Comprehensive Assessment of the Potential for Efficient Heating and Cooling in the Slovak Republic Pursuant to Article 14 of Directive 2012/27/EU

Drawn up by: Ministry of Economy of the Slovak Republic
Slovak Innovation and Energy Agency

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Introduction

The first comprehensive assessment of the potential for DH and HE CHP was prepared in 2016 on the basis of Directive 2012/27/EU. The Commission laid down the requirements and contents of the comprehensive assessment in amending Directive 2018/2002, which amended Annex IX to Directive 2012/27/EU containing details of the comprehensive assessment under a new name, Comprehensive Assessment of the Potential for Efficient Heating and Cooling. Subsequently, on 23 May 2019, the Commission published, in the Official Journal of the European Union, Commission Delegated Regulation (EU) 2019/826 of 4 March 2019 amending Annexes VIII and IX to Directive 2012/27/EU of the European Parliament and of the Council on the contents of comprehensive assessments of the potential for efficient heating and cooling.

The Delegated Regulation clearly defines the contents of the comprehensive assessment of the potential for efficient heating and cooling, to be drawn up by 31 December 2020 on the basis of the Commission's requirement. Under the Delegated Regulation, Part 1 of Annex IX is deleted, notwithstanding that the text of the Directive referring to Part 1 of Annex IX remains unchanged, in spite of the fact that it should in fact refer to Annex VIII. The details have been moved to Annex VIII. Part 2 of Annex IX remains valid, notwithstanding that it contains other measures relating to Articles 14(5) to 14(7) of the Energy Efficiency Directive.

Annex VIII has been changed and extended significantly in comparison with the previous comprehensive assessment: in line with the links between certain sections of Part 1 of Annex IX on the one hand and, on the other hand, in accordance with the requirements from practice and evaluation of the first version of the comprehensive assessment from 2016.

The contents of the comprehensive assessment itself is fixed in Commission Delegated Regulation 2019/826 and consists of four main parts:

- **Part I Overview of Heating and Cooling,**
- **Part II Objectives, Strategies and Policy Measures,**
- **Part III Analysis of the Economic Potential for Efficiency in Heating and Cooling,**
- **Part IV Potential New Strategies and Policy Measures.**

It is necessary to add to these contents the requirement from Directive 2018/2001 on renewable energy sources, which spells out in Article 15(7) the specific requirement for specifying RES in the comprehensive assessment, which, however, is unfortunately not taken into consideration in the above-specified Commission Delegated Regulation.

The output of the new and considerably more detailed comprehensive assessment should be a document describing the present state in the heat production sector, in the area of production, supply and use of heat, hot water and cooling. Such a document represents an analytical basis for designing energy policy in the area of heating and cooling. Significant parts of the comprehensive assessment should inform the planning of further heating and cooling production and regular updating of the Integrated National Energy and Climate Plan and, at a later point, directly an integral part of NECP. This document analyses in fundamental aspects the heating and cooling sector in Slovakia.

List of abbreviations used

EU	European Union,
SR	Slovakia,
MH SR	Ministry of Economy of the Slovak Republic,
SIEA	Slovak Innovation and Energy Agency,
EEMS	Energy Efficiency Monitoring System,
ÚRSO	Regulatory Office for Network Industries,
ŠÚ SR	Statistical Office of the Slovak Republic,
SHMÚ	Slovak Hydrometeorological Institute,
DH	district heating,
RES	renewable energy sources,
NRES	non-renewable energy sources,
CHP	combined heat and power or heat and mechanical energy production,
FEC	final energy consumption,
HE CHP	high-efficiency combined heat and power production,
IERW	installation for energy recovery of waste,
NECP, INEKP	Integrated National Energy and Climate Plan.

1. PART I – OVERVIEW OF HEATING AND COOLING

The heating and cooling sector in Slovakia is represented by a combination of individual heating and cooling and district heating. District cooling remains rare.

In its current condition, the heat production sector, i.e. the sphere responsible mainly for district heating and entrepreneurship in heat energy, must cope with new challenges. The expansion of municipal districts and mass construction in the 1970s and 1980s and the subsequent industrial development and development of the services sector created a need for sufficient capacities to cover the requirements of heating and hot water supply. Therefore, most buildings in cities are served by district heating using heating plants and primary heat distribution or local and block boiler rooms distributing heat to several houses and facilities. These heat sources were established 30 to 40 years ago and have become outdated. Similarly, many heat distribution networks connected to them are reaching their technical life limit and need to be replaced and modernised. A majority of heat sources used for individual heating burn mainly natural gas or biomass and are located mainly at the very point of consumption.

In the current situation, new requirements and policies are implemented as described above, either directly in the heat production sector or in individual heating, as well as in new challenges such as the climate change, energy efficiency, renewable energy sources and renovation of buildings. These new aspects, together with new technologies and digitalisation across the national economy, constitute the basic factors and parameters to be taken into consideration in describing the existing situation and setting new planned measures in order to ensure a safe, reliable and climate-friendly (or indeed emission-free) heating and cooling across the whole of society. It is expected that new, modern technical systems and technologies for heating and cooling production will be installed and existing systems modernised and adapted to new challenges so has to achieve the required energy and climate objectives while increasing the quality of the heating and cooling services provided.

New specific requirements in the area of energy efficiency have probably the greatest impact in the heating and cooling sector. These requirements will be further intensified in the new Fit for 55 package. Given that heat in buildings represents the majority of heat consumed in Slovakia, policies in the area of energy efficiency of buildings aimed at insulating and renovating buildings to achieve the best energy efficiency classes (nearly-zero energy buildings, passive houses) strongly influence the requirements on the future of heating and cooling supply and clearly define the challenges ahead. Significantly reducing the heating requirement of buildings relieves strain on heat sources and reduces the use of existing systems of heat production and supply, making them over-dimensioned. Therefore, the new, modern systems must be adjusted to the smaller need for heating production but an unchanged amount of hot water production while being able to use the latest, often emission-free, heat production technologies. In relation to cooling, the number of cooling degree days has significantly increased in the past decade, which implies an increasing number of tropical days and the related higher requirement for cooling of buildings and hence an increased requirement for cold in general.

Promotion of the principle of priority for energy efficiency underlines the basic methodological rule that the heating requirement of buildings must be clearly defined in the first place and subsequently used for adjusting heat sources. The same applies to cold. In either case the total heat or cold requirement must be assessed by taking into account also the technologies that produce heat ‘for free’, such as solar collectors.

A mandatory objective is the requirement for renovation of public buildings, with a focus on buildings of central government authorities, about 80% of which are located in Slovakia’s capital city of Bratislava and most of which are connected to DH systems. The proposed future changes include extension of the obligation to all public buildings or a mandatory quantity/share of RES used in buildings.

The current topic of climate neutrality has even greater implications in heating and cooling supply from the perspective of fuels and energy used for the production of heat, hot water and cold. Support for renewable energy sources and the mandatory objectives of increasing the share of RES in heat production by 1.1 to 1.3% per year will have a long-term effect on the heat production sector, with the aim of achieving the required, and indeed necessary, modernisation towards low-carbon and emission-free installations. Use of waste heat and multi-fuel systems is becoming an urgent requirement in the effort to achieve the above objectives. Attention will be paid to efficient DH systems with waste heat supply including industrial processes and cost-effective use of waste and RES, especially heat pumps and locally available biomass, including biomethane and biogas. Development of the use of geothermal energy also requires investment support. This includes the requirement for decarbonisation of buildings, closely related to the requirement for the use of various forms of energy and primary energy sources in buildings, often specified on the basis of emission-free or low-carbon requirements on these sources.

1.1 Demand for heating and cooling expressed as useful energy and quantified final energy consumption by sector

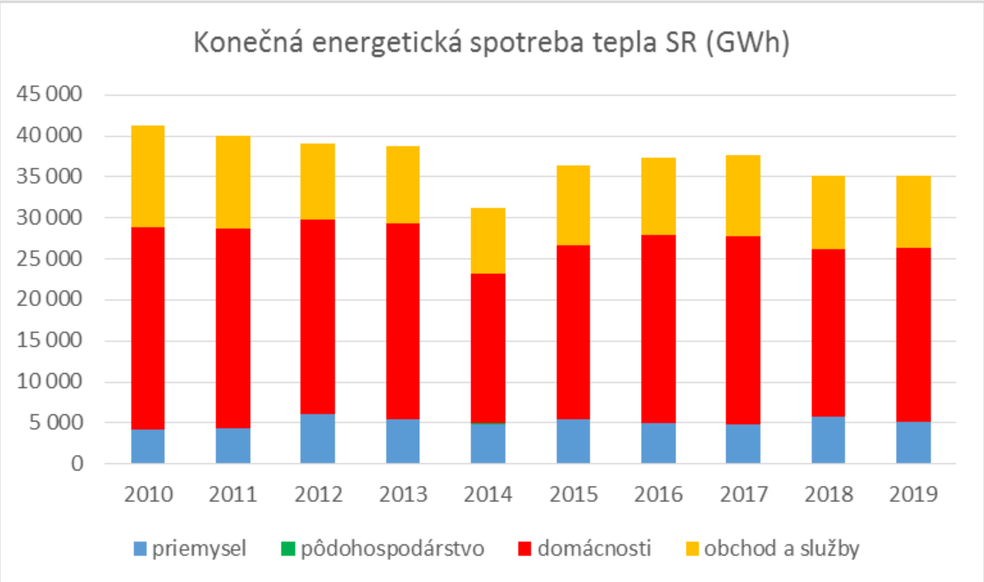
Heating and cooling requirement in Slovakia expressed as useful heating and cooling requirement quantified in the final heating energy consumption by sector provides information on the total amount of heat used in Slovakia at all levels of consumption, including individual heating and use of individual energy sources for heat production. It specifies the final energy consumption (rather than requirement) and represents the total amount of heat consumed in Slovakia.

Table 1: Final energy consumption in Slovakia by sector

Final heating energy consumption (GWh)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Final heating energy consumption – industry	4 154	4 296	6 036	5 395	4 895	5 454	4 910	4 891	5 774	5 154
Final heating energy consumption – agriculture	39	39	12	11	10	8	8	8	10	10
Final heating energy consumption – households	24 595	24 430	23 800	23 876	18 365	21 190	22 945	22 873	20 429	21 170
Final heating energy consumption – trade and services	12 510	11 281	9 240	9 528	8 005	9 806	9 519	9 930	8 896	8 848
Final heating energy consumption – total	**41 299**	**40 046**	**39 087**	**38 810**	**31 275**	**36 458**	**37 382**	**37 702**	**35 109**	**35 183**

Source: ŠÚ SR, SIEA, EEMS, SHMU, MH SR

Chart 1: Development of the final heating energy consumption in Slovakia in 2010–2019



Source: ŠÚ SR, SIEA, EEMS, SHMU, MH SR

Key to graphic	
Original text	Translation
Konečná energetická spotreba tepla SR (GWh)	Final heating energy consumption in Slovakia (GWh)

priemysel	industry
pôdohospodárstvo	agriculture
domácnosti	households
obchod a služby	trade and services

The total heating energy consumption showed a continuing downward trend in the 2010 to 2019 period – a 16.4% decrease. 2014 was anomalous as the production of heat was influenced by a very mild winter.

The data on the final heating energy consumption by industry and agriculture was derived by a specific calculation from ŠÚ SR data. The data on the final heating energy consumption by households and in the trade and services sector were compiled and calculated on the basis of detailed monitoring and analyses; the basic data on heat supplied were now extended with heat from individual production, which is often reported only as the combustion of primary energy sources. Biomass in households was added on the basis of a SHMÚ project.

Final heating energy consumption reported in energy statistics

Heat consumption in Slovakia is reported in energy statistics only for certain forms of heat, especially for the production and supply of heat from sources in which heat is distributed across the basic statistical chain of production, transformation, losses and the actual consumption and supply of heat to the final consumer. However, a large part of heat is produced individually (i.e. at the point of consumption), i.e. it is present in the statistics only as the supplied fuel, with heat being produced only at the point of consumption. Biomass constitutes a specific problem in relation to individual production because a large part of it is not directly subject to statistical surveys. It has been/will be added to the statistics based on a calculation using greenhouse gas emissions as its input.

Final heating energy consumption in Slovakia according to Eurostat

These are Eurostat data on final heating energy consumption. The decrease in the final heating energy consumption between 2010 and 2019 is up to 35.1%, with all monitored sectors showing a decrease, including consumption by the energy sector itself. Biomass used in households is not included in these figures as yet.

Table 2: Final heating energy consumption in Slovakia according to Eurostat

Final energy consumption of supplied heat (GWh)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Final energy consumption of derived heat – industry	1 239	1 226	1 824	1 698	1 423	1 743	1 483	1 558	732	805
Final energy consumption of derived heat – trade and services	2 913	2 335	1 432	1 123	684	335	1 080	964	933	852
Final energy consumption of derived heat – households	5 712	5 325	5 605	5 806	4 974	5 267	5 215	5 256	4 847	4 698

Final energy consumption of derived heat – total	10 547	9 594	9 520	9 307	7 700	8 006	8 497	8 476	7 048	6 848

Source: Eurostat (Supply, transformation and consumption of derived heat [nrg_cb_h])(12 February 2021), ŠÚ SR

Gross heat production in Slovakia

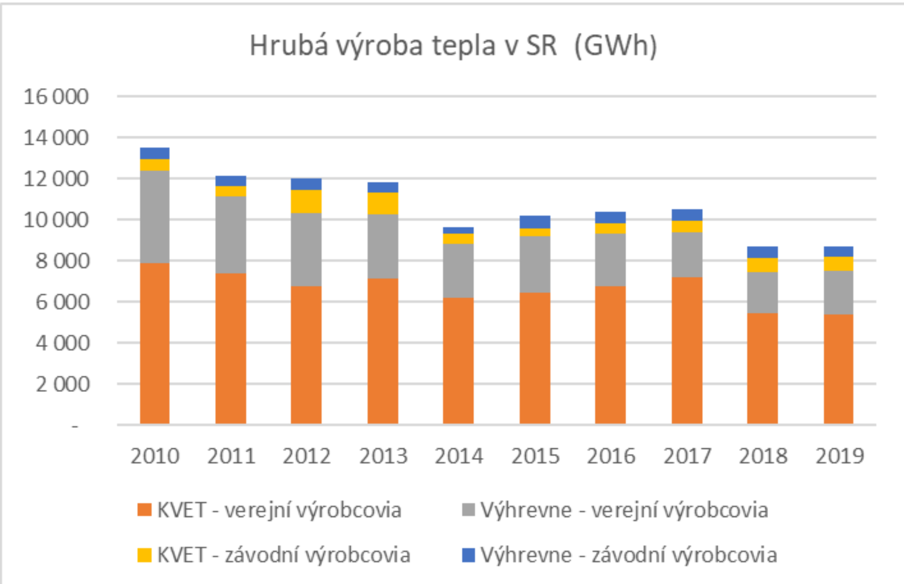
Gross heat production provides data on the quantity of produced heat monitored by statistical surveys. In view of the trend of heat production moving from centralised and large production units to small or even individual sources of heat, these statistics provide only partial data on the quantity of heat produced in Slovakia. The tables and charts also analyse in detail the data on gross heat production classified by heat producers and individual primary fuels.

Table 3: Gross heat production in Slovakia by producers

Gross heat production (GWh)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
CHP – main activity producers	7 866	7 380	6 764	7 163	6 194	6 471	6 755	7 174	5 445	5 410
Heat plants – main activity producers	4 540	3 776	3 580	3 089	2 648	2 741	2 599	2 218	2 019	2 104
CHP – autoproducers	572	496	1 101	1 079	457	389	466	541	699	669
Heat plants – autoproducers	516	501	547	483	369	584	600	561	536	504
Total gross heat production	**13 495**	**12 152**	**11 992**	**11 814**	**9 668**	**10 184**	**10 421**	**10 495**	**8 699**	**8 686**

Source: ŠÚ SR

Chart 2: Development of gross heat production in Slovakia in individual years by producers



Source: ŠÚ SR

Key to graphic	
Original text	Translation

Hrubá výroba tepla v SR (GWh)	Gross heat production in Slovakia (GWh)
KVET – verejní výrobcovia	CHP – main activity producers
Výhrevne – verejní výrobcovia	Heat plants – main activity producers
KVET – závodní výrobcovia	CHP – autoproducers
Výhrevne – závodní výrobcovia	Heat plants – autoproducers

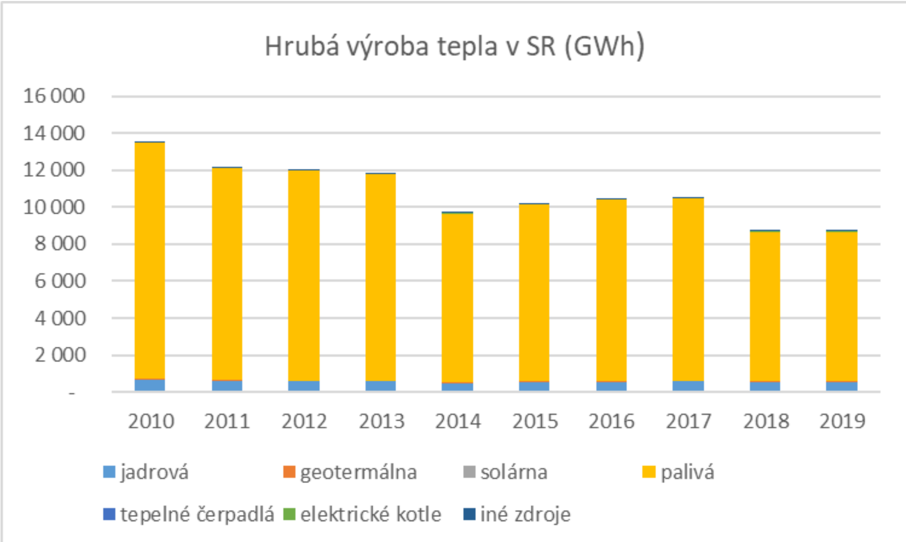
Table 4: Gross heat production in Slovakia by energy carriers

Gross heat production by energy carriers (GWh)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Fuels	12 742	11 486	11 363	11 164	9 118	9 586	9 813	9 843	8 087	8 078
Nuclear	694	614	588	596	499	547	549	582	533	523
Geothermal	39	29	26	28	33	34	39	41	44	49
Solar	0	0	1	0	0	0	0	0	0	1
Ambient heat	1	2	3	3	2	1	2	7	11	16
electric boilers	0	0	10	10	13	13	16	19	18	17
other sources	19	20	3	11	2	2	3	2	5	4
Total gross production	**13 495**	**12 152**	**11 992**	**11 814**	**9 668**	**10 184**	**10 421**	**10 495**	**8 698**	**8 686**

Source: ŠÚ SR

These data do not cover the quantity of heat produced by autoproducers and entities with less than 20 employees; it follows that e.g. biomass in households is not included.

Chart 3: Development of gross heat production in Slovakia in individual years by energy carriers 2010–2019



Source: ŠÚ SR

Key to graphic	
Original text	Translation
Hrubá výroba tepla v SR (GWh)	Gross heat production in Slovakia (GWh)
jadrová	nuclear
geotermálna	geothermal
solárna	solar
palivá	fuels

tepelné čerpadlá	heat pumps
elektrické kotle	electric boilers
iné zdroje	other sources

Data for the past 10 years can be divided into three areas which are separated by the step change in 2014 The continuing downward trend in heat production is obvious from these data.

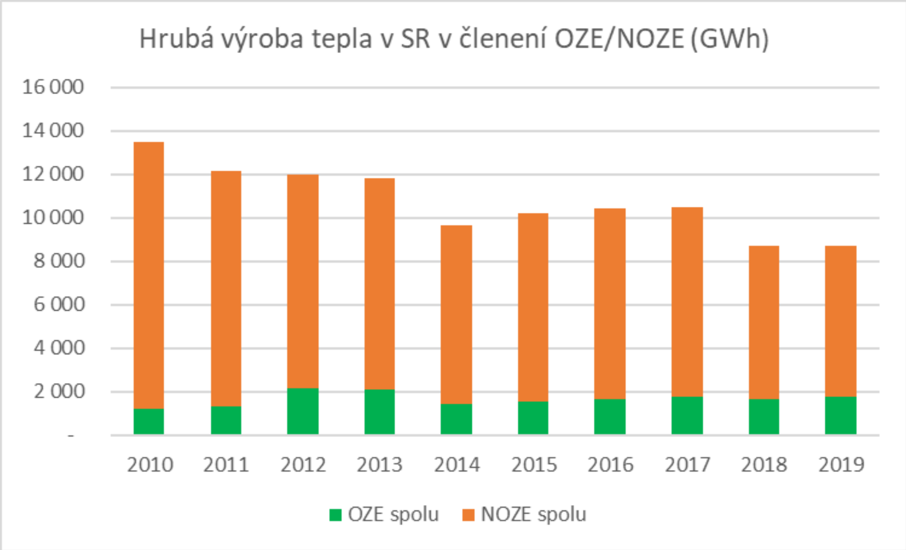
Table 5: Gross production of heat in Slovakia by RES/NRES

Gross production of heat in Slovakia by RES/NRES in (GWh)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total gross production	13 495	12 152	11 992	11 814	9 668	10 184	10 421	10 495	8 698	8 686
NRES total	12 262	10 819	9 859	9 724	8 209	8 630	8 777	8 733	7 033	6 921
RES total	1 233	1 333	2 133	2 090	1 459	1 554	1 644	1 761	1 665	1 766
RES – geothermal energy	*39*	*29*	*26*	*28*	*33*	*34*	*39*	*41*	*44*	*49*
RES – solar energy	*0*	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*1*	*1*
RES – heat pumps	-	-	-	-	-	-	-	*7*	*11*	*16*
RES – industrial waste	*20*	*47*	*35*	*36*	*12*	*1*	*1*	*1*	-	*17*
RES – solid renewable municipal waste	*14*	*13*	*13*	*8*	-	-	-	*9*	*16*	*18*
RES – solid non-renewable municipal waste	*14*	*20*	*19*	*22*	*2*	*6*	*14*	*8*	*14*	*14*
RES – wood	*1 127*	*1 180*	*2 007*	*1 963*	*1 320*	*1 381*	*1 459*	*1 543*	*1 415*	*1 466*
RES – biogases	*19*	*43*	*31*	*33*	*91*	*131*	*131*	*152*	*165*	*186*
RES share (%)	9.1	11.0	17.8	17.7	15.1	15.3	15.8	16.8	19.1	20.3

Source: ŠÚ SR

In the period in question, i.e. 2010–2019, fossil fuels were the dominant energy carrier in gross heat production in Slovakia. In 2019, gross heat production from renewable sources in Slovakia increased by 43.2% compared to 2010, from 1 233 GWh to 1 766 GWh. The share of gross heat production from renewable sources in 2019 reached 20.3%, as opposed to a mere 9.1% in 2010.

Chart 4: Development of gross heat production in Slovakia in individual years by RES/NRES in 2010–2019



Source: ŠÚ SR

Key to graphic	
Original text	Translation
Hrubá výroba tepla v SR v členení OZE/NOZE (GWh)	Gross production of heat in Slovakia by RES/NRES (GWh)
OZE spolu	RES total
NOZE spolu	NRES total

1.2 Data on heating and cooling consumption in Slovakia

This section presents a more detailed analysis of individual sectors of heat production and consumption. The data were collected and grossed up from various sources in order to come as close as possible to the actual quantity of heat used in Slovakia. The objective of this section is to present the actual share of heat in all energy consumption sectors in Slovakia.

The following sections provide a detailed analysis of heat and cold production and supply in households, trade and services, industry and agriculture. The supply of heat and cold from district systems and from high-efficiency combined heat and power production is analysed as well. Therefore, the following data better reflect the use of heat in Slovakia.

1.2.1 Individual heat consumption in the household sector

Individual heat consumption in households seems to be the most neglected area. This is because there are no proper statistics that would specifically focus on individual production, despite the fact that individual production is a pivotal part of the overall heat production.

According to the 2011 ŠÚ SR population and housing census, there were 815 386 occupied single-family houses in Slovakia in that year, with a majority of them using their own sources of heat. In addition, 2 615 multi-apartment buildings use their own heat sources.

The following tables and charts show heat production and consumption by households using individual heating in 2010–2019. The consumption of fuels is structured by energy carriers and by RES/NRES. Individual heat production by households is calculated on the basis of the consumption of fuels used for heat production. Fuels consumption was ascertained using data from multiple databases, especially energy statistics, a SHMÚ project and gas consumption. Biomass for the 2010–2018 period was grossed up based on the SHMÚ project, the data for 2019 were already available in the official energy statistics. The development of the use of individual renewable energy sources is taken from the energy statistics. The figure was subsequently grossed up using data from supporting SIEA data for the support of solar collectors, heat pumps and biomass, from structural funds and the Green Households project. Heat pumps data were added from the study of the Slovak Association for Cooling, Air Conditioning and Heat Pumps drawn up for MH SR, with theoretical heat production using a heat pump being included in the heat production figure based on an average number of hours.

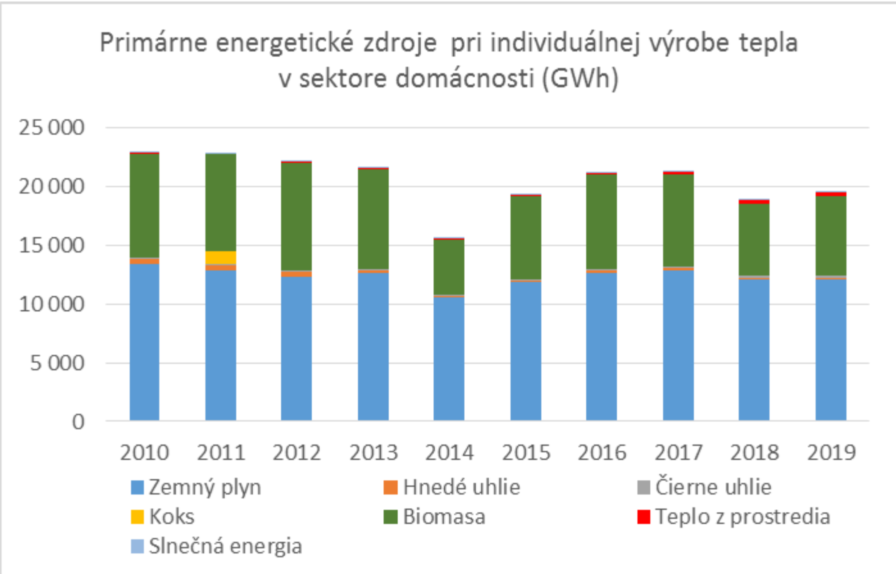
Indicating energy sources used for individual heat production represents a specific problem. Heat sources are specified as fuel used for heat production. Thus, e.g. natural gas or biomass are indicated instead of heat. The quantity of heat produced should thus be smaller than the consumption of fuels for individual heat production, reduced by the efficiency of transformation of these primary sources depending on heat production technology. For renewable energy sources, heat production involves in particular the harnessing of solar energy using solar collectors and using photovoltaics, as well as the harnessing of ambient heat using heat pumps and biomass. For heat pumps, only ambient heat is included in the calculation, i.e. the renewable part of the energy entering the heat pump. Heat is also produced directly from photovoltaics in a small quantity (several hundreds of units of approx. 1 kW) for heating water. Individual underfloor/wall/ceiling heating or cooling is also used in certain quantities.

Table 6: Primary energy sources used for individual heat production in the household sector by energy carriers

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Natural gas	(GWh)	13 368	12 810	12 364	12 662	10 554	11 922	12 687	12 859	12 091	12 086
Brown coal	(GWh)	490	433	377	177	117	120	167	200	150	147
Hard coal	(GWh)	102	109	121	109	89	70	153	160	173	160
Coke	(GWh)	36	1 127	22	14	7	7	14	22	7	7
Biomass	(GWh)	8 834	8 305	9 158	8 533	4 755	7 094	8 035	7 784	6 090	6 753
Solar energy	(GWh)	12	23	55	61	54	54	54	68	74	79
Ambient heat	(GWh)	33	45	58	72	89	112	139	200	291	407
Total	**(GWh)**	**22 875**	**22 852**	**22 155**	**21 627**	**15 665**	**19 379**	**21 250**	**21 293**	**18 877**	**19 639**

Source: ŠÚ SR, SIEA, SPP - distribúcia, a.s., SHMÚ, MH SR

Chart 5: Primary energy sources in individual heat production in the household sector by energy carriers 2010–2019



Source: ŠÚ SR, SIEA, SPP - distribúcia, a.s., SHMÚ, MH SR

Key to graphic	
Original text	Translation
Primárne energetické zdroje pri individuálnej výrobe tepla v sektore domácnosti (GWh)	Primary energy sources in individual heat production in the household sector by (GWh)
Zemný plyn	Natural gas
Hnedé uhlie	Brown coal
Čierne uhlie	Hard coal
Koks	Coke
Biomasa	Biomass
Teplo z prostredia	Ambient heat
Slnečná energia	Solar energy

Table 7: Consumption of fuels in individual heat production in the household sector by RES/NRES

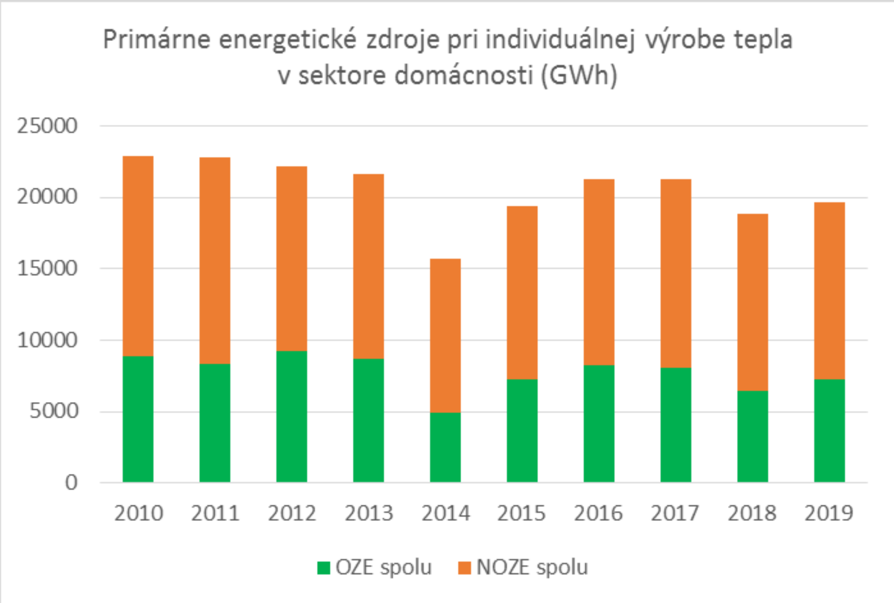
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
RES total	(GWh)	8 879	8 373	9 272	8 666	4 898	7 260	8 229	8 053	6 454	7 239
NRES total	(GWh)	13 996	14 478	12 884	12 962	10 767	12 119	13 021	13 240	12 421	12 400
RES share	(%)	38.8	36.6	41.8	40.1	31.3	37.5	38.7	37.8	34.2	36.9

Source: ŠÚ SR, SIEA, SPP - distribúcia, a.s., SHMU, MH SR

The high share of heat produced from biomass results from adjustment of the actual consumption of biomass for household heating, which followed from the grant project 'Quality Improvements of Air Emission Accounts and Extension of Provided Time-Series', aimed at ascertaining the current situation concerning emissions from individual heating of houses and flats using solid fuels (coal, briquettes, wood) in Slovakia using a specific statistical survey. The research team of the grant project comprised, in particular, the Department of Emissions in co-operation with ŠÚ SR, the Cross-sectional Statistics Department and the regional office in Banská Bystrica (Section of Industrial Data Collection and Processing and Field Surveys in Banská Bystrica – the Field Statistical Survey Department). The data from 1 549 selected households (natural gas was excluded from the survey) showed that up to 90% of households use wood as solid fuel and the average consumption of wood is 8.7 tonnes per year per household. Based on this project, biomass consumption was derived also for the previous years. These data can be added to obtain a balanced data trend including also biomass consumption. However, rather than official data, this chart integrates multiple data without convergence and review. It has not been produced on the basis of data on the use and consumption of biomass but rather based on the emissions measured and the consumption derived from such measurement.

The resulting share of renewable sources in the individual heating sector is highly questionable. It should be calculated from the gross final energy consumption; however, fuels such as natural gas, coke, electricity and biomass are indicated in the form of consumption of this fuel which should be further recalculated to the final consumption of heat. Preserving the status of primary fuel forming part of FEC, and with the losses in the transformation and actual consumption of these installations being part of the fuel consumption data in the final energy consumption, the following data are obtained as the 'gross final energy consumption'.

Chart 6: Primary fuels included in FEC in individual heat production in the household sector by RES/NRES

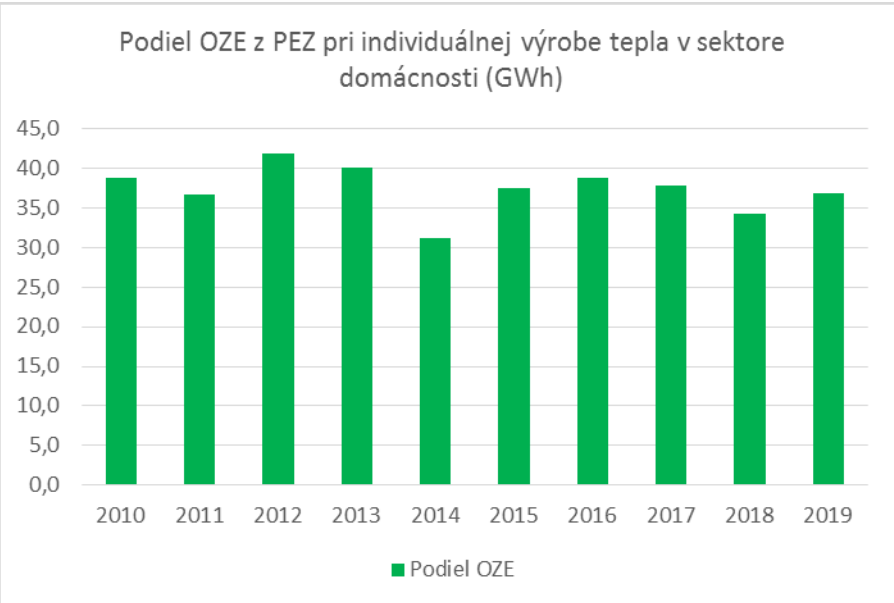


Source: ŠÚ SR, SIEA, SPP - distribúcia, a.s., SHMU, MH SR

Key to graphic	
Original text	Translation
Primárne energetické zdroje pri individuálnej výrobe tepla v sektore domácnosti (GWh)	Primary energy sources in individual heat production in the household sector by (GWh)
OZE spolu	RES total
NOZE spolu	NRES total

The share of RES in individual heating of households ranges between 30 and 45%. The rapid increase in the share of RES from previous years in individual heating of households is due to the newly included energy source of individual biomass based on emission data.

Chart 7: Share of RES in individual heat production in the household sector



Source: ŠÚ SR, SIEA, SPP - distribúcia, a.s., SHMU, MHSR

Key to graphic	
Original text	Translation

Podiel OZE z PEZ pri individuálnej výrobe tepla v sektore domácnosti (GWh)	Share of RES from primary energy sources in individual heat production in the household sector (GWh)
Podiel OZE	RES share

Thus, the quantity of heat from individual heating of households can only be calculated by recalculating the consumption of heat given in Table 8.

Table 8: Individual heat production in the household sector

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Heating energy production	(GWh)	19 067	18 923	18 472	18 102	13 226	16 300	17 851	17 943	16 046	16 752
Consumption of fuels:	(GWh)	22 875	22 852	22 155	21 627	15 665	19 379	21 250	21 293	18 877	19 639

Source: ŠÚ SR, SIEA, SPP - distribúcia, a.s., SHMU, MH SR

Installed capacity of installations used for individual heating in households

The installed capacity of installations for the production of heat and cold is not covered by statistics. Therefore, installed capacity is determined from various sources of data. The basic source of data is available at SIEA.

The following table provides an overview, as of the reference year 2019, of the installed capacities of heat production installations used for individual supplies/heat production in the household sector. The data are structured by fuel type, with the capacity of the installations for fuels (natural gas, brown coal, hard coal, coke and biomass) being obtained from a technical recalculation.

Table 9: Installed capacity of heat production installations used for individual supplies of heat in the household sector by energy carriers

Installed capacity of installations for heat production in the household sector in 2019		
Boilers burning natural gas	(MW)	9 449
Boilers burning brown coal	(MW)	93
Boilers burning hard coal	(MW)	102
Coke-burning boilers	(MW)	5
Biomass-burning boilers	(MW)	4 911
Heat pumps	(MW)	628*
Solar collectors	(MW)	65*
Total	(MW)	15 222

Source: SIEA

The installed capacity of heat pumps corresponds to the capacity of the heat pumps installed by 2019. The installed capacity of solar collectors by 2019 is based on the support programmes for solar collectors and the national 'Green Households' and 'Green Households II' projects from Operational Programme Quality of the Environment implemented by SIEA.

In 2009 to 2011, SIEA supported, under the programme of support for solar collectors and biomass, installations with a total area of 35 994 m^2 and an installed capacity of 10 821 kW. Since 2015, SIEA has been supporting the installation of solar collectors and heat pumps under the Green Households programmes. By July 2021, SIEA had supported the installation of solar collectors with an area of 64 408 m^2 and an installed capacity of 41 865 kW and heat pumps with an installed capacity of 65 MW. So far, SIEA has supported the installation of solar collectors with a total area of over 100 000 m^2 and a total installed capacity of 65 262 kW.

1.2.2 Individual heat supply in the trade and services sector

The method of calculation of heat supply and data coverage in the trade and services sector is similar to that for individual heating of households. In this category, biomass is left in the original quantity indicated in the energy statistics because detailed data are not available. The following tables and charts provide data on the production and supply of heat from individual heating in the trade and services sector for 2010–2019 and consumption of fuels structured by energy carriers and by RES/NRES.

Table 10: Individual heat production in the trade and services sector

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Heat production – FEC	(GWh)	6 584	5 378	4 543	5 036	3 962	4 299	4 318	4 651	4 548	4 543
Consumption of fuels – initial energy consumption	(GWh)	8 250	6 665	5 486	6 220	4 845	5 242	5 164	5 568	5 484	5 523

Source: ŠÚ SR, SIEA, SPP - distribúcia, a.s., MH SR

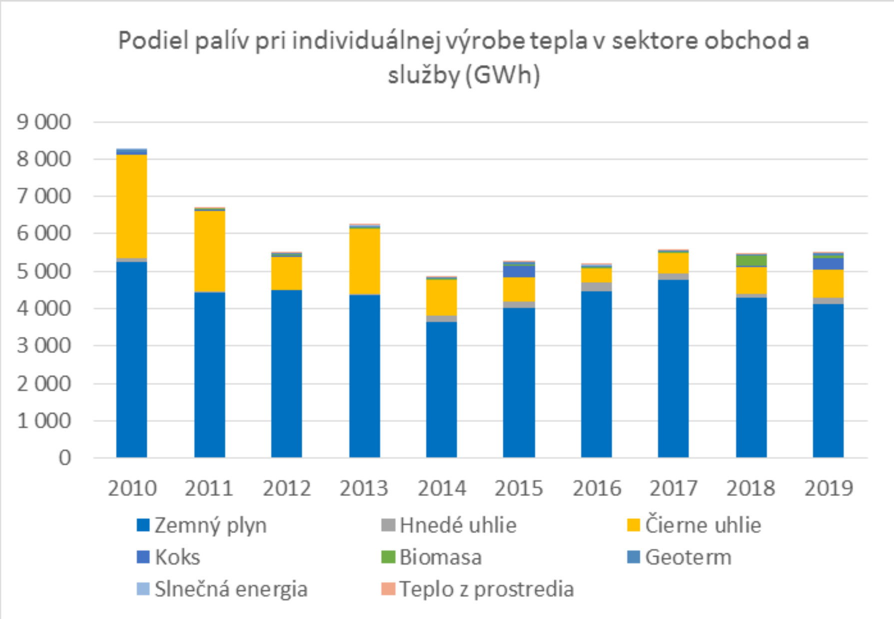
Table 11: Consumption of fuels in individual heat production in the trade and services sector by energy carriers

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Natural gas	(GWh)	5 259	4 439	4 479	4 347	3 630	4 000	4 463	4 777	4 288	4 121
Brown coal	(GWh)	87	27	30	47	170	187	237	177	87	183
Hard coal	(GWh)	2 766	2 153	869	1 751	958	639	371	518	741	748
Coke	(GWh)	58	29	29	0	0	332	0	0	22	311
Geothermal	(GWh)	66	0	40	41	40	44	50	51	52	55
Solar energy	(GWh)	0	0	6	3	13	9	10	8	8	8
Ambient heat	(GWh)	0	0	0	0	1	3	4	6	21	38
Biomass	(GWh)	13	18	33	32	32	28	31	32	266	59
Total	(GWh)	8 250	6 665	5 486	6 220	4 845	5 242	5 164	5 568	5 484	5 523

Source: ŠÚ SR, SIEA, SPP - distribúcia, a.s., MH SR

Heat production and supply in the trade and services sector using individual heating decreased by 32.1% as compared to 2010. The share of renewable sources represented only 1.1% in this sector in 2019, the dominant energy carrier being natural gas, the share of which was up to 76% in heat production. If more accurate data are available, the share of biomass and other renewable energy sources is expected to increase.

Chart 8: Share of fuels in individual heat production in the trade and services sector by energy carriers 2010–2019



Source: ŠÚ SR, SIEA, SPP - distribúcia, a.s., MH SR

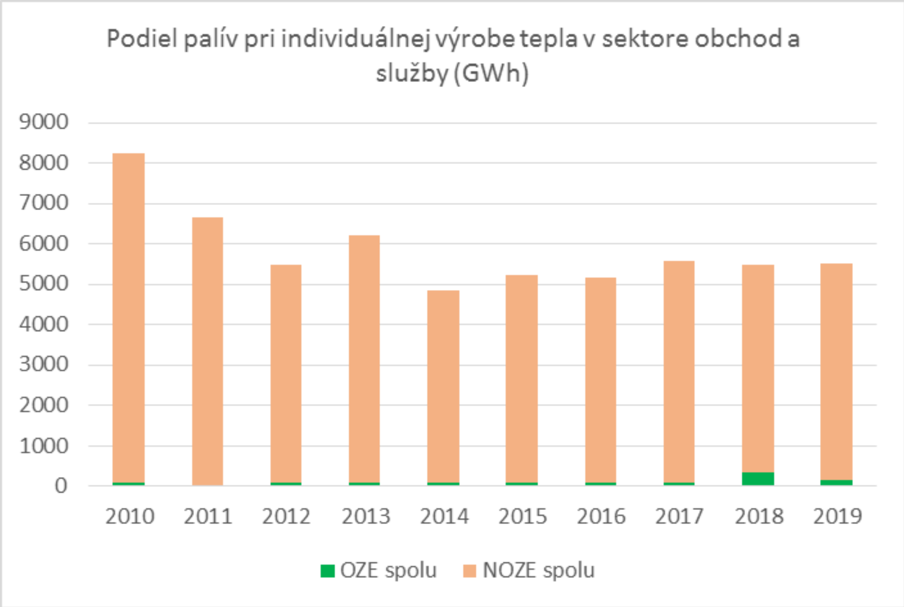
Key to graphic	
Original text	Translation
Podiel palív pri individuálnej výrobe tepla v sektore obchod a služby (GWh)	Share of fuels in individual heat production in the trade and services sector (GWh)
Zemný plyn	Natural gas
Hnedé uhlie	Brown coal
Čierne uhlie	Hard coal
Koks	Coke
Biomasa	Biomass
Geoterm	Geothermal
Slnečná energia	Solar energy
Teplo z prostredia	Ambient heat

Table 12: Consumption of fuels in individual heat production in the trade and services sector by RES/NRES

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
RES total	(GWh)	79	18	78	76	85	81	90	97	346	161
NRES total	(GWh)	8 170	6 647	5 407	6 144	4 759	5 158	5 070	5 472	5 138	5 362
RES share	(%)	1.0	0.3	1.4	1.2	1.7	1.5	1.7	1.7	6.3	2.9

Source: ŠÚ SR, SIEA, SPP - distribúcia, a.s., MH SR

Chart 9: Share of fuels in individual heat production in the trade and services sector by RES/NRES



Source: ŠÚ SR, SPP - distribúcia, a.s., MH SR

Key to graphic	
Original text	Translation
Podiel palív pri individuálnej výrobe tepla v sektore obchod a služby (GWh)	Share of fuels in individual heat production in the trade and services sector (GWh)
OZE spolu	RES total
NOZE spolu	NRES total

Installed capacity of installations for individual heat production in the trade and services sector

The following table provides an overview of the installed capacity of installations for individual heat production as of the reference year 2019 in the trade and services sector by fuel type. The installed capacity figure was obtained from a technical recalculation. The installed capacity of solar collectors and geothermal energy is not known.

Table 13: Installed capacity of installations for individual heat production in the trade and services sector by energy carriers.

Installed capacity of installations for individual heat production in the trade and services sector		
Boilers burning natural gas	(MW)	3 222
Boilers burning brown coal	(MW)	117
Boilers burning hard coal	(MW)	476
Coke-burning boilers	(MW)	198
Biomass-burning boilers	(MW)	43
Solar collectors	(MW)	8
Heat pumps	(MW)	43
Total	(MW)	4 106

Source: SIEA, MH SR

Heat production in industry

The quantity of heat used in industry is one of key parameters. It consists of two separate parts – own consumption of heat produced in industry and consumption of heat supplied from an external party. Heat produced and consumed in industry is included in the energy statistics but it has never been specifically reported as heat produced and also consumed. Therefore, data for individual sectors of industry are not available, and the same applies to data on how the heat is structured in terms of fuel types. At present, the available statistical data allow us to calculate the quantity of heat produced in industry and the quantity of heat consumed in industry. The installed capacity of heat pumps in industry was 2.8 MW in 2019.

Table 14: Heat in industry

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Heat production (TJ)	56 163	56 051	54 121	52 733	48 405	51 315	49 633	49 484	58 207	51 954
Heat sale (TJ)	45 667	45 000	38 959	39 422	35 905	37 956	37 296	37 485	40 055	36 337
Heat produced and consumed (TJ)	10 496	11 050	15 162	13 310	12 500	13 359	12 336	11 999	18 152	15 617
Heat supplied to industry from outside (TJ)	4 459	4 415	6 566	6 112	5 121	6 275	5 340	5 607	2 634	2 939
Heat in industry in total (TJ)	14 955	15 465	21 728	19 422	17 621	19 634	17 676	17 606	20 786	18 556

Source: ŠU SR, MH SR recalculation

1.2.3 Production and supply of heat from district heating systems

Slovakia is among the countries with a high proportion of district heating. A large part of heat sources and distribution systems were built and developed together with the development of urban agglomerations, mainly residential and communal construction and construction of public amenities before 1990. Heat from district heating systems is supplied mainly to flats, the industrial sector and the trade and services sector.

In recent years the quantity of heat supplied in the DH systems has been decreasing. The decrease is mainly due to the decrease in the consumption of heat in residential and public buildings owing mainly to the implemented energy efficiency measures (thermal insulation and other rationalisation measures). Despite the large scale of the measures implemented so far in multi-apartment buildings all over Slovakia (e.g. the highest share of renovated multi-apartment buildings in the EU – approx. 67%), it is expected that the trend of decreasing consumption observed in the preceding years will continue also in the upcoming period.

The significant decrease in heat consumption is likely to shift from multi-apartment buildings to single-family houses and public buildings, which will be the key sectors for reducing heat consumption from the perspective of the renovation of buildings in 2020–2030. A high degree of financial support intended for the renovation of buildings is expected, which in turn will result in a significant decrease in heat consumption in such buildings. As for multi-apartment buildings, the 'first' stage of renovation is expected to be accomplished and renovation activities intensified in buildings whose renovation was completed earlier.

The decrease in the consumption of heat in multi-apartment buildings will slightly decelerate but it is reasonable to assume that it will continue to some extent.

The following tables and charts show data on the production of heat in DH systems, consumption of fuels structured by energy carriers and by RES/NRES and heat supplies from DH systems structured by consumption sector for 2010–2019.

Table 15: Total heat production from DH systems

Heat production in DH systems		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Heating energy production	(GWh)	16 763	16 088	16 164	15 868	14 925	15 857	13 858	13 308	13 862	14 258
Consumption of fuels:	(GWh)	19 136	18 430	18 656	18 375	17 233	18 164	15 775	15 054	15 686	16 176

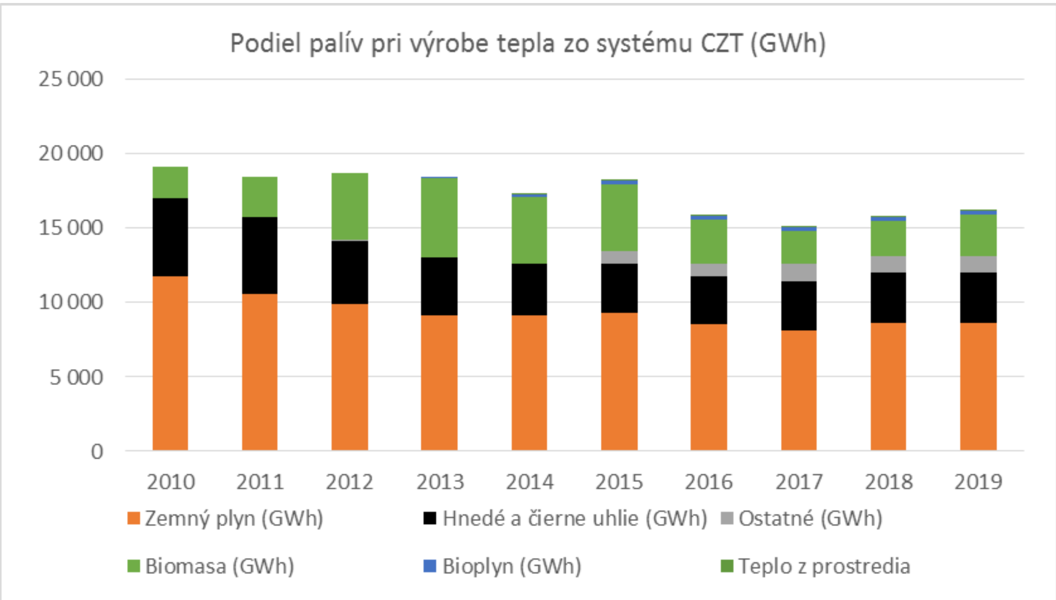
Source: ÚRSO, SIEA

Table 16: Consumption of fuels in heat production from DH systems by energy carriers

Consumption of fuels in heat production in DH systems		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Natural gas	(GWh)	11 739	10 597	9 919	9 136	9 146	9 292	8 514	8 141	8 637	8 597
Brown coal and hard coal	(GWh)	5 245	5 085	4 203	3 849	3 462	3 291	3 252	3 286	3 337	3 388
Other	(GWh)	44	36	36	53	0	861	852	1 137	1 137	1 128
Biomass	(GWh)	2 108	2 713	4 499	5 273	4 483	4 513	2 937	2 230	2 314	2 803
Biogas	(GWh)	0	0	0	64	142	207	220	261	261	261
Ambient heat	(GWh)	0	0	0	0	0	0	0	1	1	2
Total	(GWh)	19 136	18 430	18 656	18 375	17 233	18 164	15 775	15 055	15 687	16 178

Source: ÚRSO, SIE, MH SR

Chart 10: Share of fuels in heat production from DH systems by energy carriers 2010–2019



Source: ÚRSO, SIEA, MH SR

Key to graphic	
Original text	Translation
Podiel palív pri výrobe tepla zo systému CZT (GWh)	Share of fuels in heat production from DH systems (GWh)
Zemný plyn (GWh)	Natural gas (GWh)
Hnedé a čierne uhlie (GWh)	Brown coal and hard coal (GWh)
Ostatné (GWh)	Other (GWh)
Biomasa (GWh)	Biomass (GWh)
Bioplyn (GWh)	Biogas (GWh)
Teplo z prostredia	Ambient heat

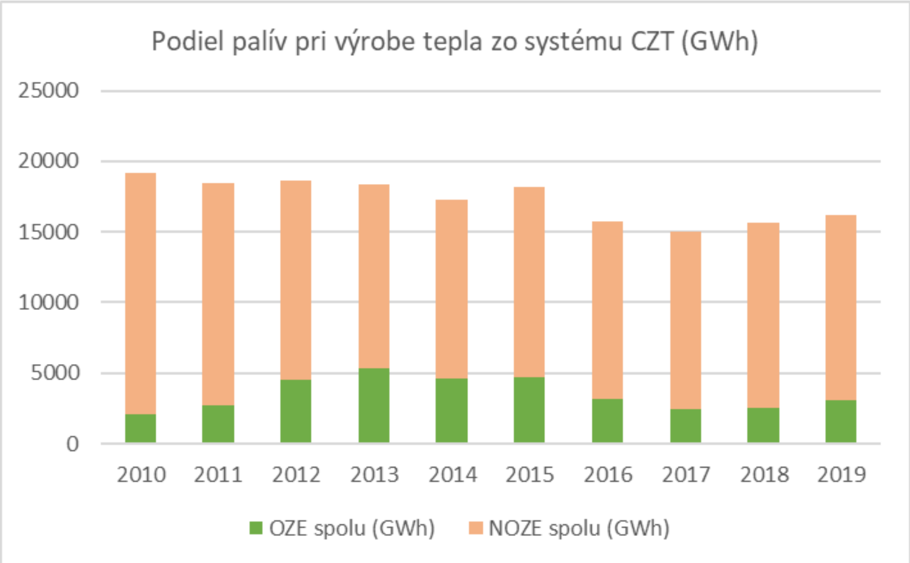
In terms of the structure of the fuels used and energy for the generation of heat in DH systems, the dominating fuel is natural gas. The share of natural gas in heat production ranges between 50 and 60% throughout the period under assessment.

Table 17: Consumption of fuels in heat production from DH systems by RES/NRES

Consumption of fuels in heat production in DH systems		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
RES total	(GWh)	2 108	2 713	4 499	5 337	4 625	4 720	3 157	2 491	2 575	3 063
NRES total	(GWh)	17 028	15 718	14 157	13 039	12 608	13 445	12 618	12 563	13 111	13 113
RES share	(%)	11.0	14.7	24.1	29.0	26.8	26.0	20.0	16.5	16.4	18.9

Source: ÚRSO, SIEA

Chart 11: Share of fuels in heat production from DH systems by RES/NRES 2010–2019



Source: ÚRSO, SIEA, MH SR

Key to graphic	
Original text	Translation
Podiel palív pri výrobe tepla zo systému CZT (GWh)	Share of fuels in heat production from DH systems (GWh)
OZE spolu (GWh)	RES total (GWh)
NOZE spolu (GWh)	NRES total (GWh)

The share of RES in heat production in DH systems in the monitored period increased percentage-wise from 11.0% in 2010 to 18.9% in 2019. Biomass is the dominant RES, its share of total RES being up to 90%.

Table 18: Total supply of heat from DH systems structured by supplies to the household sector and the trade and services sector

Supply of heat in DH systems by sectors		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
households	(GWh)	5 528	5 507	5 181	5 195	4 656	4 890	5 094	4 930	4 383	4 418
trade and services	(GWh)	5 926	5 903	5 553	5 569	4 991	5 507	5 201	5 279	4 348	4 305
Total	(GWh)	11 453	11 409	10 734	10 765	9 647	10 397	10 295	10 209	8 731	8 723

Source: ÚRSO

Table 19: Total supply of heat from DH systems to the household sector structured by heat for heating and heat in hot water

Supply of heat from DH systems for the household sector		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
for heating	(GWh)	3 660	3 646	3 528	3 823	3 403	3 210	3 404	3 297	2 881	2 916
in hot water	(GWh)	1 868	1 860	1 800	1 951	1 736	1 680	1 690	1 633	1 502	1 502
Total	(GWh)	5 528	5 507	5 328	5 774	5 139	4 890	5 094	4 930	4 383	4 418

Source: ÚRSO

Supply of heat to the household sector and trade and services sector in 2019 decreased by 23.8% compared to 2010. The significant decrease in the consumption of heat supply in 2014 was mainly due to climatic conditions consisting in the largest decrease of degree days in the monitored period in that year. Heat for technological consumption is also supplied from DH systems.

Installed capacity of heat sources for heat production in DH systems

The following table provides an overview of the installed capacities of installations for heat production in DH systems (excluding CHP and HE CHP installations) in which heat supplies are performed as of the reference year 2019, structured by fuel type.

Table 20: Installed capacity of installations for heat production in DH systems by energy carriers

Installed capacity of installations for heat production in DH system (excluding CHP)		
Boilers burning natural gas	(MW)	4 992.2
LPG-burning boilers	(MW)	3.7
Boilers burning butane-propane	(MW)	0.7
Boilers burning brown coal and hard coal	(MW)	257.5
Coke-burning boilers	(MW)	8.9
Electric boilers	(MW)	4.8
Biomass-burning boilers	(MW)	332.6
Heat pumps	(MW)	16.3
Total	(MW)	5 611.8

Source: ÚRSO, SIEA, MH SR

1.2.4 Supply of heat and cold from HE CHP installations

The following tables and charts present the basic balance of electricity and heat production using high-efficiency combined production, consumption of fuels structured by energy carriers and by RES/NRES and heat supplies from HE CHP structured by the consumption sector for 2010–2019.

Table 21: Total HE CHP

HE CHP		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Electricity production	(GWh)	3 798	3 901	4 285	4 720	4 074	2 516	2 640	3 057	2 563	2 837
Heating energy production	(GWh)	10 998	11 395	11 870	12 298	11 027	9 344	7 759	7 613	6 843	7 956
Consumption of fuels:	(GWh)	19 050	18 965	20 012	21 034	18 641	15 173	13 016	13 342	11 768	13 661

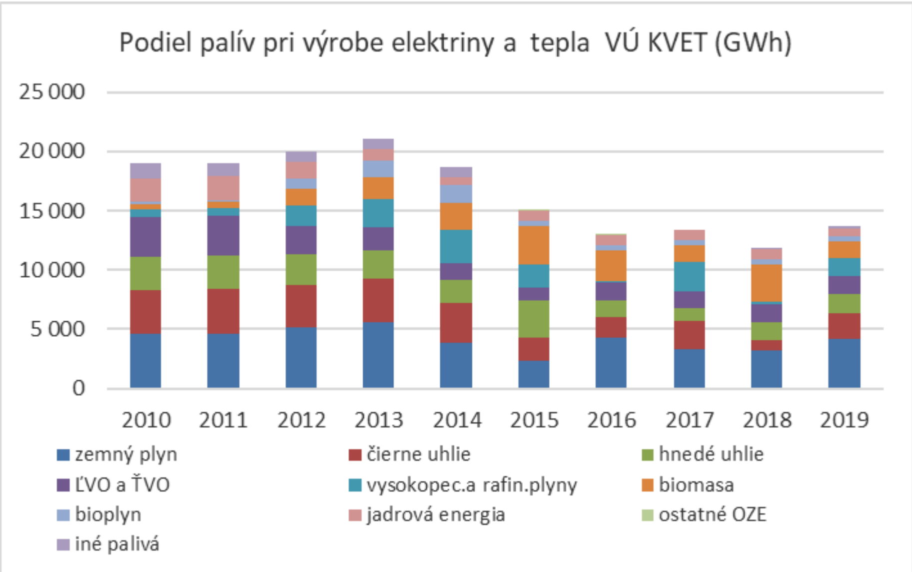
Source: SIEA – EEMS

Table 22: Consumption of fuels in HE CHP structured by energy carriers

Consumption of fuels in HE CHP		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
natural gas	(GWh)	4 601	4 630	5 144	5 645	3 861	2 366	4 333	3 307	3 191	4 171
hard coal	(GWh)	3 731	3 777	3 636	3 631	3 404	1 935	1 690	2 355	913	2 191
brown coal	(GWh)	2 789	2 813	2 561	2 367	1 874	3 179	1 385	1 127	1 506	1 617
light heating fuel and heavy heating fuel	(GWh)	3 366	3 406	2 354	1 961	1 454	1 030	1 582	1 435	1 529	1 562
blast furnace gases and refined gases	(GWh)	597	602	1 716	2 372	2 815	1 920	70	2 420	138	1 418
biomass	(GWh)	497	501	1 409	1 827	2 207	3 251	2 632	1 490	3 198	1 502
biogas	(GWh)	145	146	897	1 384	1 613	482	384	362	410	434
nuclear energy	(GWh)	1 991	2 010	1 378	1 058	639	833	871	846	867	654
other RES	(GWh)	0	0	0	0	0	176	70	0	0	0
other fuels	(GWh)	1 332	1 080	917	789	774	0	0	0	17	112
Total fuels	(GWh)	19 050	18 965	20 012	21 034	18 641	15 173	13 016	13 342	11 768	13 661

Source: SIEA – EEMS

Chart 12: Share of fuels in HE CHP structured by energy carriers 2010–2019



Source: SIEA – EEMS

Key to graphic	
Original text	Translation
Podiel palív pri výrobe elektriny a tepla VÚ KVET (GWh)	Share of fuels in HE CHP (GWh)
zemný plyn	natural gas
čierne uhlie	hard coal
hnedé uhlie	brown coal
ĽVO a ŤVO	light heating fuel and heavy heating fuel
vysokopec. a rafin. plyny	blast furnace gases and refined gases
biomasa	biomass
bioplyn	biogas
jadrová energia	nuclear energy
ostatné OZE	other RES
iné palivá	other fuels

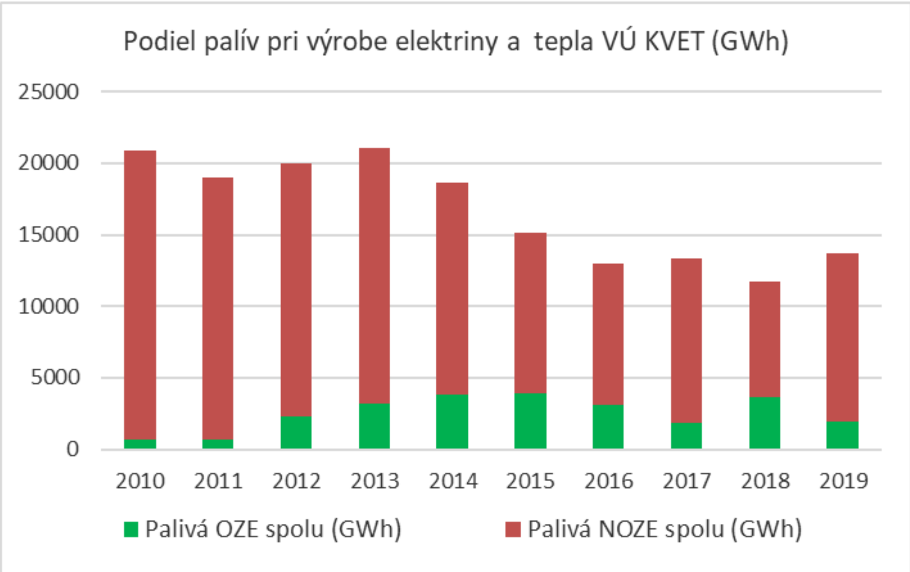
In terms of the representation of fuels in high-efficiency combined production, fossil fuels are dominant, mainly natural gas and coal. The share of biomass increased in the monitored period from 2.6% in 2010 to 11.0% in 2019.

Table 23: Consumption of fuels in HE CHP structured by RES/NRES

Consumption of fuels in HE CHP		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total RES fuels	(GWh)	642	647	2 305	3 211	3 820	3 910	3 086	1 851	3 608	1 937
Total NRES fuels	(GWh)	18 408	18 319	17 707	17 823	14 821	11 263	9 930	11 491	8 160	11 724
Share of RES fuels	(%)	3.4	3.4	11.5	15.3	20.5	25.8	23.7	13.9	30.7	14.2

Source: SIEA – EEMS

Chart 13: Share of fuels in HE CHP structured by RES/NRES 2010–2019



Source: SIEA – EEMS

Key to graphic	
Original text	Translation
Podiel palív pri výrobe elektriny a tepla VÚ KVET (GWh)	Share of fuels in HE CHP (GWh)

Palivá OZE spolu (GWh)	Total RES fuels (GWh)
Palivá NOZE spolu (GWh)	Total NRES fuels (GWh)

The share of RES in HE CHP in the monitored period increased percentage-wise from 3.4% in 2010 to 14.2% in 2019.

Table 24: Total supply of heat and cold from HE CHP structured by supplies to the industry sector, household sector and trade and services sector

Production and supply of heat from HE CHP		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Industry sector	(GWh)	5 829	6 035	6 282	6 506	5 833	4 295	3 331	4 857	3 962	4 432
- of which heat for cold production	*(GWh)*	*0.0*	*2.8*	*7.1*	*9.6*	*9.8*	*14.6*	*11.8*	*12.3*	*13.2*	*12.7*
DH – heat supply to households and services	(GWh)	5 059	5 242	5 460	5 657	5 072	4 934	4 337	2 688	2 843	3 448
- of which heat for cold production	*(GWh)*	*0.2*	*1.6*	*1.7*	*1.6*	*1.5*	*2.2*	*2.0*	*2.0*	*2.7*	*2.8*
DH – supply of cold to households and services	(GWh)	0	0	0	0	0	0	0	0	0	0
Supply of heat directly for heating	(GWh)	110	114	119	123	110	98	77	54	22	60
Total	(GWh)	10 998	11 395	11 870	12 298	11 027	9 344	7 759	7 613	6 843	7 956

Source: SIEA – EEMS

Average share of the supply of heat and cold from HE CHP to the industry sector represents 53% of the total supply of heat from HE CHP and 46% to the households and services sector.

Installed capacity of CHP installations

The following table provides an overview of the installed capacity of CHP installations as of the reference year 2019.

Table 25: Installed capacity of CHP installations by technologies

Installed capacity of CHP installations			
combined cycle	installed power	(MW)	150
	heat output	(MW)	141
Steam backpressure turbines	installed power	(MW)	437
	heat output	(MW)	1 319
Condensing steam turbines[1]	installed power	(MW)	1 642
	heat output	(MW)	1 666
Combustion turbines with heat recovery	installed power	(MW)	74
	heat output	(MW)	95
Internal combustion engines	installed power	(MW)	149
	heat output	(MW)	177
ORC	installed power	(MW)	5
	heat output	(MW)	13

[1] For condensing steam turbines, the total installed power is indicated

Total HE CHP installations	installed power (MW) heat output (MW)	2 458 3 411

Source: SIEA – EEMS

It is clear from the overview that in terms of the total installed power, the dominating technologies of combined production are condensing extraction turbines and backpressure turbines installed in main activity producer and autoproducer heating and power plants. A significant proportion of power and heat production is provided by combined-cycle gas turbines and internal combustion engines.

1.2.5 Share of heat consumption from individual sources of heat and from DH systems

Based on the above detailed analyses of consumption of heat from individual heat sources (IHS) and from DH systems (this includes also supply from CHP), the following tables summarise data on the consumption of heat intended for heating and hot water in the households and services sector for 2010–2019.

Table 26: Consumption of heat from individual sources of heat and from DH systems for 2010–2019

Individual heat production and supply											
Sector		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
households	(GWh)	19 004	18 829	18 323	17 925	13 029	16 067	17 593	17 598	15 581	16 128
trade and services	(GWh)	6 571	5 378	4 528	5 022	3 937	4 273	4 287	4 620	4 495	4 460
Total supply	(GWh)	25 574	24 206	22 851	22 947	16 967	20 340	21 880	22 219	20 076	20 588
Supply of heat from DH systems											
Sector		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
households	(GWh)	5 528	5 507	5 328	5 774	5 139	4 890	5 094	4 930	4 383	4 418
trade and services	(GWh)	5 926	5 903	4 696	4 492	4 044	5 507	5 201	5 279	4 348	4 305
Total supply	(GWh)	11 453	11 409	10 024	10 266	9 183	10 397	10 295	10 209	8 731	8 723

Source: ŠÚ SR, ÚRSO, SIEA, SPP - distribúcia, a.s., SHMU

Table 27: Share of heat supplies from individual sources of heat and from DH systems for 2010–2019

Share of heat supplies		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
individual heat sources	(GWh)	25 574	24 206	22 851	22 947	16 967	20 340	21 880	22 219	20 076	20 588
DH systems	(GWh)	11 453	11 409	10 024	10 266	9 183	10 397	10 295	10 209	8 731	8 723
individual heat sources	(%)	69.07	67.97	69.51	69.09	64.88	66.17	68.00	68.52	69.69	70.24
DH systems	(%)	30.93	32.03	30.49	30.91	35.12	33.83	32.00	31.48	30.31	29.76

Source: MH SR, SIEA

The share of heat supplies from DH systems in 2010–2019 in the total heat supplies ranged between 30 and 35%.

1.2.6 Installations producing waste heat or cold with a supply potential

For installations which can supply waste heat or cold, only municipal waste incineration plants are analysed because there are no installations in Slovakia other than these incineration plants that would have the required thermal input for supplying waste heat or cold.

There are two municipal waste incineration plants in Slovakia:

- Kosit, a.s., Košice,
- Odvoz a likvidácia odpadu, a.s., Bratislava.

Spaľovňa komunálneho odpadu Kosit, a. s., Košice

Two steam boilers with the heat output of 20.9 MW and 23.7 MW respectively and one condensing steam turbine with the output of 6.43 MW are installed in the incineration plant. The capacity of the municipal waste incineration plant is 10 t/h. KOSIT a. s. currently supplies heat in the volume of 36 000 MWh/year and is able to supply from the IERW source, in the present technology performance parameters, a maximum of 77 000 MWh of thermal energy/year. Projects of modernisation and construction of new installations are under preparation, after the completion of which the potential for supplies of thermal energy to the Košice central district heating system from KOSIT sources would increase to a maximum of 160 000 MWh/year by 2030.

Municipal waste incineration plant Odvoz a likvidácia odpadu, a. s., Bratislava

Two steam boilers with the heat output of 2x20 MW and one condensing steam turbine with the output of 6.3 MW are installed in the incineration plant. The capacity of the municipal waste incineration plant is 32.7 t/h. At present (2021), the company is carrying out preparatory work for the project 'Modernisation and greening of ZEVO OLO a.s.'. The modernisation includes an effort to increase potential heat (hot steam) supplies to the Bratislava DH system. Preparatory work is also underway to ensure a market for the production before the modernisation is completed. The current potential for waste heat supplies to DH (until 2025) is approximately 47 260 MWh/year. After the modernisation of the IERW (to be completed at the end of 2025, i.e. from 2026 onwards), this potential will increase to 161 961 MWh/year.

The following table provides data on the current supply of heat to DH systems, the current potential for heat supply and the potential for heat supply to DH systems after the completion of the planned IERW modernisation projects after 2030.

Table 28: Potential for the supply of waste heat from incineration plants

Municipal waste incineration plant		Current supply of heat to DH systems	Current potential for supply of heat to DH systems	Potential for supply of heat to DH systems after 2030
Kosit, a. s., Košice	(GWh)	36.0	77.0	160.0
Odvoz a likvidácia odpadu, a. s., Bratislava	(GWh)	-	47.3	162.0
Total	(GWh)	36.0	124.3	322.0

Source: Kosit a. s., Košice, Odvoz a likvidácia odpadu, a. s., Bratislava

1.3 Slovakia heat map

SIEA, which operates an energy efficiency monitoring system, has created and operates the Heat Map of the Slovak Republic. The detailed requisites of a heat map are set forth in Section 6(5) of Act No 321/2014 on energy efficiency. The impulse for heat mapping by individual EU member states came from EU legislation, specifically EU Directive 2012/27/EU on energy efficiency. The detailed requisites of a heat map were originally stipulated in Section 6(5) of Act No 321/2014 on energy efficiency and are currently laid down in Commission Delegated Regulation 2019/826.

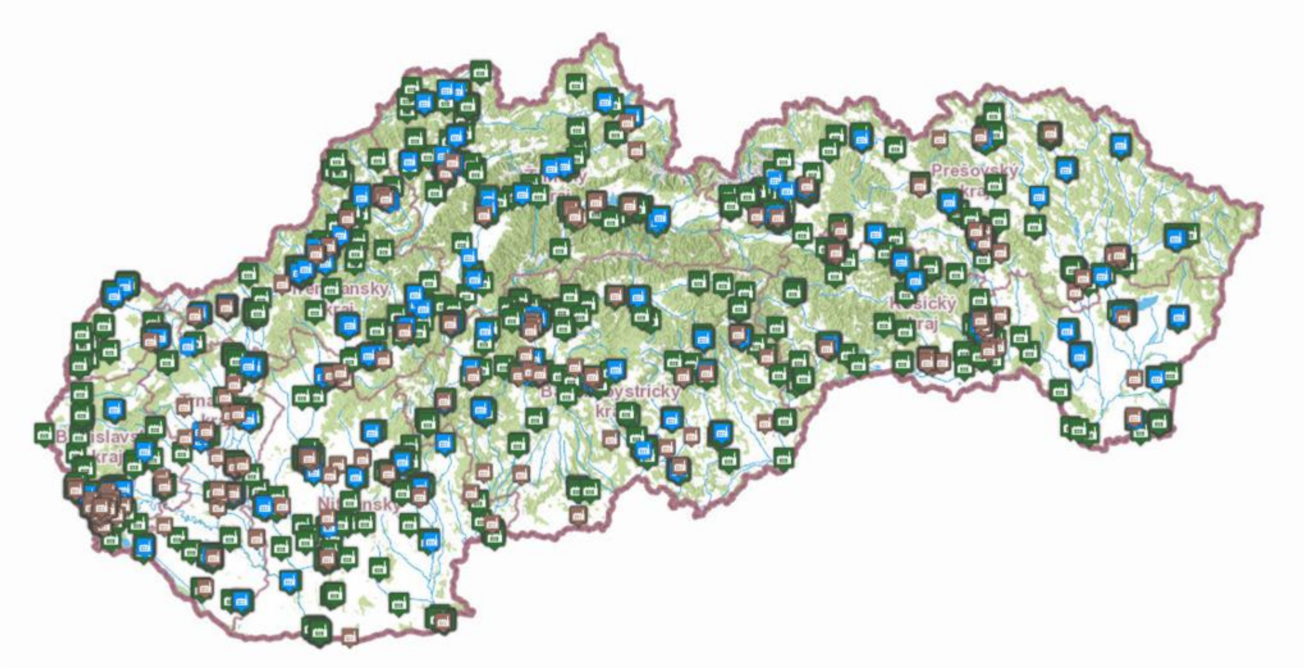
The maps are to ensure that anyone interested in investing in this activity has information about areas where future introduction of DH systems could be contemplated as DH systems are considered to be an efficient method of heat and hot water supply. In Slovakia, which unlike other EU countries can rely on its developed DH systems, the map serves primarily for identifying territories where it is possible and efficient to generate heat using high-efficiency combined heat and power production, renewable energy sources and use of heat from industrial processes for heating and cooling.

The map layers show areas where heat and cold are consumed in industrial zones as well as in municipalities and cities with most of their territory built up. The map also summarises information about existing DH infrastructure and installations for the production of electricity with a total annual electricity production exceeding 20 GWh, waste incineration plants and installations for combined heat and power production.

The data are updated from time to time. New data are usually processed after the providers within the meaning of the applicable legislation supply them to the energy efficiency monitoring system. Figures provided in detail are available only after having been approved, i.e. after the reports kept in the energy efficiency monitoring system have been checked and closed.

1.3.1 Areas of heating and cooling demand/requirement

Figure 1: Areas of heating and cooling demand/requirement

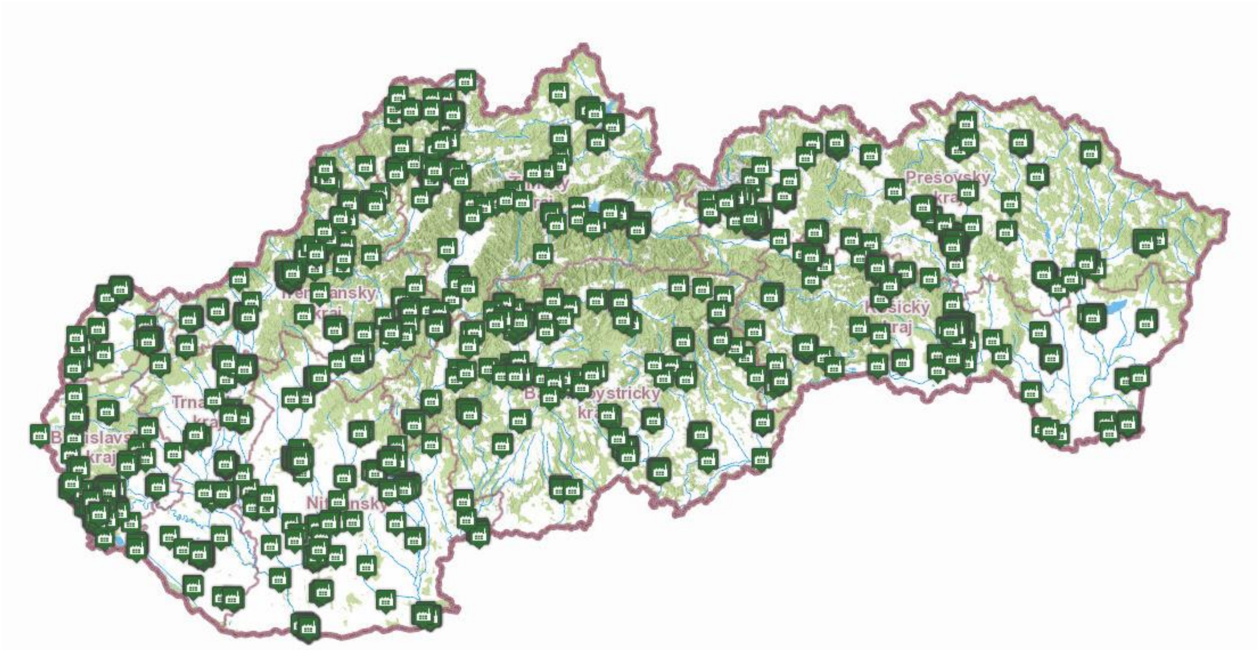


Source: Heat map of the Slovak Republic, SIEA

Key to graphic	
Original text	Translation
Žilinský kraj	Žilina Region
Prešovský kraj	Prešov Region
Trenčiansky kraj	Trenčín Region
Košický kraj	Košice Region
Trnavský kraj	Trnava Region
Banskobystrický kraj	Banská Bystrica Region
Bratislavský kraj	Bratislava Region
Nitriansky kraj	Nitra Region

1.3.2 Existing locations of heating and cooling supply and DH system installations

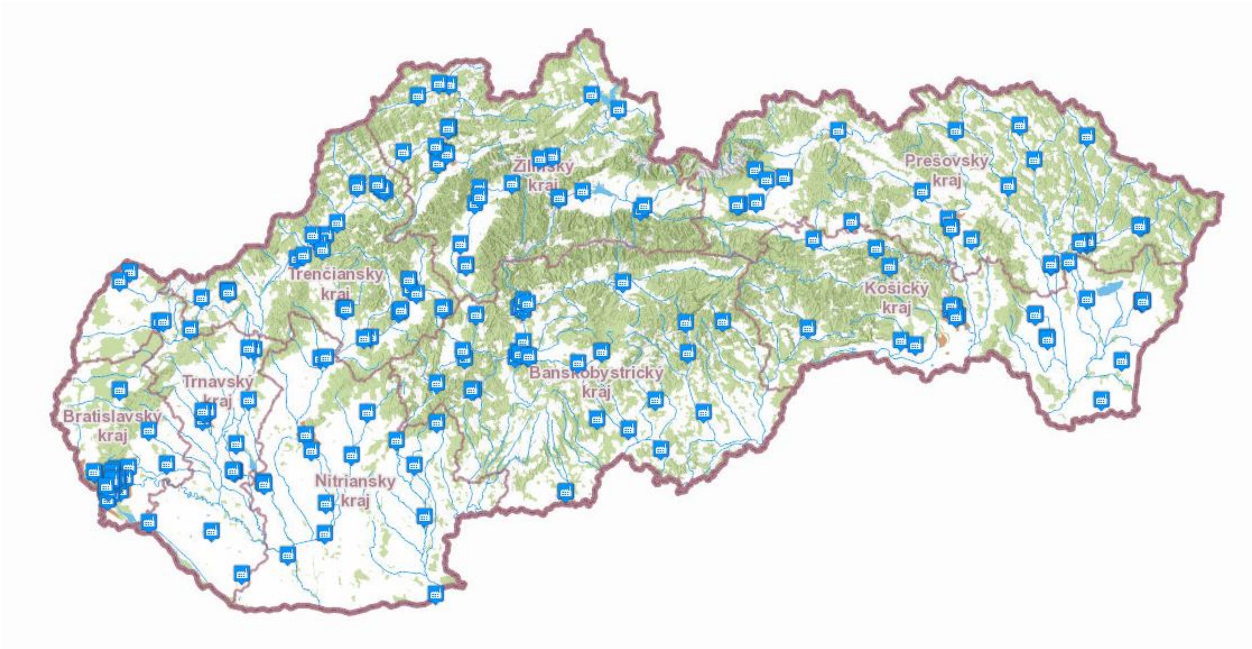
Figure 2: Existing heat and cold production installations



Source: Heat map of the Slovak Republic, SIEA

Key to graphic	
Original text	Translation
Žilinský kraj	Žilina Region
Prešovský kraj	Prešov Region
Trenčiansky kraj	Trenčín Region
Košický kraj	Košice Region
Trnavský kraj	Trnava Region
Banskobystrický kraj	Banská Bystrica Region
Bratislavský kraj	Bratislava Region
Nitriansky kraj	Nitra Region

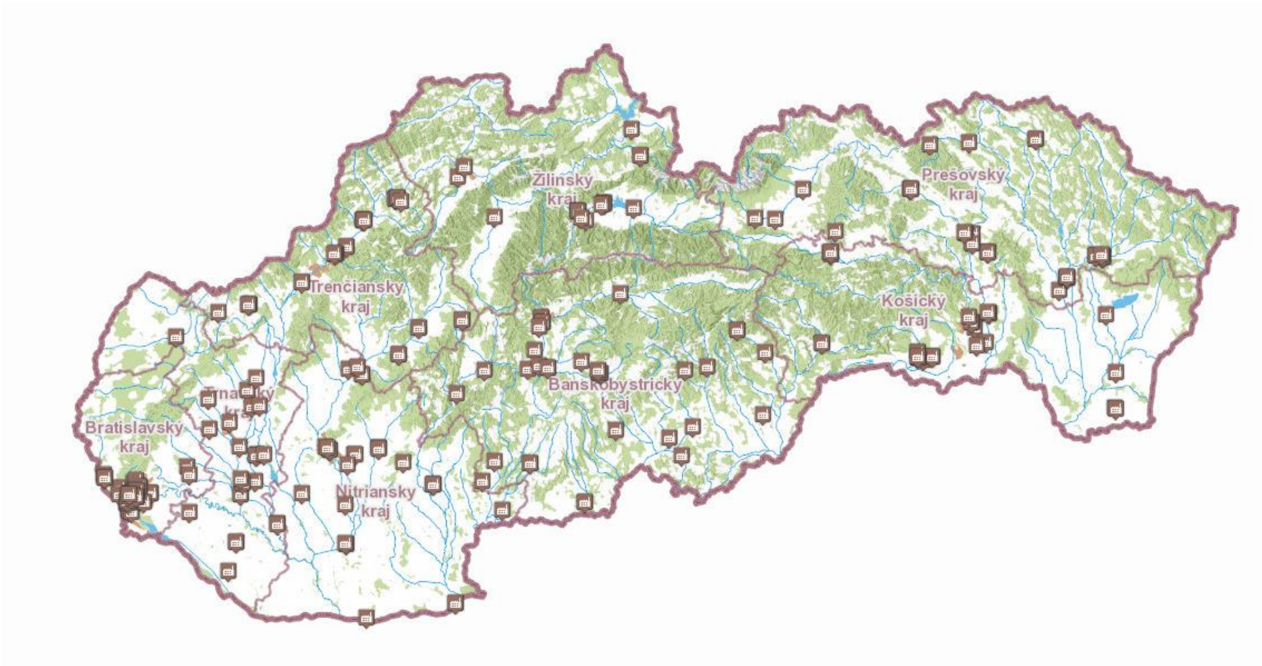
Figure 3: Existing sources of DH systems



Source: Heat map of the Slovak Republic, SIEA

Key to graphic	
Original text	Translation
Žilinský kraj	Žilina Region
Prešovský kraj	Prešov Region
Trenčiansky kraj	Trenčín Region
Košický kraj	Košice Region
Trnavský kraj	Trnava Region
Banskobystrický kraj	Banská Bystrica Region
Bratislavský kraj	Bratislava Region
Nitriansky kraj	Nitra Region

Figure 4: Existing CHP installations

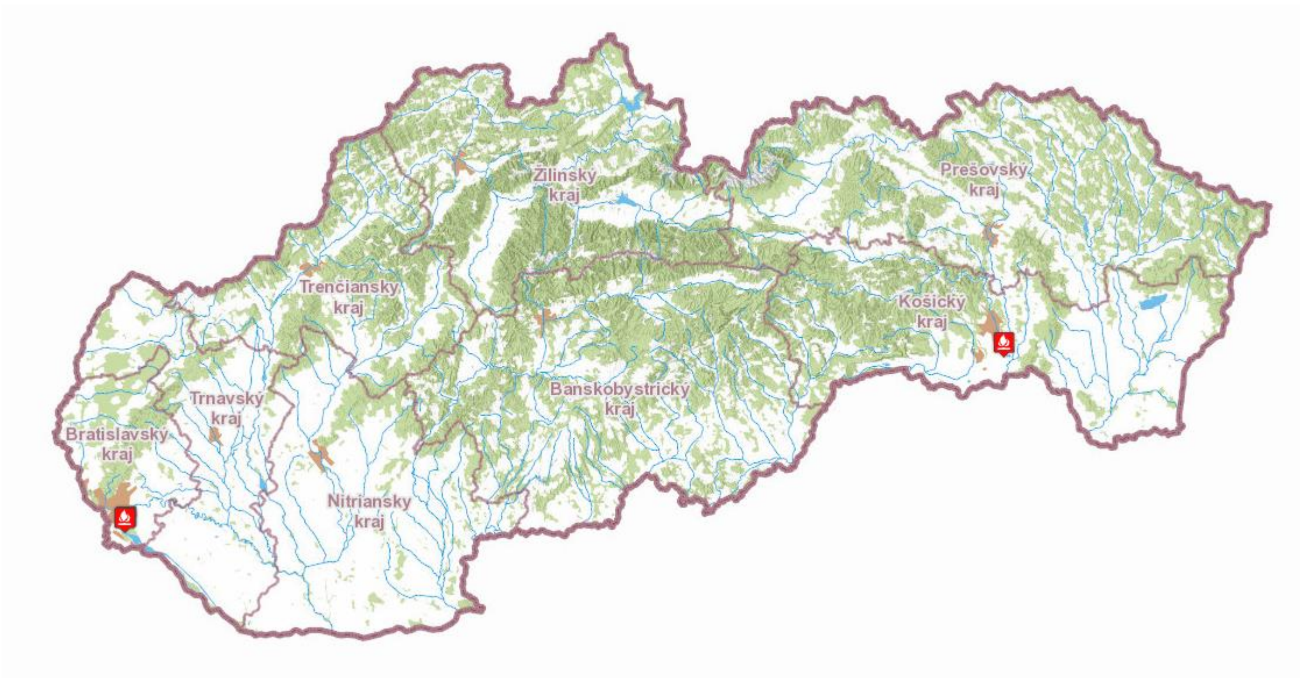


Source: Heat map of the Slovak Republic, SIEA

Key to graphic	
Original text	Translation
Žilinský kraj	Žilina Region
Prešovský kraj	Prešov Region
Trenčiansky kraj	Trenčín Region
Košický kraj	Košice Region
Trnavský kraj	Trnava Region
Banskobystrický kraj	Banská Bystrica Region
Bratislavský kraj	Bratislava Region
Nitriansky kraj	Nitra Region

1.3.3 Planned locations of heating and cooling supply and DH system installations

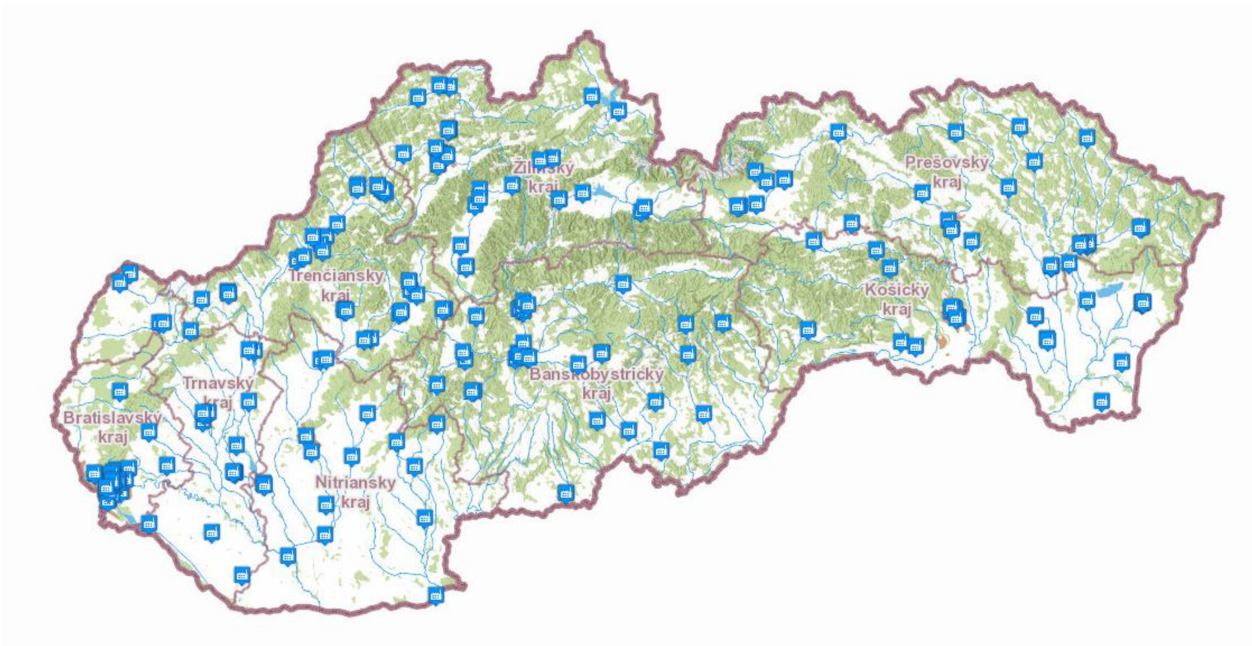
Figure 5: Planned heating and cooling locations – supply of waste heat from incineration plants



Source: Heat map of the Slovak Republic, SIEA

Key to graphic	
Original text	Translation
Žilinský kraj	Žilina Region
Prešovský kraj	Prešov Region
Trenčiansky kraj	Trenčín Region
Košický kraj	Košice Region
Trnavský kraj	Trnava Region
Banskobystrický kraj	Banská Bystrica Region
Bratislavský kraj	Bratislava Region
Nitriansky kraj	Nitra Region

Figure 6: Possible locations of HE CHP sources – *internal combustion engines in existing DH systems*



Source: Heat map of the Slovak Republic, SIEA

Key to graphic	
Original text	Translation
Žilinský kraj	Žilina Region
Prešovský kraj	Prešov Region
Trenčiansky kraj	Trenčín Region
Košický kraj	Košice Region
Trnavský kraj	Trnava Region
Banskobystrický kraj	Banská Bystrica Region
Bratislavský kraj	Bratislava Region
Nitriansky kraj	Nitra Region

Table 29: Potential HE CHP sources – internal combustion engines in existing DH systems

District	Current heat production in DH systems			Determination of HE CHP potential		
	District heating (kWh)	Domestic hot water (kWh)	Total district heating + domestic hot water (GWh)	Number of HE CHP sources (-)	Total heat output (kW)	Total installed power (kW)
Banská Bystrica	98 129 270	46 165 129	144	13	617	492
Banská Štiavnica	8 373 282	4 994 318	13	7	540	431
Brezno	29 660 984	11 130 601	41	10	1 236	988
Detva	14 558 415	6 245 148	21	4	1 622	1 297
Krupina	5 391 544	2 770 943	8	2	630	504
Lučenec	32 969 144	13 911 206	47	12	1 605	1 283
Poltár	7 321 684	2 600 168	10	3	362	289
Revúca	32 308 149	8 555 311	41	4	315	252
Rimavská Sobota	52 803 961	14 978 756	68	6	1 847	1 615
Veľký Krtíš	16 308 654	6 094 685	22	2	878	703
Zvolen	75 818 944	29 839 785	106	8	4 677	4 134
Žarnovica	7 883 693	3 803 936	12	4	430	343
Žiar nad Hronom	39 168 142	16 875 084	56	1	75	60
Bratislava I.	68 687 514	17 055 479	86	16	1 211	970
Bratislava II.	295 074 295	114 193 783	409	15	1 854	1 482
Bratislava III.	136 903 410	38 356 012	175	21	1 744	1 396
Bratislava IV.	215 556 897	84 969 122	301	18	10 707	9 409
Bratislava V.	186 970 918	98 743 843	286	25	10 484	8 389
Malacky	53 234 155	12 963 646	66	10	1 697	1 358
Pezinok	16 535 083	7 443 780	24	10	917	735
Senec	9 101 944	4 763 810	14	3	584	468
Gelnica	15 729 399	6 189 133	22	3	428	343
Košice-okolie	12 608 133	6 135 826	19	2	133	107
Košice I.	170 947 979	61 246 829	232	2	143	114
Košice II.	121 666 980	58 674 393	180	2	25	20
Košice III.	42 651 901	25 908 753	69	0	0	0
Košice IV.	93 751 069	40 536 213	134	1	17	14
Michalovce	53 745 306	28 186 600	82	18	3 064	2 451
Rožňava	31 016 566	12 362 906	43	15	806	644
Sobrance	3 657 957	152 355	4	1	84	67
Spišská Nová Ves	73 403 975	30 353 371	104	28	3 301	2 639
Trebišov	11 055 709	4 641 244	16	6	520	417
Komárno	61 512 529	28 358 498	90	18	2 940	2 568
Levice	101 768 252	31 216 549	133	16	852	682
Nitra	83 945 821	39 008 748	123	19	2 459	1 970
Nové Zámky	83 940 052	32 783 320	117	7	1 673	1 337
Šaľa	809 949	50 425	1	1	22 617	20 355
Topoľčany	32 709 676	14 784 875	47	0	0	0

Zlaté Moravce	11 432 000	4 636 960	16	1	734	587
Bardejov	55 802 270	19 446 935	75	12	2 238	1 791
Humenné	73 574 111	29 017 233	103	0	0	0
Kežmarok	16 888 057	9 240 528	26	8	1 041	834
Levoča	11 126 207	4 686 974	16	5	331	265
Medzilaborce	6 646 425	2 796 110	9	1	359	287
Poprad	70 252 941	32 380 220	103	33	3 333	2 666
Prešov	144 639 643	61 058 299	206	34	7 193	6 207
Sabinov	11 563 046	5 732 319	17	6	614	491
Snina	24 304 776	11 136 813	35	1	158	126
Stará Ľubovňa	12 615 000	7 140 122	20	6	850	679
Stropkov	5 481 772	2 103 928	8	2	238	190
Svidník	22 089 434	6 713 043	29	6	529	424
Vranov nad Topľou	22 118 651	11 212 535	33	15	1 046	838

District	**Current heat production in DH systems**			**Determination of HE CHP potential**		
	District heating (kWh)	**Domestic hot water (kWh)**	**Total district heating + domestic hot water (GWh)**	**Number of HE CHP sources (-)**	**Total heat output (kW)**	**Total installed power (kW)**
Bánovce nad Bebravou	39 302 536	8 129 172	47	6	1 061	849
Ilava	188 769 647	26 827 913	216	6	996	797
Myjava	75 318 478	9 858 566	85	7	864	692
Nové Mesto nad Váhom	65 033 938	16 615 367	82	13	2 012	1 611
Partizánske	42 145 261	13 107 550	55	11	1 368	1 096
Považská Bystrica	402 544 462	24 595 715	427	3	308	247
Prievidza	258 362 491	46 385 711	305	16	2 042	1 634
Púchov	75 284 310	13 663 860	89	9	10 628	9 536
Trenčín	130 104 154	31 547 313	162	33	3 508	2 806
Dunajská Streda	130 332 655	22 631 123	153	8	1 446	1 159
Galanta	32 266 843	12 016 874	44	6	1 544	1 236
Hlohovec	22 241 504	9 555 767	32	2	7 914	7 121
Piešťany	41 949 389	15 463 316	57	21	1 937	1 549
Senica	53 414 162	13 058 736	66	3	996	797
Skalica	48 641 598	16 079 298	65	10	1 213	970
Trnava	105 967 815	43 621 392	150	1	168	134
Bytča	7 234 368	3 502 070	11	6	375	299
Čadca	39 134 486	16 822 937	56	10	1 679	1 344
Dolný Kubín	41 658 775	13 259 832	55	8	2 190	1 752
Kysucké Nové Mesto	2 431 741	722 126	3	2	238	191
Liptovský Mikuláš	63 108 613	24 920 674	88	31	3 947	3 158
Martin	117 529 299	41 645 380	159	1	10	8
Námestovo	10 011 110	3 151 783	13	3	444	355
Ružomberok	46 958 261	15 028 774	62	2	215	172
Turčianske Teplice	5 099 717	2 156 164	7	2	235	188
Tvrdošín	10 942 864	5 331 449	16	2	213	171
Žilina	120 984 841	52 458 431	173	8	1 155	923
Slovakia total	**5 062 988 986**	**1 676 503 895**	**6 739**	**693**	**150 464**	**126 506**

Source: SIEA

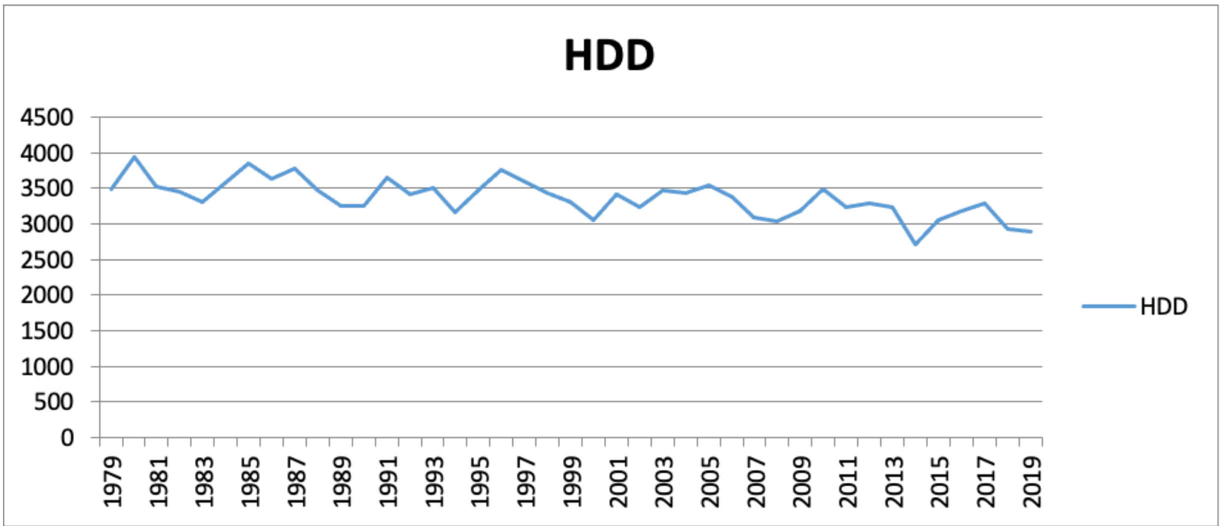
Comprehensive current information on industrial parks and industrial zones in the Slovak territory is available on the website https://www.priemyselneparkyslovenska.sk/en/, including an interactive map of Slovakia with information on investment possibilities and industrial parks.

1.4 Forecast of the trend in demand for heating and cooling with a 30-year outlook

The existing trend of decreasing heat consumption is expected to continue, mainly due to the planning and implementation of rationalisation measures related to energy efficiency in various sectors of final energy consumption of heat and modernisation and increasing efficiency of existing heating systems. Energy efficiency measures aimed at buildings have the greatest impact on the forecasts of heat consumption development. In terms of sources of heat and fuels for heat production, a transition to alternative and low-carbon fuels is underway, with a high support for renewable energy sources. It is also important to analyse the impacts of various policies aimed at decreasing consumption of heat and cold in society.

The climate neutrality commitment should result in maintaining or even moderately accelerating the process of decreasing the requirement for heat especially in public buildings, in the services sector and in residential buildings. In industry, further measures aimed at decreasing the requirement for heat are anticipated, as well as the possible use of heat generated in industry for heating or cooling. Climatic conditions in the heating season have a significant effect on the consumption of heat for heating and cooling. The year 2014 marked the most temper climatic conditions in winter, which resulted in the absolute lowest production of heat in the years in question. The long-term trend in climatic conditions is characterised by a slight decrease in (heating) degree days. Cooling degree days, on the other hand, show an opposite trend, namely a slight increase in cooling degree days in the past ten years, which results especially in an increased requirement for the cooling of buildings in summer months. The development of degree days in Slovakia is given in the following charts.

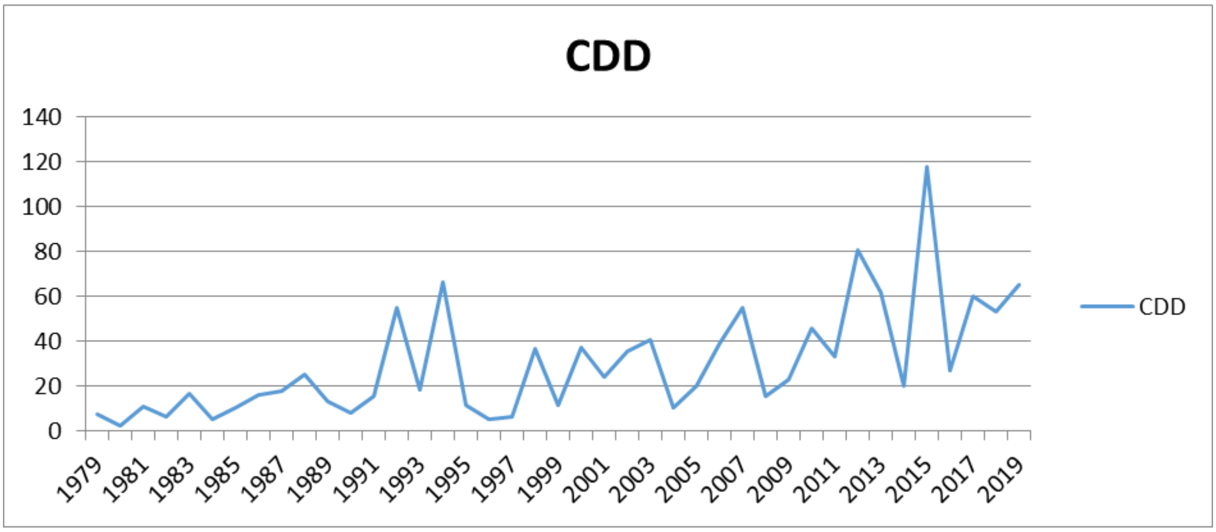
Chart 14: Long-term development of degree days since 1979



Source: Eurostat

Key to graphic	
Original text	Translation
HDD	HDD

Chart 15: Long-term development of cooling degree days since 1979



Key to graphic	
Original text	Translation
CDD	CDD

Source: Eurostat

Based on the updated document ‘Strategy for the renovation of the stock of multi-apartment buildings and non-residential buildings’, at the current rate of renovation, all occupied single-family houses will be renovated by 2040, more than a half of non-residential buildings should undergo medium renovation by 2030, multi-apartment buildings should undergo deep renovation, gradually achieving 29% of such renovations by 2030, with this percentage then increasing until 2041, when all the buildings should be renovated in order to ensure that this sector can significantly contribute to Slovakia’s climate neutrality commitment, a target which we would like to achieve in 2050.

1.4.1 Forecast of the trend in demand for heating from NECP

The Integrated National Energy and Climate Plan contains basic forecasts of the development of consumption of heat and cold in connection with the fulfilment of one of the basic energy and climate objectives – the objective for renewable energy sources. The general objective for Slovakia for 2030 is 19.2%, which is an increase by 5.2% in comparison with the objective set for 2020. The reference points in the indicative trajectory for the years 2022, 2025 and 2027 are set at 14.94%, 16.24% and 17.38%. However, these values do not yet reflect the adjustment of the objective and the trajectories in connection with the supplementation of data on the use of biomass at an individual level.

The total investment costs for achieving RES objectives are estimated at 4.3 billion euros in NECP. These investment costs include the electricity and heating sector. They are based on the estimated increase in installed capacity for power and heat from RES and the necessary investment per unit of output.

Table 30: Estimated trajectory for RES in heat

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
RES – heat and cold production (%)	13.0	14.3	14.6	15.2	16.1	16.7	17.5	18.1	18.5	19.0

Source: NECP

Table 31: Representation of renewable energy in the final energy consumption in heat and cold (ktoe)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expected gross final consumption of renewable energy sources in the production of heat and cold	685	721	780	788	810	844	868	898	913	924	937

Source: NECP

Table 32: Estimated total expected representation (final energy consumption) of individual technologies from renewable sources in Slovakia in the production of heat and cold in 2021–2030 (ktoe)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Geothermal energy excluding use in heat pumps	7	13	12	15	30	35	46	47	48	50
Solar energy	14	17	20	23	26	29	32	35	39	43
Biomass:										
solid	600	620	625	630	635	640	645	650	650	650
biogas/biomethane	65	75	80	85	90	95	100	100	100	100
Renewable energy from heat pumps, of which										
aerothermal	16	18	22	25	28	31	34	37	40	44
geothermal	12	15	18	20	22	24	26	28	30	32
hydrothermal	7	9	11	12	13	14	15	16	17	18
TOTAL	**721**	**767**	**788**	**810**	**844**	**868**	**898**	**913**	**924**	**937**

Source: NECP

The RES Directive lays down also an indicative objective of 1.3% as the annual average for the periods 2021 to 2025 and 2026 to 2030. This indicative value decreases to 1.1% where waste heat and cold are not used.

The following table presents the fulfilment of the indicative objective for heating and cooling, with heat from RES in the numerator and estimated requirement for heat for heating and cooling in the denominator. The average indicative annual values are 1.3% and 1.4%, respectively. Given the annual installation and replacement of installations using RES, we consider it very problematic to expect that a higher growth could be achieved or a calculation made in reference to the total consumption of heat in technological processes in industry.

Table 33: Estimated total expected representation of individual technologies from renewable sources in Slovakia in the heating and cooling sector

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
RES for heat production (ktoe)	685	721	768	788	810	844	868	898	913	924	936

Estimated requirement for heat for heating and cooling (ktoe).	3 344	3 284	3 224	3 164	3 104	3 044	2 984	2 924	2 864	2 804	2 744
Share of RES in heating	20.5%	22.0%	23.8%	24.9%	26.1%	27.7%	29.1%	30.7%	31.9%	33.0%	34.1%
Annual increase		1.5%	1.9%	1.1%	1.2%	1.6%	1.4%	1.6%	1.2%	1.1%	1.2%
Average over 5 years		1.4%					1.3%				

Source: NECP

1.4.2 Forecast of the trend in demand for heating from individual heat sources in the household sector

Based on the 2011 ŠÚ SR population and housing census, there were 815 233 occupied single-family houses in Slovakia in that year, with a majority of them using their own sources of heat.

Of the total number of occupied single-family houses:

- 15% were insulated (in the census questionnaire, a house was considered to be insulated if its envelope was insulated and, simultaneously, the windows and doors were treated to prevent heat losses),
- 12% were partly insulated (in the census form, a house was partly insulated if only some parts were insulated),
- 52.6% were non-insulated,
- no data were provided for 20.4% of single-family houses.

Based on data from the civic association titled Association for Insulation of Buildings, it was possible to specify the degree of renovation of single-family houses in the reference year 2019, where of the total number of 815 233 single-family houses with individual heating:

- 48.97 % were insulated,
- 55.03% were not insulated.

Of the total number of 2 615 multi-apartment buildings with individual heating (according to EEMS):

- 67.87% were insulated,
- 32.13% were not insulated.

The forecast of the trend in demand for heating from individual heat sources in the household sector was prepared on the basis of the following data and principles:

- the reference year for heat consumption is 2019,
- the effects of the measures and strategies adopted in the current situation will be visible from 2023 onwards,

- all occupied single-family houses will be completely renovated by 2040 (in the sense of the updated document 'Strategy for the renovation of the stock of multi-apartment buildings and non-residential buildings'),
- all multi-apartment buildings with individual heating will be completely renovated by 2041 (in the sense of the updated document 'Strategy for the renovation of the stock of residential and non-residential buildings'),
- another partial renovation of the buildings which are already insulated will occur between 2020 and 2050 and beyond.

The following tables and chart provide a forecast of the trend in demand for heating in the household sector from individual sources of heat for the next 10 years and for the next 30 years. Based on the above forecast, the consumption of heat for heating from individual sources of heat in the household sector should decrease by 10.9% by 2030 and by 27.3% by 2050 as compared to the reference consumption of heat in 2019.

Table 34: Forecast of the trend in demand for heating from individual heat sources in the household sector in 2020–2030

Demand for individual heating in the household sector		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Heat consumption	(GWh)	16 128	16 128	16 128	15 908	15 688	15 468	15 248	15 028	14 808	14 588	14 368

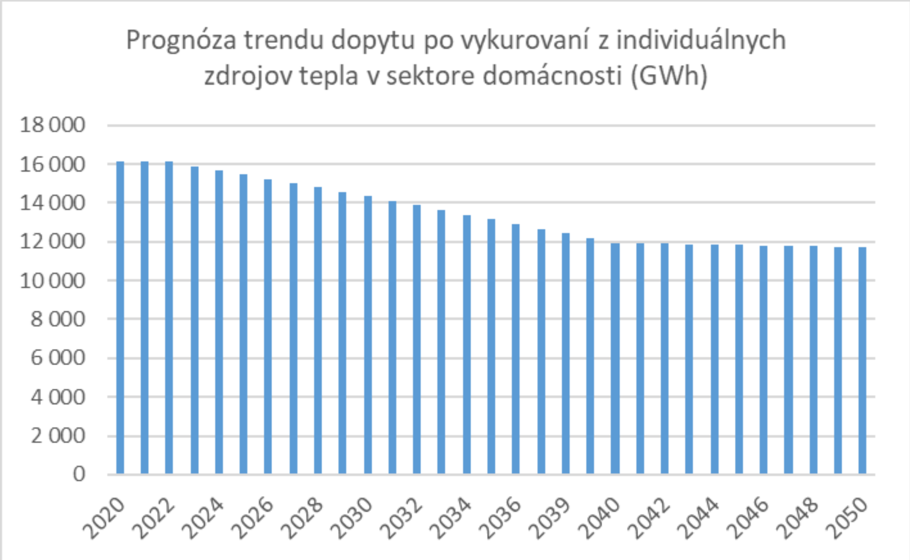
Source: SIEA

Table 35: Forecast of the trend in demand for heating from individual heat sources in the household sector in 2020–2050

Demand for individual heating in the household sector		2020	2025	2030	2035	2040	2045	2050
Heat consumption	(GWh)	16 128	15 468	14 368	13 157	11 945	11 830	11 718

Source: SIEA

Chart 16: Forecast of the trend in demand for heating from individual heat sources in the household sector



Source: SIEA

Key to graphic	
Original text	Translation
Prognóza trendu dopytu po vykurovaní z individuálnych zdrojov tepla v sektore domácnosti (GWh)	Forecast of the trend in demand for heating from individual heat sources in the household sector (GWh)

1.4.3 Forecast of the trend in demand for heating from individual heat sources in the trade and services sector

The forecast of the trend in demand for heating from individual heat sources in the trade and services sector was prepared on the basis of the following data and principles:

- the reference year for heat consumption is 2019,
- the effects of the measures and strategies adopted in the current situation will be visible from 2023 onwards,
- currently, 20% of buildings are insulated and 80% of buildings are not insulated,
- all trade and services buildings with individual heating will be completely renovated by 2041 (in the sense of the updated document ‘Strategy for the renovation of the stock of residential and non-residential buildings’),
- another partial renovation of the buildings which are already insulated will occur between 2020 and 2050.

The following tables and chart provide a forecast of the trend in demand for heating in the trade and services sector from individual sources of heat for the next 10 years and for the next 30 years.

Table 36: Forecast of the trend in demand for heating from individual heat sources in the trade and services sector for 2020–2030

Demand for individual heating in the trade and services sector		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Heat consumption	(GWh)	4 460	4 460	4 460	4 385	4 310	4 235	4 160	4 085	4 010	3 935	3 859

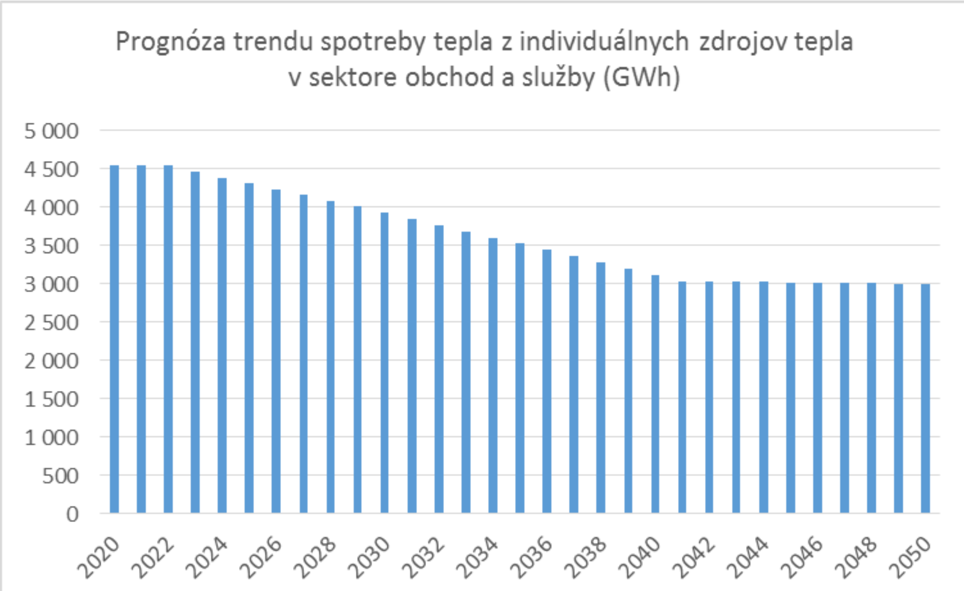
Source: SIEA

Table 37: Forecast of the trend in demand for heating from individual heat sources in the trade and services sector for 2020–2050

Demand for individual heating in the trade and services sector		2020	2025	2030	2035	2040	2045	2050
Heat consumption	(GWh)	4 460	4 235	3 859	3 462	3 064	2 966	2 944

Source: SIEA

Chart 17: Forecast of the trend in demand for heating from individual heat sources in the trade and services sector



Source: SIEA

Key to graphic	
Original text	Translation
Prognóza trendu spotreby tepla z individuálnych zdrojov tepla v sektore obchod a služby (GWh)	Forecast of the trend in consumption of heat from individual heat sources in the trade and services sector (GWh)

Based on the above forecast, the consumption of heat for heating from individual sources of heat in the trade and services sector should decrease by 13.5% by 2030 and by 34.0% by 2050 as compared to the reference consumption of heat in 2019.

1.4.4 Forecast of the trend in demand for heating from DH systems in the trade and services sector

The forecast of the trend in demand for heating from DH systems in the trade and services sector was prepared on the basis of the following data and principles:

- the reference year for heat consumption is 2019,
- the effects of the measures and strategies adopted in the current situation will be visible from 2023 onwards,
- currently, 20% of buildings are insulated and 80% of buildings are not insulated,
- all trade and services buildings will be completely renovated by 2041 (in the sense of the updated document 'Strategy for the renovation of the stock of residential and non-residential buildings'),
- another partial renovation of the buildings which are already insulated will occur between 2020 and 2050.

The following tables and chart provide a forecast of the trend in demand for heating in the trade and services sector from DH systems for the next 10 years and for the next 30 years.

Table 38: Forecast of the trend in demand for heating from DH systems in the trade and services sector for 2020–2030

DH – Demand for heating in the trade and services sector		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Heat consumption	(GWh)	4 305	4 305	4 305	4 232	4 160	4 087	4 015	3 942	3 870	3 797	3 725

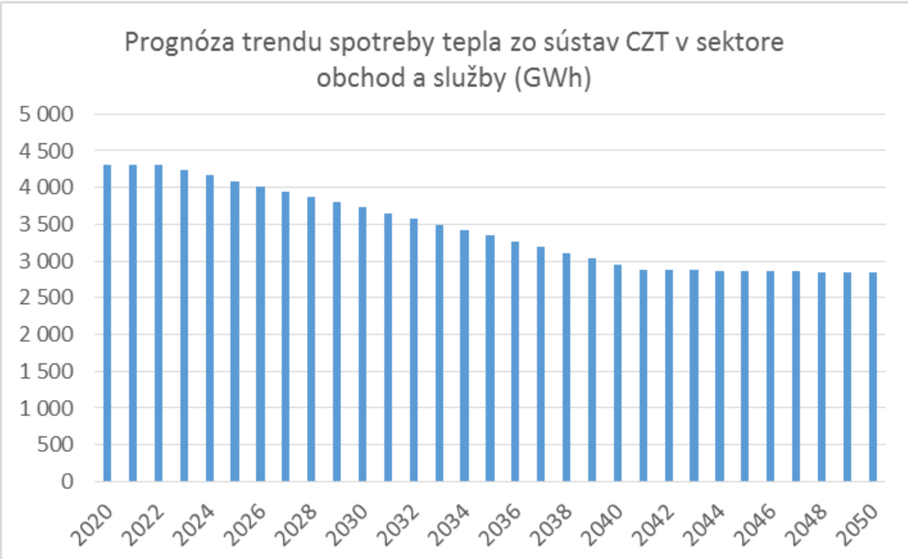
Source: SIEA

Table 39: Forecast of the trend in demand for heating from DH systems in the trade and services sector for 2020–2050

DH – Demand for heating in the trade and services sector		2020	2025	2030	2035	2040	2045	2050
Heat consumption	(GWh)	4 305	4 087	3 725	3 341	2 957	2 863	2 841

Source: SIEA

Chart 18: Forecast of the trend in demand for heating from DH systems in the trade and services sector



Source: SIEA

Key to graphic	
Original text	Translation

Prognóza trendu spotreby tepla zo sústav CZT v sektore obchod a služby (GWh)	Forecast of the trend in heat consumption from DH systems in the trade and services sector (GWh)

Based on the above forecast, the consumption of heat for heating from DH systems in the trade and services sector should decrease by 13.5% by 2030 and by 34.0% by 2050 as compared to the reference consumption of heat in 2019.

1.4.5 Forecast of the trend in demand for heating from DH systems in the household sector

Heat is supplied from DH systems to 19 111 multi-apartment buildings with approx. 1.9 million inhabitants. The consumption of heat in multi-apartment buildings shows a continuing downward trend and it is reasonable to assume that this tendency will continue. The past 5 years saw a continuation of the trend of decreasing consumption of heat mainly on account of better thermal-insulation characteristics of building envelopes thanks to insulation and replacement of windows and doors. Significantly contributing to the decreasing consumption are also the rationalisation measures on technical equipment of buildings (hydraulic control of heating systems and hot water distribution lines, insulation of circulation hot water distribution systems, installation of thermostatic valves, heat cost allocation meters).

Between 2015 and 2019, the consumption of heat for heating and hot water preparation in multi-apartment buildings to which heat is supplied from DH systems decreased by 9.6%, which in absolute figures represents a decrease in the quantity of produced heat by 470 GWh.

The monitoring system of energy efficiency operated by SIEA has generated the following data for the past 5 years showing the actual annual consumption of heat for heating and hot water preparation for the relevant number of multi-apartment buildings (8 000 to 11 000) held in the energy efficiency monitoring system:

- the average annual specific consumption of heat for heating in 2015–2019 calculated on the basis of the actual consumption of heat for heating decreased from 52.03 kWh/m^2 to 46.46 kWh/m^2,
- the average annual specific consumption of heat for hot water preparation decreased from 30.20 kWh/m^2 to 28.98 kWh/m^2.

The specific indicators of the consumption of heat for hot water preparation show slight differences in the recent years and no significant decrease in the consumption of heat in this consumption sector is anticipated as the basic energy efficiency measures have already been set in legislation. The current average consumption of hot water in Slovakia is 11 m^3/(person/year), the specific consumption of heat is approx. 900 kWh/(person/year) and 78.6 kWh/m^3 .

Of the total of 19 111 multi-apartment buildings, 12 971 were insulated and 6 140 were not insulated, according to data from EEMS.

The forecast of the trend in demand for heating from DH systems in the household sector was prepared on the basis of the following data and assumptions:

- the reference year for heat consumption is 2019, where in the total annual heat consumption of 4 418 GWh consumption of heat for heating was 2 916 GWh and consumption of heat for hot water preparation was 1 502 GWh. However, in simulating the heat consumption forecast, it is not anticipated that a significant decrease in the consumption of heat for hot water preparation will occur if rationalisation measures are implemented because, from the viewpoint of legislative requirements, most measures have been implemented,
- the effects of the measures and strategies adopted in the current situation will be visible from 2023 onwards,
- all multi-apartment buildings with individual heating will be completely renovated by 2041 (in the sense of the updated document 'Strategy for the renovation of the stock of residential and non-residential buildings'),
- another partial renovation of the houses which are already insulated will take place between 2020 and 2050.

The following tables and chart provide a forecast of the trend in demand for heating in the household sector from DH systems for the next 10 years and for the next 30 years.

Table 40: Forecast of the trend in demand for heat from DH systems in the household sector in 2020–2030

DH – Demand for heating in the household sector		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total heat consumption	(GWh)	4 418	4 418	4 418	4 395	4 373	4 350	4 328	4 305	4 283	4 260	4 238
- of which heat for heating	(GWh)	2 916	2 916	2 916	2 893	2 871	2 848	2 826	2 803	2 781	2 758	2 736

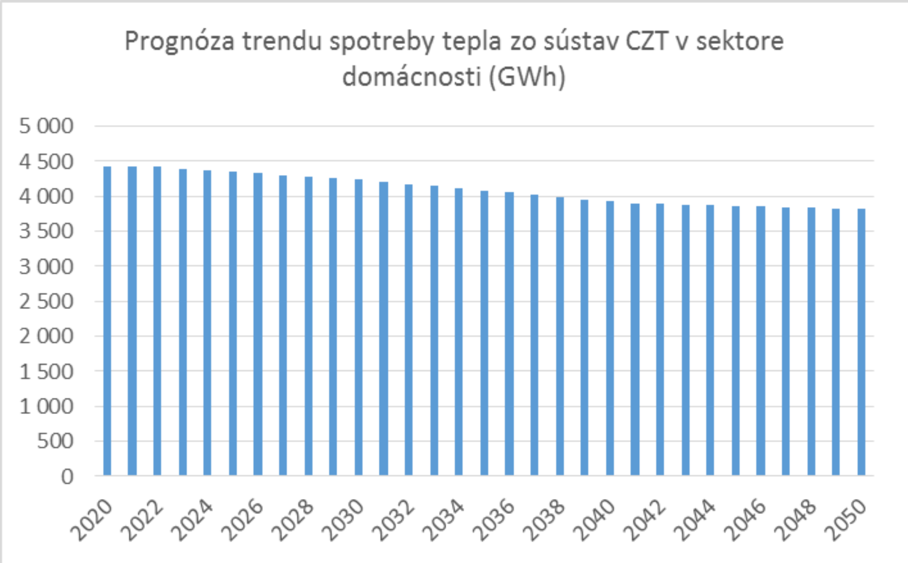
Source: SIEA

Table 41: Forecast of the trend in demand for heat from DH systems in the household sector in 2020–2050

DH – Demand for heating in the household sector		2020	2025	2030	2035	2040	2045	2050
Total heat consumption	(GWh)	4 418	4 350	4 238	4 082	3 927	3 862	3 820
- of which heat for heating	(GWh)	2 916	2 848	2 736	2 580	2 425	2 360	2 318

Source: SIEA

Chart 19: Forecast of the trend in demand for heat from DH systems in the household sector



Source: SIEA

Key to graphic	
Original text	Translation
Prognóza trendu spotreby tepla zo sústav CZT v sektore domácnosti (GWh)	Forecast of the trend in heat consumption from DH systems in the household sector (GWh)

Based on the above forecast, the consumption of heat from DH systems in the household sector should decrease by 4.1% by 2030 and by 13.5% by 2050 as compared to the reference consumption of heat in 2019. The anticipated relatively small decrease in heat consumption from DH systems in the household sector is attributable to the fact that almost 68% of all multi-apartment buildings are already insulated, which means that the potential for a massive decrease in heat consumption has been exploited for these buildings, and the implementation of any further energy efficiency measures does not provide room for any significant reductions in heat consumption.

1.4.6 Forecast of the trend in demand for heating in Slovakia

The following tables and charts provide a summarised forecast of the trend in demand for heating in Slovakia in the next 10 to 30 years.

Table 42: Forecast of the trend in demand for heating in Slovakia in 2020–2030

Forecast of the trend in demand for heating (GWh)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Individual heating – household sector	16 128	16 128	16 128	15 908	15 688	15 468	15 248	15 028	14 808	14 588	14 368
Individual heating – trade and services sector	4 460	4 460	4 460	4 385	4 310	4 235	4 160	4 085	4 010	3 935	3 859
DH – trade and services sector	4 305	4 305	4 305	4 232	4 160	4 087	4 015	3 942	3 870	3 797	3 725
DH – household sector	4 418	4 418	4 418	4 395	4 373	4 350	4 328	4 305	4 283	4 260	4 238

Total	29 311	29 311	29 311	28 921	28 531	28 141	27 751	27 361	26 970	26 580	26 190

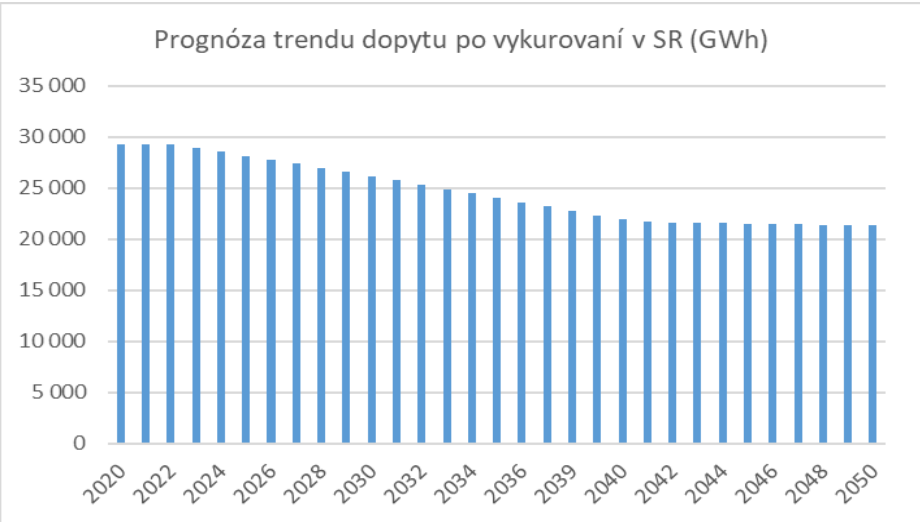
Source: SIEA

Table 43: Forecast of the trend in demand for heating in Slovakia in 2020–2050

Forecast of the trend in demand for heating (GWh)	2020	2025	2030	2035	2040	2045	2050
Individual heating – household sector	16 128	15 468	14 368	13 157	11 945	11 830	11 718
Individual heating – trade and services sector	4 460	4 235	3 859	3 462	3 064	2 966	2 944
DH – trade and services sector	4 305	4 087	3 725	3 341	2 957	2 863	2 841
DH – household sector	4 418	4 350	4 238	4 082	3 927	3 862	3 820
Total	29 311	28 141	26 190	24 041	21 893	21 522	21 323

Source: SIEA

Chart 20: Forecast of the trend in demand for heating in Slovakia



Source: SIEA

Key to graphic	
Original text	Translation
Prognóza trendu dopytu po vykurovaní v SR (GWh)	Forecast of the trend in demand for heating in Slovakia (GWh)

Based on the above forecast, the consumption of heat for heating in Slovakia should decrease by 10.6% by 2030 and by 27.3% by 2050 as compared to the reference consumption of heat in 2019.

2. PART II – OBJECTIVES, STRATEGIES AND POLICY MEASURES,

The objectives, strategy and policy measures for efficient heating and cooling in a long-term reduction of greenhouse emissions are part of the Integrated National Energy and Climate Plan.[2] Under Regulation 2018/1999 on the Governance of the Energy Union, this plan is to be regularly updated, including on the basis of outputs from the 'Comprehensive Assessment of Efficient Heating and Cooling in the Slovak Republic'. According to the measures proposed under the 'Fit for 55' package introduced by the Commission on 14 July 2021, the importance of the comprehensive assessment of the heating and cooling potential will increase and the comprehensive assessment should be used more often for planning heating and cooling measures and projects and should become an integral part of NECP.

Since the approval of NECP by the Slovak Government[3] in December 2019, the following relevant strategies and programmes supporting measures related to heating and cooling have been adopted or prepared in Slovakia:

- National Emission Reduction Programme of the Slovak Republic,[4] (March 2020[5])
- Low-Carbon Development Strategy of the Slovak Republic until 2030 with a View to 2050,[6] (March 2020[7])
- Long-Term Renovation Strategy for Building Stock,[8] (January 2021[9])
- National Hydrogen Strategy,[10] (June 2021[11])
- The 'Fit for 55' package introduced by the Commission on 14 July 2021

New financial mechanisms are being prepared in 2020 and 2021 to support also efficient heating and cooling

- Recovery and Resilience Plan,[12]
- Modernisation Fund,[13]
- European Structural and Investment Funds for 2021–2027,
- Just Transition Fund,
- Adjustment of the European Commission rules for state aid (to be released on 1 January 2022)

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[2] Integrated National Energy and Climate Plan, https://ec.europa.eu/energy/sites/ener/files/sk_final_necp_main_en.pdf
[3] Resolution of the Government of the Slovak Republic No 606 of 11 December 2019, https://rokovania.gov.sk/RVL/Resolution/18101
[4] https://rokovania.gov.sk/RVL/Material/24535/2
[5] Resolution of the Government of the Slovak Republic No 103 of 5 March 2020, https://rokovania.gov.sk/RVL/Resolution/18241
[6] https://rokovania.gov.sk/RVL/Material/24531/2
[7] Resolution of the Government of the Slovak Republic No 104 of 5 March 2020, https://rokovania.gov.sk/RVL/Resolution/18242
[8] Long-Term Renovation Strategy for Building Stock, https://rokovania.gov.sk/RVL/Material/25606/3
[9] Resolution of the Government of the Slovak Republic No 36 of 20 January 2021, https://rokovania.gov.sk/RVL/Resolution/19000
[10] Draft National Hydrogen Strategy, https://rokovania.gov.sk/RVL/Material/26128/1
[11] Resolution of the Government of the Slovak Republic No 356 of 23 June 2021, https://rokovania.gov.sk/RVL/Resolution/19331
[12] https://www.mfsr.sk/sk/verejnost/plan-obnovy-odolnosti/
[13] https://minzp.sk/klima/modernizacny-fond/modernisation-fund/

2.1 National Emission Reduction Programme of the Slovak Republic

The National Emission Reduction Programme contributes to achieving the air quality objectives pursuant to Directive 2008/50/EC, as well as to ensuring coherence with plans and programmes set in other relevant policy areas, including climate, energy, agriculture, industry and transport. At the same time, it will support the shift of investments to clean and efficient technologies.

The following measures are planned in the area of efficient heating and cooling with a view to decreasing emissions of pollutants into the air:

- enlightenment campaign and education on good practice in the combustion of coal and biomass,
- support for the replacement of old boilers burning solid fuels with low-emission boilers; this support is related to the programme for the insulation of single-family houses,
- shift of households using solid fuels for heating to other, low-emission sources (e.g. natural gas), accompanied by reduction or prohibition of the combustion of solid fuels,
- inspections targeting households which use solid fuels,
- introducing a standard for fuels – reducing wood moisture under 20%,
- establishment of social enterprises for the preparation of fuels for people suffering from energy poverty in socially disadvantaged regions,
- transformation of the Nováky Power Plant after the termination of domestic coal combustion into a modern CHP installation.

The measures will contribute to decarbonisation and energy efficiency. Taking into account the objective of the programme, these contributions are not explicitly specified.

2.2 Low-Carbon Development Strategy of the Slovak Republic

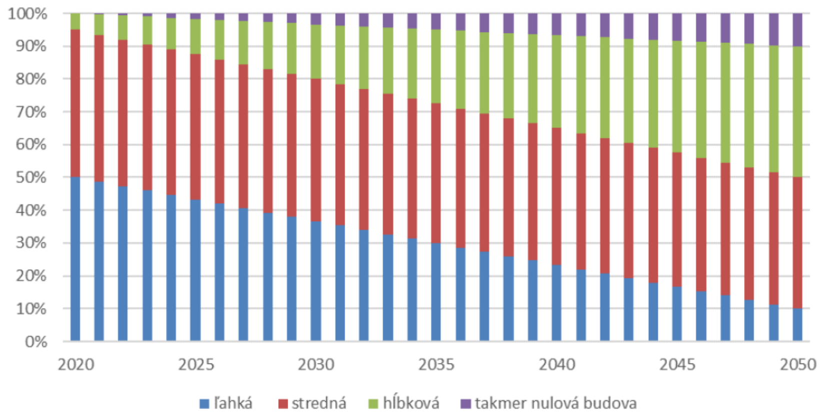
The Strategy is a cross-sectional document across all sectors of economy, which must implement individual policies so as to complement each other in the fulfilment of the joint objective, i.e. complete decarbonisation of Slovakia as a whole by the middle of the century. It is also consistent with the Integrated National and Energy Climate Plan for 2021–2030.

2.3 Long-Term Renovation Strategy for Building Stock

Energy consumption in buildings should be reduced by 40% by 2050 compared to 2020; emissions will fall by 79% and 87% compared to 2020 and 1990, respectively.

The renovation scenario in line with the defined milestones requires a significant shift from partial renovation of buildings (light/shallow and medium forms of renovation) towards deep renovation (also in a gradual fashion) so that the ratio of deep renovation to renovations of buildings carried out in 2050 is 40%.[14]

Chart 21: Forecast of the degree of renovation of buildings in Slovakia



Source: Long-Term Renovation Strategy for the Building Stock of Residential and Non-Residential Buildings, Ministry of Transport and Construction of the Slovak Republic

Key to graphic	
Original text	Translation
ľahká	light
stredná	medium
hĺbková	deep
takmer nulová budova	almost zero building

All buildings are expected to be renovated by 2050. By 2030, more than a half of non-residential buildings should undergo medium renovation; residential buildings should undergo deep renovation, gradually achieving 29% of such renovations in 2030, with this percentage then increasing until 2041, when all the buildings should be renovated.

Ensuring a functioning support for reducing the energy intensity of heat distribution is part of the policies to improve energy efficiency in the heating and cooling sector, as set out in NECP. New measures are introduced to support the construction of new district heating and cooling systems and the transition of existing district heating and cooling systems to efficient district heating and cooling systems.

A significant increase in the energy efficiency of district heating and cooling systems and an increase in the share of renewable energy sources in these systems is, in view of the above, one of the preconditions for achieving the milestones identified in the buildings sector.

[14] Long-Term Renovation Strategy for Building Stock, pp. 31-32

2.4 National Hydrogen Strategy

The Ministry of Economy of the Slovak Republic has developed the National Hydrogen Strategy, which was approved by the Government of the Slovak Republic on 23 June 2021. Alongside other sectors of national economy, hydrogen is to be used also in the area of heat supply, especially as regards the utilisation of seasonal accumulation, i.e. hydrogen accumulation in periods of excess electricity produced from renewable energy sources in the system[15], the storage and subsequent use thereof, especially in the processes of combined heat and power production e.g. at times of increased heat consumption, in winter, as well as for covering peaks in electricity consumption.

Hydrogen in a gaseous state can be injected into the natural gas distribution network, which is well developed in Slovakia. It will be possible to use it for hydrogen transportation after technical adjustments preceded by a detailed expert analysis of the technical condition of the distribution lines. The use of hydrogen and various forms of gaseous mixtures containing hydrogen will play an important role in decarbonisation of heat management.

Quantification of an efficient degree of replacement of natural gas with hydrogen for use in heat supply requires further analyses focused on the ability of the power network to cover the generated additional consumption of electricity and the ability of the gas system to accumulate and store the necessary volumes of hydrogen in the long term.

In addition to contributing to the decarbonisation of heating/cooling, under certain conditions it is possible to anticipate a positive effect on reduced primary energy consumption in Slovakia. Subsequently, action plans for the implementation of this effort will be prepared that will quantify the actual decarbonisation and energy efficiency benefits.

2.5 Recovery and Resilience Plan

In the area of green economy, there is a focus especially on support for the production of electricity from renewable energy sources. The objective is to increase the production capacities from RES in accordance with the requirements of the Integrated National Energy and Climate Plan. Investments in the new production capacities (10 kW to 50 MW) will be supported through investment aid.

In the ‘renovation of buildings’ component, the objective is to decrease energy consumption through measures to improve energy efficiency of single-family houses and public historic buildings and heritage protected buildings, thus contributing to reduction in CO_2 emissions. The objective is in line with the Long-Term Renovation Strategy for Building Stock, the Low-Carbon Development Strategy of the Slovak Republic until 2030 with a View to 2050, the Integrate Energy and Climate Plan until 2030 in the energy efficiency aspect, as well as with the objectives of the European Union in the area of climate and energy

[15] Production of green hydrogen through electrolysis using electricity from renewable energy, especially solar and wind energy.

efficiency until 2030, in particular with the aim of decreasing greehouse gas emissions by 55% by 2030.

Plans for the renovation of single-family houses are an important part of the Renovation and Resilience Plan, with 30 thousand single-family houses to be renovated. This renovation should include renovation and modernisation of heating and air-conditioning systems in single-family houses.

2.6 Modernisation Fund

The Modernisation Fund is a support tool established in line with Article 10d of the recast Directive for the EU ETS trading system for the 4th trading period 2021–2030 to support investments, which are divided into priority and non-priority ones. Priority investments include the production and use of electricity from renewable energy sources, increasing energy efficiency, energy storage, modernisation of energy networks and shift in carbon-dependent areas. Solid fossil fuels are excluded from the support. The Modernisation Fund falls within the competence of the Slovak Ministry of Environment, which closely liaises with the Slovak Ministry of Economy in a joint commission. The first indicative list of potential projects has been prepared as well as two schemes of state aid for the heat production sector and for the support of the production of electricity from RES.

2.7 European Structural and Investment Funds for 2021–2027

European Structural and Investment Funds for 2021–2027, which follow on from the existing funds for 2014–2020, are under preparation. In the new programming period, planning is underway under priority axis 2 concerning the energy sector and the environment, with support intended for the renovation of multi-apartment houses and public buildings, renovation and modernisation of district heating systems and support for extended installation of renewable energy sources including renewable sources for the production of heat and cold.

2.8 Just Transition Fund

Just Transition Fund concentrates on changes in the Upper Nitra region, which will be the most affected by the cessation of coal mining and power and heat production using coal after 2023, as well as in other Slovak regions which are the most dependent on fossil fuels, in order to mitigate the social and economic impacts of the transformation measures related particularly to climatic measures.

3. PART III ANALYSIS OF THE ECONOMIC POTENTIAL FOR EFFICIENCY IN HEATING AND COOLING

Assessment of the potential for the use of certain technologies in heating and cooling. The assessment needs to be done separately for DH systems and HE CHP, including their combination, which must be assessed from a broader perspective. This is due to the independent character of the DH systems and their broader impact and effect in the whole economy. Waste incineration plants provide specific opportunities for sources of supply to DH systems. It is assumed that they will not be directly connected to an individual DH system with a single source, but rather supply heat to the municipal DH distribution systems in the two largest cities in Slovakia. The assessment also examines the possible reduction of heat losses and cold losses from existing DH networks.

The assessment of the potential for renewable energy sources such as geothermal energy, solar thermal energy and biomass, excluding those used for high-efficiency cogeneration, is carried out mainly for individual production and consumption of heat. Assessment of the potential for heat pumps.

3.1 Analysis of the economic potential for waste incineration

An analysis of the economic potential for the incineration of waste in the municipal waste incineration plant Odvoz a likvidácia odpadu, a. s., Bratislava has been separately annexed to this document.

3.2 Analysis of the economic potential for high-efficiency combined production

The Energy Efficiency Directive 2012/27/EU requires the Member States in Art. 14(3), based on climate conditions, economic feasibility and technical suitability, to carry out a cost-benefit analysis ('CBA') for their territory in accordance with Part 1 of Annex IX to the Directive. The CBA is to identify the most resource- and cost-efficient solutions to meet heating and cooling needs. The CBA is drawn up in order to assess and analyse the costs and benefits of the potential application of the high-efficiency CHP in the reference period from 2021 to 2030. It does not reflect the operational support provided in Slovakia.

3.2.1 CBA background

The assessment of the potential for additional high-efficiency cogeneration was based on, *inter alia,* the current and anticipated energy balances of electricity production and consumption in Slovakia. According to the concept of the current energy policy and the annual 'Reports on the Results of Monitoring the Safety of Electricity Supplies' developed by the Ministry of Economy of the Slovak Republic, Slovakia currently produces enough electricity to cover almost all its consumption. The expectation is that once the electricity generation plants currently under construction are complete, more facilities will not be needed to meet electricity demands in Slovakia until 2030. Only a slight increase is projected in installations for combined high-output production with steam and gas turbines, which will be achieved by the inevitable refurbishment of existing combined production technologies.

Additional high-efficiency cogeneration is anticipated to have the greatest potential in existing district heating systems ('DH systems') from which heat is supplied to end customers.

Further development of DH systems is limited by demand for usable heat within the reach of existing heat networks. In the upcoming years, these installations are not expected to significantly increase their heat supplies. The potential increase attributable to the development of the areas supplied will be covered mainly from the expected decrease in supply to existing thermal energy customers and refurbishment and modernisation of existing DH systems.

It is expected that the technical potential for high-efficiency combined heat and power production will be used mostly in the segment of heat sources from heat plants and central boiler rooms in which natural gas is combusted using the cogeneration technology with internal combustion engine, by replacing or supplementing separate production with combined production. The current and anticipated electricity production by the type of combined production technology is presented in Table 44 and Chart 22.

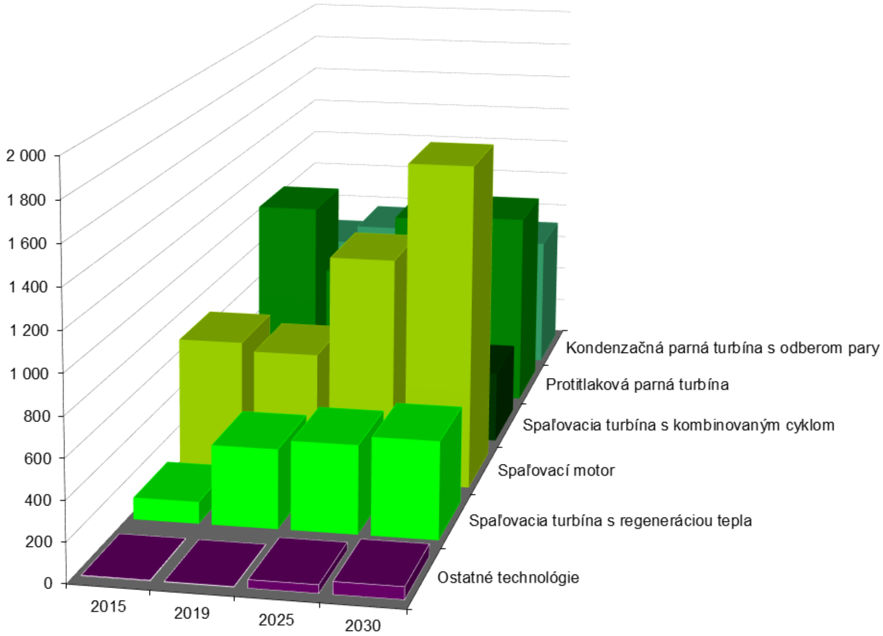
Table 44: Anticipated economic potential for electricity production using high-efficiency combined production

Year	Actual state	Prediction

CHP technology	2015		2019		2025		2030	
	Installed capacity of CHP installations	Electricity produced using HE CHP	Installed capacity of CHP installations	Electricity produced using HE CHP	Installed capacity of CHP installations	Electricity produced using HE CHP	Installed capacity of CHP installations	Electricity produced using HE CHP
	(MWe)	(GWh)	(MWe)	(GWh)	(MWe)	(GWh)	(MWe)	(GWh)
Combined-cycle combustion turbine	166.7	0	150.2	332.0	150.2	360.5	150.2	368.0
Steam backpressure turbine	357.5	1 042.4	436.8	685.4	441.2	1 014.8	450.0	1 035.1
Condensing steam turbine with steam extraction	1 829.3	666.8	1 642.1	765.6	1 422.1	682.6	1 422.1	711.1
Combustion turbine with heat recovery	25.0	109.2	74.1	402.0	81.5	448.4	89.7	493.2
Internal combustion engine	**160.1**	693.5	**149.3**	650.2	194.1	1 164.8	277.6	1 665.6
Other technologies	1.2	3.8	5.2	2.4	10.3	41.2	15.5	61.8
Total	**2 539.8**	**2 515.7**	**2 457.8**	**2 837.5**	**2 299.5**	**3 712.3**	**2 405.1**	**4 334.8**

Source: EEMS, SIEA

Chart 22: Existing and anticipated electricity production in the process of high-efficiency combined production



Source: SIEA

Key to graphic	
Original text	Translation
Kondenzačná parná turbína s odberom pary	Condensing steam turbine with steam extraction
Protitlaková parná turbína	Steam backpressure turbine
Spaľovacia turbína s kombinovaným cyklom	Combined-cycle combustion turbine
Spaľovací motor	Internal combustion engine
Spaľovacia turbína s regeneráciou tepla	Combustion turbine with heat recovery
Ostatné technológie	Other technologies

Selected method of cost-benefit analysis for HE CHP

The methodology according to the requirements of Part 1 of Annex IX to Directive 2012/27 EU and Commission Delegated Regulation (EU) 2019/826 of 4 March 2019, amending Annexes VIII and XI to Directive 2012/27/EU of the European Parliament and of the Council on the contents of the comprehensive assessments of the potential for efficient heating and cooling was used for developing the cost-benefit analysis regarding the possibility of additional use of high-efficiency combined heat and power production. The essential background is given in Table 45.

Table 45: Essential background for the development of CBA

Steps and aspects		Use in methodology
(a)	Determination of systematic and geographic demarcation	Use of high-efficiency combined heat and power production in Slovak territory.
(b)	Integrated approach to demand and supply variants	The current situation and anticipated development of the offer of and demand for heat takes into consideration all available information on the heat market and its anticipated development on the basis of the available data obtained from regular verification of the economy of operation of thermal installations (Act No 657/2004 on the thermal energy sector, as amended) and data on combined heat and power production (obtained in accordance with Act No 309/2009 on support for renewable energy sources and high-efficiency combined production. Given the minimum supply of cold from DH systems in Slovakia, the analysis did not incorporate trends in demand for cooling.
(c)	Baseline scenario development	In section 4.2 was determined the economic potential for the construction and refurbishment of installations for combined production with an outlook until 2025 by type of combined production technology, which will serve as a basis for alternative scenarios.
(d)	Identification of alternative scenarios	The alternative scenarios are derived from the baseline scenario. The individual variants take into account the achievement of the technical potential for high-efficiency combined production in percentage terms.
(e)	Method of calculation of the positive benefit-cost balance	The net present value (NPV) criterion will be used in the evaluation. Discounted costs and benefits of the alternative scenarios will be compared with those of the baseline scenario.
(f)	Price calculation and forecast and other inputs for economic analysis	National energy price forecasts and the anticipated national prices of the main input and output quantities will be used in the calculation of costs and benefits.

(g)	Economic analysis: impact assessment	The costs and benefits quantified in the CBA can be determined with a high degree of accuracy on the basis of specific indicators, namely: • anticipated investment expenditures and operating costs, • saved costs of primary energy sources and externalities for the separate production of electricity when replaced by combined production, • additional costs (or savings) related to emissions of harmful substances, • saved costs of transmission and distribution of electricity (consumption at the point of consumption). Being difficult to quantify and having a minimum effect on the CBA results, the following were omitted: • benefits on grounds of increased reliability of electricity supply, • savings following from limited investments in infrastructure due to the need to establish power output lines (the use of existing infrastructure is contemplated), • cost of job creation – the existing number of jobs is not expected to be changed significantly.
(h)	Sensitivity analysis	It includes variable factors that have a significant effect on the results of the calculations (change in NPV).

Source: EEMS, SIEA

In developing the cost-benefit analysis of additional use of high-efficiency combined heat and power production, it is expected that the economic potential for high-efficiency combined heat and power production will be used mostly in the existing sources of heat in DH systems with separate heat production in which natural gas is combusted, by establishing installations for combined production with very small and small outputs with the use of combined production technology with internal combustion engines.

The CBA was developed using the following procedure:

1) Determination of anticipated supply of heat by the type of technology used by the installation for the production of heat and the type of fuel burned (as a proportion of the total anticipated supply of heat from DH systems in Slovakia) in the reference period 2021–2030 in the following scenarios:
   a) baseline scenario,
   b) 'Low CHP use scenario'
   c) 'High CHP use scenario',

   with each of these scenarios operating with a different share (of the total economic potential of combined production) and replacement (supplementation) of separate heat production using the CHP technology.
2) Costs and benefits determined by the calculation in the individual scenarios using levelised costs.
3) Analysis of individual scenarios based on discounted accumulated differences between benefits and costs in individual years and the net present value ('NPV') in the reference period.

4) Development of a sensitivity analysis taking into account NPV change based on the change of values of the critical parameters that have a fundamental effect on the cost-benefit calculation.

For the comparison of the scenarios, an equal decrease (by 2025) and increase (from 2025 to 2030) in the quantity of heat supply is projected. The cost-benefit comparison anticipates that the increase in the output of the established CHP installations will result in a decrease in the quantity of the generated condensing electricity without the supply of useful heat and a decrease in the supply of heat from separate heat production. In the individual scenarios, benefits are saved costs of fuels and externalities in comparison with separate heat and power production.

3.2.2 Basic preconditions for determining benefits and costs

In the CBA analysis, the benefits consist in non-produced electricity in electricity production installations with a condensing steam turbine without producing heat using a primary energy source burning fossil fuels with projected efficiency of electricity production of 38.0 % ('condensing electricity'). It is assumed in the individual scenarios that the electricity not produced will be replaced by electricity production in installations for high-efficiency combined heat and power production.
In these assumptions, the costs of the following will be saved:

a) fuel for condensing electricity not produced,
b) CO_2 emission allowances,
c) emissions (SO_x, NO_x, particulate matter),
d) transmission and distribution of electricity (it is expected that the electricity in the built installations for high-efficiency combined heat and power production will be consumed at the point of production).

The types of costs under subparagraphs (a), (b), (c) are included also in the costs of newly built installations for high-efficiency combined heat and power production in the relevant scenarios. The critical parameters used in the CBA are given in Table 46.

Table 46: Basic input data for the development of CBA

Parameter	Unit	Value	Note
Discount rate	%	**6.47**	Determined while factoring in the parameters of the rate of return of regulated asset base WACC
Inflation		**2.1**	Based on the prediction of the Institute of Financial Policy at the Slovak Ministry of Finance

Reference evaluation period	year	**10**	CHP technologies fall, in the sense of Act No 595/2003 on income tax, in depreciation class 3 with a depreciation period of 8 years. In the NPV calculation, fixed straight line annual depreciations of one eighth of the investment amount were used.
Efficiencies	-		By type of technology, fuel and anticipated nature of the operation A conservative approach was taken.
Price per unit of NO_x	EUR/t	**1 240**	Determined based on the reference costs of preventing emissions of polluting substances.
Price per unit of SO_2	EUR/t	**620**	
Price per unit of particulate matter	EUR/t	**3 760**	
Price per unit of CO_2	EUR/t	**20 – 40**	Based on the anticipated price of allowances in individual years
Levelised investment costs for CHP installations with a technology using natural gas internal combustion engines	EUR/kW_e	**455**	Reference value of investment costs of procurement of the new technological part of the electricity producer's installation within the meaning of Section 7(15) of Implementing Decree No 221/2013, which sets out price regulation in the electricity sector, as amended by Implementing Decree No 189/2014 and Implementing Decree No°143/2015, amended effective from 1 January 2017 with application of the energy sector method of cost sharing within the meaning of Implementing Decree No 222/2013, which sets out price regulation in the thermal energy sector.

Source: EEMS, SIEA

In the individual years of the CBA reference period, **variable costs** for the purchase of fuels **and fixed costs** (mainly costs of repairs and maintenance, personnel costs, financial costs – costs of economic activity) are included in operating expenses (OPEX) for newly built installations for high-efficiency combined heat and power production. **Investment costs** (CAPEX) are included for the CBA purposes as the proportional part of depreciation.

3.2.3 Formulation of HE CHP scenarios

The economic potential of the new installations with high-efficiency CHP, defined by different types of combined production technologies, was determined as the basis for formulating individual scenarios. There is a negligible requirement for cold supply in DH systems in Slovakia. Therefore, this expert analysis does not take this requirement into consideration.

3.2.4 Main baseline scenario

The baseline scenario operates with a minimum or zero development of installations for combined production with very small or small outputs using the technology of combined production with internal combustion engines. The proportion of heat supply in DH systems by heat production technology and type of fuel to the total supply of heat in this scenario is given in Table 47. Other fuels include blast furnace gases, refinery gases, fuel oils, etc.

Table 47: Share of heat supply in DH systems by heat production technology in the baseline scenario

Heat production technology		Heat supplied to DH systems		
		2019	2025	2030
		%	%	%
Separate heat production – heat sources by fuels burned and energy	natural gas	28.69	28.75	26.12
	brown coal	0.19	0.00	0.00
	biomass	5.71	6.01	4.48
	geothermal energy	0.32	0.32	0.35
	other fuels	0.52	0.53	0.58
Total		**35.42**	**35.60**	**31.52**
Combined heat and power production – combined production technology by fuels burned	natural gas	17.32	30.36	31.68
	brown coal	8.50	0.00	0.00
	hard coal	10.04	4.47	4.35
	biomass	7.73	8.14	8.69
	biogas	0.11	0.11	0.12
	solid municipal waste	0.06	0.06	0.06
	nuclear fuel	2.43	2.48	2.72
	other fuels*	18.40	18.79	20.60
Total		**64.58**	**64.40**	**68.48**
Heat production technologies total		**100.00**	**100.00**	**100.00**

Source: SIEA

No increase in the installed capacity is projected for combined production installations with great outputs (main activity producer heating plants, industrial heating plants). For these sources, modernisation or refurbishment of existing installations is projected with the objective of increasing their energy efficiency or diversifying the fuel base. This scenario builds on the assumption that there will be no operational support for high-efficiency combined heat and power production, which would eliminate the economic motivation for building and operating such installations.

The decrease in the share of brown coal and hard coal from CHP installations in 2025 and 2030 is attributable to the cessation of brown coal mining by Hornonitrianske bane Prievidza, a.s., the pledge of the management of six state-operated heating plants to cease burning coal as of 2023, as well as shift to different fuel bases by other private parties.

A decrease in the supply of heat is anticipated from 2021 (when the energy efficiency policy is applied, the consumption of usable heat decreases in the household sector and in the trade and services sector).

3.2.5 Low CHP use scenario

It is expected in the ‘Low CHP use scenario’ that the technical potential for high-efficiency combined heat and power production will be used in the existing DH systems (heat plants, central boiler rooms) where natural gas is burned. For these heat sources, separate heat production should be partly replaced with combined heat and power production technologies.

Based on the real energy balances of these heat sources by Slovak districts (annual heat production and supply in the heating and water heating categories), there is an economic potential for building additional new CHP installations with a total installed power of 128.3 MW_e until 2030. This scenario projects the installation of 55% of the installed power of the total economic potential for new CHP installations using the combined production technology with internal combustion engines burning natural gas.

Projected parameters of the 'Low CHP use scenario' in 2030:

- 70.55 MW_e of new installations for combined heat and power production with very small or small outputs using the technology of combined production with internal combustion engines burning natural gas,
- projected production by these installations – 380 975 MWh electricity and 445 092 MWh heat.

The proportion of heat supply coverage in DH systems by heat production technology and type of fuel to the total supply of heat in this scenario is given in Table 48.

Table 48: Share of heat supply to DH systems by heat production technology – 'Low CHP use scenario'

Heat production technology		Heat supplied to DH systems		
		2019	2025	2030
		%	%	%
Separate heat production – heat sources by fuels burned and energy	natural gas	28.69	26.89	22.24
	brown coal	0.19	0.00	0.00
	biomass	5.71	6.01	4.47
	geothermal energy	0.32	0.32	0.35
	other fuels	0.52	0.53	0.58
Total		**35.42**	**33.75**	**27.64**
Combined heat and power production – combined production technology by fuels burned	natural gas	17.32	32.22	35.65
	brown coal	8.50	0.00	0.00
	hard coal	10.04	4.47	4.35
	biomass	7.73	8.14	8.96
	biogas	0.11	0.11	0.12
	solid municipal waste	0.06	0.06	0.06
	nuclear fuel	2.43	2.48	2.72
	other fuels*	18.40	18.77	20.58
Total		**64.58**	**66.25**	**72.36**
Heat production technologies total		**100.00**	**100.00**	**100.00**

Source: SIEA

If the ‘Low CHP use scenario’ is implemented, in comparison with the baseline scenario there will be a decrease in separate heat production (mainly in terms of natural gas consumption that will be replaced by the new CHP installations) and an increase in the share of heat supply from combined production. In economic terms, based on the results of the cost-benefit analysis, the following changes will occur in the ‘Low CHP use scenario’ as opposed to the baseline scenario in the reference period 2021–2030 under evaluation:

- total costs (OPEX, CAPEX, costs of CO_2, costs of externalities – particulate matter, SO_x, NO_x emissions) will be higher by EUR 28 766 662 EUR in comparison with the baseline scenario,
- the total benefits (saved fuel costs, costs of CO_2, emissions of SO_x, NO_x, particulate matter, -costs of electricity not produced in installations for the production of electricity using a condensing steam turbine without producing heat; saving of costs of electricity transmission and distribution) will be higher by EUR 50 858 107 in comparison with the baseline scenario.

From the overall social perspective, the following will occur in the ‘Low CHP use scenario” in comparison with the baseline scenario: saving of EUR 22 091 446, which, when recalculated to the net present value (NPV), represents EUR 11 801 891, reduction of CO_2 emissions by 67 172 tonnes per year, saving of primary energy by 100.3 GWh per year; the implementation of this scenario would not change the share of renewable energy sources in the national energy mix.

The results of the calculation for the ‘Low CHP use scenario’ are presented in Table 49.

Table 49: Costs and benefits in the 'Low CHP use scenario' in comparison with the baseline scenario

	Parameter (EUR)		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
COSTS	OPEX	Variable cost component	1 549 653	3 443 775	5 240 009	8 615 497	11 790 408	13 748 134	15 832 551	18 044 858	20 386 256	22 857 944
		Fixed cost component	213 346	472 409	716 233	1 173 404	1 600 096	1 859 159	2 133 461	2 423 002	2 727 782	3 047 801
	Proportional part of tax amortisation (contribution towards CAPEX)		134 927	298 767	452 969	742 098	1 011 952	1 175 791	1 349 269	1 532 384	1 725 137	1 927 527
	CO_2 – purchase of emission allowances		41 336	91 529	138 770	227 347	310 019	360 212	413 358	469 457	528 508	590 512
	Externalities (particulate matter, SO_x,NO_x emissions)		24 001	53 146	80 576	132 008	180 011	209 155	240 014	272 588	306 876	342 878
	Total costs		**1 963 263**	**4 359 627**	**6 628 558**	**10 890 354**	**14 892 485**	**17 352 452**	**19 968 653**	**22 742 288**	**25 674 558**	**28 766 662**
BENEFITS	Saved costs of fuels for electricity not produced using the CHP technology with a condensing steam turbine		1 263 233	2 797 160	4 240 855	6 947 784	9 474 251	11 008 177	12 632 335	14 346 723	16 151 342	18 046 193
	Saved costs of emissions (SOx, NOx, particulate matter) for electricity not produced using the CHP technology with a condensing steam turbine		374 052	828 258	1 255 746	2 057 285	2 805 389	3 259 595	3 740 519	4 248 160	4 782 520	5 343 598
	Saved costs of CO_2 for electricity not produced using the CHP technology with a condensing steam turbine		940 407	2 498 796	4 104 205	7 241 135	10 579 580	13 111 962	15 986 921	19 224 609	22 845 176	26 868 776
	Saved costs of transmission and distribution including externalities		41 968	92 929	140 892	230 823	314 759	365 720	419 679	476 635	536 589	599 541
	Total benefits		**2 619 660**	**6 217 143**	**9 741 698**	**16 477 028**	**23 173 980**	**27 745 455**	**32 779 454**	**38 296 128**	**44 315 628**	**50 858 107**
BENEFITS – COSTS			**656 397**	**1 857 516**	**3 113 141**	**5 586 674**	**8 281 495**	**10 393 003**	**12 810 801**	**15 553 839**	**18 641 071**	**22 091 446**
BENEFITS – COSTS (discounted)			**616 509**	**1 638 619**	**2 579 390**	**4 347 547**	**6 053 025**	**7 134 730**	**8 260 104**	**9 419 321**	**10 602 922**	**11 801 891**

Source: SIEA

3.2.6 High CHP use scenario

In comparison with the ‘Low CHP use scenario’, this scenario projects a higher installed power of the new installations for combined heat and power production.
Projected parameters of the ‘High CHP use scenario’ in 2030:

- 70.55 MW_e of new installations for combined heat and power production with very small or small outputs using the technology of combined production with internal combustion engines burning natural gas,
- 12.83 MW_e of new installations for combined heat and power production with very small or small outputs using the technology of combined production using RES,
- projected production by these installations – 450 243 MWh electricity and 526 018 MWh heat.

The proportion of heat supply coverage in DH systems by heat production technology and type of fuel to the total supply of heat in this scenario is given in Table 50.

Table 50: Share of heat supply to DH systems by heat production technology – ‘High CHP use scenario’

Heat production technology		Heat supplied to DH systems		
		2019	2025	2030
		%	%	%
Separate heat production – heat sources by fuels burned and energy	natural gas	28.69	26.66	21.54
	brown coal	0.19	0.00	0.00
	biomass	5.71	6.01	4.47
	geothermal energy	0.32	0.32	0.35
	other fuels	0.52	0.53	0.58
Total		**35.42**	**33.52**	**26.94**
Combined heat and power production – combined production technology by fuels burned	natural gas	17.32	30.78	34.51
	brown coal	8.50	0.00	0.00
	hard coal	10.04	4.47	4.35
	biomass	7.73	9.81	1 062
	biogas	0.11	0.11	0.22
	solid municipal waste	0.06	0.06	0.06
	nuclear fuel	2.43	2.48	2.72
	other fuels*	18.40	18.77	20.58
Total		**64.58**	**66.25**	**72.36**
Heat production technologies total		**100.00**	**100.00**	**100.00**

Source: SIEA

If the ‘High CHP use scenario’ is implemented, in comparison with the baseline scenario there will be a significant decrease in separate heat production and a high increase in the share of heat supply from combined production. The results of the calculation of costs and benefits for this scenario are presented in Table 51.

Table 51: Costs and benefits in the 'High CHP use scenario' in comparison with the baseline scenario

Parameter (EUR)			***2021***	***2022***	***2023***	***2024***	***2025***	***2026***	***2027***	***2028***	***2029***	***2030***
COSTS	OPEX	Variable cost component	1 735 333	3 912 304	6 091 170	9 856 233	13 475 815	15 983 200	18 675 843	21 506 790	24 626 912	27 890 341
		Fixed cost component	351 883	749 482	1 214 964	1 893 793	2 569 851	3 133 694	3 740 484	4 362 512	5 082 902	5 818 530
	Proportional part of tax amortisation (contribution towards CAPEX)		281 160	462 523	644 761	961 927	1 263 322	1 465 713	1 681 245	1 906 415	2 151 737	2 406 696
	CO_2 – purchase of emission allowances		46 704	102 266	158 096	255 262	347 597	409 600	475 630	544 613	619 769	697 877
	Externalities (particulate matter, SO_x,NO_x emissions)		27 119	59 380	91 798	148 217	201 830	237 832	276 172	316 227	359 866	405 219
	Total costs		**2 442 198**	**5 285 954**	**8 200 789**	**13 115 432**	**17 858 415**	**21 230 040**	**24 849 375**	**28 636 557**	**32 841 185**	**37 218 663**
BENEFITS	Saved costs of fuels for electricity not produced using the CHP technology with a condensing steam turbine		1 427 290	3 125 272	4 831 458	7 800 877	10 622 645	12 517 495	14 535 388	16 643 511	18 940 299	21 327 318
	Saved costs of emissions (SOx, NOx, particulate matter) for electricity not produced using the CHP technology with a condensing steam turbine		422 630	925 414	1 430 627	2 309 892	3 145 436	3 706 514	4 304 025	4 928 255	5 608 349	6 315 161
	Saved costs of CO_2 for electricity not produced using the CHP technology with a condensing steam turbine		1 062 538	2 791 910	4 675 778	8 130 247	11 861 954	14 909 728	18 395 341	22 302 305	26 790 001	31 754 007
	Saved costs of transmission and distribution including externalities		47 418	103 830	160 514	259 165	352 912	415 864	482 903	552 941	629 246	708 549
	Total benefits		**2 959 876**	**6 946 426**	**11 098 376**	**18 500 181**	**25 982 947**	**31 549 601**	**37 717 657**	**44 427 011**	**51 967 895**	**60 105 036**
BENEFITS – COSTS			**517 678**	**1 660 472**	**2 897 587**	**5 384 749**	**8 124 531**	**10 319 561**	**12 868 282**	**15 790 454**	**19 126 710**	**22 886 373**
BENEFITS – COSTS (discounted)			**486 220**	**1 464 796**	**2 400 793**	**4 190 409**	**5 938 299**	**7 084 312**	**8 297 167**	**9 562 613**	**10 879 151**	**12 226 564**

Source: SIEA

In economic terms, based on the results of the cost-benefit analysis, the following changes will occur in the ‘High CHP use scenario’ as opposed to the baseline scenario in the reference period 2021–2030 under evaluation:

- total costs (OPEX, CAPEX, costs of CO_2, costs of externalities – particulate matter, SO_x, NO_x emissions) will be higher by EUR 37 218 663 EUR in comparison with the baseline scenario,
- the total benefits (saved fuel costs, costs of CO_2, emissions of SO_x, NO_x, particulate matter, -costs of electricity not produced in installations for the production of electricity using a condensing steam turbine without producing heat; saving of costs of electricity transmission and distribution) will be higher by EUR 60 105 036 in comparison with the baseline scenario.

From the overall social perspective, the following will occur in the ‘High CHP use scenario’ in comparison with the baseline scenario:

- a saving of EUR 22 886 373, which represents EUR 12 226 564 when recalculated to the net present value (NPV),
- reduction in CO_2 emissions by 79 385 tonnes per year,
- primary energy savings by 118.5 GWh per year;

the implementation of this scenario would result in an increase in RES consumption in the heat and power production by 185 GWh per year, which, however, would have a minimum impact on the share of renewable energy sources in the national energy mix.

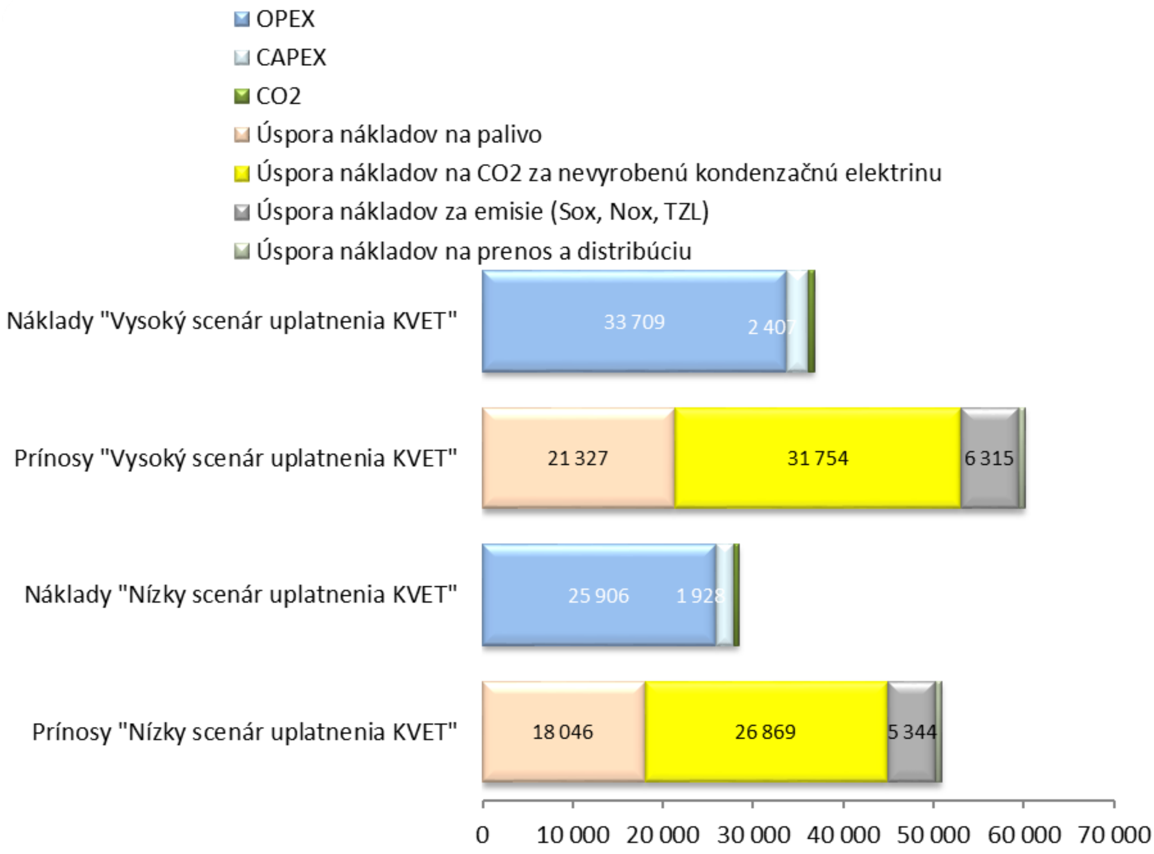
3.2.7 Comparison of scenarios formulated on the basis of the cost-benefit analysis

Compared to the baseline scenario in alternative scenarios ‘Low CHP use scenario’ and ‘High CHP use scenario’, benefits prevail over necessary costs in satisfying demand for heat from newly built installations for the combined heat and power production; as shown in Chart 23, benefits prevail over the necessary costs in the reference period (2021–2030).

The predominance of benefits over costs in both alternative scenarios is given mainly by the saved costs of non-produced electricity in electricity production installations with a condensing steam turbine without producing heat using a primary energy source burning fossil fuels. Such non-produced electricity will be replaced by electricity production in installations for high-efficiency combined production, with the higher saving being achieved by saving costs of fuel and CO_2. These savings do not operate for the benefit of operators and investors of the high-efficiency CHP installations – they must be looked at from the overall social perspective.

Overall social benefit is higher when the ‘Low CHP use scenario’ is implemented. In the ‘High CHP use scenario’ the absolute benefit is lower. This is mainly because of the higher fixed operating expenses and higher investment in new combined heat and power production installations using RES, which involve higher costs of building infrastructure, in addition to the installation itself.

Chart 23: Total costs and benefits (in EUR) of the alternative scenarios in comparison with the baseline scenario



Source: SIEA

Key to graphic	
Original text	Translation
OPEX	OPEX
CAPEX	CAPEX
CO2	CO2
Úspora nákladov na palivo	Saved costs of fuel
Úspora nákladov na CO2 za nevyrobenú kondenzačnú elektrinu	Saved costs of CO2 for condensing electricity not produced
Úspora nákladov za emisie (Sox, Nox, TZL)	Saved costs of emissions (SOx, NOx, particulate matter)
Úspora nákladov za prenos a distribúciu	Saved costs of transmission and distribution
Náklady „Vysoký scenár uplatnenia KVET“	Costs of the 'High CHP use scenario'
Prínosy „Vysoký scenár uplatnenia KVET“	Benefits of the 'High CHP use scenario'
Náklady „Nízky scenár uplatnenia KVET“	Costs of the 'Low CHP use scenario'
Prínosy „Nízky scenár uplatnenia KVET“	Benefits of the 'Low CHP use scenario'

3.2.8 Sensitivity analysis

The critical factors that have an effect on the chosen model of cost-benefit analysis are the development of natural gas price, which significantly contributes to the costs in both alternative scenarios of CHP development, and the prices of brown coal, which have an effect on the degree of benefits from the overall social perspective. The price of CO_2 allowances is a factor that also has a strong effect on the CBA results. In the analysis, the price is escalated from EUR 20 per tonne in 2021 to EUR 40 per tonne by 2030. If the price of the allowances increases more than projected, the benefits in both alternative scenarios will increase as well.

3.2.9 Sensitivity analysis for the 'Low CHP use scenario'

Sensitivity analysis for NPV in the 'Low CHP use scenario' based on changes in the prices of fuels is given in Table 52 and Chart 24.

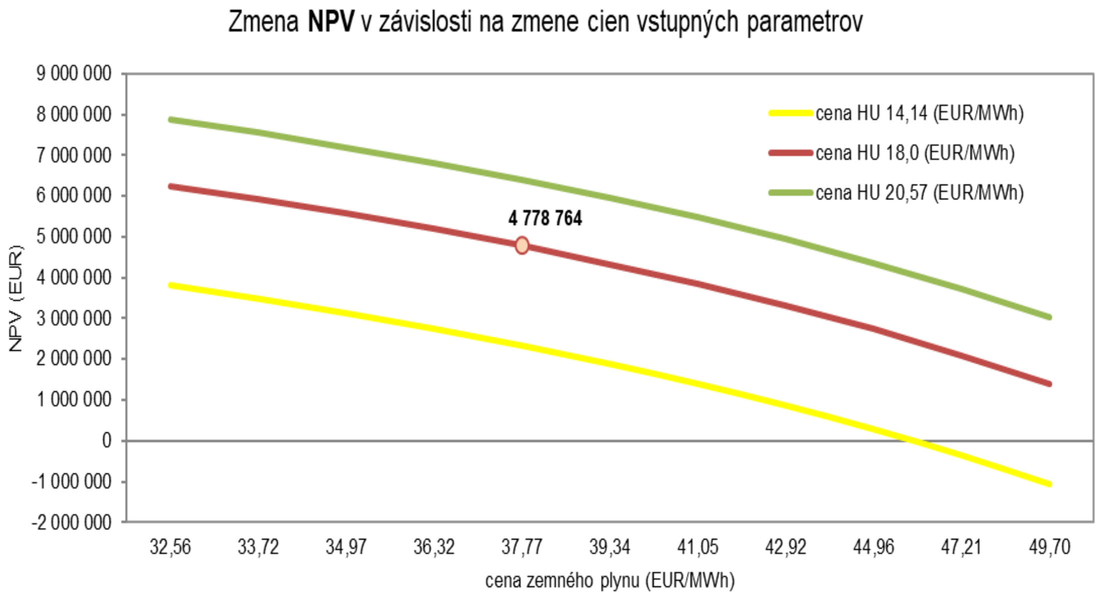
It follows from this table and chart that the 'Low CHP use scenario' becomes more advantageous when the price of brown coal increases. In contrast, growing price of natural gas results in a decrease in NPV, which is due to the increase in the variable element of OPEX in CHP installations burning natural gas.

Table 52: Sensitivity analysis for the NPV change in the price of fuels in the 'Low CHP use scenario'

NPV (EUR thousand)		Change in brown coal price (EUR(MWh)					
		14.14	**16.17**	**18.0**	**19.29**	**20.57**	**21.86**
Change in natural gas price (EUR/MWh)	**32.56**	3 814.72	5 442.07	6 256.78	7 069.42	7 883.10	8 696.78
	33.72	3 484.80	5 112.16	5 926.87	6 739.51	7 553.19	8 366.86
	34.97	3 130.45	4 757.80	5 572.52	6 385.16	7 198.83	8 012.51
	36.32	2 748.84	4 376.19	5 190.90	6 003.55	6 817.22	7 630.90
	37.77	2 336.70	3 964.05	4 778.76	5 591.41	6 405.08	7 218.76
	39.34	1 890.22	3 517.57	4 331.24	5 144.92	5 958.60	6 772.27
	41.05	1 404.91	3 032.26	3 845.93	4 659.61	5 473.29	6 286.96
	42.92	875.48	2 502.83	3 316.51	4 130.18	4 943.86	5 757.53
	44.96	295.63	1 922.98	2 736.65	3 550.33	4 364.01	5 177.68
	47.21	-342.21	1 285.14	2 099.85	2 912.50	3 726.17	4 539.85
	49.70	-1 047.19	580.17	1 394.88	2 207.52	3 021.20	3 834.87

Source: SIEA

Chart 24: Sensitivity analysis for the NPV change in the price of fuels in the 'Low CHP use scenario'



Source: SIEA

Key to graphic	
Original text	Translation
Zmena NPV v závislosti na zmene cien vstupných parametrov	Change in NPV based on the change in the prices of input parameters
cena HU 14,14 (EUR/MWh)	brown coal price 14.14 (EUR/MWh)
cena HU 18,0 (EUR/MWh)	brown coal price 18.0 (EUR/MWh)
cena HU 20,57 (EUR/MWh)	brown coal price 20.57 (EUR/MWh)
NPV (EUR)	NPV (EUR)
32,56	32.56
33,72	33.72
34,97	34.97
36,32	36.32
37,77	37.77
39,34	39.34
41,05	41.05
42,92	42.92
44,96	44.96
47,21	47.21
49,70	49.70
cena zemného plynu (EUR/MWh)	natural gas price (EUR/MWh)

3.2.10 Sensitivity analysis for the 'High CHP use scenario'

NPV sensitivity analysis in the 'High CHP use scenario' based on the change in fuel price is given in Table 53 and Chart 25.

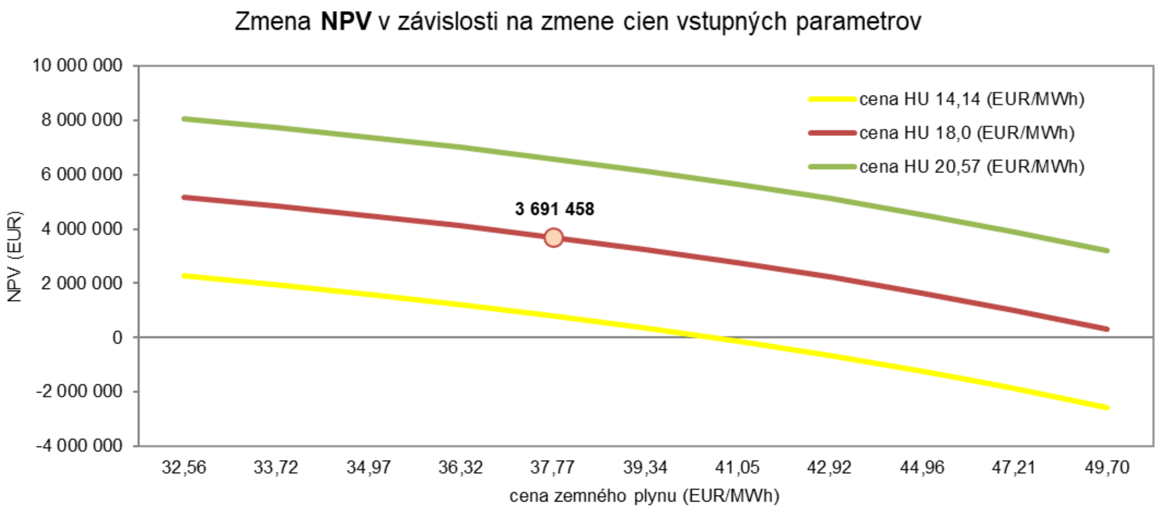
Similar to the 'Low CHP use scenario', in the 'High CHP use scenario', growing brown coal price makes the scenario more advantageous, although less than in the former scenario. NPV decreases with growing natural gas price.

Table 53: Sensitivity analysis for the NPV change in the price of fuels in the 'High CHP use scenario'

NPV (EUR thousand)		Change in brown coal price (EUR(MWh)					
		14.14	**16.17**	**18.0**	**19.29**	**20.57**	**21.86**
Change in natural gas price (EUR/MWh)	**32.56**	2 284.63	4 207.86	5 169.48	6 131.09	7 092.71	8 054.33
	33.72	1 954.71	3 877.94	4 839.56	5 801.18	6 762.80	7 724.41
	34.97	1 600.36	3 523.59	4 485.21	5 446.83	6 408.44	7 370.06
	36.32	1 218.75	3 141.98	4 103.60	5 065.22	6 026.83	6 988.45
	37.77	806.61	2 729.84	3 691.46	4 653.08	5 614.69	6 576.31
	39.34	360.12	2 283.36	3 244.97	4 206.59	5 168.21	6 129.82
	41.05	-125.19	1 798.05	2 759.66	3 721.28	4 682.90	5 644.51
	42.92	-654.62	1 268.62	2 230.23	3 191.85	4 153.47	5 115.09
	44.96	-1 234.47	688.77	1 650.38	2 612.00	3 573.62	4 535.24
	47.21	-1 872.30	50.93	1 012.55	1 974.17	2 935.78	3 897.40
	49.70	-2 577.28	-654.05	307.57	1 269.19	2 230.81	3 192.42

Source: SIEA

Chart 25: Sensitivity analysis for the NPV change in the price of fuels in the 'High CHP use scenario'



Source: SIEA

Key to graphic	
Original text	Translation
Zmena NPV v závislosti na zmene cien vstupných parametrov	Change in NPV based on the change in the prices of input parameters
cena HU 14,14 (EUR/MWh)	brown coal price 14.14 (EUR/MWh)
cena HU 18,0 (EUR/MWh)	brown coal price 18.0 (EUR/MWh)
cena HU 20,57 (EUR/MWh)	brown coal price 20.57 (EUR/MWh)
NPV (EUR)	NPV (EUR)
32,56	32.56
33,72	33.72
34,97	34.97
36,32	36.32
37,77	37.77
39,34	39.34

41,05	41.05
42,92	42.92
44,96	44.96
47,21	47.21
49,70	49.70
cena zemného plynu (EUR/MWh)	natural gas price (EUR/MWh)

3.2.11 Summary of the cost-benefit analysis for HE CHP and DH

In developing the cost-benefit analysis of additional use of high-efficiency combined heat and power production, it is expected that the economic potential for high-efficiency combined heat and power production will be used mostly in the existing sources of heat in DH systems with separate heat production in which natural gas is combusted, by establishing installations for combined heat and power production with very small and small outputs with the use of combined production technology with internal combustion engines burning natural gas.

For the comparison of the scenarios in the CBA reference period, an equal decrease in the quantity of heat supply in DH systems is projected. The cost-benefit comparison anticipates that the increase in the output of the established CHP installations will result in a decrease in the quantity of the generated condensing electricity without the supply of useful heat and a decrease in the supply of heat from separate heat production. In the individual scenarios, benefits from the overall social perspective are saved costs of fuels and externalities in comparison with separate heat and power production. The methodology used in preparing the CBA is in accordance with the requirements of Part 1 of Annex IX to Directive 2012/27/EU.

The analysis has shown that the discounted accumulated benefits are higher than the costs in either of the alternative scenarios of additional installation of CHP equipment, in comparison with the baseline scenario in which their installation is not projected. Overall social benefit is the highest when the ‘Low CHP use scenario’ is implemented. A saving of EUR 22 091 446, which represents EUR 11 801 891 when recalculated to the net present value, is achieved in comparison with the baseline scenario. In this scenario, new installations for combined heat and power production with very small and small outputs using the technology of combined production with internal combustion engines burning natural gas are projected to be installed by 2030, with a total output of 70.55 MWe and anticipated production of 380 975 MWh electricity and 445 092 MWh heat. The key factors that have an effect on the CBA are the price of fuels and the price of emission allowances. From the overall social perspective, the CBA has shown the need to continue creating conditions in Slovakia for developing a high-efficiency combined heat and power production.

3.3 Analysis of the economic potential for individual heat production

Cost-benefit analysis for individual sources of heat and cold.

3.3.1 CBA inputs

The assessment of the potential for individual heat production was based inter alia on the analytical part of this document, mainly section 1.2.1 Individual heat consumption in the household sector and section 1.2.2 Individual heat supply in the trade and services sector. It is obvious from the power balance presented in the above sections that the highest consumption of heat produced by individual sources is in the household sector, up to 78%, which includes more than 815 thousand single-family houses and more than 2 600 multi-apartment buildings. The heat produced in these sources is mainly consumed directly in the building where the heat source is installed, i.e. without the need to install external distribution of heat. The heat produced in this manner is used mainly for heating the building and preparation of hot water for hygienic purposes.

Given the present legislative requirements for energy efficiency of buildings (Act No 555/2005 on energy efficiency of buildings), all new buildings and important buildings undergoing renovation must meet energy class A0, which significantly influences the requirements for efficiency of the heat source and the energy carrier used. In these circumstances, the average installed capacity of the source of heat is low and a 10 kW installation is the average, especially in single-family houses.

In the climatic conditions of Slovakia, the requirement for cold supply is negligible in comparison with the requirement for heating. Therefore, this expert analysis does not take this requirement into consideration.

Selected method of cost-benefit analysis for individual heat production

The methodology according to the requirements of Part 1 of Annex IX to Directive 2012/27 EU and Commission Delegated Regulation (EU) 2019/826 of 4 March 2019, amending Annexes VIII and XI to Directive 2012/27/EU of the European Parliament and of the Council on the contents of the comprehensive assessments of the potential for efficient heating and cooling was used for developing the cost-benefit analysis regarding the possibility of individual heat production. The scenarios analysed are developed on the basis of the average single-family house model given the majority share of individual heat production in the household sector. The essential background is given in Table 54.

Table 54: Essential background for the development of CBA

Steps and aspects		Use in methodology
(a)	Determination of systematic and geographic demarcation	Individual heat production on the basis of the average single-family house model reflecting the average climatic and economic conditions in Slovakia.
(b)	Baseline scenario development	The baseline scenario is the model of a single-family house receiving heat from a hot water boiler burning natural gas because the latter is the energy carrier with the highest representation in energy consumption in the household sector (see Table 5). An alternative baseline scenario is the model of a single-family house using an electric boiler for heating. Despite the fact that electricity is not

		the primary energy carrier here, this is the most common method of individual heat production in agglomerations outside the reach of natural gas networks.
(c)	Identification of alternative scenarios	The alternative scenarios are variations of the baseline scenario, replacing the natural gas boiler and electric heating boiler with installations using renewable energy sources.
(d)	Method of calculation of the positive benefit-cost balance	The net present value (NPV) criterion will be used in the evaluation. Discounted costs and benefits of the alternative scenarios will be compared with those of the baseline scenario.
(e)	Price calculation and forecast and other inputs for economic analysis	The analysis uses the average prices of energy inputs and average prices of technological installations, taking into account only prices for the calendar year 2020. The prices of installations using renewable energy sources were determined on the basis of several hundreds of actual installations supported from the Green Households project.
(f)	Economic analysis: impact assessment	The costs and benefits quantified in the CBA can be determined with a high degree of accuracy on the basis of specific indicators, namely: • anticipated investment cost and operating costs, • saved costs of primary energy sources. Being difficult to quantify and having a minimum effect on the CBA results, the costs of creating jobs were omitted – it is not expected that the number of jobs would change significantly.
(g)	Sensitivity analysis	It includes variable factors that have a significant effect on the results of the calculations (change in NPV).

In developing the cost-benefit analysis for individual production of heat, the individual scenarios are evaluated from energy, economic and environmental perspective and the costs and benefits are subsequently assessed by comparing the results of evaluation of the individual scenarios.

The CBA was developed using the following procedure:

1) Determination of baseline scenarios through a model of heat production and consumption in a single-family house of a size corresponding to the average newly built single-family houses, serving a family of four people. Individual heat production in the baseline scenario is addressed in two scenarios covering a significant share of newly built single-family houses without an installation using RES.
2) Determination of alternative scenarios in which heat production involves also an installation using RES.
3) Costs and benefits are determined by the difference between the costs and environmental data between the different scenarios.
4) Specification of the economic potential of the technologies proposed in the alternative scenarios using the net present value (NPV) criterion.
5) Development of a sensitivity analysis taking into account NPV change based on the change of values of the critical parameters that have a fundamental effect on the cost-benefit calculation.

3.3.2 Basic preconditions for determining benefits and costs

In the CBA, costs are the increased investment cost which must be incurred to procure the installation defined in the relevant alternative scenario in comparison with the baseline scenario installation. Benefits are energy saved and the related saving of costs, as well as lower emissions.

The prices of the costs of energy carriers are determined as the average prices of the suppliers of individual energy carriers in the relevant tariff corresponding to the quantity of energy consumed. Given the low costs of energy in the individual scenarios and to ensure an objective calculation, only the variable component of the price of individual energy carriers was taken into consideration. In the scenarios using individual heat production, the costs of CO_2 emission allowances were not taken into consideration, as opposed to the CHP use scenarios.

The critical parameters used in the CBA are given in the following table.

Table 55: Basic input data for the development of CBA

Parameter	Unit	Value	Note
Nominal discount rate	%	**2.19**	Based on the interest statistics of the National Bank of Slovakia, determined as the average interest rate of loans for a period exceeding 5 years. Nominal rate is determined only on the basis of the costs of loan capital because own funds are difficult to valuate in the target group, i.e. households.
Inflation	%	**2.1**	Based on the prediction of the Institute of Financial Policy at the Slovak Ministry of Finance
Annual increase in energy prices	%	**1.9**	Based on a short-term prediction of the National Bank of Slovakia. Given the price regulation of selected energy carriers, their prices grow in a pace other than that of other commodities on the market expressed by the inflation index. Therefore, the annual saving of the costs of energy is corrected by the rate of energy price increase.
Real discount rate	%	**0.09**	Determined on the basis of the nominal discount rate while factoring in inflation.
Reference evaluation period	year	**15**	Uniform figure for the determination of NPV. The 15-year value corresponds to the length of technical life of solar equipment and heat pumps.
Efficiencies	-		By type of technology, fuel and anticipated nature of the operation. The installations' efficiencies are given in the description of the individual scenarios.

3.3.3 Formulation of the scenarios for individual heat production

The individual scenarios for individual heat production are based on the model of a household in an insulated single-family house with the total floor area of 100 m^2 and an annual hot water consumption of 50 m^3. In the average climatic conditions of Slovakia, this represents the following requirement for heating energy: 4 500 kWh per year. The requirement for energy for hot water preparation in a system with a 250-litre water accumulation tank is 2 800 kWh per year.

In a location with the outdoor calculation temperature of '-15°C', a heat source with an output of 10 kW is sufficient to produce the above-specified quantity of heat. The model projects a hot-water low-temperature heating system (e.g. floor heating) as the most frequent heating system in existing newly built structures.

3.3.4 Main baseline scenario

In the main baseline scenario, heat for heating and hot water preparation is generated using a natural gas condensing boiler with an average heat production efficiency of 98%. Given the low-temperature heating system, the boiler is operated mostly in the condensing mode. A summary of the costs and the environmental load in the baseline scenario is given in the following table.

Table 56: Cost and environmental data for the main baseline scenario

Investment costs of building a heat source	EUR 3 500
Natural gas consumption	7 450 kWh/year
Costs of natural gas	EUR 268 per year
Production of CO_2 emissions	1 639 kg/year
Production of SO_x emissions	0.007 kg/year
Production of NO_x emissions	1 315 kg/year
Production of particulate matter emissions	0.062 kg/year

3.3.5 Alternative baseline scenario

The alternative baseline scenario projects heat production for heating and hot water preparation using an electric hot water boiler with a heat production efficiency of 99.5%. An overview of the costs and the environmental load for the alternative baseline scenario is given in the following table.

Table 57: Cost and environmental data for the alternative baseline scenario

Investment costs of building a heat source	EUR 2 700
Consumption of electricity	7 337 kWh/year
Cost of electricity	EUR 799/year
Production of CO_2 emissions	1 225 kg/year

Production of SO_x emissions	0 kg/year
Production of NO_x emissions	0 kg/year
Production of particulate matter emissions	0 kg/year

3.3.6 Scenario for the use of solar energy

This scenario projects the use of solar energy for hot water preparation using solar thermal collectors. The production of heat for heating is again based on natural gas or electricity as in the baseline scenarios. Hot water for hygienic purposes will be prepared in a combined manner:

- in climatically suitable months, using flat solar collectors with the total aperture area of 5 m^2, with about 50% of hot water (i.e. 25 m^3) being prepared in this manner,
- in the rest of the calendar year, with frequent cloud inversion and temperature below 5°C, hot water will be prepared using a boiler burning natural gas or electric boiler so that the heat production system for heating and hot water preparation is identical with the baseline scenario being subject to comparison, with about 50%/ of hot water (i.e. 25 m^3) being prepared in this manner.

Circulation of heat carrier fluid from solar collectors to the accumulation tank is provided by an electric circulating pump, the projected annual electricity consumption being 20 kWh. Compared with the baseline scenario, the consumption of energy in commercially available energy carriers and thus the related emissions will be reduced as shown in the following table.

Table 58: Cost and environmental data for the scenario using solar energy

	Solar system + natural gas boiler	Solar system + electric boiler
Investment cost of building the heat source + solar system	EUR 6 000	EUR 5 200
Energy consumption	6 040 kWh/year	5 950 kWh/year
Cost of energy	EUR 220/year	EUR 649 /year
Production of CO_2 emissions	1 328 kg/year	993.65 kg/year
Production of SO_x emissions	0.006 kg/year	0 kg/year
Production of NO_x emissions	1 063 kg/year	0 kg/year
Production of particulate matter emissions	0.050 kg/year	0 kg/year

The costs and benefits of the scenario using solar energy are specified in the following table as the difference between the investment cost and the difference between the heat production energy and the related costs, with the following being compared:

- scenario using solar energy with additional heating using a natural gas boiler versus the main baseline scenario,
- scenario using solar energy with additional heating using an electric boiler versus the alternative baseline scenario

Table 59: Costs and benefits of the scenario using solar energy versus the baseline scenarios

	Parameter	Main baseline scenario	Alternative baseline scenario
COSTS	Increased investment cost	EUR 2 500	EUR 2 500
BENEFITS	Energy saving in energy carriers	1 410 kWh	1 387 kWh
	Cost saving on energy carriers	EUR 48.3	EUR 150.3
	Reduction in the production of CO_2 emissions	311 kg/year	231.35 kg/year
	Reduction in the production of SO_x emissions	0.001 kg/year	0 kg/year
	Reduction in the production of NO_x emissions	0.252 kg/year	0 kg/year
	Reduction in the production of particulate matter emissions	0.012 kg/year	0 kg/year
Real payback period		**36.4 years**	**14.4 years**
NPV at the end of the reference evaluation period *		**EUR -1 661**	**EUR 110**

** the length of the reference period is defined in Table 47*

It is obvious from the results of the cost-benefit analysis for the scenario using solar energy that solar thermal collectors for hot water preparation are economically sound only for heat sources where a more expensive energy carrier, e.g. electricity, was originally used. For heat sources using natural gas with parameters similar to the main baseline scenario, the investment in solar collectors will not pay back. Therefore, we have set up supporting financial mechanisms to stimulate the demand for these installations, which significantly shortens the payback period for the investment in these installations.

3.3.7 Scenario using aerothermal energy

This scenario projects the use of aerothermal energy for heating and hot water preparation using an air-to-water heat pump. For the low-temperature heating system, the seasonal coefficient of performance (SCOP) for a heat pump is 3.8.

Table 60: Cost and environmental data for the scenario using aerothermal energy

Investment costs of building a heat source	EUR 10 000
Consumption of electricity	1 921 kWh/year
Cost of electricity	EUR 206/year
Production of CO_2 emissions	321 kg/year
Production of SO_x emissions	0 kg/year
Production of NO_x emissions	0 kg/year
Production of particulate matter emissions	0 kg/year

The costs and benefits of the scenario using aerothermal energy are specified in the following table as the difference between the energy for heat production and the related costs of this scenario versus both baseline scenarios.

Table 61: Costs and benefits of the scenario using aerothermal energy versus the baseline scenario

	Parameter	Main baseline scenario	Alternative baseline scenario
COSTS	Increased investment cost	EUR 6 500	EUR 7 300
BENEFITS	Energy saving in energy carriers	5 529 kWh	5 416 kWh
	Cost saving on energy carriers	EUR 62	EUR 593
	Reduction in the production of CO_2 emissions	1 318 kg/year	904 kg/year
	Reduction in the production of SO_x emissions	0.007 kg/year	0 kg/year
	Reduction in the production of NO_x emissions	1 315 kg/year	0 kg/year
	Reduction in the production of particulate matter emissions	0.062 kg/year	0 kg/year
Real payback period		**58.6 years**	**11.3 years**
NPV at the end of the reference evaluation period *		**EUR -5 423**	**EUR 2 999**

** the length of the reference period is defined in Table 55*

It is obvious from the results of the cost-benefit analysis for the scenario using aerothermal energy that heat pumps are economically sound only for heat sources where natural gas or some other cost-effective energy carrier is not available. There is a support system in place to stimulate demand for these installations – Green Households, which has significantly increased demand for heat pumps in this segment.

3.3.8 Sensitivity analysis

The key factors influencing the chosen model of the cost-benefit analysis is the development in the prices of energy carriers, which translates in CBA into the annual rate of increase in energy prices. The reference evaluation period was chosen for 15 years, and predicting the increase in energy prices for a period this long is unrealistic. In the analysis, the prices of energy carriers are escalated by 1.9% per year. This figure is based on the short-term prediction of the National Bank of Slovakia until 2024. Increased rate of the annual energy price increase in comparison with the predicted value will have a positive effect on the benefits in both alternative scenarios, and vice versa, deflation in energy prices will have a negative effect on these benefits.

3.3.9 Sensitivity analysis for the scenario using solar energy

The NPV sensitivity analysis in the scenario using solar energy depending on the change in the annual increase in energy prices is shown in the following tables, with sensitivity to the change in this parameter being assessed separately for either of the baseline scenarios. The NPV change is given also in relative terms versus the basis NPV value that is set while assuming an annual increase in energy prices of 1.9%.

Table 62: Sensitivity analysis of NPV change depending on the change in the rate of increase in annual energy prices for the scenario using solar energy in comparison with the main baseline scenario

Rate of annual increase in energy prices (%)	1.90%	3.90%	5.90%	7.90%	9.90%	10.90%	11.90%
NPV (€)	-1 661	-1 510	-1 328	-1 107	-841	-688	-519
Rate of NPV change in comparison with the basis value (%)	0.0%	9.1%	20.1%	33.3%	49.4%	58.6%	68.8%

Table 63: Sensitivity analysis of NPV change depending on the change in the rate of increase in annual energy prices for the scenario using solar energy in comparison with the alternative baseline scenario

Rate of annual increase in energy prices (%)	1.90%	3.90%	5.90%	7.90%	9.90%	10.90%	11.90%
NPV (€)	110	580	1 147	1 833	2 662	3 140	3 665
Rate of NPV change in comparison with the basis value (%)	0.0%	426.0%	940.6%	1 562.4%	2 314.4%	2 747.4%	3 223.6%

The sensitivity analysis for the scenario using solar energy in comparison with the main baseline scenario has shown that a 1% change in the annual increase in energy prices will result in a 4.5% to 6.9% change in NPV. The sensitivity analysis for the scenario using solar energy in comparison with the alternative baseline scenario has shown that a 1% change in the annual increase in energy prices will result in a 213% to 320% change in NPV, depending on the amount of saving of annual energy costs.

To summarise these results, it should be pointed out that a higher year-on-year increase in energy prices significantly increases the sensitivity of the economic evaluation of the scenario if higher savings of energy costs are achieved.

3.3.10 Sensitivity analysis for the scenario using aerothermal energy

The NPV sensitivity analysis in the scenario using aerothermal energy depending on the change in the annual increase in energy prices is shown in the following tables, with sensitivity to the change in this parameter being assessed separately for either of the baseline scenarios.

Table 64: Sensitivity analysis of NPV change depending on the change in the rate of increase in annual energy prices for the scenario using aerothermal energy in comparison with the main baseline scenario

Rate of annual increase in energy prices (%)	1.90%	3.90%	5.90%	7.90%	9.90%	10.90%	11.90%
NPV (€)	-5 423	-5 229	-4 995	-4 712	-4 370	-4 173	-3 957
Rate of NPV change in comparison with the basis value (%)	0.0%	3.6%	7.9%	13.1%	19.4%	23.0%	27.0%

Table 65: Sensitivity analysis of NPV change depending on the change in the rate of increase in annual energy prices for the scenario using aerothermal energy in comparison with the alternative baseline scenario

Rate of annual increase in energy prices (%)	1.90%	3.90%	5.90%	7.90%	9.90%	10.90%	11.90%
NPV (€)	2 999	4 852	7 091	9 797	13 068	14 952	17 024
Rate of NPV change in comparison with the basis value (%)	0.0%	61.8%	136.5%	226.7%	335.8%	398.6%	467.7%

The sensitivity analysis for the scenario using aerothermal energy in comparison with the main baseline scenario has shown that a 1% change in the annual increase in energy prices will result in a 1.7% to 2.7% change in NPV. The sensitivity analysis for the scenario using aerothermal energy in comparison with the alternative baseline scenario has shown that a 1% change in the annual increase in energy prices will result in a 30% to 47% change in NPV, depending on the amount of saving of annual energy costs.

The result is that a higher year-on-year increase in energy prices significantly increases the sensitivity of the economic evaluation of the scenario if higher savings of energy costs are achieved. The scenarios using electricity are more sensitive to price increase, especially when comparing them with the alternative baseline scenario. The currently escalating price of electricity has a strongly positive effect on the rentability of projects aimed at the establishment of RES-based installations.

3.3.11 Summary of the cost-benefit analysis for individual heat production

The analysis performed has shown that each of the scenarios involving the use of renewable energy sources can generate benefits that have a positive economic effect for the investor (e.g. household) or positive environmental effect for improving air quality and reducing greenhouse gas emissions, i.e. a broad social effect. The degree of the generated benefits depends on the conditions of the baseline scenario.

Where infrastructure for the supply of natural gas is absent, an investor acquiring a source for individual heat production must take into account other available energy carriers such as electricity, as was the case in the alternative baseline scenario. The significantly higher price of this energy increases attractiveness of installations using RES in heat production despite the higher cost of their acquisition.

As confirmed by the main baseline scenario with natural gas as the energy carrier, lower operating costs of this scenario have shifted the payback of the investment in installations using RES beyond economic soundness. Given the very high representation of individual production of heat using natural gas, supporting financial programmes play an important role. These can bring the economic payback of the investment using the investor’s own funds before the end of the technical life of the installation using RES, which causes a considerable demand for these installations among those who use natural gas as heat source. From the overall social perspective, the CBA has shown the need to continue creating conditions in Slovakia for establishing installations using RES in sources for individual heat production.

4. PART IV – POTENTIAL NEW STRATEGIES AND POLICY MEASURES

The basic policies and measures in the area of heating and cooling are set out in the Integrated National Energy and Climate Plan and supplemented with new measures, especially the financial supporting mechanisms contained in section 2. In future, these measures will be supplemented with additional measures related to the new requirements proposed in the 'Fit for 55' package, which will have an effect also on the role of the comprehensive assessment itself. According to the Commission's proposal, the comprehensive assessment could become an integral part of NECP in the future.

Under Regulation 2018/1999 on the Governance of the Energy Union, a draft update of the NECP document shall be drawn up by 30 June 2023. The draft should include new and modernised measures in the area of heating and cooling. It should reflect new knowledge concerning heating and cooling, new procedures and measures and new proposals taking into account the final wording of European legislation from the 'Fit for 55' package.

The comprehensive assessment is an analytical document assessing the current state of the heating and cooling sector. It is specifically the experience from the preparation of the first and second comprehensive assessment which make it possible to plan new measures and procedures; these must be performed in such a way as to be able to plan new measures in the area of heating and cooling in the updated NECP.

Experience from the preparation of the comprehensive assessment – establishing a system enabling regular updating of the comprehensive assessment in its full scope

The main conclusion following from the preparation of the comprehensive assessment is the lack of specific data on heat and cold. Besides that, the addition of the comprehensive assessment and the requirement for extension of data concerning sources of heat from renewable energy sources has increased the required quantity of data and areas of production and consumption of heat and cold several fold. This applies mainly to methods of individual heating, in which new and progressive technologies continue to emerge, aimed at the most environmentally friendly possible use of energy from renewable sources.

The basic experience from the preparation of the comprehensive assessment as an analytical document promoting further development of heating and cooling also reveal the need to carry out analytical activities for which it would be suitable to use collected and calculated heat and cold data. A significant part of the comprehensive assessment focuses on analytical activity related to assessment of the situation in the area of heating and cooling in Slovakia. The result is a picture of the state of heating and cooling. Therefore, this document represents a comprehensive picture which is close to the actual state of heating and cooling in Slovakia.

In preparing the comprehensive assessment, various data sources were used, which, when combined, made it possible to at least partly discover and describe the current state of heating and cooling in Slovakia. However, there is a lack of comprehensive data on the heating and cooling sector. The requirements for data are not related only to the current state of heat consumption, but also provide an analysis of the future potential and economic and technical assessment of various methods of heat production and use of various technologies. This represents a high quantity of data from various sources, which must be interconnected and analysed in order to obtain the required result.

The contents of the comprehensive assessment are given by the Commission Delegated Regulation and are designed to form an annex to the Energy Efficiency Directive in the future. The comprehensive assessment is to be developed regularly every 5 years. Given the high analytical and data requirements, it is necessary to ensure that the required data are available for preparing the analytical part of the comprehensive assessment. The process of collection of the required basic data and their subsequent processing should be automated to the maximum possible degree in order to minimise the burden associated with the development of the comprehensive assessment. This means increased requirements for simplification and automation of the collection and processing of data, as well as the analytical activities associated with the comprehensive assessment. It follows from the above that there are several specific tasks related to increased availability of the required data and their further processing.

Tasks necessary for a high-quality comprehensive assessment:

- Legislative analysis, methodologies, data collection.
- Extended monitoring of energy efficiency within the meaning of legislative analysis.
- Extending the energy efficiency information system (EE IS) with analytical and planning tools.
- Automation of the process of evaluation and planning and specific outputs to NECP.

Requirement for the collection of data on heating and cooling

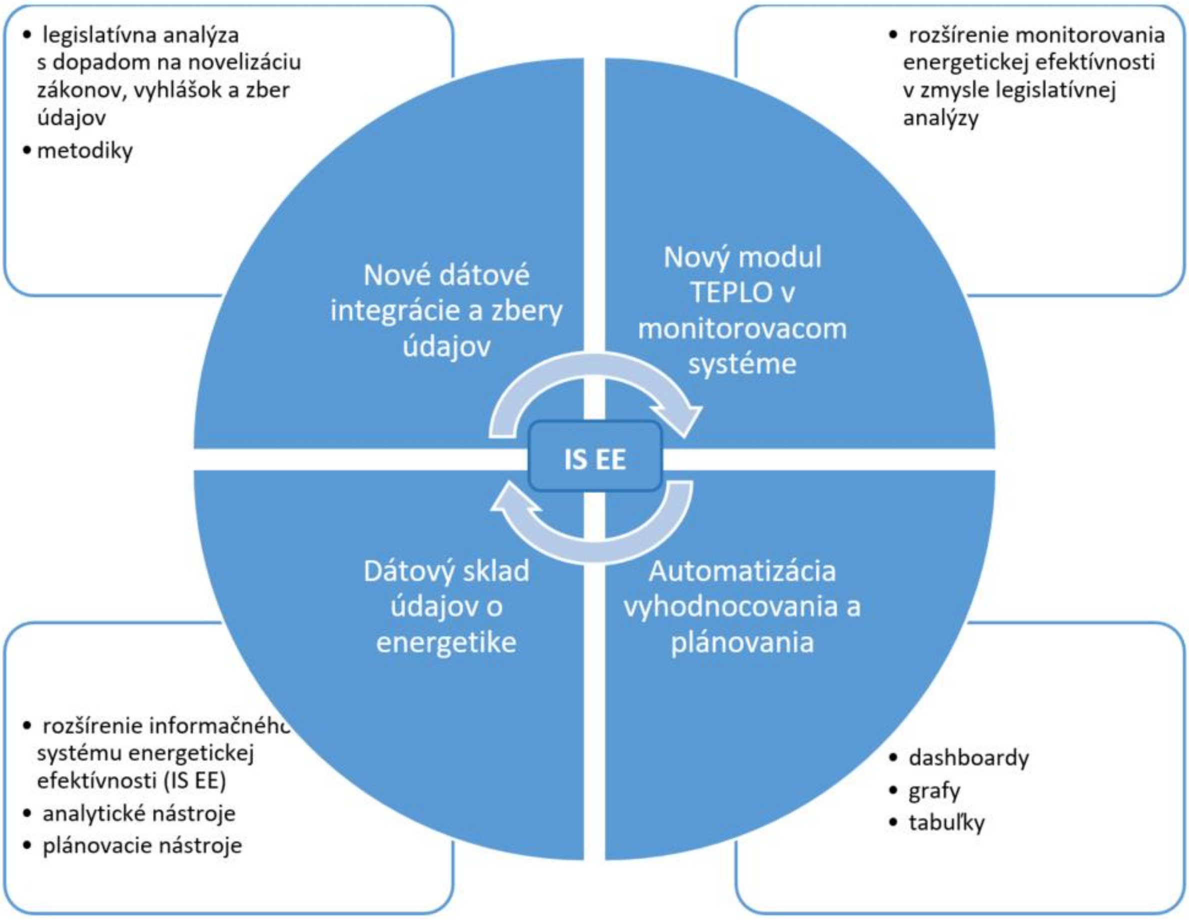
In the preparation of the comprehensive assessment, it is necessary to answer the basic question of the quantity of heat used in Slovakia. This is by far not an easy question because a large quantity of heat is used from individual production, which is not covered by statistics at all. Therefore, it is necessary:

- to provide for a higher quality and extension of data collection,
- to develop a methodology enabling additional calculation of missing data.

Requirement for legislative amendments and the required methodological instructions

Given the constantly changing European legislation concerning heating and cooling, it will be necessary to ensure the development of legal regulations and rules applicable to the comprehensive assessment in future. This will also establish legislative support in certain areas without which the comprehensive assessment cannot be prepared.

Figure 7 Graphic overview of tasks



Source: SIEA

Key to graphic	
Original text	Translation
legislatívna analýza s dopadom na novelizáciu zákonov, vyhlášok a zber údajov	legislative analysis with an impact on amendment of laws and implementing decrees and data collection
metodiky	methodologies
rozšírenie monitorovania energetickej efektívnosti v zmysle legislatívnej analýzy	extended monitoring of energy efficiency within the meaning of legislative analysis.
Nové dátové integrácie a zbery údajov	New data integrations and data collections
Nový modul TEPLO v monitorovacom systéme	New HEAT module in the monitoring system
IS EE	EE IS
Dátový sklad údajov o energetike	Data warehouse for energy sector data
Automatizácia vyhodnocovania a plánovania	Automation of the process of evaluation and planning
rozšírenie informačného systému energetickej efektívnosti (IS EE)	extension of the energy efficiency information system (EE IS)
analytické nástroje	analytical tools
plánovacie nástroje	planning tools

dashboardy	dashboards
grafy	charts
tabuľky	tables

Requirement for automation of output reports

Given that NECP is set to be updated every 5 years starting in 2018 and the comprehensive assessment starting in 2020, it is obvious that the basic tables regarding the use of heat and cold in Slovakia will need to be updated on a regular basis. Automation of this process would be very useful. One of the possible solutions is to create specific output reports (dashboard, charts, tables, etc.) within the energy efficiency monitoring system, which would focus on data required for the comprehensive assessment and for the heating and cooling part of NECP. At the same time, the system will provide for regular updating of the necessary data in the EE IS data warehouse. All the required data sources will be interconnected through the monitoring system in such a way that a high-quality analysis of the heating and cooling sector can be developed and a basis formed for the planned platform required for determining the potential in the area of heating and cooling as well as for predictions of the long-term development of heat and cold consumption in Slovakia.

Requirements for analytical tools and determination of the long-term potential

The requirements for the comprehensive assessment include also determination of the potential for the next 30 years and development of an economic/technical evaluation of the main primary energy sources and technologies used for the production of heat and cold. In view of the above requirements, it is necessary to create a robust analytical and planning tool as a superstructure of the monitoring system, which will be able to process these robust CBA by fuels and technologies and combinations thereof for the entire Slovak Republic, as well as for its individual regions and cities, so that heat concepts are in accordance with the comprehensive assessment.

5. CONCLUSION

The comprehensive assessment is an analytical document assessing the current state of heating and cooling. Therefore, this document represents a comprehensive picture which is close to the actual state of the heating and cooling sector and provides information on the consumption of heat and cold in Slovakia.

The main conclusion following from the preparation of the comprehensive assessment refers to a lack of specific data on heat and cold. These data are necessary for identifying the state of heating and cooling in Slovakia to the required extent, as well as the quantity of heat and cold used in Slovakia. Data need to be available also in order to perform the required analytical activities related to assessing the potential in the heating and cooling sector and planning future development of heating and cooling in Slovakia in accordance with the latest energy and climate objectives and the requirement for climate neutrality by 2050.

6. ANNEX

The Institute for Environmental Policy has developed an analysis of the costs and benefits of the construction of a third boiler in the installation for energy recovery of waste at the Bratislava OLO, a.s. incineration plant. The analysis is enclosed in a separate document.

institute for
environmental
policy

Ministry of Environment of the Slovak Republic

www.minzp.sk/en/iep/

What to Do with Bratislava Waste?

Analysis of the costs and benefits of the construction of a third boiler at the OLO installation for energy recovery of waste

December 2020

Discussion study 10

Abstract

The project of construction of a third boiler at the Bratislava OLO a.s. incineration plant would pay back both financially and from the overall social perspective. This result is relatively sensitive to the amount of investment costs and the quantity of waste recovered. If, for example, the quantity of waste subject to energy recovery was by 16% smaller or the investment costs by 20% higher, the project would no longer pay back financially. However, the construction of the third boiler is not essential for maintaining the 10% landfill rate in Bratislava and will not increase the degree of recycling.

Author

Stella Slučiaková stella.sluciakova@enviro.gov.sk

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Review proceedings

The analysis was approved by the Specialised and Methodological Committee as a reviewed analysis on the basis of the review by Martin Darm (Slovak Ministry of Transport and Construction), Daniel Mušec (Value for Money Department of the Slovak Ministry of Finance) and Katarína Bednáriková (Bratislava City Hall).

Contents

List of charts, boxes and tables

List of abbreviations

CBA	cost-benefit analysis
MBT	mechanical biological treatment
OLO	Odvoz a likvidácia odpadu, a.s.
SAF	solid alternative fuel
FNPV	financial net present value
FIRR	financial internal rate of return
ENPV	economic net present value
ERR	economic rate of return
BCR	benefit-cost ratio
IERW	installation for energy recovery of waste

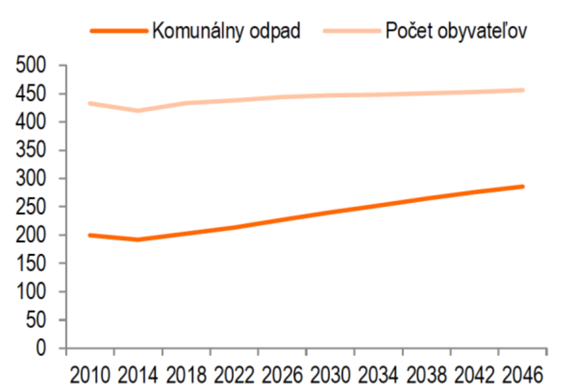
Summary

The capital city of Bratislava has traditionally belonged to cities with the lowest landfill rate. Thanks to installations for the energy recovery of waste, only one tenth of all municipal waste is landfilled in Bratislava, which is significantly less than the national average of 52%. The city's objective is to maintain the landfill rate at about 10% also in the next period with growing waste generation; it has therefore decided to examine the potential investment in extending the installation for energy recovery of waste of the municipal enterprise Odvoz a likvidácia odpadu a.s. (OLO a.s.) in cooperation with the Institute for Environmental Policy of the Slovak Ministry of Environment. OLO a.s. commissioned a project for the construction of a third boiler with the set capacity of 65 400 tonnes of waste processed annually and a life of 20 years within an existing installation for the energy recovery of waste. The project was assessed from the perspective of the financial and economic cost-benefit analysis.

Mechanical biological treatment of waste is an alternative way of handling municipal waste. Under the amendment to the Waste Act, effective from 2021 municipal waste must be treated before being landfilled. Mechanical biological treatment provides for separation and stabilisation of the bio-component, thus reducing the production of emissions of greenhouse gases on the landfill. We expect that a part of the waste will continue to be landfilled after treatment and the rest will be used for the production of solid alternative fuels for cement works.

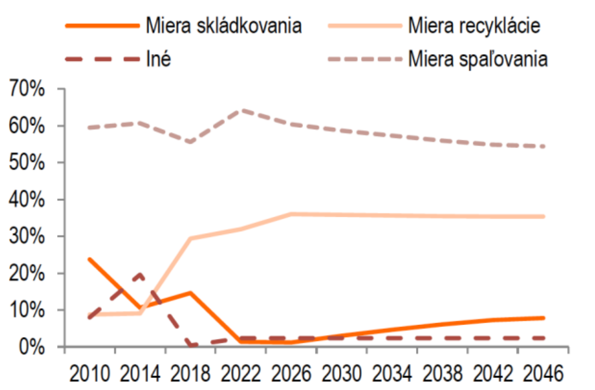
In the 2025–2045 period, the municipal waste production in Bratislava will grow by an average of 2.5% year-on-year and the recycling rate will increase to 36%. The growing production of municipal waste will be driven by the higher consumption of households and growing population. At the same time, the introduced measures change the structure of waste management and will increase the recycling rate. Enhancing the targets for separate collection, duty to comply with separate collection of kitchen bio-waste and deposit scheme for non-reusable drinks packaging decrease the production of non-separately collected mixed municipal waste while increasing the rate of sorting and recycling. We estimate that the recycling rate will increase especially until 2027 as a result of the adopted measures and will reach 36% by 2045.

Chart 1: Forecast of the development of municipal waste in Bratislava (thousand tonnes)



Source: IEP

Chart 2: Forecast of municipal waste management in Bratislava (in %)



Source: IEP

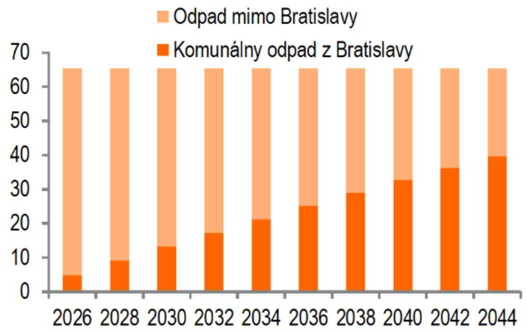
Key to graphic	
Original text	Translation
Komunálny odpad	Municipal waste
Počet obyvateľov	Population
Miera skládkovania	Landfill rate
Miera recyklácie	Recycling rate
Iné	Other

Miera spaľovania	Incineration rate

The existing capacities of the installation for energy recovery of waste will be sufficient for maintaining the landfill rate at 10%. There will be less unsorted municipal waste as a result of the increased sorting and recycling rate. At the same time, mechanical biological treatment of waste will further reduce landfilling. The existing capacity of the installation for energy recovery of waste (IERW) equal to 134 thousand tonnes of waste per year would thus be sufficient for achieving the required landfill rate. If Slovakia manages to meet the national objectives for the recycling and landfilling of municipal waste set by the EU, the quantity of non-separately collected municipal waste would be even smaller than the present capacity of the OLO a.s. IERW.

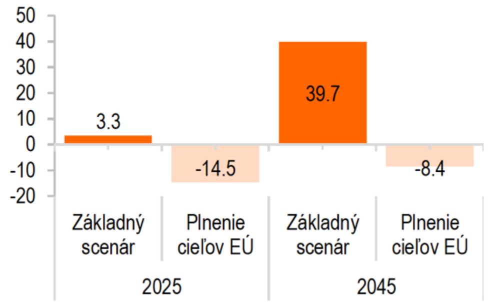
A majority of the capacity of the new third boiler would be used for managing other than municipal waste from Bratislava. If all non-separately collected, non-recycled municipal waste from Bratislava was subject to energy recovery, it would fill approximately 35% of the available capacity in 2025–2044. The remaining waste would be industrial waste or municipal waste from other municipalities.

Chart 3: Composition of waste in the newly built third boiler (thousand tonnes)



Source: IEP

Chart 4: Development of non-recycled waste in Bratislava in excess of the existing capacity of the IERW (thousand tonnes)



Source: IEP

Key to graphic	
Original text	Translation
Odpad mimo Bratislavy	Waste outside Bratislava
Komunálny odpad z Bratislavy	Municipal waste from Bratislava
Základný scenár	Baseline scenario
Plnenie cieľov EÚ	Achievement of EU objectives

The financial and economic analysis shows that the project will pay back financially and from the overall social perspective. The financial net present value of discounted revenue and expenditure is EUR 12.2 million. Since the 6.1% rate of return of the project is higher than the 4% discount rate, the project revenues exceed the costs. The cumulative net cash flow is not negative in any of the project years, which makes it sustainable in financial terms.

Table 1: Resulting financial indicators (EUR mil.)

Cash flows	Total (discounted)
Costs	**-79.1**
Investment costs	-60.8
Operating costs	-18.3
Benefits	**91.3**
Revenues	91.3
Residual value	0

Financial net present value (FNPV)	**12.2**
Financial internal rate of return (FIRR)	**6.1%**

Source: IEP

In contrast to the financial analysis, which reflects only the costs and benefits from the perspective of OLO a.s., the economic analysis takes into consideration all direct and indirect costs and benefits of the project from the overall social perspective. The economic net present value equals EUR 11.2 million. The 7.1% rate of return exceeds the economic discount rate which equals 5%. The benefit-cost ratio is 1.2.

Table 2: Evaluation of costs and benefits from the overall social perspective (EUR mil.)

Cash flows	Total (discounted)
Costs	**-72.9**
Investment costs	-58.8
Operating costs	-14.1
Savings	**84.1**
Savings on resources	94.2
Avoided external costs	-10.1
Residual value	0
ENPV	**11.2**
ERR	**7.1%**
BCR	**1.2**

Source: IEP

The results of the financial and economic analysis are sensitive especially to the amount of investment costs and the quantity of waste recovered. If the quantity of waste subject to energy recovery was 16% smaller or if the investment costs were 20% higher, the project would not be profitable from the viewpoint of the financial analysis. From the overall social perspective, the project would be economically non-profitable if the quantity of waste recovered was 16% smaller than the capacity of the new third boiler or if the investment costs were 19% higher. Given the estimated future waste production, we do not expect a high risk in connection with the construction of additional installations for energy recovery of waste. If the mechanical biological treatment was not introduced, the demand for energy recovery could be insufficient and the project would not be economically sound.

The capacity of the third boiler may be used on a one-off basis also to eliminate illegal landfills. The costs of energy recovery of waste from illegal landfills would translate into higher costs for the city, or rather its citizens. The quantity of waste on illegal landfills in Bratislava is approximately 50 thousand tonnes, i.e. an equivalent of almost the entire annual capacity of the third boiler. However, waste from illegal landfills represents only a one-off source of waste and it cannot be expected to be a major part of energy recovery of waste during the lifetime of the project.

Comparison with alternative projects was not included in the analysis. The project for building a third boiler is assessed as a single project for which design documents were drawn up. The objective of the minimisation of landfilling of municipal waste in Bratislava would be met even without implementing the third boiler construction project. The City of Bratislava could consider setting more ambitious objectives, such as a higher sorting or recycling rate and preventing the generation of waste. An appropriate measure to meet these objectives is e.g. the introduction of a more targeted quantity-based waste charging scheme with collection using waste bin tags or support for separate collection of kitchen bio-waste. The selection of a cost-effective project that would make it possible to meet these objectives would require the preparation of several alternative projects.

As an alternative scenario, we proposed building a centre for recovery and support for separate collection of kitchen bio-waste. The total costs would be EUR 49.3 million, with the recycling rate possibly increasing to 42%. The recovery centre could provide for the recovery or recycling of up to 32% of bulky waste. Furnishing collection bins, baskets and bags for the collection of kitchen bio-waste for every household could increase the separation of kitchen bio-waste from mixed municipal waste to as much as 60% of the total potential. Overall, 10 thousand tonnes of kitchen bio-waste would be sorted annually and the waste could be recovered in a compost site or a biogas installation. We estimate the total costs of building a recovery centre, collection of kitchen bio-waste and the building of an installation for its recovery at EUR 49.3 million in the 2025–2044 period, i.e. the lifetime of the proposed project of third boiler construction. At the same time, the introduction of these measures could increase the recycling rate in Bratislava from 36% to 42%.

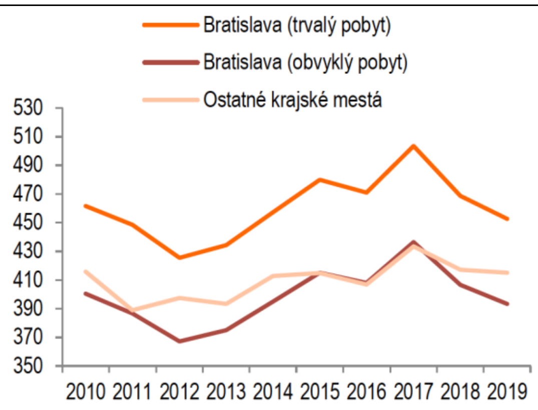
1 Identification of the project

Thanks to the energy recovery of municipal waste at the installation for energy recovery of waste (IERW) of the municipal enterprise OLO a.s., Bratislava is one of the cities with the lowest landfill rate, which ranges between 10 and 15%. The city's goal is to keep the landfill rate at 10% also in the future. In this context, cooperation was established between the city and the Institute for Environmental Policy in order to develop an analysis of the costs and benefits of the construction of a third boiler at the OLO a.s. IERW. The aim of the analysis is to assess not only the financial but also the economic impacts of the project implementation compared to a zero scenario in which no additional boiler would be built.

1.1 Current state

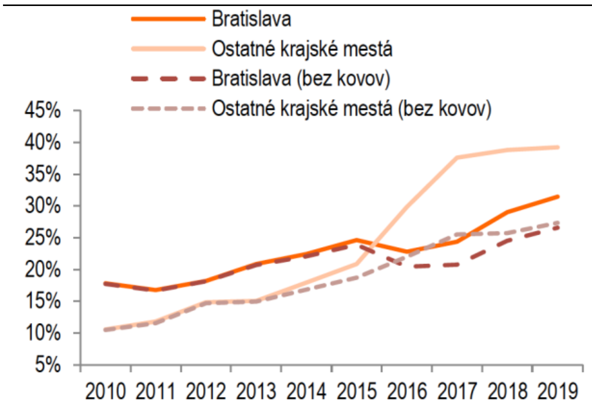
In 2019, the average municipal waste generation in Bratislava was 453 kg per capita[1], and has been constant since 2010. Per capita production is higher compared to other regional capitals where the weighted average is 410 kg per capita. The reason for this may be that the actual population in Bratislava is higher than the number of permanent residents according to the data of the Statistical Office. If we take into account the population with 'habitual residence' (Harvan et al., 2019), the population would be greater by about 66 thousand people and the average municipal waste production in Bratislava would be only 398 kg per capita.

Chart 5: Municipal waste production (kg/capita)



Source: IEP, according to the Statistical Office of the Slovak Republic

Chart 6: Municipal waste sorting rate (%)



Source: IEP, according to the Statistical Office of the Slovak Republic

Key to graphic	
Original text	Translation
Bratislava (trvalý pobyt)	Bratislava (permanent residence)
Bratislava (obvyklý pobyt)	Bratislava (habitual residence)
Ostatné krajské mestá	Other regional capitals
Bratislava	Bratislava
Ostatné krajské mestá	Other regional capitals
Bratislava (bez kovov)	Bratislava (excluding metals)
Ostatné krajské mestá (bez kovov)	Other regional capitals (excluding metals)

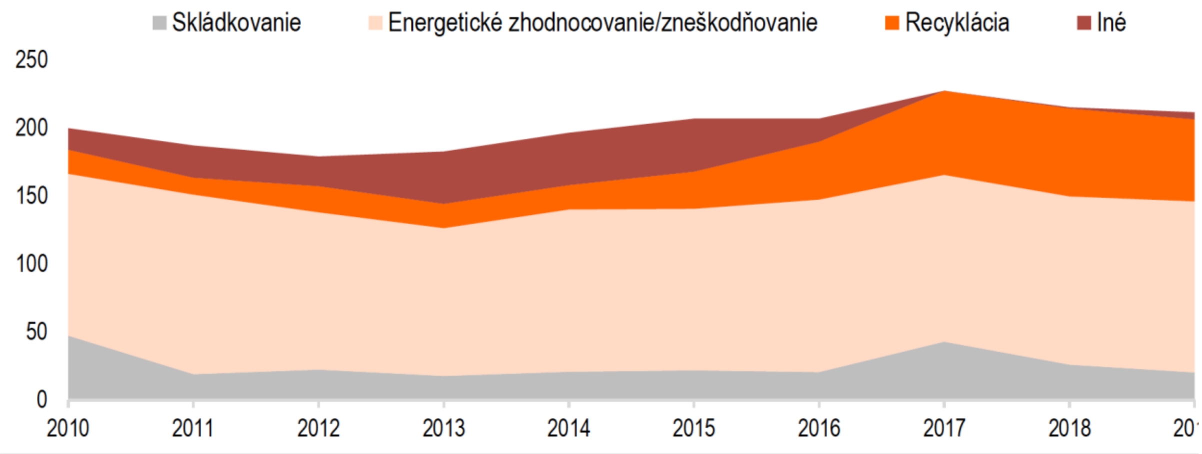
Bratislava's sorting rate has gradually increased since 2010 to 32% in 2019, which is less than in other regional capitals where the figure is 39%. However, excluding metal waste, the sorting rate is at the same level of 27% in

[1] We omit metals from municipal waste production due to problems with their recording and the sharp increase since 2016.

Bratislava and in the other regional capitals. The higher quantity of metals sorted in the other regional capitals may be linked to the change in metal registration since 2016, as well as the drive to achieve higher sorting rates and thus lower legal fees for municipal waste landfilling. As most of the waste is subject to energy recovery in Bratislava, achieving a higher sorting rate in order to reduce landfill charges is not necessary. There are no legal fees for energy recovery in Slovakia.

Most of the municipal waste sorted is recycled, with a recycling rate of around 29% in 2019. The reason for the lower recycling compared to the sorting rate is that plastic waste cannot be recycled. According to data from the Statistical Office and OLO a.s., only 22% of the weight of all sorted plastic waste is recycled in Bratislava, the rest is subject to energy recovery. In 2018, an average of 40% of sorted household plastic waste was recycled in Slovakia, according to data from producer responsibility organisations that finance separate waste collection. The low recycling rate of plastics is attributable mainly to non-recyclability and the fact that the recycling of certain types of plastics is very costly.

Chart 7: Municipal waste management in Bratislava (thousand tonnes)



Source: IEP, according to the Statistical Office of the Slovak Republic and OLO a.s.

Key to graphic	
Original text	Translation
Skládkovanie	Landfilling
Energetické zhodnocovanie/zneškodňovanie	Energy recovery/disposal
Recyklácia	Recycling
Iné	Other

Municipal waste in Bratislava that is not sorted and recycled is used for energy recovery at the OLO a.s. IERW. This is mainly mixed municipal waste, bulky waste and sorted paper and plastic waste that cannot be recycled. The total amount of municipal waste subject to energy recovery is approximately 121 thousand tons annually. The remainder of municipal waste, approximately 10 to 15%, ends up in landfills each year during ZEVO outages.

1.2 Project description and objectives

Thanks to energy recovery, Bratislava is one of the cities with the lowest landfill rates in Slovakia. The city's goal is to keep the landfill rate at approx. 10%. The current capacity of IERW is 134 thousand tonnes per year, which is sufficient for meeting the target set for municipal waste management in Bratislava. In the future, an increase in municipal waste production can be expected, whether due to improving living standard and higher consumption or due to population growth. In such a case, the capacity of the IERW might not be sufficient and waste management would have to be arranged differently.

On the backdrop of the city's long-lasting interest in expanding the OLO a.s. IERW, cooperation between the Institute for Environmental Policy and the City of Bratislava was arranged in order to prepare a cost-benefit analysis for the construction of a third boiler. The aim of the analysis is to compare the 'zero scenario' without project implementation and the scenario of building a third boiler with a predetermined capacity and other parameters according to the project documentation with respect to the expected waste production including the measures taken.

The theoretical capacity of the planned boiler is 87 200 tonnes of waste per year. However, according to OLO a.s., due to fluctuations in the calorific value of waste, it is not possible to use the capacity to the full extent. OLO a.s. expects that the actual annual capacity can reach 65 400 tonnes, assuming a combustion power of 10.9 t/h, an annual operating time of 8 000 h/y and performance coefficient of 0.75. If industrial waste is used, which is homogeneous and shows smaller variations in calorific value, it is possible to envisage the performance coefficient to increase to 0.85, or a capacity of 74 120 tonnes per year.

According to the CBA methodology (IEP, 2019), the typical reference period for waste management projects is 30 years. The lifetime of the third boiler technology determined by the producer is 15 years. It can be extended with proper maintenance and preventive servicing. Based on previous experience of OLO a.s., we are projecting a service life of 20 years. The construction is expected to start in 2022 and be completed in 2024. The third boiler is planned to start operation in 2025.

1.3 Analysis of the offer

Waste management is mainly influenced by the cost of disposal or recovery, as well as by European Union's requirements and targets. In the waste hierarchy, the worst option is landfilling, followed by energy recovery, recycling, preparation for reuse, and waste prevention as the best option.

In line with the hierarchy, numerous measures have been adopted in Slovakia, such as the introduction of separate collection of municipal waste, which encourages increasing recycling or increasing landfill charges in order to reduce the rate of landfilling municipal waste. The different measures influence both the ways in which waste is managed and the costs of waste management.

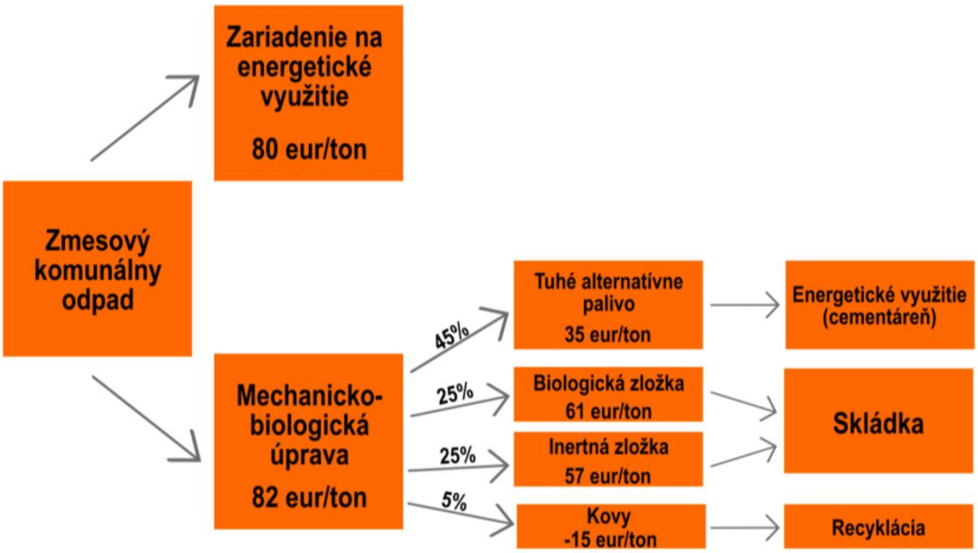
For non-separately collected municipal waste in Slovakia, the cost of landfilling is still lower compared to the cost of energy recovery. Based on data from landfill operators and the expected sorting rate, we estimate that the average cost of landfilling municipal waste (including the statutory charge) is €55 per tonne in 2020. The cost of energy recovery ranges from EUR 80 to EUR 100/tonne (Ewia, Kosit, OLO).

The treatment of municipal waste before landfilling is regulated effective from 2021 in accordance with the amended Waste Act[2]. The aim is to reduce the proportion of biodegradable waste going to landfills in order to comply with the EU Landfill Directive (European Parliament, 2018). Mechanical biological treatment (MBT) will ensure separation and stabilisation of the bio-component in the recovery of a part of waste for the production of SAF.

The estimated costs of waste treatment and further management are based on the composition of the waste after treatment, the costs of disposal and the costs of constructing the treatment technology. Data on the investment and operating costs of the mechanical biological treatment installation are based on the planned project. The costs of landfilling together with the treatment process can rise to €82/tonne, which is close to the costs of energy recovery. The calculation of the treatment costs is given in Annex 1: Municipal waste forecast

[2] Act No 79/2015 on waste.

Chart 8: Scheme for the possible management of mixed municipal waste from 2021



Source IEP

Key to graphic	
Original text	Translation
Zariadenie na energetické využitie 80 eur/ton	Energy recovery installation EUR 80/tonne
Zmesový komunálny odpad	Mixed municipal waste
Mechanicko-biologická úprava 82 eur/ton	Mechanical biological treatment EUR 82/tonne
Tuhé alternatívne palivo 35 eur/ton	Solid alternative fuel EUR 35/tonne
Energetické využitie (cementáreň)	Energy recovery (cement works)
Biologická zložka 61 eur/ton	Bio-component EUR 61/tonne
Skládka	Landfill
Inertná zložka 57 eur/ton	Inert component EUR 57/tonne
Kovy -15 eur/ton	Metals EUR -15/tonne
Recyklácia	Recycling

Municipal waste from separate collection, such as paper, plastics, glass, metals and sorted biodegradable waste, must not be disposed of by landfilling and most of it is recovered in recycling installations, compost sites or biogas installations. Plastics in particular are a problematic component, as some materials cannot be recycled in a technologically or economically advantageous manner. Some of them are subject to energy recovery, landfilled as waste after additional sorting or used as high-calorific waste to produce solid alternative fuels.

The costs of landfilling of waste after additional sorting, which becomes industrial waste, amount to €84/tonne including the statutory charge. The cost estimate is based on price lists from landfill operators and the statutory charge under the Government Regulation on the amount of charges for waste disposal[3]. According to data from producers, the cost of

[3] Government Regulation No 330/2018 laying down the amount of charges for waste disposal and details relating to the redistribution of revenues from

producing SAF from such waste is EUR 45-55/tonne. Despite this, up to 35% of waste is currently landfilled after additional sorting. This may be because several sorting line operators are also landfill operators. In addition, they can claim a lower statutory rate for landfilling this waste, in the amount of €7/tonne instead of €30/tonne. According to the Regulation, that rate is applicable to waste after additional sorting only if it cannot be recovered in an alternative way by reason of its characteristics.

The costs of landfilling industrial waste range from €54 to €124/tonne depending on the type of waste. For most industrial waste, recycling is an alternative to landfilling. The exceptions are, in particular, waste after additional sorting and mixed packaging, which are either landfilled or subject to energy recovery. The cost of landfilling them is EUR 84 or EUR 88/tonne, respectively, as it is often bulky waste, which takes up a lot of space in the landfill and is difficult to compact. The cost of landfilling such waste is thus equal to the cost of its energy recovery.

1.4 Demand analysis

The evaluation of the project for the construction of the third boiler depends significantly on the development of the production of municipal and industrial waste. In projecting trends, we have based our forecasts on historical waste data since 2010 and on measures taken in waste management that have an impact on the production or management of waste. In addition, we have included macroeconomic forecasts for the Slovak economy and population trends in Slovakia and Bratislava.

Non-separately collected municipal waste from Bratislava would not be sufficient to fill the entire capacity of the third boiler. Based on the forecast of waste production and management in Slovakia, we estimate that there will be sufficient demand for the capacity of a new third boiler from municipalities for the energy recovery of municipal waste. This is mainly due to the introduction of mechanical biological treatment of waste, the costs of which are equivalent to the costs of energy recovery at the OLO IERW. We are projecting the demand for energy recovery of industrial waste at the current level. We do not expect demand to increase as a result of cheaper alternatives for the management of this type of waste.

1.4.1 Forecast of production and management of municipal waste in Slovakia

The forecast of municipal waste production in Slovakia is based on a regression model in which we took into account the production of municipal waste in individual EU member states and household consumption. On the basis of the macroeconomic forecast and population development, we then calculated the production of municipal waste in Slovakia until 2045. The calculation is given in Annex 1: Municipal waste forecast

We then used the forecast of the total municipal waste production to estimate the production and management of municipal waste in individual municipalities in Slovakia. We assumed that the method of management of individual types of municipal waste will be the same as in 2017 and 2018 according to the records of the Statistical Office of the Slovak Republic.

In the next phase, we included in the forecast the measures taken at the national level. In estimating waste management, we only took into account measures and targets already adopted in waste management at the national level: increasing landfill charges, collection targets for separate collection, treatment of waste before landfilling, separate collection of kitchen bio-waste and deposit scheme for PET bottles and beverage cans.

A gradual increase in municipal waste landfill charges to between €11 and €33 per tonne of landfilled waste in 2021[4] will result in a reduction in landfill rates. Similarly, increasing the separate collection targets up to 60% of the municipal waste potential in 2022 will reduce the landfill rates and increase the sorting and subsequent recycling rates. We estimate that the introduction of separate collection of kitchen bio-waste, without further measures, will gradually increase its separation rate to 20% of the potential in mixed municipal waste. The introduction of mechanical biological treatment starting in 2022 will result in higher prices and a reduction in the landfill rates for municipal waste. The

waste disposal charges.

[4] Section 4(4) of Act No 329/2018 Coll. on waste disposal charges.

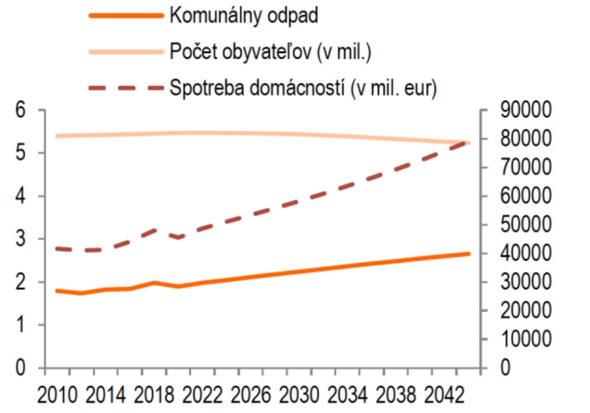
calculation of the impacts of each measure is presented in Annex 1:Municipal waste forecast

In addition to the measures taken, we also took into account the current capacities of the existing IERW for municipal waste management. We did not limit the quantity of waste intended for recycling because the recycling capacities for individual waste types in Slovakia are not fully known. In addition, while unsorted municipal waste is banned from transboundary shipments, sorted waste components can be sold to treatment facilities abroad as secondary material. Therefore, the available recycling capacity in Slovakia does not limit recycling. The same applies to the energy recovery of waste in the form of SAF after mechanical biological treatment.

Resulting forecast with measures

The resulting forecast thus includes measures that affect the production or management of municipal waste. The quantity of municipal waste is projected to continue its growth, but at a slower rate than household consumption due to population decline. Municipal waste per capita will grow from the current 430 kg to 580 kg in 2045 due to higher consumption by households.

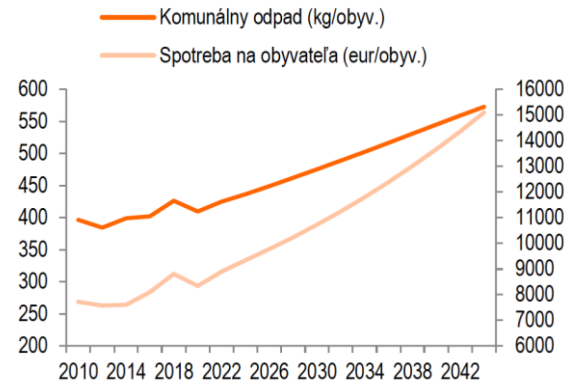
Chart 9: Forecast of municipal waste production in Slovakia (million tonnes)



*excluding metal waste

Source EIP

Chart 10: Municipal waste production forecast per capita in Slovakia

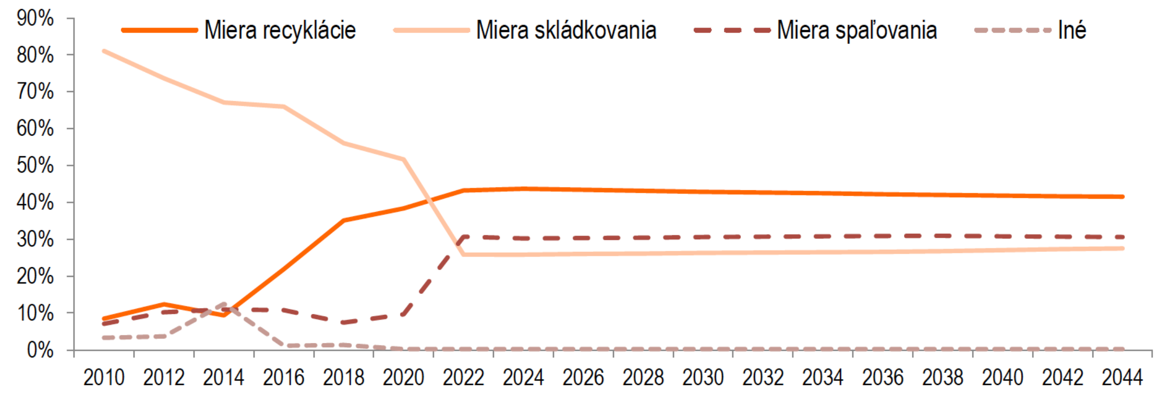


Source: EIP

Key to graphic	
Original text	Translation
Komunálny odpad	Municipal waste
Počet obyvateľov (v mil.)	Population (million)
Spotreba domácností (v mil. eur)	Household consumption (EUR million)
Komunálny odpad (kg/obyv.)	Municipal waste (kg per capita)
Spotreba na obyvateľa (eur/obyv.)	Per capita consumption (EUR per capita)

For municipal waste management, we expect recycling to increase to 40%. The collection targets for the separate collection of packaging and non-packaging products will have the greatest effect. After 2027, we do not anticipate any additional effects of the measures. Landfilling will decrease significantly, in particular as a result of the introduction of waste treatment. Although energy use in IERW will decline due to capacity constraints, the energy recovery rate will increase overall due to the impact of the energy recovery of SAF in cement works.

Chart 11: Forecast of municipal waste management in Slovakia



Source: EIP

Key to graphic	
Original text	Translation
Miera recyklácie	Recycling rate
Miera skládkovania	Landfill rate
Miera spaľovania	Incineration rate
Iné	Other

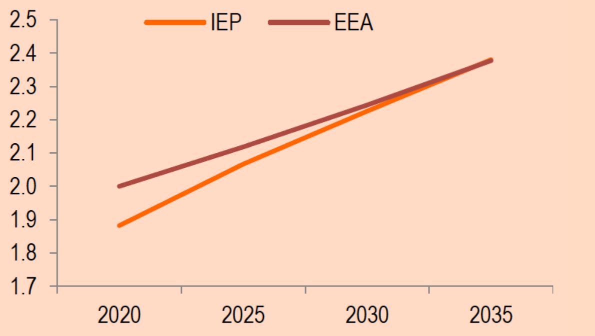
Box 1: Comparison of the forecast with EEA results

We compared the estimated municipal waste production and management with the results of the 2018 EEA report (EEA, 2018), which are taken from the updated version of the European Reference Model on Municipal Solid Waste Management. The report provides a forecast for 2020–2035 based on EU member states' municipal waste data up to 2015 and includes known measures. Measures in Slovakia include the introduction of extended producer responsibility, collection standards for separate collection and increasing landfill charges. For the comparison, we have again omitted data on metal waste, as its production has increased significantly since 2017 due to changes in record-keeping.

The municipal waste production according to our results is approximately the same as the EEA results. In 2020, the difference in production is approximately 120 thousand, i.e. about 6%, with a decreasing trend in the following years. The difference in 2020 may be due to projected reduced consumption caused by the coronavirus and thus lower waste production. Other minor differences may be due to the inclusion of more recent data in our model, a different methodology, or a greater expected effect of landfill charges.

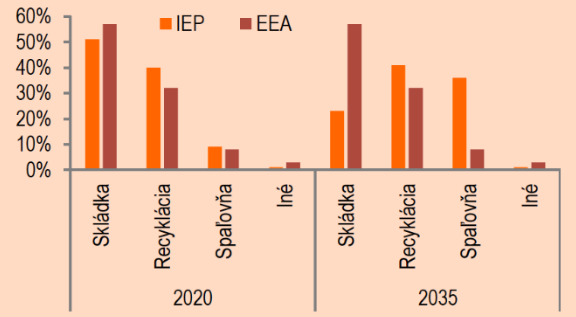
For waste management, the results are different mainly due to new measures having been factored in, most importantly waste treatment. According to the EEA, only 3% of waste undergoes mechanical biological treatment. In our case, we expect a higher recycling rate compared to the EU model. This may again be due to the use of more recent data and the consideration of additional measures such as collection targets.

Chart 12: Comparison of municipal waste production (million tonnes)



*excluding metal waste Source: IEP

Chart 13: Comparison of municipal waste management

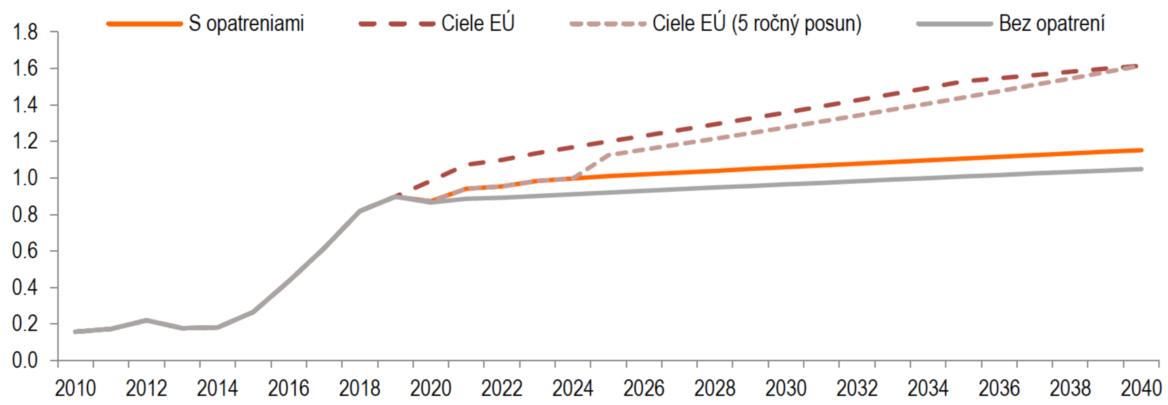


Source: IEP

Key to graphic	
Original text	Translation
IEP	IEP
EEA	EEA
Skládka	Landfill
Recyklácia	Recycling
Spaľovňa	Incineration plant
Iné	Other

Current measures will not be sufficient to meet the national targets set by the EU. The EU sets national recycling targets of 50% in 2020 with an increase of 5 % every 5 years up to 2035, with a target of 65%. At the same time, a landfill target of no more than 10% of municipal waste in 2035 has been set. It is possible that Slovakia may be able to apply for a 5-year postponement of the targets on account of its high landfill rates until 2020. Comparing the recycling achieved in the zero-measure forecast with the measures taken and with European Union's targets, it is obvious that to meet the target we will need to adopt additional measures that will increase recycling by around 300 thousand tonnes by 2035. The introduction of landfill charges has reduced municipal waste production and, together with the sorting of kitchen bio-waste, collection targets and the deposit scheme, has resulted in increased recycling.

Chart 14: Comparison of municipal waste recycling forecasts (million tonnes)



*excluding small construction waste

Source: IEP

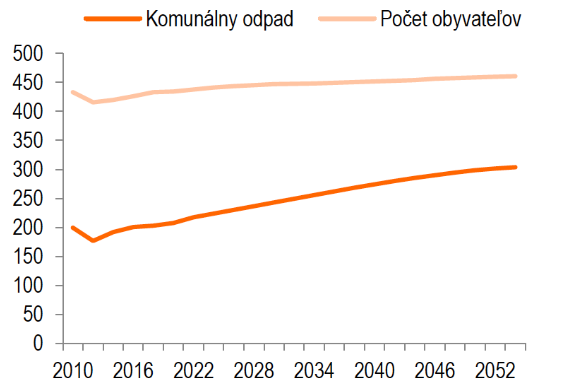
Key to graphic	
Original text	Translation
S opatreniami	If measures are taken
Ciele EÚ	EU targets
Ciele EÚ (5 ročný posun)	EU targets (5-year shift)
Bez opatrení	No measures

1.4.2 Forecast of production and management of municipal waste in Bratislava

Based on the results of the forecast in which measures are taken in Bratislava, we anticipate an increase in the production of municipal waste due to the increase in population as well as the increase in consumption from 213 thousand tonnes in 2019 to just under 282 thousand tonnes of municipal waste in 2045. The largest quantity of waste will continue to be subject to energy recovery, but the rate of energy recovery will gradually decrease due to capacity constraints. Recycling rates will increase mainly due to the introduction of collection targets, separate collection of kitchen waste and, to a lesser extent, deposit schemes. We estimate that the recycling rate will stabilise at around 36%, assuming no further action is taken. The increase in landfill charges has almost no impact due to the low landfilling of municipal waste.

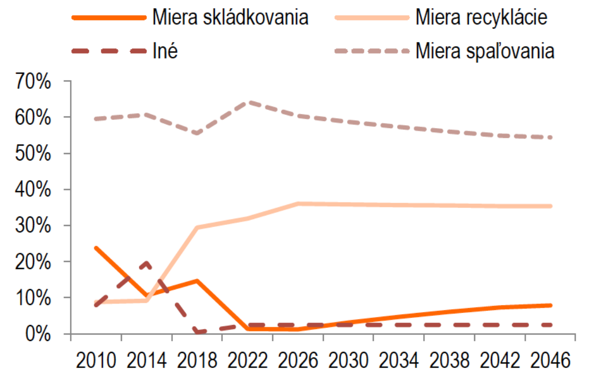
The impact of the measures would be to keep the landfill rate below 10% without the need to increase IERW capacity. The main reason for the significant reduction in landfill rates after 2021 is the introduction of mechanical biological treatment for waste to be landfilled, as 45% of this waste will be subject to energy recovery in the form of SAF.

Chart 15: Forecast of the development of municipal waste in Bratislava (thousand tonnes)



Source: IEP

Chart 16: Forecast of municipal waste management in Bratislava if the project is not implemented (in %)



Source: IEP

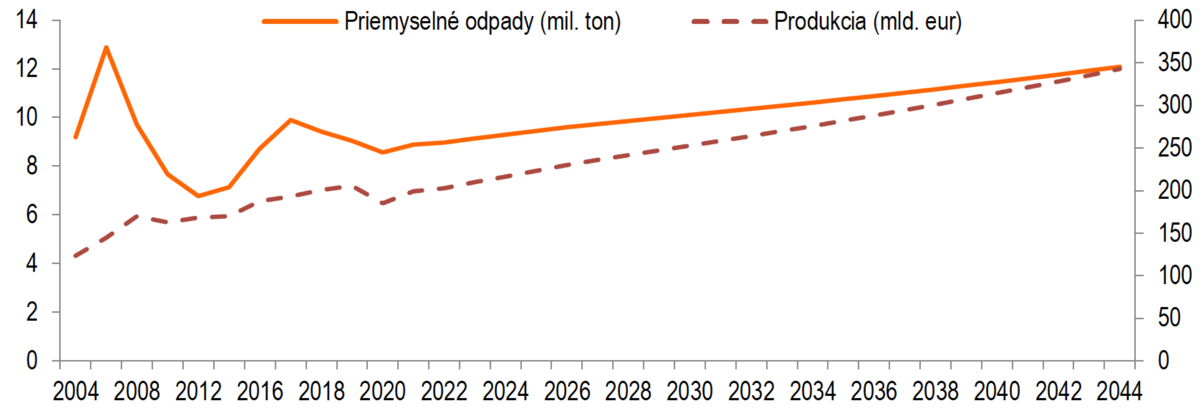
Key to graphic	
Original text	Translation
Komunálny odpad	Municipal waste
Počet obyvateľov	Population
Miera skládkovania	Landfill rate
Miera recyklácie	Recycling rate
Iné	Other
Miera spaľovania	Incineration rate

1.4.3 Forecast of production and management of industrial waste in Slovakia

In forecasting the production of industrial waste, we used a regression model for the dependence of the quantity of waste on production (value of goods and services produced) for 16 NACE sectors. The model is based on data from EU member states for 2004–2016. The full calculation is given in Annex 2.

The production of industrial waste in Slovakia will continue to grow to almost 12.2 million tonnes in 2045, but the growth in waste production will be slower than the growth in production. The estimated quantity of industrial waste in each sector was then divided among the different types of waste, the operations that generate them and the ways of managing these wastes. We based our considerations on the 2017 and 2018 waste ratios based on data from the RISO information system.

Chart 17: Forecast of industrial waste production in Slovakia



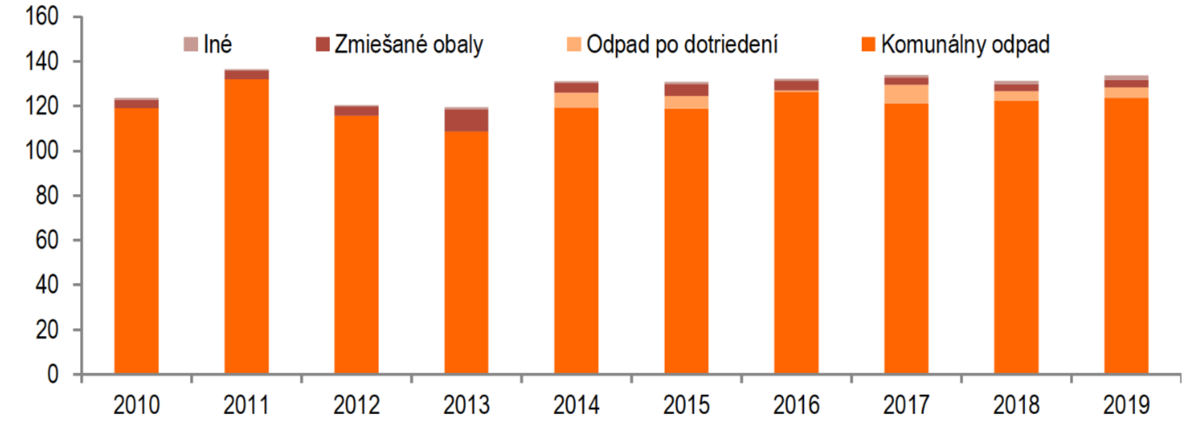
Source: IEP

Key to graphic	
Original text	Translation
Priemyselné odpady (mil. ton)	Industrial waste (million tonnes)
Produkcia (mld. eur)	Production (EUR billion)

1.4.4 Prediction of the potential for energy recovery of waste at the OLO IERW

The current capacity of the OLO a.s. IERW with 2 boilers is 134 thousand tonnes of waste per year. Since OLO a.s. is a municipal enterprise of Bratislava, the installation primarily uses municipal waste from the city. Over the last 10 years, municipal waste has accounted for approximately 93% of the total capacity. The remainder was industrial waste, mainly mixed packaging and mixed waste from mechanical processing on sorting lines.

Chart 18: Composition of waste at OLO IERW (thousand tonnes)

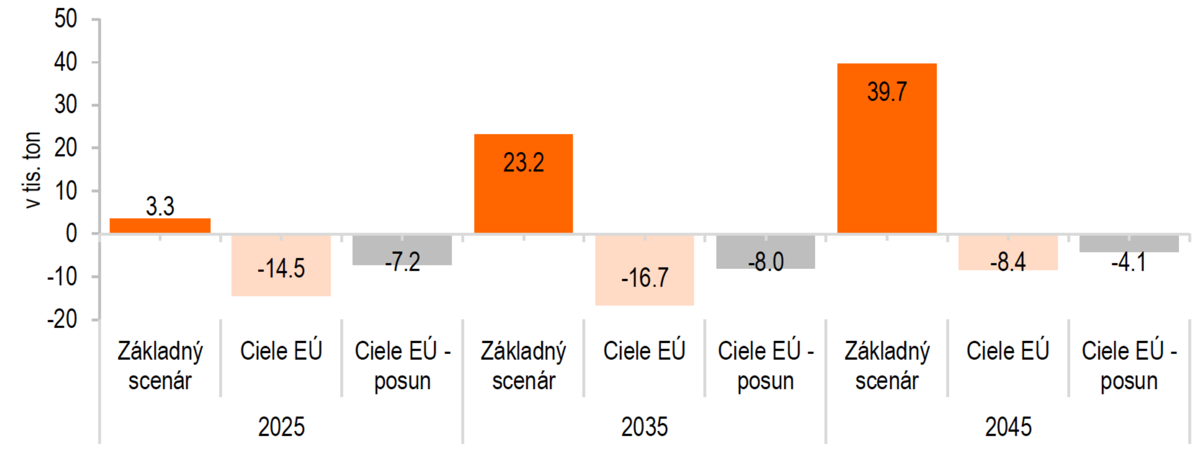


Source: IEP according to OLO a.s.

Key to graphic	
Original text	Translation
Iné	Other
Zmiešané obaly	Mixed packaging
Odpad po dotriedení	Waste after additional sorting
Komunálny odpad	Municipal waste

According to the forecast with measures adopted, in 2025 the quantity of mixed municipal waste and non-recyclable waste from Bratislava would exceed the current capacity by only 3.3 thousand tonnes. However, this quantity would gradually increase, with a capacity shortage of 39.7 thousand tonnes as early as 2045. If the project was not implemented, this waste would have to undergo mechanical biological treatment, following which some of it would be landfilled, with a landfill rate of 8%. If Slovakia manages to meet the national targets set by the EU, in which Bratislava would also have a share, the current capacity would exceed the quantity of unsorted municipal waste from Bratislava for the whole 2025–2045 period.

Chart 19: Non-recyclable municipal waste in Bratislava in addition to the current IERW capacity



Source: IEP

Key to graphic	
Original text	Translation
v tis. ton	thousand tonnes
Základný scenár	Baseline scenario
Ciele EÚ	EU targets
Ciele EÚ - posun	EU targets — shift

Municipal waste from Bratislava would not be sufficient to fill the entire capacity of the third boiler of 65 400 tonnes. If all non-separately collected, non-recycled municipal waste from Bratislava was subject to energy recovery, it would fill approximately 35% of the available capacity in 2025–2044. Another source of waste could be municipal waste from other municipalities or some industrial waste for which the IERW has a permit.

As for municipalities, we have accounted for mixed municipal waste, bulky waste, street cleaning waste and the part of sorted plastics that cannot be recycled. Whether a municipality would choose to place waste in an IERW depends mainly on the cost of energy recovery and the alternative option of mechanical biological treatment. The price for energy recovery is EUR 80-100/tonne. The costs of mechanical biological treatment and subsequent energy recovery/disposal are EUR 80/tonne. In addition, total costs include transport costs. For each municipality we calculated the distance to the OLO a.s. IERW and to the nearest mechanical biological treatment installation and then the distance to the cement works.

The introduction of municipal waste treatment prior to landfilling will require the construction of mechanical biological treatment installations, which are currently lacking. As we do not foresee any significant government subsidies, we anticipate that numerous small regional installations will be established close to the landfill sites, thereby saving the cost of removing the part of the waste that will be landfilled.

Based on Kosit's data on the investment and operating costs of such facilities, we expect that 45 installations with a capacity of 20 000 tons will be built. We have distributed the installations evenly near the existing largest landfills. We subsequently calculated the distances of the mechanical biological treatment installations from the cement works where some of the waste would be transported in the form of SAF. We considered only municipalities within the Bratislava, Nitra, Trnava and Trenčín regions due to the excessive distances in other regions. At the same time, other regions could potentially use the capacity of the Košice IERW. According to information from the cement producers' association, the cost of transporting waste, or SAF, is EUR 1.1-1.5/km. Long-distance waste shipments are carried out using freight transport, with an average weight of 20 tonnes per journey. We assume that the lorry will make two journeys, there and back.

By comparing the costs of mechanical biological treatment and energy recovery at the OLO a.s. IERW and the transport costs, we calculated the quantity of municipal waste that would be subject to energy recovery in the third boiler. Part of the capacity of the third boiler would be used for municipal waste from Bratislava and the rest would be used for municipal waste from selected municipalities. Municipalities that would allocate preferential financing to the energy recovery of waste are located at an average distance of 43 km from the OLO IERW. At the same time, due to the gradual increase in the quantity of waste, the OLO a.s. IERW could gradually slightly increase the price for energy recovery from EUR 84/tonne in 2025 to EUR 87/tonne in 2045. Examples of municipalities that we expect to choose energy recovery are Šamorín, Ivanka pri Dunaji, Svätý Jur, Dunajská Lužná and Rovinka.

Chart 20: Municipalities expected to direct their waste to the OLO IERW

Source: IEP

Key to graphic	
Original text	Translation
Obce, ktoré by zvolili zariadenie OLO	Municipalities that would choose the OLO facility
Skládka odpadov	Landfill site
Cementáreň	Cement works

When calculating the quantity of industrial waste that could potentially be used for energy recovery, we considered only waste for which OLO a.s. has a permit and at the same time that waste is currently not subject to energy recovery but rather disposed of in a landfill site.

Waste after additional sorting and mixed packaging (which already accounts for 7% of the energy recovery at OLO) has the greatest potential for recovery in IERW. Waste after additional sorting is mainly sorted waste from plastics, paper and metals that was not suitable for recycling after additional sorting on the sorting line. According to the data from the RISO information system, we estimate that approximately 180 thousand tonnes of waste after additional sorting and mixed packaging were produced in 2018. The exact figure cannot be determined due to incorrect recording and duplication of some data. Data on waste after additional sorting are not known at the level of the generators of this waste, whether municipalities or companies, but only at the level of processors. At the same time, the waste catalogue number 19 12 12 is used not only for waste after additional sorting but also for waste after treatment, i.e. solid alternative fuel. However, solid alternative fuel from industrial waste is produced not only from waste after additional sorting, but by combining it with other wastes, in particular mixed packaging, plastic waste and tyre waste.

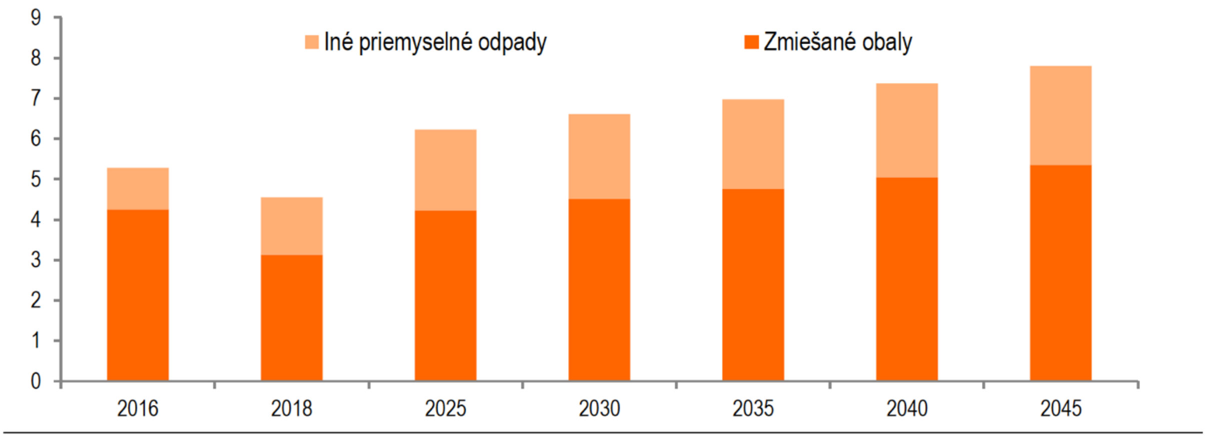
The cost of landfilling these types of waste is EUR 84 or EUR 88/tonne, respectively, as it is often bulky waste, which takes up a lot of space in the landfill and is difficult to compact. At the same time, according to data from the Integrated Pollution Prevention and Control, only 60% of landfill sites have a permit for landfillingsuch waste. Nevertheless, up to 44% of these wastes are currently landfilled. This may be because several sorting line operators are also landfill operators. In addition, they can claim a lower statutory rate for landfilling such waste (€7/tonne instead of €30/tonne). According to the Regulation, that rate is applicable to waste after additional sorting only if it cannot be recovered in an alternative way by reason of its characteristics.

An alternative option for the recovery of these wastes is mechanical treatment and recovery in the form of high calorific SAF at cement works. In 2018, around 26% of waste after additional sorting and waste from mixed packaging was recovered that way. According to the operators of mechanical treatment installations for the production of SAF, the cost is approximately EUR 45-55/tonne.

The costs of mechanical treatment of waste after sorting and mixed packaging are lower compared to the costs of energy recovery at IERW. Nevertheless, part of this waste is already being used for energy recovery at the OLO IERW or the KOSIT IERW – approximately 10% in 2018. This may be due to insufficient capacity or unsuitability of a particular waste for SAF production. According to KOSIT, many foreign companies will give priority to energy recovery because of the 'zero landfilling' policy.

We assumed that the demand for the energy recovery of mixed packaging would continue. In 2016–2018, 5% of all mixed packaging in Slovakia was subject to energy recovery at the OLO IERW, and we maintained this ratio for the next period in our projection. Waste after additional sorting, which represents on average 4% of the waste subject to energy recovery at OLO IERW in 2014–2019, comes from only one company with which OLO had a contract for energy recovery at a significantly lower price. As of 2020, that waste is no longer subject to energy recovery, and we therefore do not expect it to be used in the future. Other industrial waste that is used for energy recovery at the OLO IERW is mainly organic waste, waste from the food industry, plastic waste and waste from mechanical processing of paper, plastics and textiles. These types of waste represent on average 1% of the waste subject to energy recovery at the OLO IERW and 1.2% of the total waste production in Slovakia. As with mixed packaging, we have maintained this ratio in our projection.

Chart 21: Estimated quantity of industrial waste going to the OLO IERW (in thousand tonnes)



Source: IEP

Key to graphic

Original text	Translation
Iné priemyselné odpady	Other industrial waste
Zmiešané obaly	Mixed packaging

1.5 Analysis of alternatives

The project for building a third boiler is assessed as a single project for which design documents were developed. If the project is not implemented, the zero scenario would be the 'nothing is done' scenario. Under the amendment to the Waste Act, non-separately collected municipal waste would thus undergo mechanical biological treatment and then be landfilled or recovered in the form of solid alternative fuel in cement works.

The objective of the minimisation of landfilling of municipal waste in Bratislava would be met even without constructing the third boiler. At the same time, the project has no effect on the performance indicator of sorting rates. The City of Bratislava could consider setting more ambitious targets. The selection of a cost-effective project that would make it possible to meet these objectives would require the preparation of several alternative projects.

Examples of such targets are higher sorting or recycling rates or prevention of waste generation. A more targeted quantity-based waste charging scheme with collection using the labelling of collecting bins may be an appropriate measure. This system has been shown to reduce the production of mixed municipal waste by up to 33% and increase sorting rates (Slučiaková, 2019). Waste prevention can be supported by the establishment of reuse centres.

Another option is to promote separate collection of kitchen bio-waste. On average, kitchen bio-waste accounts for up to 24% of mixed municipal waste; in multi-apartment buildings it is up to 44%. Sorting this waste would thus contribute to reducing mixed municipal waste and increasing sorting rates. The city could subsequently consider building a sanitation line and compost site or biogas installation for the recovery of sorted kitchen bio-waste from Bratislava.

As an alternative scenario, we proposed building a centre for recovery and support for separate collection of kitchen bio-waste. The reuse centre could ensure the use or recycling of 32% of bulky waste, which in Bratislava accounts for up to 50 kg per inhabitant. Furnishing collection bins, baskets and bags for the collection of kitchen bio-waste for every household could increase the separation of kitchen bio-waste from mixed municipal waste to as much as 60% of the total potential. Overall, 10 thousand tonnes of kitchen bio-waste would be sorted annually and the waste could be recovered in a compost site or a biogas installation.

We estimate the total costs of building a recovery centre, collection of kitchen bio-waste and the building of an installation for its recovery at EUR 49.3 million in the 2025–2044 period, i.e. the lifetime of the proposed project of third boiler construction. At the same time, the introduction of these measures could increase the recycling rate in Bratislava from 36% to 42%. By comparison, the investment and operating costs of the third boiler, net of revenues from the sale of electricity, would amount to EUR 53.6 million.

Table 3: Comparison of the third boiler project with the alternative project

	Third boiler	Alternative project
Recycling rate	36%	42%
Net costs (EUR million, undiscounted)	53.6	49.3
Quantity of waste recovered (thousand tonnes)	65.4 (22.9*)	17.7

*only municipal waste from Bratislava

Source: IEP

1.5.1 Design and quantification of the alternative scenario

According to the forecast of municipal waste production and management in Bratislava, we estimate that the landfill minimisation target will be met even without the construction of the third boiler at the OLO IERW. At the same time, the third boiler does not affect the sorting or recycling rate.

An alternative could be to introduce measures that can contribute to increased sorting and subsequent recycling rates.

The collection and recovery of sorted components is carried out by a producer responsibility organisation, which finances these activities through fees from producers. On the contrary, the city is responsible for the management of mixed municipal waste, bulky waste, small building waste, garden and kitchen bio-waste. As an alternative scenario, it would be possible to build a centre for recovery and support for separate collection of kitchen bio-waste.

From 2023 onwards, separate collection of kitchen bio-waste will be compulsory in Bratislava or 100% of residents will have to compost this waste. Since 90% of Bratislava's inhabitants live in apartment buildings, we anticipate that Bratislava will introduce separate collection of kitchen bio-waste and that it will be subsequently recovered in a composting plant or biogas installation. According to an analysis carried out by OLO in 2017, about 17% of kitchen bio-waste is found in Bratislava's mixed municipal waste. This amounts to about 23 thousand tons of non-separately collected kitchen waste per year.

Based on the experience of municipalities in Slovakia so far, we have assumed in the baseline forecast that the impact of the collection of kitchen waste will be gradual, with 15% separation in the first year and 17.5% in the second year and 20% of its potential in mixed municipal waste in the following years (Annex 1: Municipal Waste Forecast). Based on the best practice from municipalities in Slovakia (Box 3), we estimate that with the right setup it is possible to separate up to 60% of kitchen bio-waste potential in mixed municipal waste. Thus, the quantity of sorted kitchen bio-waste compared to the baseline forecast could increase by 10 thousand tonnes per year.

According to the experience from abroad and Slovakia, convenient and accessible infrastructure is important for the proper setup of separate collection of kitchen bio-waste. Each household in a single-family house would receive a 30l container to collect kitchen bio-waste with one bag per week. Households in multi-apartment buildings would receive 7 to 10l baskets with bags for collecting kitchen waste in the apartment. The filled basket would be brought to 120 or 240l collection bins at multi-apartment buildings. The kitchen bio-waste bins have antibacterial treatment, aeration holes, and possibly biofilters to minimise odours and bacterial growth. The containers would be collected weekly or twice a month, so that the frequency of collection corresponds to the frequency of collection of mixed municipal waste.

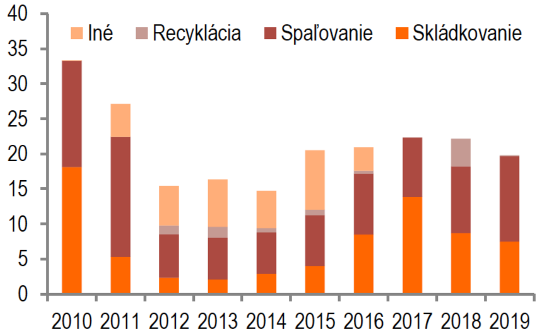
Based on market research, we estimated the costs of providing collection bins, baskets and bags to single-family houses and multi-apartment buildings. According to information from JRK and Elkoplast, the expected lifetime of the containers and baskets is 10 years. Data on the number of single-family houses and multi-apartment buildings in Bratislava in 2019 come from the information system of the land register. We assumed that the number of single-family houses and multi-apartment buildings would increase in direct proportion to the forecast population development. The cost of providing infrastructure for the collection of bio-waste for 20 years amounts to EUR 33.5 million.

The sorted kitchen bio-waste would be recovered in a compost site or biogas installation. According to a study by Eunomia (Eunomia, 2014), the net cost of a compost site, including operating costs and revenues, was EUR 43/tonne and the net cost of a biogas installation was EUR 46/tonne in 2012. We indexed the costs using the GDP deflator based on Eurostat data. As a result of the lower subsidies on the price of electricity from renewable sources, we estimate that the current net cost of a biogas installation could currently be around EUR 59/tonne. The investment and operating costs net of revenue for an installation with an annual capacity of 10 thousand tonnes would amount to EUR 11.8 million.

The total net cost of the infrastructure for the collection, construction and operation of the installation for the recovery of kitchen bio-waste is thus estimated at EUR 45.3 million. We do not anticipate any significant additional collection costs as the sorting of kitchen bio-waste will result in lower costs for the collection of mixed municipal waste.

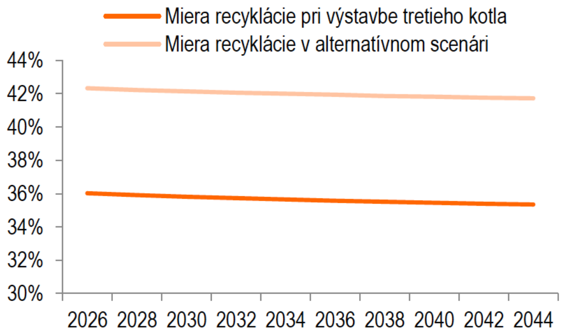
Bulky waste, such as old furniture, carpets, flooring, makes up on average 10% of all municipal waste in Bratislava, which is about 50 kg per capita per year. Most of this waste will be subject to energy recovery at the OLO IERW or landfilled. According to a UK study (WRAP, 2012), up to 32% of bulky waste can be reused without any treatment. After minor repairs, up to 51% of bulky waste can be recovered. In Bratislava, a reuse centre could be established where residents could bring functional and well-preserved items for further use. Such centres are common abroad, e.g. in Vienna, Prague and Brno. Assuming 32% use, approximately 7 700 tonnes of bulky waste would thus be reused or recycled annually in Bratislava.

Chart 22: Bulky waste management in Bratislava (thousand tonnes)



Source: IEP

Chart 23: Comparison of recycling rates in the project implementation scenario and the alternative scenario



Source: IEP

Key to graphic	
Original text	Translation
Iné	Other
Recyklácia	Recycling
Spaľovanie	Incineration
Skládkovanie	Landfilling
Miera recyklácie pri výstavbe tretieho kotla	Recycling rate in the scenario with the construction of the third boiler
Miera recyklácie v alternatívnom scenári	Recycling rate in the alternative scenario

The cost of building such a centre varies depending on its size, use and sophistication. Vienna, for example, has a sophisticated centre, which includes a shop and organises workshops. The project implementation took over 5 years at a total cost of EUR 5 million. In Prague, a market hall building, which will serve as a reuse centre, is planned to be renovated at a cost of around EUR 3.7 million. Similarly, in Bratislava, there are plans to renovate the current headquarters of the Municipal Enterprise, which would serve as a reuse centre. According to our experience in Vienna and Prague, we estimate the cost at EUR 4 million.

The total cost of the alternative scenario with the promotion of sorting and recovery of kitchen bio-waste and the construction of a reuse centre amounts to EUR 49.3 million. At the same time, the introduction of these measures could increase the recycling rate in Bratislava from 36% to 42%.

Table 4: Cost of the alternative scenario (EUR million)

Type of costs	
Infrastructure for separate collection of kitchen bio-waste	33.5
Installation for the recovery of kitchen bio-waste	11.8
Reuse centre	4.0
TOTAL	**49.3**

Source: IEP

According to the composition analysis by OLO a.s. prepared in 2017, up to 42% of mixed municipal waste is made up of paper, plastics, glass, multi-layered composite materials and metal packaging. However, the separate collection of these components is not the responsibility of the city, but of the contracted producer responsibility organisation. A suitable measure to promote the separate collection of these components, which is the responsibility of the city, is for example waste collection in a quantity-based waste charging scheme. In Bratislava, the container-interval waste collection system is already in place, in which residents can choose the frequency of collection as well as the size of the bin. A more targeted quantity-based waste charging scheme using labelled collection bins and electronic registration is only possible in single-family houses, which is a type of housing that makes up only 10% of dwellings in Bratislava. The introduction of such a collection would therefore not have a significant impact on the production of mixed municipal waste in the whole city.

2 Financial analysis

The results of the financial analysis show that the project would pay back financially. The financial net present value of discounted future revenue and expenditure is EUR 12.2 million. The project's rate of return of 6.1% is higher than the financial discount rate of 4% used, which means that the project's revenues exceed its costs. Since the cumulative net cash flow is non-negative in each year, the project is also financially sustainable.

2.1 Investment and operating costs of the project

The investment costs are estimated at EUR 70 million excluding VAT. The contingency reserve for the purchase of machinery and equipment is EUR 5 million. OLO a.s. will provide EUR 20 million from its internal resources, the remaining part will be financed by borrowings. Given the lifetime of the infrastructure, which is as long as the duration of the project, we anticipate a zero residual value at the end of the period. The operating costs are estimated at EUR 1.56 million per year, with the largest part being costs for the disposal of waste from energy recovery.

Investment costs

The investment costs for the construction of the third boiler are based on the quotation of the German company Martin, which was made in July 2020 based on a technical specification from OLO. The 2 current boilers are from the same company, which is an advantage consisting in compatibility and identical spare parts. The project also includes the installation of a second condensing turbo-generator with a higher electrical output.

The total investment costs are estimated at EUR 70 million, EUR 60 million being machinery and equipment and the remaining EUR 10 million construction works. Since the boiler would be added to the already existing IERW site, no costs related to the purchase of land or earthworks are foreseen. The contingency reserve for the purchase of machinery and equipment is EUR 5 million.

The contribution by OLO a.s. should amount to EUR 20 million. The remaining EUR 50 million will be financed in the form of a loan over 15 years at an interest rate of 1% per annum, which is a conservative estimate of the interest rate.

The construction is expected to start in 2022 and be completed in 2024. The third boiler is planned to start operation in 2025. Based on the previous experience of OLO a.s., the estimated lifetime of the third boiler is 20 years. The investment expenditure will be paid after the implementation of individual works in stages in the amount of EUR 5 million, EUR 20 million and EUR 43 million in the years 2022–2024. Part of the cost in the amount of EUR 2 million will be paid in 2025, as retention money is expected to be collected for possible claims etc.

Residual value

The residual value is calculated based on the useful life of the infrastructure. According to OLO a.s., the machinery and equipment will be depreciated over a period of 15 years, so the residual value at the end of the project will be zero. The residual value of the land is zero as the investment does not involve any land purchase. Structures are depreciated for a period 20 years, which is the lifetime of the project. Their residual value at the end is thus zero.

Operating costs

Current operating costs consist of labour, electricity, gas, water and various chemicals. Despite the use of electricity mainly from own production, during technological outages, costs are incurred for the purchase of electricity from the distribution network. At the same time, network access charges for reserved capacity are paid throughout the period. The amount of the costs was provided by OLO a.s. with a conversion to euros per tonne of waste subject to energy recovery.

A large part of the costs is the management of the waste generated in the energy recovery process. Gas purification generates solid waste that must be disposed of in a hazardous waste site. The costs are EUR 162/tonne. After the energy recovery process, ash and slag is left at the bottom of the boiler, which is disposed of at a cost of EUR 44/tonne. Another operating cost is insurance in the amount of EUR 100 000 per year.

Based on experience, OLO a.s. estimates the operating costs for repairs and maintenance at EUR 150 000 per year. Replacements equal EUR 50 000 every 5 years.

Table 5: Unit operating costs (EUR/tonne excluding VAT, fixed prices 2020)

General operating expenses	EUR/tonne
Labour	2.2
Electrical energy	0.8
Fuels	0.8
Water	0.2
Other	2.6
Disposal of hazardous waste	2.9
Disposal of non-hazardous waste	10.6
TOTAL	20.1

Source: IEP according to OLO

2.2 Project revenues

The estimated annual revenues amount to EUR 8.2 million. The largest revenues come from waste-to-energy charges and electricity sales. At present, sales of heat are not foreseen due to a lack of withdrawal.

Revenues from waste-to-energy charges

The largest source of revenue for the IERW are revenues from waste-to-energy charges. The charge for Bratislava is EUR 80/tonne, for other entities we are projecting an average fee of EUR 85/tonne. The amount of the charge for other entities is derived from a calculation comparing the costs of energy recovery and mechanical biological treatment of municipal waste in order to ensure that the charge works as an incentive for energy recovery.

Revenues from the sale of electricity, heat and ferrous metals

Another source is the sale of electricity. Thanks to the more powerful turbo-generator, approximately 0.85 MWh of electricity will be generated from 1 tonne of waste subject to energy recovery compared to the current value of 0.34 MWh/tonne of waste. According to data from OLO a.s., approximately 0.07 MWh/tonne of waste will be used for own consumption. In total, electricity sold should be 0.78 MWh/tonne of waste. We estimate the unit price of electricity at EUR 46/MWh or EUR 36/tonne of waste subject to energy recovery, based on the long-term 3-year average on the Power Exchange Central Europe commodity exchange.

Sale of heat is another potential source of revenue. Part of the heat produced is used by OLO a.s. for its own consumption, part for electricity generation and the remainder is not used due a lack of heat withdrawal. Total heat production amounts to around 2 MWh/tonne of waste, depending on its calorific value. The heat produced could potentially be withdrawn by the Bratislavská teplárenská company. According to ongoing negotiations, the supply of heat could amount to 47 260 MWh per year, i.e. 0.24 MWh/tonne of waste. The price for the sale of heat of EUR 46/MWh or EUR 11/tonne of waste subject to energy recovery is set according to the cost data from the annual reports of the Bratislavská teplárenská company for 2016–2018.

No heat consumption is currently foreseen, i.e. the revenue from the sale of heat is zero. As a result of the lack of heat extraction, the OLO a.s. installation will not achieve the required efficiency for obtaining a permit for energy recovery, but only for waste disposal by incineration. The incineration plant will thus not operate as a high-efficiency combined heat and power production and will not be eligible for potential subsidies for electricity production for these types of plants, such as support in the form of a surcharge under a call of the Slovak Ministry of Economy[5]. In the past, the subsidy for electricity production was as high as EUR 106/MWh.

According to data from the annual reports of OLO a.s., approximately 12 kg of ferrous metals per tonne of waste are

[5] Invitation to tender for electricity producer installations with the right to receive support .

separated in the energy recovery process. The average purchase price of ferrous metals is EUR 72/tonne, i.e. the revenue from the sale is EUR 0.88/tonne of waste.

Table 6: Unit revenues (EUR/tonne of waste subject to energy recovery)

Revenues	EUR/tonne
Waste-to-energy charge	80-85
Sale of electricity	36
Heat sale	11
Sale of ferrous and non-ferrous metals	0.88

Source: IEP according to OLO

2.3 Zero scenario costs and revenues

If the project is not implemented, we assume that municipal waste from Bratislava in excess of the capacity of the current IERW would undergo mechanical biological treatment and then be landfilled or subject to energy recovery in cement works. OLO a.s. would not incur any investment or operating costs or revenues in the zero scenario, as it is not the owner of the landfill or any other installation for the management of non-separately collected municipal waste.

OLO a.s. is also a collection company. Thus, in the zero scenario, OLO a.s. would have higher revenues from transportation in waste collection due to the longer distances to the nearest mechanical biological treatment installation compared to transporting waste to the IERW. Since we do not want the zero scenario to be favoured because of higher revenues from transportation, transportation is not considered in the financial analysis.

2.4 Calculation of financial indicators

The result of the financial analysis is assessed on the basis of the financial net present value (FNPV) of the investment and the financial internal rate of return (IRR) of the investment. Financial net present value refers to the difference between discounted income and expenditure. The project for the construction of the third boiler has a net present value of EUR 12.2 million, which means that the project is profitable.

Unlike the financial net present value, the IRR is independent of the scale of the project and therefore serves as a more important indicator of financial profitability. This value is compared to the discount rate used. In this case, the IRR is 6.1%, which means that the revenue generated covers the costs of the project. In accordance with the Framework for the Evaluation of Public Investment Projects (Slovak Ministry of Finance, 2017), the discount rate used in the financial analysis is set at 4%.

Table 7: Financial analysis (million euros)

Cash flows	Total (discounted)	2022	2023	2024	2025	2026	...	2030	2044
Costs	**-79.1**								
Investment costs	-60.8	-5	-20	-43	-2	0		0	0
Operating costs	-18.3	0	0	0	-1.6	-1.6		-1.6	-1.6
Revenues	**91.3**								
Revenues	91.3	0	0	0	7.9	7.9		7.9	7.8
Residual value	0	0	0	0	0	0		0	0
FNPV	**12.2**	**-5**	**-20**	**-43**	**4.4**	**6.4**		**6.3**	**6.2**
IRR	**6.1%**								

Source: IEP

The final step of the financial analysis is to assess the financial sustainability of the project. Financial sustainability is calculated based on cumulative net cash flows calculated as the difference between income and expenses in each year. In contrast to the calculation of the financial profitability, the assessment of financial sustainability also takes into account unforeseeable expenditure and repayment of the loan, including interest. Since the cumulative net cash flow is not negative in any of the project years, the project is sustainable in financial terms.

Table 8: Financial sustainability (million euros)

Cash flows	2022	2023	2024	2025	2026	2030	...	2044
Total revenues								
Financial resources	5	20	50	0	0	0		0
Revenues	0	0	0	7.9	7.9	7.9		7.8
Total expenditure								
Investment expenditure (including unforeseeable)	-5	-20	-48	-2	0	0		0
Operating expenses	0	0	0	-1.6	-1.6	1.6		-1.6
Loan repayments (including interest)	0	0	0	-4.2	-4.2	-4.0		0
Total cash flows	**0**	**0**	**2**	**0.2**	**2.2**	**2.3**		**6.2**
Cumulative net cash flow	**0**	**0**	**2**	**2.2**	**4.3**	**13.3**		**66.0**

Source: IEP

3 Economic analysis

The project for the construction of the third boiler is economically viable from the overall social perspective. Unlike the financial analysis, which only considers the financial costs and benefits from OLO's perspective, the economic analysis examines the impact of the project from the overall social perspective. The zero scenario, i.e. with the project not being implemented, consists in the mechanical biological treatment of municipal waste. The economic net present value of the project is EUR 11.2 million. The 7.1% rate of return exceeds the economic discount rate which equals 5%. The benefit-cost ratio (BCR), which compares the net present value of economic benefits and costs, is 1.2, so the benefits exceed the costs of the project.

The project is economically viable as it achieves high resource savings of EUR 65.9/tonne, mainly owing to electricity production. On the other hand, other socio-economic costs (emissions, pollutants) are on average 14.8 EUR/tonne worse compared with the zero scenario. This is mainly because the current Slovak energy mix is largely low-emission (zero scenario) and, therefore, the construction of an incineration plant produces relatively more emissions and pollutants. At the same time, there is only a very small saving on external costs from the mechanical biological treatment of waste. Since we assume that cement works would continue to use solid alternative fuels in cement production, the external costs of production remain unchanged. At the same time, the part of the waste that goes to landfills in the zero scenario produces very few emissions owing to the stabilisation of the waste in biological treatment.

Table 9: Average savings in energy recovery of waste compared to treatment (EUR/tonne)

Type	
Resources	**65.9**
Costs	2.4
Energy and material recovery	59.6
Transport	3.9
Externalities	**-14.8**
Greenhouse gas emissions and pollutants	-25.4
Discomfort	0.8
Land occupation	0
Seepage	0
Energy and material recovery	9.4
Transport	0.4
TOTAL	**51.1**

Source: IEP

3.1 Cost and savings of resources in energy recovery

We estimate the total savings of resources in energy recovery compared to mechanical biological treatment at an average of EUR 65.9/tonne of waste. The largest savings come from the cost of conventional electricity production. If OLO a.s. supplies heat, the saving would be even higher – by EUR 26.7 per tonne.

Table 10. Average savings of resources in energy recovery compared to treatment (EUR/tonne of waste)

Type	
Costs	2.4
Mechanical biological treatment	77.4
Energy recovery	-75.0
Electrical energy	58.7
Heat	0
Metals	0.9
Transport	3.9
TOTAL	**65.9**

Source: IEP

The costs from the financial analysis are used as an estimate of the economic costs of energy recovery. We converted market prices to shadow prices using conversion factors according to the CBA methodology (IEP, 2019). Shadow prices in the economic analysis reflect the willingness to pay for project benefits and opportunity costs for project inputs.

The economic investment costs are the same as in the financial analysis. For operating costs, we adjusted labour and fuel costs using conversion factors. We deducted the costs of the statutory landfill disposal charge for solid waste from the purification of gases, ash and slag from the costs of their disposal. The statutory charge is a transfer payment that does not represent a real economic cost or benefit to society. The statutory charge for landfilling hazardous solid waste from gas purification is EUR 40/tonne, for ash and slag it is EUR 7/tonne[6]. The total economic costs of energy recovery thus amount to EUR 75/tonne without discounting.

In estimating the economic value of mechanical biological treatment, we projected a treatment cost of EUR 82/tonne, as described in section 1.4.1. These costs include the cost of landfilling as well as energy recovery at cement works. Costs of landfilling include both labour costs and the costs of an earmarked financial reserve, which will be used for the closure, rehabilitation, monitoring and care of the landfill after it has been closed. Part of the landfilling costs is a transfer payment in the form of a statutory landfill charge of EUR 7/tonne, which we deducted in the economic analysis. Since we assume that 50% of the waste after treatment will be landfilled, we deducted EUR 3.5/tonne of waste after mechanical biological treatment. From the costs of mechanical biological treatment, we separated labour costs in order to calculate the shadow price of wages. According to data from Kosit, the labour costs of the treatment itself are approximately EUR 5.8/tonne. According to data from operators, the labour costs of landfilling are an average of EUR 10/tonne of landfilled waste. We multiplied these costs by a conversion factor of 0.9 (IEP, 2019). The economic value of mechanical biological treatment thus amounts to EUR 77.4/tonne after deduction of EUR 3.5/tonne in the form of the statutory charge and EUR 1.5/tonne in labour costs after applying the conversion factor.

We calculated the savings on the economic costs of electricity production as the long-term marginal costs from conventional electricity generation. We based our estimate on the average levelised cost of electricity (LCOE) of existing electricity production installations according to the European Commission report (European Commission, 2019), taking into account the energy mix in Slovakia. We converted the costs shown in the 2013 constant prices to 2020 constant prices using the harmonised index of consumer prices. The savings thus amount to EUR 76/MWh of electricity or EUR 59/tonne of waste subject to energy recovery.

Similarly, we calculated the economic savings on the costs of conventional heat production that would come from the Bratislavská teplárenská company. Bratislavská teplárenská produces heat by combined heat and power production and uses natural gas as fuel. The savings on economic costs are thus estimated at EUR 111/MWh or EUR 26.7/tonne of waste based on the LCOE figure for existing gas-fired power plants (European Commission, 2019).

If the third-boiler construction project is implemented, the waste could no longer be used to produce solid alternative fuels. Cement works can use coal instead of solid alternative fuels, but they have to pay for it. In fact, we assume that cement works would continue to use solid alternative fuels imported from abroad. Currently, up to 80% of the solid alternative fuels used in Slovak cement works come from abroad. As solid alternative fuels are a by-product in waste management, we assume that increased demand for fuel does not affect the supply of fuel or the production of waste. We also do not foresee any effect on fuel prices in Europe as this represents only a small amount of fuel.

As the scrap metal market in Slovakia is relatively developed, we consider the market price to be a good proxy for the avoided costs of alternative production of metals from primary sources. The economic savings amount to EUR 72/tonne of scrap metal, or EUR 0.88/tonne of waste, as shown in Section 2.2.

According to information from the cement producers' association, the cost of transporting waste or SAF amounts to

[6] Government Regulation No 330/2018 laying down the amount of charges for waste disposal and details relating to the redistribution of revenues from waste disposal charges.

EUR 1.1–1.5/km. Long-distance waste shipments are carried out using freight transport, with an average weight of 20 tonnes per journey. We assume that the lorry will make two journeys, there and back. We estimate the economic costs of transport at EUR 6.8/tonne for the zero scenario and EUR 2.9/tonne for project implementation. The economic savings on waste transport costs in the implementation of the project thus amount to EUR 3.9/tonne.

3.2 External costs and energy savings

Waste management generates significant environmental impacts that are not market valued and need to be shadow priced. Waste treatment creates negative externalities such as climate change and air pollution through greenhouse gas emissions and pollutants. In addition, both energy recovery and landfilling can cause discomfort to people living in the vicinity, such as odour, visual pollution and noise. Seepage may also occur in a landfill which may contaminate soil and groundwater. However, they can also create positive side effects in the form of avoided emissions in the recovery of energy and materials.

Incineration of waste represents an increase in external costs of up to EUR 14.8/tonne of waste compared to the zero scenario. We calculated the external costs as the difference between the external costs of the energy recovery of waste in the OLO a.s. IERW and the zero scenario with mechanical biological treatment, including landfilling and energy recovery in cement works. The reason is that conventional electricity production in Slovakia comes from sources with low emissions and pollutants. At the same time, there is only a very small saving of emissions or pollutants from the mechanical biological treatment of waste. Since we assume that cement works would continue to use solid alternative fuels in production, the external costs of production remain unchanged. At the same time, the part of the waste that goes to landfills produces very few emissions owing to the stabilisation of the waste in biological treatment.

If OLO a.s. supplied heat as well, the savings from the recovery of energy and materials would be higher and the total external costs of energy recovery compared to the zero scenario would be EUR 11.4/tonne.

Table 11: Average external costs in energy recovery of waste compared to treatment (EUR/tonne)

Type	
Greenhouse gas emissions	18.3
Pollutants	7.1
Discomfort	-0.8
Land occupation	0
Seepage	0
Transport	-0.4
Energy and material recovery	-9.4
TOTAL	**14.8**

Source: IEP

3.2.1 Unit cost of emissions and pollutants

The unit cost of CO_{2eq} emissions is based on the CBA methodology (IEP, 2019) where it is EUR 25/tonne in 2010. After taking into account the 2020 price level using the consumer price index (Institute for Financial Policy, June 2020), the cost is EUR 41 per tonne in 2020. This figure will gradually increase by one euro per year in the 2010 prices until 2030. After 2030, the annual increase will be EUR 0.5 (2010 prices) per tonne of CO_{2eq}. The price of CO_{2eq} emissions will thus gradually increase to EUR 62/tonne in 2045. The average external costs of CO_{2eq} over the 2025–2045 period will reach EUR 55/tonne.

In order to normalise the global warming potential of different greenhouse gases, the different types of greenhouse gas emissions are transformed into CO_2 equivalents. We are projecting the global warming potential for each type of emissions as reported by the Slovak Hydrometeorological Institute in 2020.

The cost of pollution for NO_X, SO_2 and particulate matter comes from World Bank estimates (2019). At the 2020 price level, these costs amount to EUR 10 036/tonne for NO_X, EUR 9 879/tonne for SO_2 and EUR 40 770/tonne for particulate matter.

3.2.2 Greenhouse gas emissions

The energy use of waste generates low CO_2 emissions, including CH_4 and N_2O. As IERW do not have to monitor or report emissions, emissions are estimated using a model of the Slovak Hydrometeorological Institute. According to data on emission factors of different types of waste and waste composition in Bratislava, the energy recovery of 1 tonne of waste produces approximately 1.04 tonnes of CO_{2eq} of greenhouse gas emissions. If we take INCIEN's analysis of the composition of municipal waste, we estimate that only 0.8 tonnes of CO_{2eq} of greenhouse gas emissions are produced. This estimate also includes the change in the composition of municipal waste as a result of measures that will increase the separation of kitchen bio-waste, paper, plastics and glass. The main reason for the difference is that the analysis of the composition of municipal waste in Bratislava showed a high representation of plastics and a low representation of garden waste due to the low number of people living in single-family houses. Compared to the composition of municipal waste in an average municipality in Slovakia, Bratislava waste is more calorific and produces more emissions during energy recovery.

Part of the waste subject to energy recovery is of biological origin – approximately 50%. Emissions from the bio-component are considered carbon neutral. However, some studies take into account all emissions regardless of their origin (Rabl et al., 2008). When these emissions are disregarded, it is impossible to favour options that would eliminate them, such as composting of bio-waste. Since in our case the zero scenario consists in mechanical biological treatment, we calculate emissions only from the fossil component of the waste.

With an average CO_{2eq} price of EUR 55/tonne in 2025–2045, we thus assume that the external cost of energy recovery emissions will be EUR 22/tonne of waste on average.

In the zero scenario, we assume that municipal waste undergoes mechanical biological treatment and then part of it is disposed of by landfilling and part is subject to energy recovery in cement works in the form of solid alternative fuel.

Landfilling mainly produces methane emissions, the amount of which depends on a number of factors. In the case of municipal waste, we assume that only inert waste and bio-components after mechanical biological treatment will be landfilled. Inert waste, which accounts for 25% after mechanical biological treatment, has no biological activity and therefore produces almost no emissions. Emissions from landfilled biosolids, including carbon dioxide emissions, average 0.5 tonnes per tonne of waste. The emissions calculation is presented in Box 2 and is based on the EPA (2005) model.

The remaining part of the municipal waste after mechanical biological treatment consists in solid alternative fuel used in cement works where it produces emissions from energy recovery. According to Ecorec data obtained from an analysis of solid alternative fuel from mixed municipal waste supplied by T+T, the carbon content in the fuel averages 51%. Emissions from energy recovery are subsequently calculated by multiplying the amount of carbon by a factor of 3.67 (Slovak Hydrometeorological Institute). This results in estimated emissions of 1.9 tonnes per tonne of solid alternative fuel. However, part of these emissions is attributable to the energy recovery of biomass. According to data from the Slovak Hydrometeorological Institute, emissions from the fossil part of SAF account for only 56% on average. We estimate the emissions from the energy recovery in cement works, after deduction of emissions from the bio-component, to be 0.83 tonnes/tonne of solid alternative fuel.

In total, this results in an average of 0.49 tonnes of emissions per tonne of waste from municipal waste after mechanical biological treatment, including landfilling and energy recovery in cement works. For comparison, emissions from the energy recovery of untreated municipal waste at OLO IERW amount to 0.41 tonnes of CO_{2eq}/tonne of waste. Taking into account the growing cost of CO_{2eq} emissions, we assume that the external costs of mechanical biological treatment would amount to EUR 29.7/tonne on average.

We assume that cement works would use solid alternative fuels even if a third boiler is built, importing them from abroad. Thus, the incremental volume of emissions from energy recovery at cement works when the project is implemented compared to the zero scenario is zero. We thus estimate the difference in external costs from greenhouse gas emissions between energy recovery and mechanical biological treatment at EUR 18.3/tonne.

Box 2: Model of the production of greenhouse gas emissions from landfilling

The main source of emissions from landfilling is landfill gas, which consists of approximately 50% methane and 50% carbon dioxide (MAEN EN, EPA, 2010). The emissions emitted depend on the quantity and composition of the waste, the humidity, temperature and oxygen at the landfill. In contrast to energy recovery in which emissions are released immediately in the energy recovery of waste, landfilling releases emissions gradually with time lags ranging from 6 months (Pipatti et al.,2006) to 100 years. Thus, emissions cannot be calculated on the basis of the amount of waste landfilled in a given year alone.

To estimate methane and carbon dioxide production, we relied on the LandGem first-order decay model (EPA, 2005). We calculated greenhouse gas emissions from landfilling for municipal waste after mechanical biological treatment and without mechanical biological treatment.

Emissions from landfilling after mechanical biological treatment

To estimate emissions from the stabilised bio-component, we first calculated emissions from the organic part of the municipal waste. Compared to mixed municipal waste, the organic component produces higher emissions per tonne of waste. In the model, we accounted for the amount of carbon in the waste and the rate of decomposition in accordance with EPA estimates (EPA, 2010). The results show that emissions from landfilling of the bio-component are 1.9 tonnes per tonne of waste.

Subsequent biological treatment reduces methane emissions by up to 74% (Pan and Voulvoulis, 2012). Emissions from landfilled bio-component, including carbon dioxide emissions, thus average 0.5 tonnes per tonne of waste.

Part of the emissions released from landfilling can be captured and used to produce electricity. According to the applicable implementing decree[7], a landfill must capture and recover landfill gas as long as biodegradable waste is disposed of there and enough gas is produced in a technically workable quantity. Since the volume of emissions produced from the stabilised bio-component is low, we assume that none of the landfills would capture landfill gas.

Emissions from landfilling without mechanical biological treatment

If mechanical biological treatment is not introduced, municipal waste disposed of in landfills emits much more greenhouse gas emissions. In this scenario, we have calculated the methane production potential based on INCIEN's analyses of the composition of mixed municipal waste, taking into account changes in composition as a result of the measures taken. The amount of carbon in each type of waste comes from EPA estimates. We assumed a decay rate of 0.038, which is applicable to landfills in the temperate climate zone (EPA). It is estimated that about 10% of the methane produced is not released to air but oxidised (EPA). We estimate the resulting emissions to be 1.01 tonnes of CO_2 equivalent per tonne of landfilled waste.

In addition, we included simultaneous landfill gas capture. Data from landfill operators in Slovakia show that only 11 landfills are actively capturing methane in landfill gas, which they use to produce electricity. These landfills contain approximately 26% of the total landfilled waste. According to MAEN, which operates a gas capture system at 8 landfills, an average of 64% of landfill gas is captured. This figure is in line with foreign literature, according to which up to 75 % of landfill gas can be captured (Acil Allen Consulting, 2014, BDA Group 2009, Rabl et al, 2008). After accounting for landfill gas capture, we estimate that 1 tonne of landfilled municipal waste produces 0.88 tonnes of CO_2 equivalent emissions. The Slovak Hydrometeorological Institute estimate is 0.87 tonnes of CO_2 equivalent emissions.

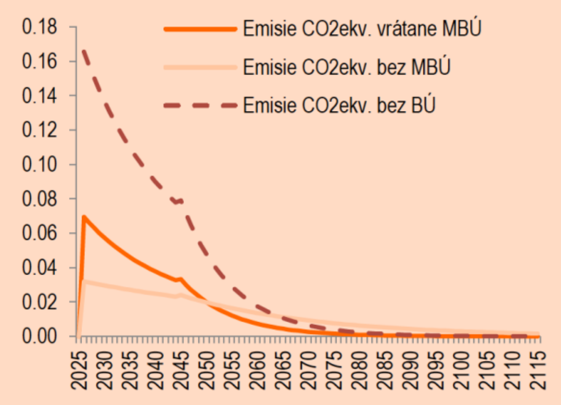
If the third boiler with a capacity of 65 400 thousand tonnes per year over a period of 20 years is not constructed,

[7] Implementing Decree No 382/2018 on landfilling of waste and storage of waste mercury.

we assume that the stabilised bio-component deposited in a landfill would gradually emit a total of 0.49 million tonnes of CO_{2eq} with the highest landfill gas production in 2045, i.e. at the end of the third boiler's lifetime.

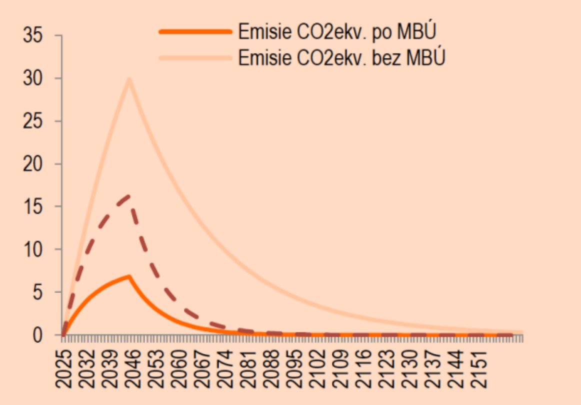
Emissions per tonne of landfilled waste after mechanical biological treatment are initially higher than emissions from mixed municipal waste due to the different composition of the waste. However, after the end of landfilling in 2044, i.e. in the year of project completion, emissions per tonne of waste will start to decrease more rapidly as this kind of waste decomposes more quickly. Compared to the scenario without mechanical biological treatment, fewer emissions are emitted overall due to the lower quantity of landfilled waste. Emissions per tonne are calculated for the cumulative amount of waste in each year.

Chart 24: Emissions from landfilling (tonnes/tonne of waste)



Source: IEP

Chart 25: Emissions from landfilling (tonnes/year)



Source: IEP

Key to graphic	
Original text	Translation
Emisie CO2ekv. vrátane MBÚ	Emissions of CO2eq including MBT
Emisie CO2ekv. bez MBÚ	Emissions of CO2eq excluding MBT
Emisie CO2ekv. bez BÚ	Emissions of CO2eq excluding BT
Emisie CO2ekv. po MBÚ	Emissions of CO2eq after MBT
Emisie CO2ekv. bez BÚ	Emissions of CO2eq excluding BT

3.2.3 Pollutants

In energy recovery in IERW, pollutants are emitted such as NO_X, SO_2, CO, particulates, total organic carbon, dioxins and heavy metals. Data on the quantities of individual pollutants produced are available from the annual emission value logs. The total cost of discharging pollutants is EUR 7.1 per tonne of waste subject to energy recovery. Air pollution charges need to be deducted from these costs due to double counting. In 2018, these costs amounted to just EUR 0.04 per tonne of waste subject to energy recovery.

The energy recovery of solid alternative fuel at cement works results in air pollution through the emissions of pollutants such as NO_X, SO_2 and particulate matter. The production of pollutants depends not only on the composition of the fuel recovered, but also on the technology used. Similar to emissions, the incremental amount of pollutants is zero as we assume unchanged cement production and the use of solid alternative fuels from abroad.

3.2.4 Discomfort

Landfilling can create discomfort for people living nearby in the form of odour, traffic noise and visual pollution (Eshet et al., 2005). Few studies, most of them in the United States, have addressed the quantification of external costs from the discomfort of landfilling (COWI, 2000; Bartelings et al., 2005). A common way of valuating discomfort is to use the hedonic pricing method, which uses housing property prices as an indicator of welfare loss due to a nearby landfill. The results of the studies show a significant adverse effect of landfill proximity on property prices (Eshet et al., 2005). External costs reported in the literature vary considerably from EUR 1.2 to EUR 37/tonne (Bartelings et al., 2005, RDC and PIRA, 2001).

According to a UK study (Cambridge Econometric et al., 2003), which assessed 11 300 landfill sites and over half a million housing prices over a 10-year period, the distance of housing within 0.4 km of a landfill site reduces the price by 7%. At greater distances from the landfill, the impact on the price gradually decreases, and at distances above 3.2 km the impact is zero.

When calculating the discomfort of living near a landfill in Slovakia, we based our calculations on the results of the UK study. Using GIS analysis, we determined the number of people living within 0.4 km, 0.4 to 0.8 km, 0.8 to 1.6 km and 1.6 to 3.2 km, respectively, of all landfills in Slovakia. We determined the number of houses or apartments based on the average household size of 2.59 persons (SODB, 2011). The average price of residential property in 2020 is EUR 1 731 per sqm (National Bank of Slovakia) and the average size of housing is 80 sqm.

We calculated the decrease in housing prices due to the proximity of a landfill site separately for individual zones based on the distance from the landfill. We estimate the total loss on the price of real estate in Slovakia at just under EUR 300 million, which is EUR 3.3 per tonne of landfilled waste. We project the landfilling of 3 million tonnes of waste per year for a period of 30 years.

A waste-to-energy installation may pose an increased perceived health risk to people living in its vicinity due to potential emissions from highly toxic dioxins (Bartelings et al., 2005). Since studies for calculating discomfort from waste-to-energy installations are not available, we projected the same calculation of external discomfort costs as for landfills.

Unlike landfills in Slovakia, only 3 600 people live in a distance of less than 3.2 km from the OLO a.s. IERW. The average price of residential property in 2020 in the Bratislava Region is EUR 2 273 per sqm (National Bank of Slovakia). We thus estimate the total loss on the price of housing at only EUR 1.3 million. With an energy recovery of 200 thousand tonnes per year, the discomfort cost is thus only EUR 0.83/tonne during the 20-year project lifetime.

The saving in external discomfort costs compared to the zero scenario thus amounts to EUR 0.84/tonne. In the zero scenario with mechanical biological treatment, only 50% of waste goes to landfill. The rest will be used for the production of solid alternative fuel and recovery in cement works, where we have not projected any discomfort.

3.2.5 Land occupation

Both landfilling and the energy recovery of waste require a certain area on which the waste management is carried out. In the case of energy recovery, this area is negligible in proportion to the quantity of waste recovered. On the contrary, the average landfill in Slovakia occupies approximately 2 hectares. According to reports from landfill operators, the capacity of 1 m^2 of landfill is approximately 11 tonnes of waste. For the external costs of land occupation, we based our estimates on the usual rent of agricultural land according to the Slovak Ministry of Agriculture data (Slovak Ministry of Agriculture, 2019), as landfills in Slovakia are mostly located outside towns and municipalities. We estimate the average amount of rent in 2020 at EUR 79 per year in the land-registry territories where landfills are located in the Bratislava, Trnava, Nitra and Trenčín Regions. The external costs of land occupation are thus only 0.07 eurocents per tonne of landfilled waste and are almost negligible.

3.2.6 Seepage into water and soil

Landfilling may cause toxic substances and emissions from the landfill to enter the surrounding soil or groundwater. According to estimates from foreign studies (COWI, 2000, BDA Group, 2009), the cost is on average EUR 0.84 per tonne of waste after taking into account the 2020 price level. The bio-component of municipal waste is already degraded in the mechanical biological treatment process resulting in a reduction in the production of organic matter that could cause seepage problems (Environmental Agency, 2004, Bone et al., 2003). Thus, no external seepage costs are expected for municipal waste after mechanical biological treatment.

In energy recovery, hazardous solid waste from gas purification is generated, which contains persistent organic pollutants, in particular dioxins. Improper handling of this waste can result in soil or water contamination. ZEVO OLO a.s. disposes of hazardous waste in a landfill, therefore we consider the effect of such disposal to be negligible.

3.2.7 Energy recovery and saved materials

Energy recovery of waste producing electricity and heat avoids emissions from the conventional production of these commodities. According to data from the annual reports of OLO a.s., approximately 0.34 MWh of electricity is produced per tonne of waste per year. The new turbo-generator, which is part of the investment under consideration, should ensure an increase in electricity production of up to 0.89 MWh per tonne of waste. According to data from OLO a.s., approximately 0.11 MWh/tonne of waste is used for own consumption. In total, electricity sold should be 0.78 MWh/tonne of waste.

Approximately 55% of conventional electricity production comes from low-emission nuclear power (Slovak Ministry of Economy, 2019). The average emissions are therefore only 0.16 tonnes of $CO2_{eq}$ per MWh of energy (electricitymap.org). Energy recovery saves the external costs of conventional electricity production of EUR 6.8/tonne of waste subject to energy recovery. The pollutant data were taken from the NEIS emissions information system. The external cost of pollutants from conventional electricity production is EUR 1.9/MWh or EUR 1.5/tonne of waste subject to energy recovery.

If OLO a.s. supplies heat, external cost savings would be achieved on conventional heat production, in this case in the Bratislavská teplárenská company. Emissions from heat production come from ETS data and amount to 0.22 tonnes of CO_{2eq}/MWh. Pollutant data are available in the NEIS emissions information system. We estimate the external cost of pollutants at EUR 0.6/tonne and the average external cost of emissions at EUR 2.9/tonne of waste.

In the energy recovery of waste, ferrous and non-ferrous metals are additionally separated using magnets and sold at a rate of 12kg/tonne of waste subject to energy recovery. Avoided emissions from conventional metal production amount to 1 521 CO_{2eq} per tonne of metal (European Commission, 2014). On average, this saves costs of EUR 1/tonne of waste subject to energy recovery.

The total savings on account of the recovery of energy and materials amount to EUR 9.4/tonne of waste subject to energy recovery. In the event of heat withdrawal, the savings would amount to EUR 12.8/tonne.

3.2.8 Transport

Waste management also includes the external costs of transporting waste from the municipalities to the IERW or to mechanical and biological treatment. Waste is mostly transported by emission-intensive truck transport. To estimate external costs, we used data on NO_X and $PM_{2.5}$ pollutants and CO_2 emissions from EEA (2005) for the heavy-duty vehicle category. Heavy-duty vehicles mostly use diesel, with a typical fuel consumption of 240 g of fuel per km (EEA, 2005). For IERW, we estimate an average external transport cost of EUR 0.3/tonne of waste, in the zero scenario this is EUR 0.6/tonne of waste. Transport costs are higher in the zero scenario mainly due to the transport of part of the waste in the form of solid alternative fuels to cement works over longer distances.

3.3 Calculation of economic indicators

After accounting for all costs and benefits of the project, we discounted the cash flows to calculate the present value of future cash flows. The economic analysis of environmental investment projects uses the real social discount rate of 5% as recommended by the Commission. Compared to the financial discount rate, it incorporates long-term social rates of time preferences.

The economic net present value (ENPV) of the project has a positive value of almost EUR 11.2 million. Thus, the discounted benefits of the project to society outweigh its costs. The benefits outweigh the costs of the project due to the high savings on resources. On the other hand, the saving of avoided externalities is negative, which means that the project will cause higher externality costs than the zero scenario.

The economic rate of return (ERR), which is compared with the value of the social discount rate used, is 7.1%. This makes the project socially beneficial. The benefit-cost ratio (BCR), which assesses the value for money of the project in question, compares the net present value of economic benefits and costs. The third boiler project achieves a BCR of 1.2, so the benefits exceed the project costs.

Table 12: Evaluation of costs and benefits from the overall social perspective

Cash flows	Total (discounted)	2022	2023	2024	2025	2026	...	2030	2044
Costs	**-72.9**								
Investment costs	-58.8	-5	-20	-43	-2	0		0	0
Operating costs	-14.1	0	0	0	-1.4	-1.4		-1.4	-1.4
Savings	**84.1**								
Savings on resources	94.2	0	0	0	9.2	9.2		9.2	9.2
Avoided external costs	-10.1	0	0	0	-1.1	-1.1		-1.1	-0.9
Residual value	0	0	0	0	0	0		0	0
FNPV	**11.2**	**-5**	**-20**	**-43**	**4.7**	**6.8**		**6.8**	**6.9**
ERR	**7.1%**								
BCR	**1.2**								

Source: IEP

4 Sensitivity analysis and risk assessment

The sensitivity analysis assesses the impacts of possible changes in key variables on the project's financial and economic indicators. The factors that have the biggest impact on the resulting indicators are the quantity of waste subject to energy recovery and the change in investment costs. If the quantity of waste subject to energy recovery was by 16% smaller or the investment costs by 20% higher, the project for the construction of the third boiler would not be profitable from the viewpoint of the financial analysis. From the overall social perspective, the project would be economically non-profitable if less than 83% of the capacity of the new third boiler was used or if the investment costs were by 19% higher.

With the possible supply of heat to Bratislavská teplárenská, the financial net present value would increase to EUR 20.6 million as a result of increased revenues from heat sales. The financial rate of return would be 7.4%. As a result of the savings on resources and external costs of conventional heat production, the economic net present value would increase to EUR 42.0 million, with a rate of return of 12.8%. The cost-benefit ratio in the economic analysis would be 1.7.

A potential risk to the use of the third boiler's new capacity is the construction of an additional IERW or the non-introduction of mechanical biological treatment. Ewia has announced a commitment to build new energy recovery capacity totalling 500 thousand tons. Given the estimated production of non-separately collected municipal waste in the future, even all potential new capacities would not cover the expected demand for energy recovery of waste.

In the absence of mechanical biological treatment of waste, the financial costs of municipal waste landfilling would be lower compared to the costs of energy recovery. Thus, the third boiler capacity could not be fully used due to the lack of municipal demand for energy use. Although the project would be non-profit in financial terms, in terms of economic analysis it would represent a society-wide benefit. This is because the significant saving on the external costs of landfilling untreated municipal waste.

The capacity of the third boiler may be used on a one-off basis also to eliminate illegal landfills. The costs of energy recovery of waste from illegal landfills would be translated into higher costs for the city, i.e. citizens. The quantity of waste on illegal landfills in Bratislava is approximately 50 thousand tonnes, i.e. an equivalent of almost the entire annual capacity of the third boiler. However, waste from illegal landfills represents only a very occasional source of waste and it cannot be expected that it should form a major part of energy recovery of waste during the lifetime of the project.

4.1 Changes in individual variables

As part of the sensitivity analysis, we calculated the elasticity value for the financial and economic net present value as well as the critical values for a change in each variable ranging from 40% to 160% of the original value. Elasticity is defined as the percentage change in the net present value indicator for a 1% increase in a given variable. The critical value is the percentage change in the variable required for the net present value indicator to fall below zero.

Table 13: Sensitivity analysis

Variable	FNPV elasticity	Critical value	ENPV elasticity	Critical value
Investment costs	-5.0%	20.0%	-5.2%	19.2%
Operating costs	-1.3%	80.0%	-1.2%	86.0%
Quantity of waste	6.2%	-15.8%	7.2%	-16.6%
Price of electricity	6.1%	-44.9%	7.1%	-28.5%
Shadow CO_2 price	-	-	-1.0%	97.0%

Source: IEP

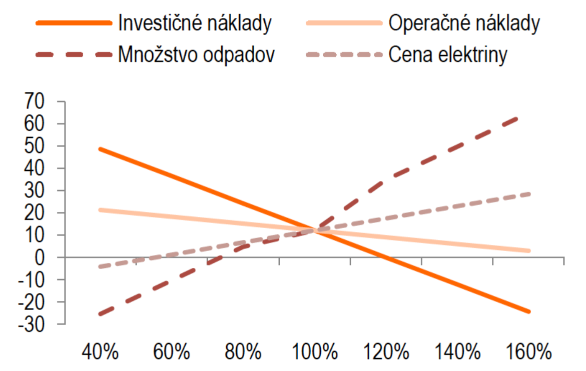
In both analyses, i.e. economic and financial, the change in the quantity of waste received for energy recovery has the greatest impact. This is due to fixed investment costs as well as part of operating costs, which eliminate benefits of scale in a lower quantity of waste. According to the forecast, the volume of municipal waste can be expected to grow.

The introduction of mechanical biological treatment also increases the costs of alternative waste management. The likelihood of insufficient demand for energy recovery is thus very low.

We projected an increase in the quantity of waste that is subject to energy recovery in the event that the remaining capacity of the third boiler would be filled with industrial waste. In such a case, it would be possible to increase the coefficient of performance and thus the capacity of the IERW. However, due to the higher cost of energy recovery at OLO a.s. compared to the cost of mechanical treatment, we assume that industrial waste would not be used at the IERW.

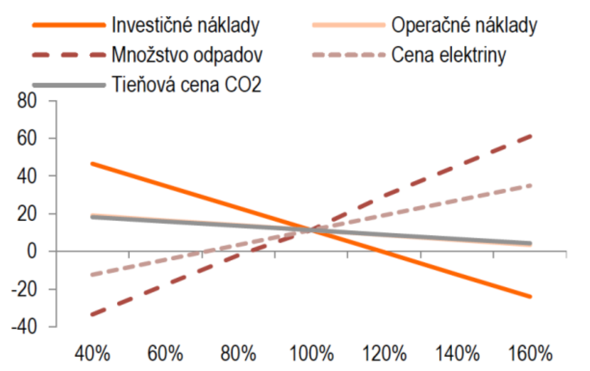
The financial and economic net present value is also elastic with respect to the level of investment costs. With an increase in investment costs of 20% and 19% respectively, the financial and economic net present value would be negative. The other variables do not have a significant impact on the net present value.

Chart 26: Sensitivity analysis — FNPV (EUR million)



Source: IEP

Chart 27: Sensitivity analysis — FNPV (EUR million)

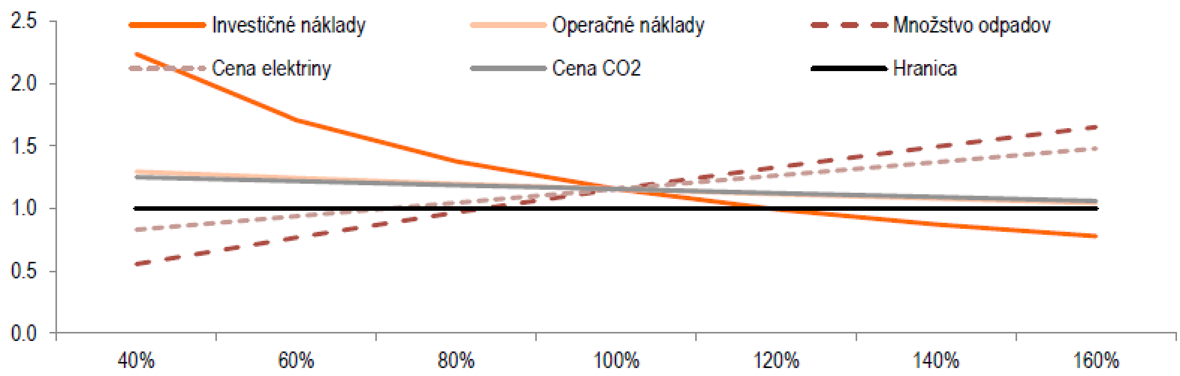


Source: IEP

Key to graphic	
Original text	Translation
Investičné náklady	Investment costs
Operačné náklady	Operating costs
Množstvo odpadov	Quantity of waste
Cena elektriny	Electricity price
Tieňová cena CO2	Shadow CO_2 price

The benefit-cost ratio in the economic analysis would fall below 1 if less than 83% of the third boiler's capacity is used or if the investment costs increase by a factor of 1.2. With a 30% reduction in price, the benefit/cost ratio would be less than 1. Operating costs as well as the price of electricity do not have a significant impact on the benefit-cost ratio.

Chart 28: Sensitivity analysis — benefit/cost ratio

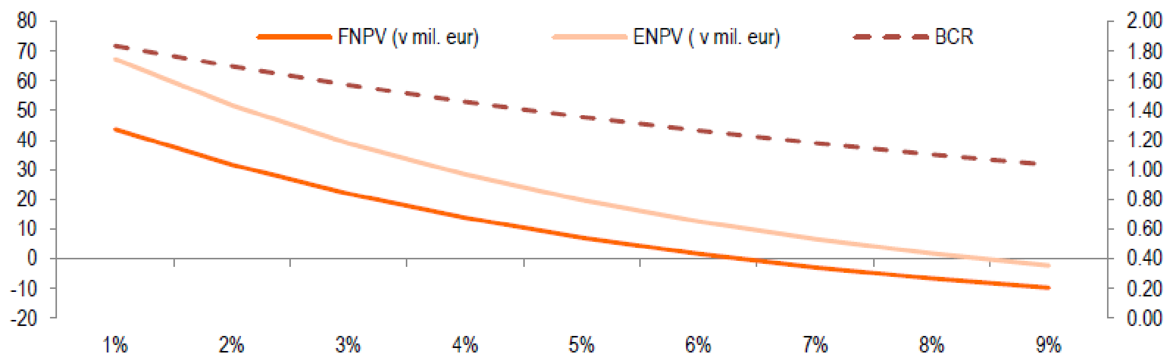


Source: IEP

Key to graphic	
Original text	Translation
Investičné náklady	Investment costs
Operačné náklady	Operating costs
Množstvo odpadov	Quantity of waste
Cena elektriny	Electricity price
Cena CO2	Price of CO2
Hranica	Threshold

At a financial discount rate higher than 6%, the project ceases to be financially viable and the financial net present value is negative. The economic net present value would be negative if the economic discount rate is more than 7%. Even then, the cost-benefit ratio would still be higher than 1.

Chart 29: Sensitivity analysis — discount rate



Source: IEP

Key to graphic	
Original text	Translation
FNPV (v mil. eur)	FNPV (in EUR million)
ENPV (v mil. eur)	ENPV (in EUR million)
BCR	BCR

Interest rate enters only the calculation of the financial sustainability of the project. For the project, we considered a 1%

annual interest rate on the loan. If the interest rate is 5%, the cumulative net cash flow in 2025 would be negative and the project would not be sustainable. At an interest rate of 6%, the cumulative net cash flow would be negative until 2031.

4.2 Heat supply and electricity subsidy

Only a part of the produced heat is used by OLO a.s. for its own consumption, the rest is not used due to the lack of withdrawal. Negotiations are currently underway on the possible supply of heat to the Bratislavská teplárenská company. According to OLO a.s., the estimated heat supply is 47 260 MWh per year, or 0.24 MWh/tonne of waste. The price for the sale of heat would be EUR 16/tonne of waste that has undergone energy recovery.

The supply of heat would increase the financial revenue by approximately EUR 726 thousand per year. The financial net present value would increase to EUR 20.6 million and the internal rate of return would rise to 7.4%. The economic net present value would be EUR 31.5 million and the rate of return would be 10.4%. The economic cost-benefit ratio would increase to 1.5. The better results in the economic analysis would be mainly due to cost savings of up to EUR 1.7 million per year in conventional heat production. Savings of external costs from emissions and pollutants from conventional heat production at Bratislavská teplárenská would amount to EUR 200 thousand per year.

If OLO a.s. supplied heat, it would operate as a high-efficiency combined heat and power production installation and could apply for support for electricity production. In 2020, the Slovak Ministry of Economy announced a call[8] in which the maximum price bid was EUR 106.8/MWh. At this price of electricity, the financial net present value would be as high as EUR 56.0 million and the internal rate of return on investment would be 12.4%. The results of the economic analysis would remain the same as the subsidy is only a transfer payment and is omitted in the economic analysis due to double counting.

Table 14: Sensitivity analysis — heat supply and electricity subsidy

	Without heat	Heat supply	Heat supply and electricity subsidy
Financial analysis			
FNPV (EUR million, discounted)	12.2	20.6	56.0
IRR	6.1%	7.4%	12.4%
Economic analysis			
ENPV (EUR million, discounted)	11.2	31.5	31.5
ERR	7.1%	10.4%	10.4%
BCR	1.2	1.5	1.5

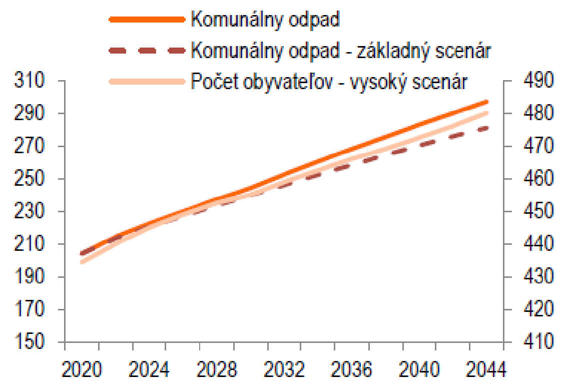
Source: IEP

4.3 Change in population development in Bratislava

According to a study of the demographic potential of the city of Bratislava, the population in the high scenario may reach 480 thousand in 2045 compared to the medium scenario with 453 thousand inhabitants. Thus, under the scenario of a high population growth in Bratislava, it can be assumed that municipal waste production will increase by an average of 3% per year. If the entire existing capacity of IERW was used for the energy recovery of municipal waste from Bratislava, the landfill rate target of 10% would be achieved by 2045 even without a new third boiler.

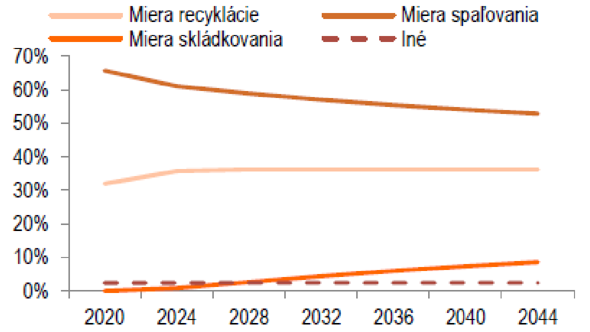
[8] Invitation to tender for electricity producer installations with the right to receive support.

Chart 30: Forecast of the development of municipal waste in Bratislava – high scenario (thousand tonnes)



Source: IEP

Chart 31: Forecast of municipal waste management in Bratislava (in %)



Source: IEP

Key to graphic	
Original text	Translation
Komunálny odpad	Municipal waste
Komunálny odpad – základný scenár	Municipal waste — baseline scenario
Počet obyvateľov – vysoký scenár	Population — high scenario
Miera recyklácie	Recycling rate
Miera spaľovania	Incineration rate
Miera skládkovania	Landfill rate
Iné	Other

Slower population growth would not have a negative effect on the meeting of the landfill rate target because less municipal waste would be generated overall. The landfill rate would thus be kept below 10% without the need to increase IERW capacity. If the project is implemented, most of the boiler's capacity would be used for non-municipal waste from Bratislava. As we anticipate a sufficient demand for energy recovery on the part of municipalities, a change in population numbers would not affect the results of the financial or economic analysis.

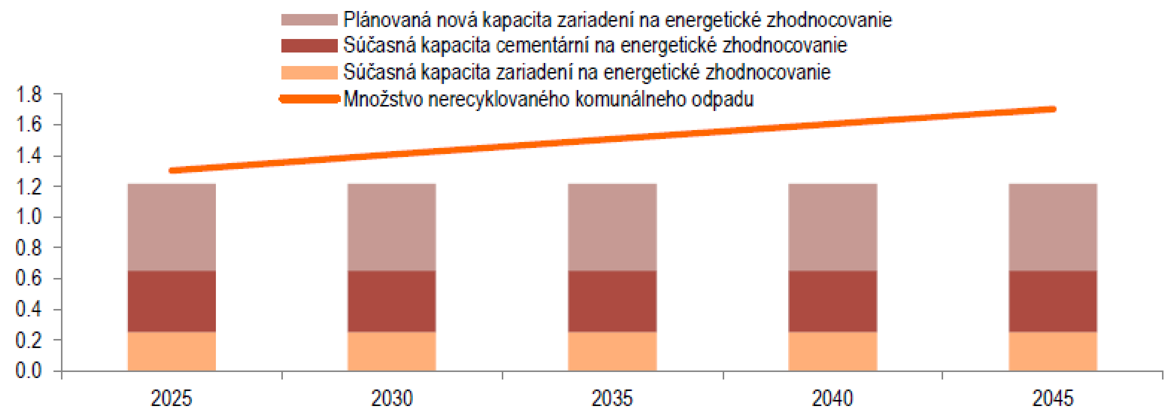
4.4 Construction of IERW in the vicinity

EWIA has presented its plan to build circular economy centres that would include an installation for the energy recovery of municipal and industrial waste. It plans to build 5 centres in total, the first of which are to be near the town of Šaľa and in the area of the Trnava-Zavar Industrial Park. Both are already in the process of environmental impact assessment (Enviroportal, 2020). Each of the centres is to have a capacity of 100 thousand tonnes of waste undergoing energy recovery per year. Thus, more installations will be established in Slovakia whose services could compete with the project for the construction of the third boiler.

Assuming increasing landfilling costs due to the introduction of mechanical biological treatment, as well as limited landfilling capacities, sufficient demand can be anticipated for all newly built capacities for energy recovery. According to data from landfill operators, only 16 landfills for depositing non-hazardous waste are currently permitted to continue operating beyond 2030. As landfilling is considered the worst waste management option in the waste hierarchy, obtaining permits to expand the capacity of existing landfills may become more complicated in the future.

At present, the capacity of IERW in Slovakia is 254 thousand tonnes of waste per year. The energy recovery capacity of waste in cement works is 320 thousand tonnes, and this capacity is expected to increase to 400 thousand tonnes in the next few years, according to information from producers. The capacity of Ewia's new IERW is expected to be 500 thousand tonnes; together with the third boiler, the planned capacity of these installations is 565.4 thousand tonnes. The anticipated quantity of municipal waste that will not be recycled is higher than the sum of these capacities.

Chart 32: Comparison of waste capacity and quantity (million tonnes)

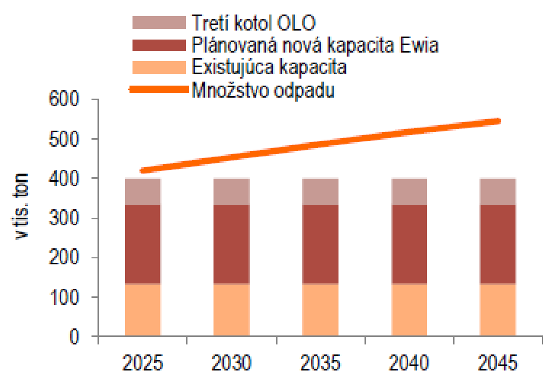


Source: IEP

Key to graphic	
Original text	Translation
Plánovaná nová kapacita zariadení na energetické zhodnocovanie	Planned new capacity of waste-to-energy installations
Súčasná kapacita cementární na energetické zhodnocovanie	Current capacity of cement works for energy recovery
Súčasná kapacita zariadení na energetické zhodnocovanie	Current capacity of waste-to-energy installations
Množstvo nerecyklovaného komunálneho odpadu	Quantity of non-recycled municipal waste

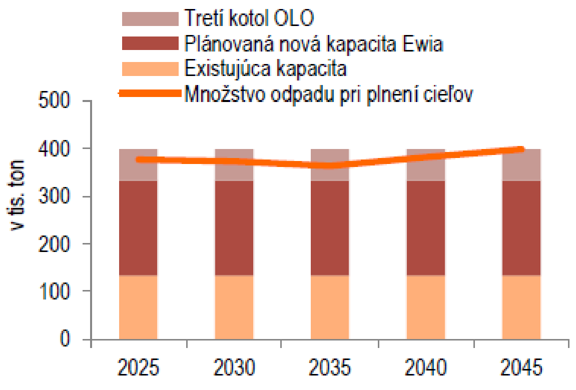
Of the planned facilities in the catchment area of the Bratislava, Trnava and Nitra Regions, two installations should be added, in Šaľa and near the Zavar municipality, with an annual capacity of 200 thousand tonnes. According to the results of the forecast, we assume that the new capacity of these installations, together with the existing and planned capacity of the third boiler at the OLO IERW, does not exceed the production of non-recyclable municipal waste in this area. If Slovakia managed to meet its recycling targets, the quantity of non-recyclable municipal waste in the three regions would reach an average of 380 thousand tonnes per year. The existing and planned capacity of waste-to-energy installations would thus exactly cover the needs for the management of non-recyclable municipal waste in the area.

Chart 33: Comparison of waste capacities and quantities in Western Slovakia



Source: IEP

Chart 34: Comparison of waste capacities and quantities in Western Slovakia in the meeting of targets



Source: IEP

Key to graphic	
Original text	Translation
Tretí kotol OLO	OLO third boiler
Plánovaná nová kapacita Ewia	Planned new capacity of Ewia
Existujúca kapacita	Existing capacity
Množstvo odpadu	Quantity of waste
Množstvo odpadu pri plnení cieľov	Quantity of waste in meeting targets
v tis. ton	thousand tonnes

4.5 Non-introduction of mechanical biological treatment of waste

The ban on landfilling of municipal waste that has not been treated is set out in the Waste Act with effect from 2021. The specification of the waste treatment process will be set out in an implementing decree that is currently pending approval. Thus, as part of the sensitivity analysis, we also examined the comparison with the zero scenario that would involve landfilling only.

According to the operators of 59 landfills out of a total of 82 landfills, the entry charge for landfilling in 2020 was EUR 38/tonne. We estimate that the statutory levy in 2020 is EUR 17/tonne, with an increase to EUR 22/tonne by 2021. The landfill price in 2020 thus averaged EUR 55/tonne, while from 2021 onwards it will be EUR 60/tonne.

Compared to the costs of energy recovery, the costs of landfilling would thus be lower and there might not be sufficient demand for the new capacity of the third boiler. Assuming that the third boiler would use only municipal waste from Bratislava, the results of the financial and economic analysis would be negative and the project would not pay back.

Table 15: Scenario without the introduction of mechanical biological treatment (lack of demand)

Indicator	
Financial net present value	-4.3%
Economic net present value	-7.6%
Benefit-cost ratio	0.4

Source: IEP

If we assume that demand would exist despite the lower landfill price and the full capacity of the third boiler would be used, the results of the financial analysis would remain unchanged. In the economic analysis we would consider the external costs of the zero scenario in the form of municipal waste landfilling.

According to the calculations in Box 2. We estimate that 1 tonne of landfilled municipal waste produces 0.85 tonnes of

CO_2 equivalent emissions. These emissions will be released gradually over time due to the gradual decomposition of the waste, with most emissions being released in the last year of the project, i.e. 2044. However, due to discounting of future cash flows, the present value of savings on external landfill costs will be low in the future. We have thus distributed the landfill emissions evenly over the project period, as in the Commission's CBA methodology (European Commission, 2014). The economic net present value is thus positive at EUR 11.1 million and the cost-benefit ratio is 1.2.

Table 16: Average emissions in municipal waste management (tonnes/tonne of waste)

Management type	
Energy recovery at the IERW*	0.41
Waste after mechanical biological treatment*	0.49
Landfilling	0.85

*emissions from the incineration of the bio-component are not factored in due to the assumption of carbon neutrality

Source: IEP

The project would thus continue to be economically favourable for the whole of society. The benefit-cost ratio would be lower mainly due to lower savings on resources. The economic costs of landfilling, without the statutory charge and with the conversion of labour costs, amount to EUR 37/tonne. The costs of landfilling are thus up to half lower than the economic costs of energy recovery at an IERW or in mechanical biological treatment. Resource savings from landfilling due to landfill gas capture and electricity production amount to only EUR 7.2/tonne of waste, while for energy recovery it is almost EUR 60/tonne. The savings on resources compared to landfilling amount to EUR 14.5/tonne of waste.

In contrast, the external cost savings of landfilling are significantly higher compared to mechanical biological treatment. The external costs of emissions from landfilling are up to EUR 55/tonne, while the savings obtained by landfill gas capture are only EUR 4.8/tonne. The difference between the total external costs of landfilling and energy recovery of municipal waste is EUR 38.3/tonne.

Table 17: Average savings in energy recovery of waste compared to landfilling (EUR/tonne)

Type	
Resources	**14.5**
Costs	-38.0
Energy and material recovery	52.5
Externalities	**38.3**
Greenhouse gas emissions and pollutants	26.2
Discomfort	2.5
Land occupation	0
Seepage	0.8
Energy and material recovery	8.8
TOTAL	**52.8**

Source: IEP

4.6 Project lifetime 15 years

The lifetime of the third boiler technology determined by the producer is 15 years. With a shorter lifetime than estimated by OLO, the financial net present value would be negative and the rate of return on investment of 3,8 % would be lower than the discount rate. From a financial point of view, this would make the project unprofitable. In terms of economic analysis, the project would be unprofitable from the overall social perspective at an economic net present value of EUR 0.58 million and a benefit-cost ratio of 0.98.

4.7 Removal of illegal landfills in Bratislava

Part of the capacity could be used to remove waste on illegal landfills in Bratislava. The largest illegal landfill is located on the premises of the Bratislavská recyklačná company. Most of the waste in this landfill is municipal waste, which was only supposed to be temporarily stored here during the outage of the OLO energy facility. According to the company's estimates, there are approximately 150 thousand m^3 of waste, which may represent about 40.5 thousand tons.

In addition, there are several smaller illegal landfills in the territory of the city, without there being an official register of the number of landfills. In estimating the number of illegal dumps, we based our estimates on data from the TrashOut mobile app, where a total of 573 dumps were reported for 2013–2019. We assumed that these are small landfills with an average area of 25m^2 and a total weight of less than 10 thousand tons of waste.

The quantity of waste on illegal landfills in Bratislava is thus approximately 50 thousand tonnes, which could use almost the entire annual capacity of the third boiler. However, illegal landfills represent only a very occasional source of waste and it cannot be expected that it should form a major part of energy recovery of waste during the lifetime of the project. At the same time, the costs of energy recovery of waste from illegal landfills would be translated into higher costs for the city, i.e. citizens.

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Annex 1: Municipal waste forecast

Forecast of municipal waste production in Slovakia

We estimated the development of municipal waste production in Slovakia based on data on municipal waste production[9] and household consumption in EU member states. Historical data for 2009–2018 are from Eurostat. We did not use older data because Slovakia has been a member of the European Union only since 2004 and until then it was possible to use a different methodology for recording waste in the country.

We estimated the regression model with fixed effects of the member states using the equation

$$W_{it} = \alpha_{0i} + \beta_1 FC_{it} + \beta_2 FC_{it}^2 + \varepsilon_{it}, \qquad (1)$$

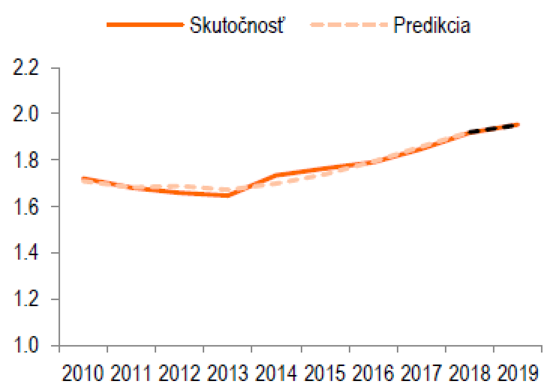
where W_{it} is the quantity of municipal waste in kilograms per capita in a given country and year and FC_{it} is the final household consumption in million euros at constant 2015 prices per capita. The fixed effect for each country α_{oi} captures unobserved country characteristics that do not change over time and have an impact on waste production.

We based the model on the World Bank methodology (Kaza et al., 2018), replacing GDP per capita with household consumption, which better captures municipal waste production. At the same time, we added fixed national effects. We omitted 5 member states in our estimation because of missing or incorrect data[10]. From the total quantity of municipal waste in Slovakia, we subtracted metal waste due to a change in records, which caused a sharp increase from 2017.

Using the calculated coefficients from equation (1) , we estimated the per capita production of municipal waste. The forecast for household consumption is based on the official macroeconomic forecasts of June 2020. Based on population forecasts from Eurostat, we estimated the total production of municipal waste in Slovakia by 2055.

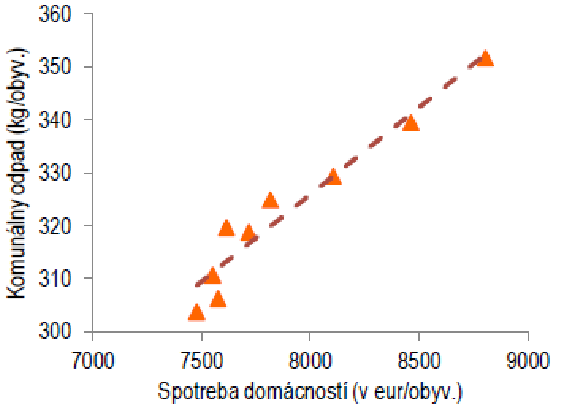
There is a strong dependency between household consumption and municipal waste production. The municipal waste forecast follows the actual waste production in 2010–2018. In 2019, which was used as a test year, the forecast municipal waste production is only 0.09% higher than the actual production.

Chart 35: Municipal waste production (million tonnes) – forecast vs. actual



* Excluding metal waste — Source: IEP

Chart 36: Dependence of municipal waste production on household consumption



Source: IEP

Key to graphic	
Original text	Translation
Skutočnosť	Actual state

[9] This is municipal waste excluding small construction waste and sewage waste.
[10] We omitted Greece, Romania, Ireland, Hungary and Bulgaria.

Predikcia	Forecast
Komunálny odpad (kg/obyv.)	Municipal waste (kg per capita)
Spotreba domácnosti (v eur/obyv.)	Household consumption (EUR per capita)

Forecast of production and management of municipal waste without measures taken

We then used the forecast of the total municipal waste production in Slovakia to estimate the production and management of municipal waste in individual municipalities in Slovakia. In the absence of a forecast of household consumption at the level of municipalities, we assumed the same growth in municipal waste production per capita in each municipality as that for the whole of Slovakia. For the number of inhabitants in individual municipalities we took into account the forecast of population development at the level of districts until 2035 from Infostat (Šprocha et al., 2013) and for the remaining period the forecast from Eurostat for the whole of Slovakia. For Bratislava, we used the results of the medium scenario of population development from the study for the capital city until 2050 by Infostat (Bleha et al., 2017). The population in the other municipalities was proportionally distributed according to the population in the municipalities in 2019 and the development in districts and in Slovakia, respectively.

The way municipal waste is managed depends on the type of waste. According to the Waste Act, it is prohibited to landfill all components of municipal waste from separate collection. Most of the separately collected waste is recycled, some of it is recovered at a waste-to-energy installation. Mixed municipal waste, bulky waste and waste from street cleaning go mainly to a landfill and a small amount to an IERW. The management of municipal waste depends strongly on the costs of the different types of recovery or disposal, but also on the various measures introduced at municipal or national level. In addition, it may also depend on various socio-economic and demographic characteristics of the residents of a given community. In the baseline scenario, we assumed that the method of management of individual types of municipal waste will be the same as in 2017 and 2018 according to the records of the Statistical Office of the Slovak Republic.

Forecast of production and management of municipal waste in Bratislava with measures taken

In the next stage, we produced a forecast with the measures taken at national level, the impacts of which we modelled against the baseline scenario. The characteristics of the population of each village as well as local measures are not known for the next time period. In estimating waste management, we thus only took into account the measures and targets adopted in waste management at the national level. These measures are: increasing landfill charges, collection targets for separate collection, treatment of waste before landfilling, separate collection of kitchen bio-waste and deposit schemes.

Landfill charges

Municipal waste landfill charges have been gradually increasing since 2019, to between EUR 11 and EUR 33 per tonne of landfilled waste in 2021[11]. The amount of the charge depends on the sorting rate in the municipality in the previous year. According to foreign literature, increasing charges incentivise a reduction in landfilling, with arc elasticity of landfilling estimated at -0.11 (Acil Allen Consulting, 2014). This means that a 1% increase in the price of landfilling reduces the amount of the landfilled waste by 0.11%. A reduction in landfilling may correspond to an overall reduction in waste production or an increase in sorting rates. Studies estimating cross elasticity, i.e. the effect of the landfill price on waste separation, differ and disagree on whether the effect is significant. We assumed that 50% of the waste that is diverted from landfilling is separately collected and the remaining 50% are not generated as a result of waste prevention.

Previously, the landfill charges depended on the number of separately collected components and amounted to only EUR 5 to 10/tonne. Based on the change in the amount of the charge compared to the previous legislation in each municipality and the elasticity of landfilling, we calculated the projected change in municipal waste production and management compared to the baseline scenario.

[11] Section 4(4) of Act No 329/2018 Coll. on waste disposal charges.

Collection targets

According to the Waste Act[12], producer responsibility organisations that provide for separate collection of packaging and non-packaging waste must meet collection targets for these types of waste. The target is to achieve 40% sorting of the potential for these waste types from July 2019 to July 2020, and then to increase sorting by 10 p.p. year-on-year until reaching 60% between 2021 and 2022. As the specific actions taken by individual organisations to meet these targets are not known, we cannot quantify their impacts. We assume that separate collection will reach the target values, while the level of sorting after 2022 will not change significantly unless additional measures are adopted. As the targets apply at the level of organisations and not municipalities, we assume that the sorting rates will increase proportionally in each municipality according to the sorting rates in 2019 so that the overall collection targets are met.

Separate collection of kitchen bio-waste

According to the Waste Act, from 2021 onwards, all municipalities will be obliged to ensure separate collection of kitchen bio-waste. Municipalities able to demonstrate that 100% of their residents practice composting will be eligible to an exemption. Municipalities that have provided for the energy recovery of their waste also qualify for an exemption until 2023.

At present, separate collection of kitchen waste is virtually non-existent in Slovakia; it exists only in a few dozen municipalities. As a result of the low sorting rates, on average up to 24% of kitchen bio-waste– 53 kg per capita – goes to mixed municipal waste.

We estimated the impact of the introduction of kitchen waste collection based on experience from abroad and Slovak municipalities where separate kitchen waste collection is already in place. The sorting rate of the potential in mixed municipal waste ranges from a low of 1 to 2% to a high of 60%. In the city of Parma, a combination of measures led to achieving an almost complete separation of kitchen waste.

We estimate that the impact of kitchen waste collection will thus be gradual, similar to the municipality of Žiar nad Hronom, i.e. approximately 15% in the first year, 17.5% in the second year and, finally, 20% of the sorting potential in mixed municipal waste in the following years.

Box 3: Separate collection of kitchen bio-waste

Best practice from abroad

According to the Altereko consulting company (Altereko, 2020), a system of collecting kitchen waste in large containers was introduced in the Italian city of Parma, leading to about 15% of mixed municipal waste being collected separately. Following the introduction of door-to-door collection, sorting increased by 100%, i.e. up to 30% of mixed municipal waste was collected separately. In the same period, the city also introduced a quantity-based waste charging scheme, which has had a significant impact on the reduction of mixed municipal waste.

Examples of good practice from Slovakia

In September 2017, the municipality of Žiar nad Hronom introduced the collection of kitchen waste from households using 120- and 240-litre containers placed at reserved sites. Each household received a 10-litre bucket along with an information leaflet. After the first year of the system's operation, the municipality managed to collect approximately 8.6 kg of kitchen waste per inhabitant, which represents about 3% of mixed municipal waste. This represents 14% of the estimated potential of kitchen waste in mixed municipal waste. The following year, 17% of the potential in mixed waste was collected separately. Žiar nad Hronom has also introduced a container-interval quantity-based waste collection scheme, which seems to enhance the effect of kitchen waste collection itself.

Topoľčany has introduced the collection of kitchen waste for single-family houses at the end of September 2019. Almost 20 tonnes of kitchen waste were collected in 3 months, which represents separate collection of about 40% of the potential in mixed municipal waste in single-family houses.

[12] Act No 79/2015 on waste.

Separate collection was also introduced in May 2019 in the municipality of Trnavá Hora, where an analysis of the composition of municipal waste was also carried out in the previous year. According to the results, kitchen bio-waste and food waste accounted for around 14% of mixed municipal waste in 2018. According to data from the Statistical Office, 10 tonnes of kitchen bio-waste were sorted in Trnavá Hora in 2019. In 8 months, up to 60% of the potential was collected separately. In the first half of 2020, the figure was around 40%. In the same year, the municipality also introduced a quantity-based waste charging scheme using tokens, which led to a significant reduction in waste production and an increase in sorting.

Other municipalities in Slovakia

In connection with the legislative amendment in 2016, several municipalities such as Stará Ľubovňa, Most pri Bratislave and Malinovo introduced separate collection of kitchen bio-waste. Bins are shared and located only in some streets, with collection taking place only once a week. Even after 4 years, only 1 to 4% of the potential of kitchen bio-waste in mixed municipal waste is collected separately.

We calculated the amount of separately collected kitchen bio-waste as well as the reduction in mixed municipal waste production in individual municipalities as the product of the effect of separate collection and the potential amount of kitchen bio-waste in mixed municipal waste. In determining the potential, we relied on INCIEN's analyses of the composition of municipal waste, with an estimated potential of 16% in single-family homes and 44% in multi-apartment buildings[13]. We then calculated the kitchen waste potential for each municipality separately based on the ratio between the number of single-family houses and multi-apartment buildings according to the 2011 census data.

The actual impact of separate collection may depend on several unknown factors. Municipalities with residents living in single-family houses can choose to introduce home composting, thus saving the operating costs of collection. However, data on home composting are not recorded, so there would be no increase in separately collected bio-waste. If the state provides subsidies for separately collecting kitchen bio-waste, municipalities could be motivated to achieve higher sorting rates through better education, information campaign and better system setup.

Treatment of waste before landfilling

According to the amendment to the Waste Act, only mixed municipal and bulky waste that undergoes mechanical biological treatment can be landfilled from 2021 onwards. This is related to the EU Waste Directive, which requires countries to reduce the proportion of bio-waste in landfills. The aim of the treatment is to stabilise the bio-component in municipal waste, thereby reducing greenhouse gas emissions of landfills as well as the overall quantity of waste landfilled.

After mechanical biological treatment, the waste can be further kept on the landfill. The dry component separated in mechanical treatment can be used to produce SAF, depending on its calorific value. According to T+T, a maximum of 50% of mixed municipal waste can be used to produce SAF. As the law does not provide any further specifications for treatment, we do not foresee additional separation of recyclables.

We assume that 45% of the waste will be used as solid alternative fuel for energy recovery at cement works. This is because the cost of selling SAF to the cement works is lower compared to landfilling. According to data from T+T, which was the only company in Slovakia to produce SAF from mixed municipal waste, the cost of recovery at cement works is approximately EUR 35/tonne. The price for landfilling combustible waste would be up to EUR 80/tonne, while the statutory rate is EUR 30/tonne and the remaining EUR 50/tonne is the average entry charge according to landfill price lists.

We assume that bio-waste after stabilisation, which would make up 25%, would be landfilled or used for land reclamation purposes. Use for compost production is often inappropriate due to the possible presence of harmful substances. This waste would be reported under catalogue number 19 12 12 and the landfill costs would be EUR

[13] Potential is calculated based on the weighted average by sample size relative to the total quantity of municipal waste for the relevant type of development in the relevant year.

61/tonne. The entry fee is EUR 54/tonne, according to data from landfill operators. We are projecting a statutory charge of EUR 7/tonne[14], as this would be waste that cannot be recovered in any other way due to its characteristics.

The remaining part of the waste, which does not show biological activity and is not flammable, amounts to 25% and can be landfilled. This type of waste is reported under catalogue number 19 12 09. We have estimated the landfill price at EUR 56/tonne, of which EUR 7/tonne is the legal rate for inert waste at a landfill for non-hazardous waste[15]. The entry charge of EUR 49/tonne is based on landfill operators' price lists. The remaining 5% is sorted metals after mechanical treatment, which would be sold for EUR 15/tonne (KOSIT).

The estimated costs of waste treatment and further management are based on the above-specified composition of the waste after treatment, the costs of disposal and the costs of constructing the treatment technology. Data on the investment and operating costs of the mechanical biological treatment installation are based on KOSIT's project. We assume that the costs of treating municipal waste prior to landfilling will be EUR 82/tonne, excluding transport costs. T+T reports the same cost based on past experience. The cost of landfilling municipal waste without treatment was EUR 55/tonne in 2020.

The introduction of waste treatment is a measure similar to increasing landfill charges, as it increases the cost of landfilling. In modelling this measure, we assumed the same landfilling elasticity of 0.11 and considered that 50% of waste is collected separately by residents and the remaining 50% is not produced.

For bulky municipal waste, we do not expect it to undergo treatment, as treatment of this type of waste is not common abroad. So we have projected diverting this waste from landfilling altogether through energy recovery, reuse or recycling.

Deposit scheme for disposable beverage packaging

Starting in 2022, Slovakia is introducing a deposit scheme for beverage packaging, namely PET bottles and cans. The target for 2024 is 77% of this packaging, and for 2027 it is 90% of beverage packaging. In 2025 and 2026, we expect a gradual increase in the sorting rate, on average by 4 p.p. year-on-year. Already in 2023, we expect the sorting rate for PET to be 77%, as the recovery rate via the separate collection system was estimated at 62% already in 2016. As this is again a national target that may not be met by every municipality equally, we expect a proportional increase in sorting in individual municipalities according to the separate collection of plastics in 2019.;

Annex 2: Industrial waste forecast

We estimated the evolution of the production of industrial waste in 16 NACE sectors based on the total production of the sector concerned. We relied on available two-year data from Eurostat for the period 2004–2016 for 23 EU member states[16]. In order to determine the relationship between waste and production, it is necessary to express production in constant prices that take into account price inflation and real growth. Given that production at constant prices is not available for all countries, we used current prices and harmonised consumer price indices as of the reference year 2015. We estimated the following regression model with member states' fixed effects:

$$W_{is} = \alpha_{0i} NACE_{is} + \beta_1 Output_{is} NACE_{is} + \beta_2 Output_{is}^2 NACE_{is} + \varepsilon_{is}, \qquad (2)$$

where W_{is} and $Output_{it}$ are the logarithmic transformations of waste tonnage and production in million euros in country i and sector s, respectively. Member states' fixed effects α_{0i} are unobserved characteristics affecting waste production. We assume that waste production in each sector may have a different dependence on the total sector output.

[14]Government Regulation No 330/2018 laying down the amount of charges for waste disposal and details relating to the redistribution of revenues from waste disposal charges.
[15] Section 4(4) of Act No 329/2018 Coll. on waste disposal charges.
[16] The member states Malta and Luxembourg were omitted due to missing production data in some sectors. Ireland, Romania and Cyprus were omitted due to inappropriate data.

Therefore, the equation includes interactions with the categorical variable $NACE_{is}$ which represents individual NACE sectors.

We used the resulting coefficients to estimate the production of industrial waste in Slovakia. The production forecast in individual sectors is calculated according to the macroeconomic forecast of GDP growth (Institute for Financial policy, June 2020) compared to 2016, as growth forecasts for individual sectors are not available.