: Eco-Driving and Speed limits	2,5 % energy saving per vehicle-km and ton-km across all road transport modes		Not used	Training, awareness raising, traffic calming, reduced speed limits, speed limit enforcement
Electric, Hybrid and Plugin vehicles	Passenger cars Hybrid Petrol vehicles 30% in 2030 Plugin Hybrid vehicles 15% in 2030 Electric vehicles 3% in 2030 **Buses** Hybrid vehicles 30% in 2030 Electric vehicles 5% in 2030 **Freight** Hybrid 5% Electric vehicles 1,75% in 2030 Using factor 1 in DST tool	Reduction factor: 2020 0,708 2030 0,750	I1. Lack of integrated governance / entities - fragmentation / bureaucracy Ec1. Lack or limited finance / incentives	CO_2 based vehicle taxation (annual, registration) and/or road charging system; Differentiated taxation system for company cars based on CO_2 Road pricing
Biofuels	Biodiesel, bioethanol and Biomethane, 3%-7% share in 2030, using factor 1 in DST tool	Reduction factor: 2020 0,992 2030 0,993 Minimized barrier S2. Concerns on reliability / Hesitation to trust new technologies S3. Socio - economic status of users Ed1. Lack of knowledge / information on EE transport	Not used	Blending obligation, investment into CNG and biomethane infrastructure

Table 49 Summary of technology shares in all scenarios

	BAU	EE T0	EE T1	EE T2	EE T3	EE T4
Electric and hybrid vehicles						
(Passenger) Share of Hybrid Petrol vehicles by 2030	**15**	**30%**	**20,6**	**20,6**	**20,6**	**22,5**
(Passenger) Share of Plugin Hybrid vehicles by 2030	**5**	**15%**	**10,3**	**10,3**	**10,3**	**11,3**
(Passenger) Share of EVs by 2030	**1**	**3%**	**2,1**	**2,1**	**2,1**	**2,3**
(Buses) Share of hybrid vehicles by 2030	**7**	**30%**	**20,6**	**20,6**	**20,6**	**22,5**
(Buses) Share of electric vehicles by 2030	**1**	**5%**	**3,4**	**3,4**	**3,4**	**3,8**
(Freight) share of hybrid vehicles by 2030	**2**	**5%**	**3,4**	**3,4**	**3,4**	**3,8**
(Freight) share of electric vehicles by 2030	**0,5**	**1,75%**	**0,86**	**0,86**	**0,86**	**0,94**
Eco-driving (energy savings per vehicle-km and ton-km across all road transport modes)	**-**	**2,5%**	**2,485%**	**2,494**	**2,485%**	**2,485%**
Modal shift (shift from road to rail by 2030)						
(Passenger) Bus share	**15**	**18,5%**	**18%**	**18%**	**18,5**	**18%**
(Passenger) Rail share	**3**	**7%**	**4%**	**4%**	**4,3%**	**4%**
Use of biofuels						
penetration of biodiesel, bioethanol and biomethane in 2030	**7**	**7,5%**	7,4%	7,45%	7,45%	7,5
More efficient vehicles (share in 2030)	**20**	**40%**	**38,32**	**38,64**	**38,68**	**38,32**

4.3.2. Analysis and results of EE scenario compared to BAU scenario and policy targets

The EE scenario with combined 5 sub-scenarios reduces transport energy consumption by 7.3% by 2030 compared to 2010. As to the national and EU energy efficiency targets for Estonia Heron Transport EE-T0 scenario almost delivers the national energy efficiency target by 2020, and reduces transport energy demand to a level of 13% below the EU 2030 target. The highest share of this energy efficiency gains is delivered by policies encouraging the take-up of fuel efficient vehicles including electric vehicles and hybrids, second managing the demand for personal mobility through integrated urban planning, third managing the demand of freight transport, fourth, encouraging the modal shift in passenger transport and third by eco-driving (see Figure 14 and Table 45).

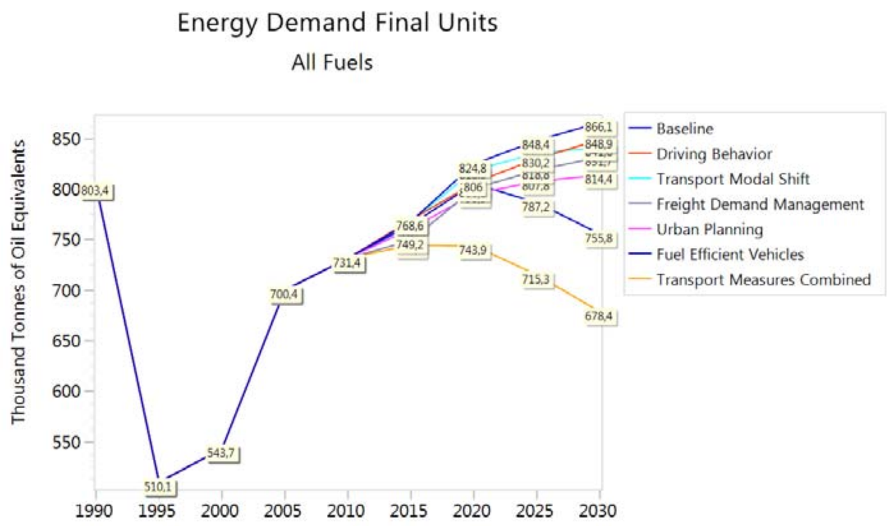

Figure 14 Final energy demand of BAU, EE scenarios and sub-scenarios, 1000 toe

Table 50 Transport Final Energy Consumption in BAU, EE scenarios, ktoe

Scenarios	2010	2015	2020	2025	2030
Baseline	731.4	768.6	824.8	848.4	866.1
Driving Behaviour	731.4	769.4	806.0	830.2	848.9
Freight Demand Management	731.4	749.2	800.5	818.8	831.7
Fuel Efficient Vehicles	731.4	765.4	805.8	787.2	755.8
Transport Modal Shift	731.4	767.9	818.9	835.8	841.6
Urban Planning	731.4	761.0	795.9	807.8	814.4
EE Scenario	731.4	744.9	743.9	715.3	678.4

As the GHG emissions are directly linked to the energy consumption, similar conclusions can be drawn in the trends of GHG emissions across the EE sub-scenarios. Compared to the EU non-ETS targets for 2020 and 2030 the transport sector with five EE T-0 measures combined would meet the 2020 targets (-10% lower than target) and closely meets the 2030 targets (-0,1% lower than target), the emissions of BAU scenario would exceed the non-ETS target with 29.5% higher emissions. (See Figure 15 and Table 46)

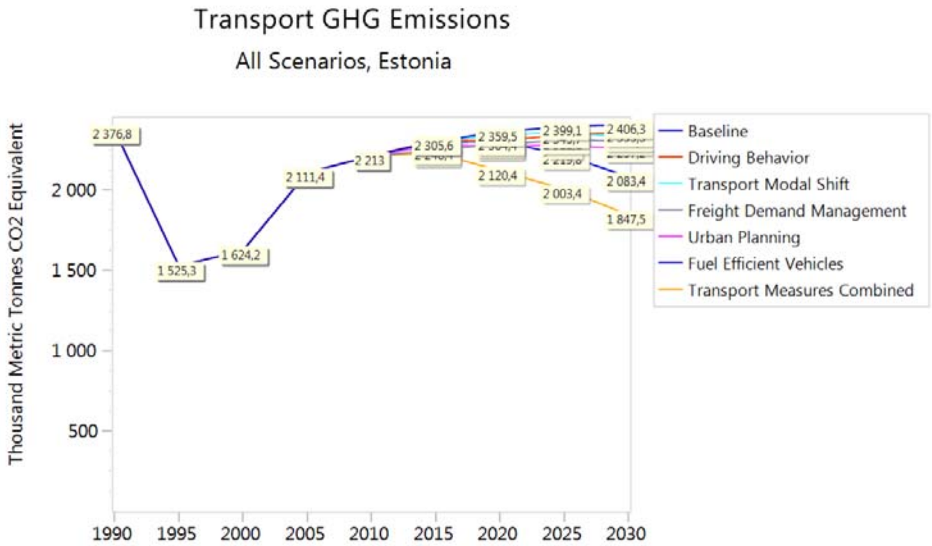

Figure 15 Transport GHG emissions until 2030, BAU and EE scenarios, 1000 t CO_2eq

Table 51 Transport GHG emissions, 1000 t CO_2eq, Estonia, BAU and EE scenarios

Scenarios	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Baseline	2 376.8	1 525.3	1 624.2	2 111.4	2 213.0	2 305.6	2 359.5	2 399.1	2 406.3
Driving Behaviour	2 376.8	1 525.3	1 624.2	2 111.4	2 213.0	2 308.2	2 304.4	2 345.7	2 355.3
Freight DemandMan	2 376.8	1 525.3	1 624.2	2 111.4	2 213.0	2 248.4	2 287.9	2 312.1	2 304.8
Fuel Efficient Vehicles	2 376.8	1 525.3	1 624.2	2 111.4	2 213.0	2 297.8	2 303.7	2 219.8	2 083.4
Transport Measures Comb	2 376.8	1 525.3	1 624.2	2 111.4	2 213.0	2 235.1	2 120.4	2 003.4	1 847.5
Transport Modal Shift	2 376.8	1 525.3	1 624.2	2 111.4	2 213.0	2 303.4	2 340.8	2 359.5	2 326.5
Urban Planning	2 376.8	1 525.3	1 624.2	2 111.4	2 213.0	2 280.4	2 274.3	2 281.0	2 257.2

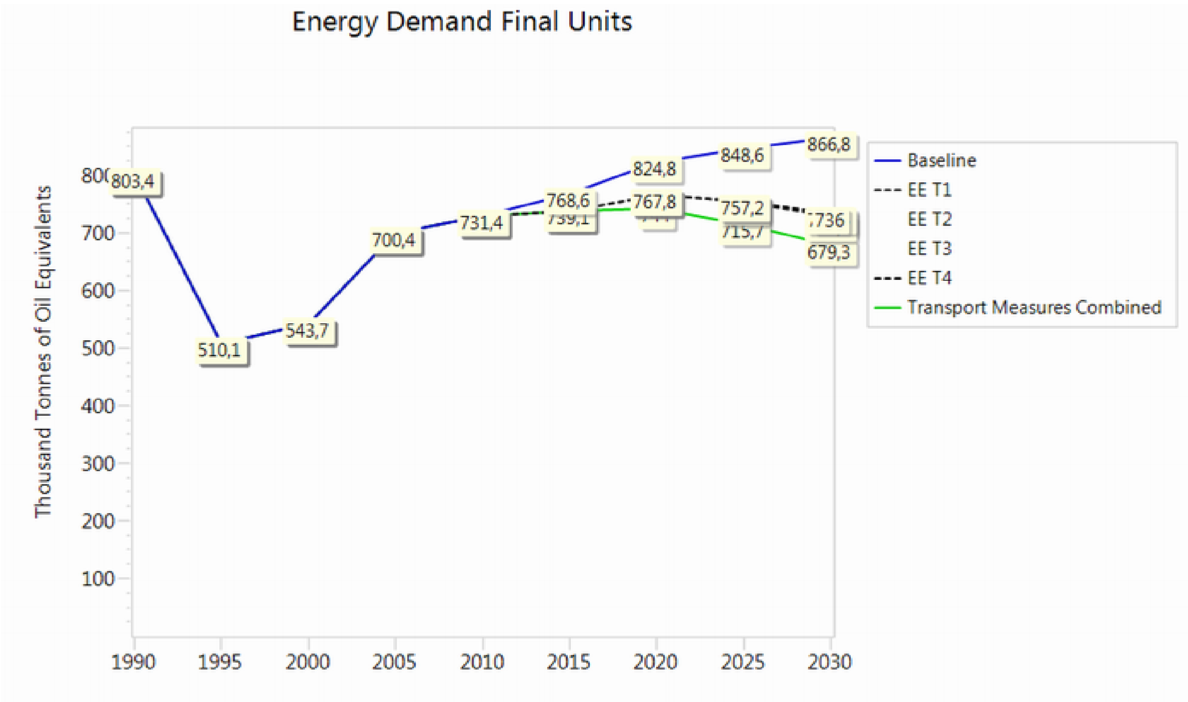

Figure 16 Final energy demand of BAU, EE scenario and DST outcomes (EE T1-T4), 1000 toe

A. First group of outcomes

Table 47 draws together the energy efficiency targets and scenario outcomes of all the analysed scenarios. As to the national and EU energy efficiency targets for Estonia Heron Transport EE-T0 scenario almost delivers the national energy efficiency target by 2020, and exceeds the EU target 2030 by 15,4%. EE T1 scenario showed that with all barriers in place the EE-T0 scenario energy efficiency improvements are not delivered and the energy demand will be 8% higher than the EU target. While combining the scenarios with least barriers and minimizing the barriers, the DST tool showed that energy efficiency gains with more fuel-efficient vehicles and Eco-Driving have least barriers and the scenario of modal shift in passenger transport and electric vehicles have barriers with highest impact for reaching the energy efficiency gains and GHG reduction targets.

Table 52 Comparisons among scenarios for final energy consumption (or energy savings) in Mtoe

	1990	**2005**	**2010**	**2020**		**2030**
EU and National Policy targets and	803.370	700.43	731.36	National Target 2020 **745.46**		**<745.5**
EU BAU PRIMES baseline scenario target, 2007 for transport				-		801.5
HERON BAU scenario				824.80		866.14
% change compared to EU BAU baseline scenario 2007						8
HERON EE B0 (without running DST)				748.00		678.40
% change compared to EU BAU baseline scenario 2007						-15.4
% change compared to HERON BAU scenario				**-9.31**	%	-21.7

HERON EE – T1 (first combination)	767.84	ktoe	736.030
% change compared to EU BAU baseline scenario 2007		%	-8.2
% change compared to HERON BAU scenario	-6.91	%	-15.0
HERON EE – T2 (second combination)	767.69	ktoe	735.5
% change compared to EU BAU baseline scenario 2007		**%**	-8.2
% change compared to HERON BAU scenario	-6.92	**%**	-15.1
HERON EE – T3 (third combination)	767.32	ktoe	722.93
% change compared to EU BAU baseline scenario 2007		**%**	-9.8
% change compared to HERON BAU scenario	-6.97	**%**	-16.5
HERON EE – T4 (fourth combination)	766.71	ktoe	730.57
% change compared to EU BAU baseline scenario 2007		**%**	-8.8
% change compared to HERON BAU scenario	-7.04	**%**	-15.7

B. Second group of outcomes

Compared to the EU non-ETS targets for 2020 and 2030 the transport sector would meet the 2020 targets (-10% lower than target) and very closely meets the 2030 target (0.1 % lower than target).

Table 53 Reductions of direct emissions – GHG in 1000 tCO_2

	1990 (historical)	**2005 (historical)**	**2020**	**2030**
EU Policy targets and nationals if applicable	2376.776	2111.416	2 372.000	1872.24
HERON BAU scenario			2372.974	2 425.399
% difference compared to non-ETS target			0.04	29.55
HERON EE T0 (without using DST)			2 135.567	1 871.239
% difference compared to non-ETS			-9.97	-0.1
HERON EE T1 (first combination)			2209.027	2 049.038
% difference compared to non-ETS			-6.871	9.4
HERON EE T2 (second combination)			2208.186	2 047.109
% difference compared to non-ETS			-6.906	9.3
HERON EE T3 (third combination)			2210.630	2 011.243
% difference compared to non-ETS			-6.803	7.4
HERON EE T4 (fourth combination)			2205.692	2 032.334
% difference compared to non-ETS			-7.011	8.6

Table 49 shows the NOx emissions of all the LEAP scenarios. As there are no sector specific NOx targets they were compared to the HERON BAU scenario (that also has lower emissions than 2010 and 2020). All scenarios deliver lower NOx emissions than currently emitted in the transport sector. EE T-0 scenario that is not considering barriers has more than 35% lower emissions compared to Heron BAU, the EE T1 scenario has 22.3% less emissions compared to BAU, the scenarios with selected combinations and minimized barriers have only minor differences compared to EE T1.

Table 54 Comparisons among scenarios for NOx emissions, 1000ton

Scenarios	2020	2030
HERON BAU scenario NO_x	9.999	7.103
HERON EE T0 (without using DST)	8.471	4.602
Reduction compared to HERON BAU 2030	-15.3	-35.2
HERON EE T1 (first combination)	8.70	5.52
Reduction compared to HERON BAU 2030	-13.0	-22.3
HERON EE T2 (second combination)	8.694	5.516
Reduction compared to HERON BAU 2030. %	-13.1	-22.3
HERON EE T3 (third combination)	8.690	5.422
Reduction compared to HERON BAU 2030. %	-13.1	-23.7
HERON EE T4 (fourth combination)	8.683	5.479
Reduction compared to HERON BAU 2030. %	-13.2	-22.9

D. Third group of outcomes

The total per capita energy savings of HERON EE T0-T4 scenarios compared to HERON BAU in 2020 and 2030 are shown in Table 50. All scenarios deliver lower emissions compared to HERON BAU scenario while the EE T3 reaches highest reduction by 2030 across the scenarios developed with DST. However, the differences between scenarios developed with DST remain marginal.

Table 55 EE T0-T4 scenario outcomes –total energy savings/capita (toe and %) compared to HERON BAU

	2020	2030
EE T0	0.058	0.145
	-9.31	-21.68
EE T1	0.043	0.100
	-6.91	-15.02
EE T2	0.043	0.101
	-6.92	-15.08
EE T3	0.043	0.110
	-6.97	-16.53

EE T4	0.044	0.105
	-7.04	-15.65

4.4. KEY FINDINGS

Transport energy demand has been growing in Estonia during the last 20 years. The growth in demand has been highly coupled with the economic growth of the country and its main drivers have been increasing car use, increasing purchasing power, suburbanization, relocation of jobs and services. The fuel economy of the car fleet has not improved as quickly as the European average and Estonian new car sales stand out as one of the least fuel-efficient. Urban sprawl, increasing commuting distances and relocation of jobs have contributed to decreased shares of public transport and walking.

The BAU scenario (representing current policies in place) projects a further growth in energy demand in the Estonian transport sector, growing by 18% from 2010 until 2030, failing to deliver the national and EU policy targets, the emissions of BAU scenario would exceed the non-ETS target with 29.5% higher emissions. The growth is driven by increased motorization, higher purchasing power, road freight and only slow improvement in fuel efficiency of the vehicles.

While applying the EE scenario, transport energy consumption will be reduced by 7.3% by 2030 compared to 2010, and the national and EU targets are reached. The highest share of this energy efficiency gains is delivered by policies encouraging the take-up of fuel efficient vehicles, including electric and hybrid vehicles. The second priority should be given to managing the demand for personal mobility through integrated urban planning, the third priority to managing the demand of freight transport and the fourth priority - by encouraging the modal shift in passenger transport and the fifth priority should be given to eco-driving. As to the national and EU energy efficiency targets for Estonia Heron Transport EE-T0 scenario almost delivers the national energy efficiency target by 2020, and reduces transport energy demand to a level of 13% below the EU 2030 target.

Compared to the EU non-ETS targets for 2020 and 2030 the transport sector with five EE T-0 sub-scenarios combined would meet the 2020 targets (-10% lower than target) and closely meets the 2030 targets (-0.1% lower than target).

Analysing the EE scenario with DST tool showed that with all barriers in place the EE-T0 scenario energy efficiency improvements are not delivered and the energy demand will be 8% higher than the EU target. While combining the scenarios with least barriers and minimizing the barriers, the DST tool showed that energy efficiency gains with more fuel-efficient vehicles and Eco-Driving have least barriers and the scenarios of modal shift in passenger transport and electric vehicles have barriers with highest impact for reaching the energy efficiency gains and GHG reduction targets.

CONCLUSIONS

In this project, scenarios for the buildings sector were modelled for the years of 2015 (last available historical data was 2014) to 2030. Within the buildings sector, the energy consumption under the BAU scenario is already controlled rather well. This is thanks to the regulations, which are already in force for all the new buildings to be built, such the Minimum Energy Performance Requirements of Buildings; 2) and the Energy Performance of Buildings Directive 2010/31 / EU, according to what all the new residential buildings to be built, must comply with the nearly zero-energy performance requirements from 2021 onward. In this project, the new building stock was divided such as buildings to be built between 2015-2025 and the new buildings to be built between 2025-2030. 5 years was assumed in this project, to be more likely the period in which a more considerable amount of properly functioning nearly zero-energy buildings exist in the new building stock.

Buildings sector

In case the energy consumption would continue under the regulations currently set into force (BAU scenario), 19 % of energy consumption in the buildings sector (residential + tertiary) needs to be reduced in order to be able to achieve the EU energy efficiency target by 2030 (1.23 Mtoe). **The top three barriers**, rated in this project, which impede the energy efficiency of the buildings sector in Estonia are 1) lack of any type of financial support; 2) High costs and risks; and 3) Misleading prices (energy/fuel/tariffs). **Additional policy measures and technologies** must be adopted in order to reduce the impact of these barriers and to achieve the EU energy efficiency target. The EU energy efficiency target would be mainly achieved (both in terms of energy efficiency and GHG emissions) if the government decides to implement large scale buildings renovations. This would assume 40% of single family homes, 50% of multi-family homes and 20% of tertiary buildings stock to be renovated within the next 20 years. Other measures, such as improvement of land usage and land use planning, the development of relevant regulatory environment and the public sector pilot projects would as well enhance the step towards more energy efficient building sector. In terms of the **policy implications**, those large scale building renovations would mean at least 35% of reconstruction allowance from the government per each building type to be given out. This would however.

Transport sector

In the Estonian transport sector current policies and measures are not sufficient for reaching the EU greenhouse gas and energy demand reduction targets. With a mixture of existing and additional policy measures and minimizing the barriers it is possible to reach both energy efficiency and GHG reduction targets in the transport sector. The highest share of energy efficiency gains is delivered by policies encouraging the take-up of fuel efficient technologies, including more efficient conventional vehicles, electric and hybrid vehicles. **The highest barriers** and related policies are lack of limited finance and fiscal incentives, the negative role of current investment schemes that prioritize new investment into car based solutions, perverse incentives related to employee benefits related to car use, limited infrastructure investment for public transport and lack of integrated governance in the field of transport, mobility and urban planning in Estonia. While combining the scenarios with least barriers and minimizing the barriers, the DST tool showed that energy efficiency gains with more fuel efficient vehicle technologies and Eco-Driving have least barriers and the scenario of modal shift in passenger transport and electric vehicles have barriers with highest impact for reaching the energy efficiency gains and GHG reduction targets. The latter which is then the most efficient **technology combination** (policy measure which should be taken) with regards to the energy efficiency. Regarding **policy implications**, this would imply first carefully planned fiscal incentives like CO_2 based car registration and annual circulation taxes. The second priority should be given to managing the demand for personal mobility through integrated urban planning, the third priority to managing the demand of freight transport and the fourth priority - by encouraging the modal shift in passenger transport through providing better public transport services and cycling infrastructure and the fifth priority should be given measures facilitating eco-driving.

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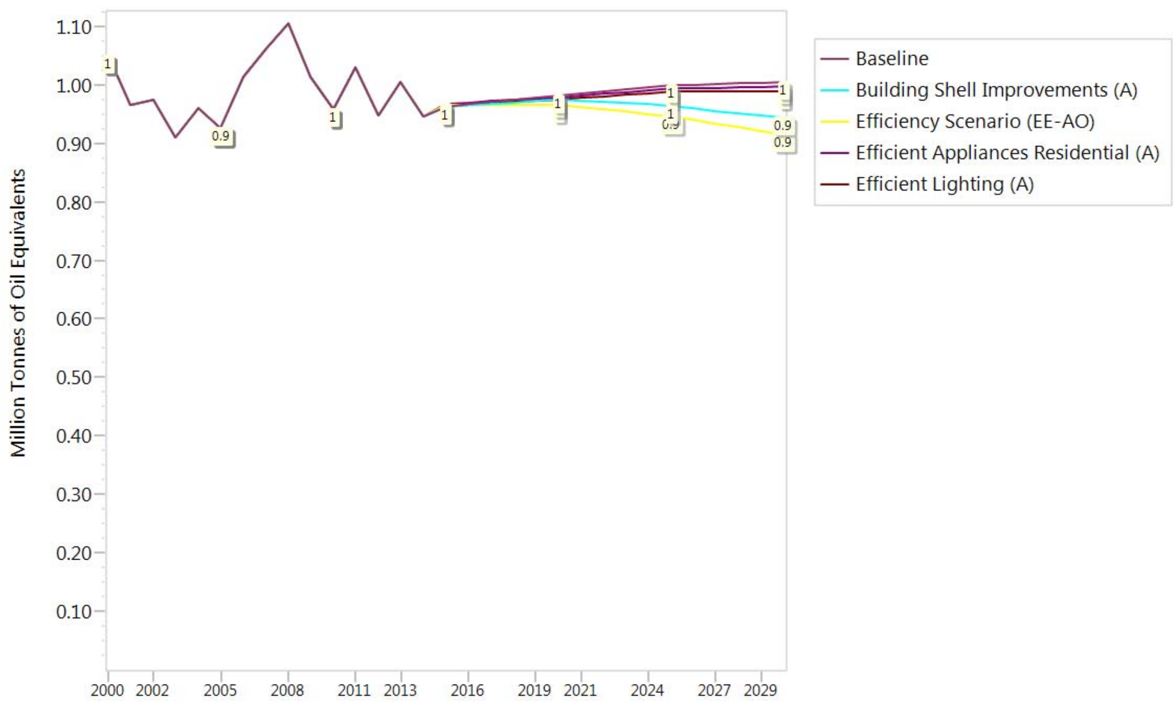
ANNEXES

Annex 1. Residential: Minimally intervening energy efficiency scenario (ENMAK 2030+)

Residential: Reduction of energy consumption between Baseline scenario and energy EE A0 scenario (+ different sub-scenarios under it)

Based on Minimally Intervening Energy Efficiency Scenario which was worked out for Estonian National Energy Development Plan 2030+



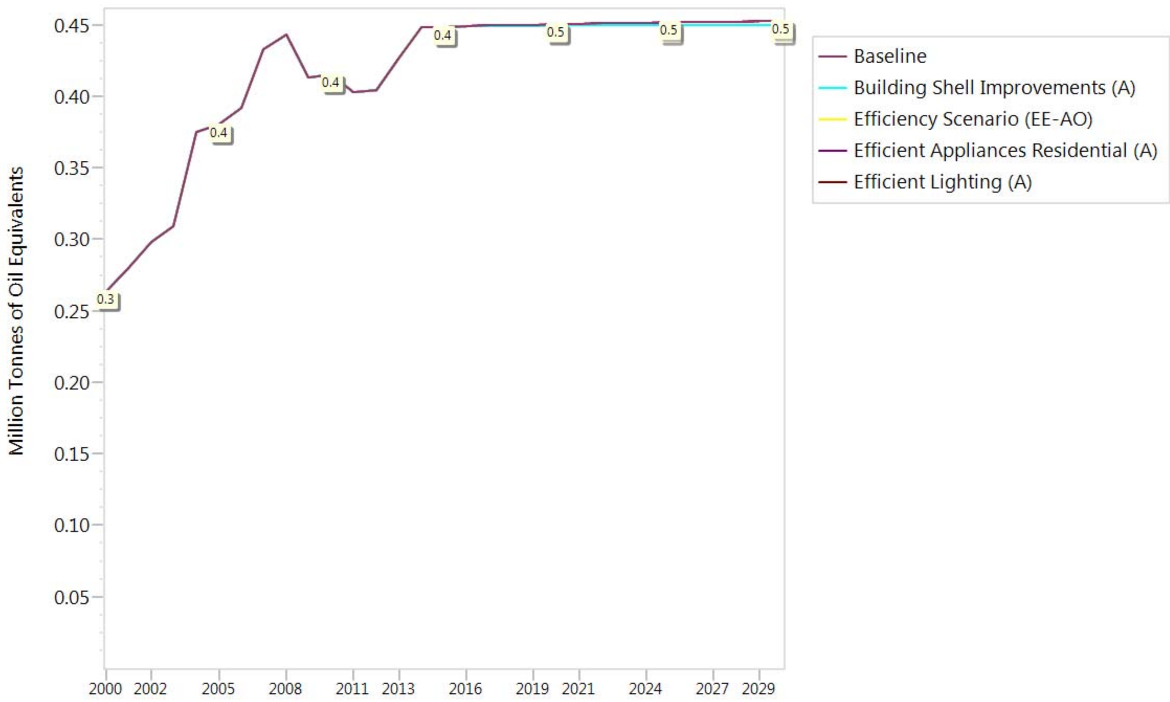
Final energy consumption in Mtoe:

Year	2010	2020	2030
HERON BAU scenario (residential)	**0.96**	**0.98**	**1.0**
HERON EE A0 (residential)	**0.96**	**0.97**	**0.92**

Annex 2. Tertiary: Minimally intervening energy efficiency scenario (ENMAK 2030+)

Tertiary: Reduction of energy consumption between Baseline scenario and energy EE A0 scenario (+ different sub-scenarios under it)

Based on Minimally Intervening Energy Efficiency Scenario which was worked out for Estonian National Energy Development Plan 2030+



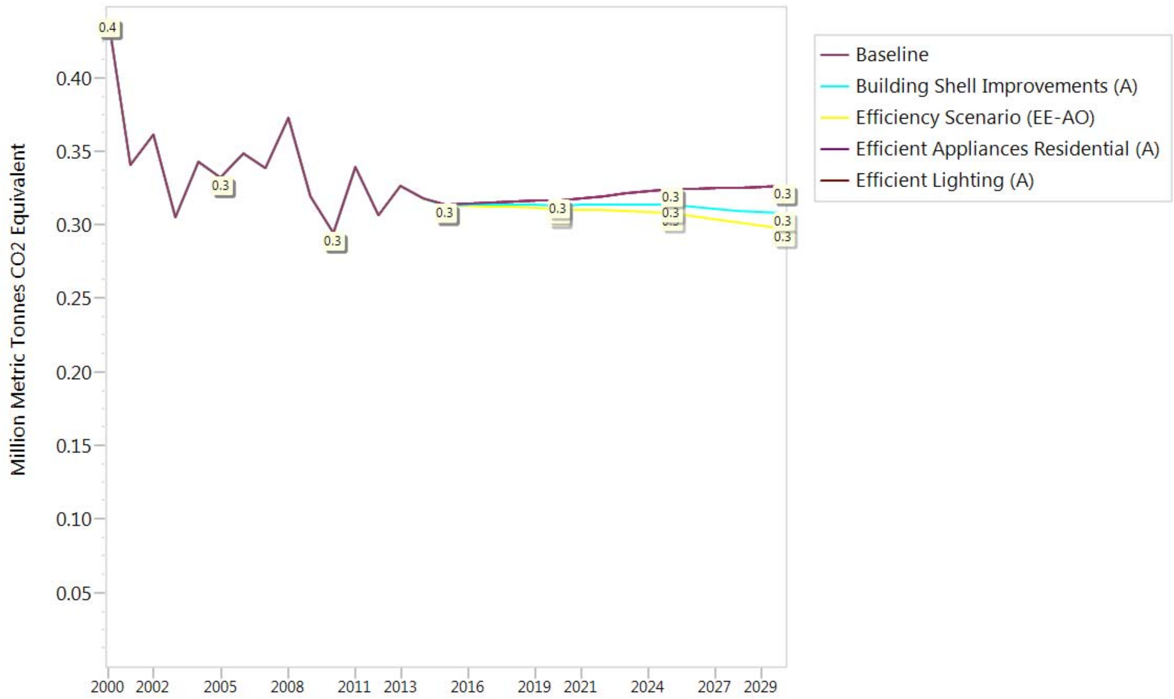
Final energy consumption in Mtoe:

Year	2010	2020	2030
HERON BAU scenario (tertiary)	0.42	0.45	0.45
HERON EE A0 (tertiary)	0.42	0.45	0.45

Annex 3. GHG Residential: Minimally intervening energy efficiency scenario (ENMAK 2030+)

Residential: Reduction of GHGs between Baseline scenario and energy efficiency EE A0 (+ different sub-scenarios under it) scenario.

Based on Minimally Intervening Energy Efficiency Scenario which was worked out for Estonian National Energy Development Plan 2030+.



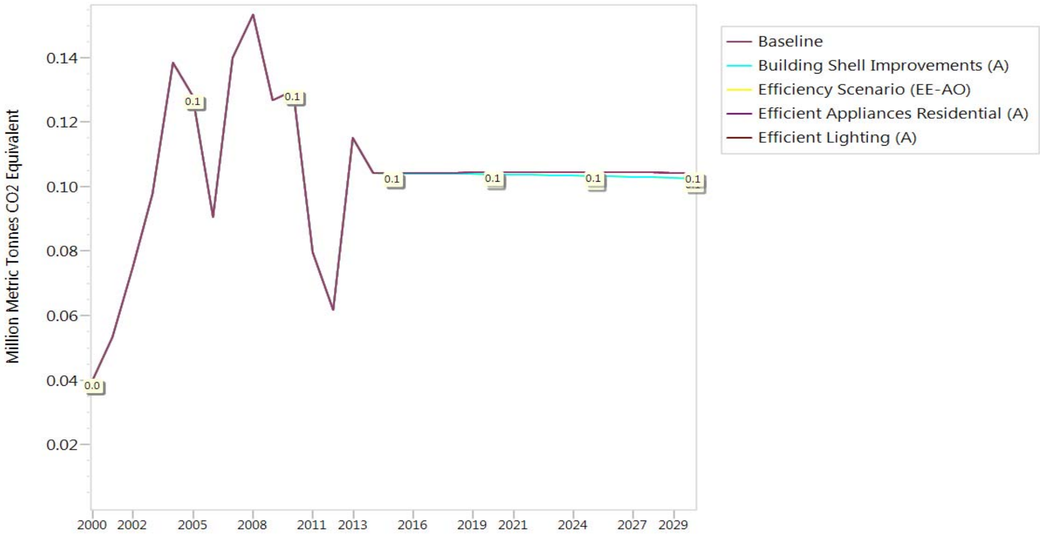
EE scenario outcomes – reduction of GHG direct (at point of) emissions ($MtCO_2$).

Year	2005	2020	2030
HERON BAU scenario (residential)	0.332	0.317	0.326
HERON EE A0 (residential)	0.332	0.311	0.297

Annex 4. Tertiary: Minimally intervening energy efficiency scenario (ENMAK 2030+)

Tertiary: Reduction of GHGs between Baseline scenario and energy efficiency EE B0 (+ different sub-scenarios under it) scenario.

Based on Minimally Intervening Energy Efficiency Scenario which was worked out for Estonian National Energy Development Plan 2030+.



EE scenario outcomes – reduction of GHG direct (at point of) emissions ($MtCO_2$).

Year	2005	2020	2030
HERON BAU scenario (tertiary)	**0.128**	**0.104**	**0.104**
HERON EE A0 (tertiary)	**0.128**	**0.104**	**0.102**

Annex 5. Residential and tertiary sector NOx (direct emissions) data of the minimally intervening state energy efficiency scenario EE-A0

Scenarios	2020	2030
HERON BAU scenario NO_x (residential)	1.93	1.95
HERON EE-A0 (residential)	1.90	1.83
Reduction compared to HERON BAU 2030	1.5%	6.2%
HERON BAU scenario NO_x (tertiary)	0.134	0.133
HERON EE-A0 (tertiary)	0.133	0.131

Reduction compared to HERON BAU 2030	0.8%	1.5%

Annex 6. Weight of barriers. DST outcome. Residential buildings

Country	Estonia
Building Sector	
Subsector	Residential sector

Type	Name of barrier	Weight coefficient
Social	S1. Social group interactions and status considerations	0.006
Social	S2. Socio - economic status of building users	0.012
Social	S3. Strong dependency on neighbors (multi - family housing)	0.009
Social	S4. Inertia	0.008
Social	S5. Lack of Commitment - motivation of public social support	0.018
Social	S6. Rebound effect	0.010

Type	Name of barrier	Weight coefficient
Economic	Ec1. Lack of any type of financial support	0.097
Economic	Ec2. High costs and risks	0.133
Economic	Ec3. Payback expectations / investment horizons	0.096
Economic	Ec4. Misleading prices (energy / fuel / tariffs)	0.135
Economic	Ec5. Unexpected costs	0.060
Economic	Ec6. Financial crisis / Economic stagnation	0.054
Economic	Ec7. Embryonic or poorly developed markets	0.049

Type	Name of barrier	Weight coefficient
Institutional	I1. Split Incentive(s)	0.012
Institutional	I2. Legislation issues	0.010
Institutional	I3. Building stock characteristics and special issues	0.036
Institutional	I4. Poor compliance - Performance gap / mismatch	0.012
Institutional	I5. Lack of data / information - diversion of management	0.026

Institutional	I6. Problematic implementation network / governance framework	0.018
Institutional	I7. Disruption / Hassie factor	0.010
Institutional	I8. Security of fuel supply	0.014

Type	Name of barrier	Weight coefficient
Educational	Ed1. Lack of experienced professionals, trusted information	0.020
Educational	Ed2. Lack of awareness on savings potential, technologies, EE	0.059

Type	Name of barrier	Weight coefficient
Cultural	C1. Lack of interest / low priority / Undervaluing EE	0.027
Cultural	C2. Customs - habits - relevant behavioural aspects	0.030
Cultural	C3. Bounded rationality / Visibility of EE	0.011
Cultural	C4. Missing credibility - mistrust in technologies / contractors	0.030

Annex 7. Weight of barriers. DST outcome. Tertiary buildings

Country	Estonia
	Building Sector
subsector	Tertiary Sector

Type	Name of barrier	Weight coefficient
Social	S1. Social group interactions and status considerations	0.006
Social	S2. Socio - economic status of building users	0.012
Social	S3. Strong dependency on neighbors (multi - family housing)	0.009
Social	S4. Inertia	0.008
Social	S5. Lack of Commitment - motivation of public social support	0.018
Social	S6. Rebound effect	0.010

Type	Name of barrier	Weight coefficient
Economic	Ec1. Lack of any type of financial support	0.097
Economic	Ec2. High costs and risks	0.133
Economic	Ec3. Payback expectations / investment horizons	0.096
Economic	Ec4. Misleading prices (energy / fuel / tariffs)	0.135
Economic	Ec5. Unexpected costs	0.060
Economic	Ec6. Financial crisis / Economic stagnation	0.054
Economic	Ec7. Embryonic or poorly developed markets	0.049

Type	Name of barrier	Weight coefficient
Institutional	I1. Split Incentive(s)	0.012
Institutional	I2. Legislation issues	0.010
Institutional	I3. Building stock characteristics and special issues	0.036
Institutional	I4. Poor compliance - Performance gap / mismatch	0.012
Institutional	I5. Lack of data / information - diversion of management	0.026
Institutional	I6. Problematic implementation network / governance framework	0.018
Institutional	I7. Disruption / Hassie factor	0.010
Institutional	I8. Security of fuel supply	0.014

Type	Name of barrier	Weight coefficient

Type	Name of barrier	Weight coefficient
Educational	Ed1. Lack of experienced professionals, trusted information	0.020
Educational	Ed2. Lack of awareness on savings potential, technologies, EE	0.059

Type	Name of barrier	Weight coefficient
Cultural	C1. Lack of interest / low priority / Undervaluing EE	0.027
Cultural	C2. Customs - habits - relevant behavioural aspects	0.030
Cultural	C3. Bounded rationality / Visibility of EE	0.011
Cultural	C4. Missing credibility - mistrust in technologies / contractors	0.030

Annex 8. List of minimized barriers within residential buildings sector of Estonia

The colours in the table indicate the barriers available to select from per each policy assumption. The barriers signed with "x" indicate the barriers what each of the technology most possibly could minimize.

Barrier number	Barriers	Building Shell Improvement	Efficient Lighting	Efficient Appliances
I1	Split incentives	x		
I3	Building stock characteristics and special issues	x		
S4	Inertia	x		
Ed2	Lack of awareness on savings potential, technologies, etc	x		
Ec5	Unexpected costs	x		
Ec2	High costs and risks	x	x	
C2	Customs-habits-relevant behavioural aspects	x		
I7	Disruption/Hassie factor	x		
S2	Socio-economic status of building users	x		x
S3	Strong dependency on neighbours, etc	x		
Ed1	Lack of experiences professionals, trusted information	x		
I6	Problematic implementation network, weak governance	x		
C4	Missing credibility/mistrust in technologies	x		
Ec1	Lack of any type of financial support	x	x	x

Annex 9. List of minimized within tertiary buildings sector of Estonia

The colours in the table indicate the barriers available to select from per each policy assumption. The barriers signed with “x” indicate the barriers what each of the technology most possibly could minimize.

	Barriers	Efficient Lighting	Building shell improvement (Including efficient heating)
Ec2	High costs and risks	x	
Ec1	Lack of any type of financial support	x	x
I 4	Poor compliance - perfomance gap/mismatch		x
I 8	Security of fuel supply		x

Annex 10. Weight of barriers. DST outcome. Transport sector

Type	Barrier	Weight
Economic	Ec1. Lack or limited finance / incentives	0,237
Economic	Ec6. Negative role of Investment schemes / employee benefits	0,188
Economic	Ec2. Limited infrastructure investment for public transport	0,133
Institutional	I1. Lack of integrated governance / entities - fragmentation / bureaucracy	0,076
Economic	Ec3. Low purchasing power of citizens / Financial crisis	0,052
Institutional	I4. Lack or limited policies on EE transport issues	0,036
Institutional	I5. Limited / complex funding procedures	0,032
Economic	Ec5. Payback period / low economic viability	0,031
Institutional	I7. Contradicting policy goals	0,031
Economic	Ec4. High costs	0,030
Institutional	I2. Lack of EE in Government Agenda / priorities / coordination	0,029
Institutional	I6. Lack of policy support (technological issues / research needs)	0,025
Social	S4. Suburbanisation trends / Low density	0,019
Institutional	I3. Problems with infrastructure / public transport services	0,015
Cultural	C1. Car - symbol status & group influence	0,012
Cultural	C2. Habit / social norm of driving - car ownership & use	0,008
Social	S1. Low satisfaction / lack of trust for public transport	0,007
Social	S5. Mobility problems	0,007
Social	S3. Socio - economic status of users	0,006

Educational	Ed4. Lack of certified and experience staff	0,006
Cultural	C4. Buyer attitude / Bounded rationality	0,006
Social	S6. Inertia	0,005
Social	S2. Concerns on reliability / Hesitation to trust new technologies	0,003
Educational	Ed2. Low / Limited awareness – environmental sensitivity on EE	0,002
Cultural	C3. Cycling is marginalized	0,002
Educational	Ed1. Lack of knowledge / information on EE transport	0,001
Educational	Ed3. Confusion on car - fuel costs – Negative perception	0,001