PEDAL CONSULTING

SLOVAK INDUSTRY DECARBONISATION

Policy and Financing Roadmap

PEDAL Consulting, s.r.o. June 2023

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Supported by:

Federal Ministry
for Economic Affairs
and Climate Action

European
Climate Initiative
EUKI

on the basis of a decision
by the German Bundestag

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Preface

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In the face of increasing concerns over climate change and the urgent need to mitigate its effects, decarbonisation has emerged as a crucial goal across various sectors of the European economy. One of the key areas demanding attention is the industrial sector, which accounts for a significant portion of greenhouse gas emissions. Within this sector, industries such as steel, cement, and chemicals play a particularly vital role due to their significant carbon footprints.

The steel, cement, and chemical industries have traditionally relied heavily on fossil fuels and energy-intensive processes, resulting in substantial carbon dioxide (CO2) emissions. As a result, addressing decarbonisation within these sectors has become a top priority in the European climate change agenda.

Recognizing the urgency of the climate crisis, efforts are underway to decarbonize these industrial sectors, seeking to reduce their environmental impact while maintaining their economic viability. By developing innovative technologies, adopting sustainable practices, and investing in research and development, the goal is to transition these industries towards low-carbon or carbon-neutral alternatives.

However, investments require funding. This work will delve into the challenges of estimating CAPEX needs for successful carbon reduction until 2030 in the three sectors in Slovakia. To fulfil our goal, we will describe policy environment, state of the steel, cement and chemical industry, will choose the appropriate decarbonisation path model. We will try to estimate sectoral cash flow in the near future. Finally, we will look at the required decarbonisation CAPEX and compare it with available financing, public or private.

Executive Summary

Executive Summary

Slovak industry has substantially reduced its GHG emissions, especially in the 1990 – 2000 period. Since 2010, the emission plateaued. The analysis focuses on three industries: Steel, cement, chemical.

Steel industry is one of the main pillars of Slovak industry and the key representative, U.S. Steel Kosice, is the biggest employer in Eastern Slovakia. It is also the biggest industrial carbon emitter in the country. All three Slovak cement producers are among the top 20 largest emitters in Slovakia. Together, they are responsible for approximately 5-8 percent of total Slovak emissions. Regarding chemical industry, our analyses focuses on 5 representatives in the ETS scheme and the refinery. Majority of emissions is concentrated in two companies, Duslo (fertilizers) and Slovnaft (refinery/chemicals).

In the second part, we will use data from the 2050 Pathway Explorer to focus on the steel, cement and chemical industry, look at the model assumptions and compare it with our assessment of the current reality. We will employ the 2050 Pathway Explorer (PE), where the Ambitious scenario is the closest fit to the -62 % target of this work. Due to the limitations in the PE model (linearity, technology switch, emission allocation, cost estimates) we also bring attention to the MACC model, prepared on a national level and the National Energy and Climate Plan.

Utilizing three different models, we arrive to three CAPEX estimations for decarbonisation in the 2023 – 2030 period, which range 1,59 – 1,98 billion EUR, albeit with very different sectoral share in each estimate.

Final part summarizes options available for public financing, both from national and European sources. Regarding private financing, we prepared simple financial model, which provides cumulative estimate of free cash flow and debt capacity until 2030. Using the model, we estimated 1,4 billion EUR CAPEX capacity for steel, around 0,5 billion EUR for cement, 0,5 billion EUR for the chemical industry excluding the refinery and 2,3 billion EUR for the refinery. The results of our modelling show the scenario, where sectors finance decarbonisation CAPEX utilizing their free cash flow and debt capacity is not out of the way. However, there are numerous limitations to this assumption, which need to be taken into account.

The emphasis should be put on the fact that industrial decarbonisation in such a short timespan remains a very ambitious goal, reaching over any industrial sector boundaries. This work's ambition is not to provide exact answers, but to provide food for ongoing public discussion about the cost of decarbonisation for steel, cement and chemical industry and the possible economic paths to reach the goals.

Content

List of abbreviations

CAPEX	capital expenditure
CEE	Central and Eastern Europe
CO_2	Carbon dioxide
EAF	electric arc furnaces
EBITDA	Earnings before interest, taxes, depreciation and amortization
ECF	European Climate Foundation
EGF	Pan-European Guarantee Fund
EIB	European Investment Bank
ESIF	European structural and investment funds
ESF	European Social Fund
ETS	Emission Trading System
EU	European Union
GHG	greenhouse gas
GVA	Gross Value Added
IDEES	Integrated Database of the European Energy System
MACC	Margina Abatement Cost Curve
NACE	classification of economic activities (Nomenclature statistique des Activités économiques dans la Communauté Européenne)
NECP 2030	National Energy and Climate Plan
NIR	National Inventory Report
OPEX	operational expenditure
PE	Pathway Explorer
PVC	Polyvinyl Chloride
R&D	Research and Development
RES	renewable energy share
RRF	Recovery and Resilience Plan
SARIO	Slovak Investment and Trade Development Agency
ZEM	Zero Emission Scenario

Decarbonisation policy environment

Slovakia was the first country among CEE countries to announce its commitment to reach ambitious decarbonization goals. Even though the country has been vocal regarding meeting the 2050 carbon neutral goal, the implementation of policy approaches is still an ongoing process.

Slovakia is lacking an overall strategy for decarbonizing the entire economy, and thus the role industry should play in these plans is not yet clearly set. Industry requires long-term stability due to the long investment cycle, while the governance to reach the decarbonisation goals is distorted. Fragmented strategies, competencies, and changing requirements create an uncertain environment about upcoming developments.

For the decarbonisation of the Slovak economy, responsibilities are divided between numerous governmental bodies (Ministry of Environment, Ministry of Economy, Ministry of Investments, Regional Development and Informatisation...). Therefore, many documents have been published and approved partially covering the decarbonisation topic with scattered competences and implementation efforts.

Policy framework

There have been numerous policy documents (strategies, acts and agendas) published regarding decarbonisation at various stages of implementation, as summarized in the table below:

Table 1: Decarbonisation policies and documents in Slovakia

Policy	Year	Status of implementation	Competent government body
NECP 2030	2021	Approved, implemented, under revision till Q4 2023	Ministry of Economy
Hydrogen Strategy	2022	Approved, action plan in final stage	Ministry of Economy
Low-Carbon Development Strategy of the Slovak Republic until 2030 with a View to 2050	2020	Approved, implemented for NECP, revision needed	Government Office
Greener Slovakia - Strategy of the Environmental Policy of the Slovak Republic until 2030	2019	Approved, ongoing revision	Ministry of Environment
Innovation strategy (2022-2050)	2022	Ongoing implementation Missing action plan	Ministry of Investments, Regional Development and Informatisation
Climate Act		In process, plan to adopt in 2023	Ministry of Environment
Agenda 2030	2018	Ongoing implementation	Ministry of Investments, Regional Development and Informatisation – internal implementation Ministry of Foreign affairs – International implementation
Slovakia 2030: Vision and Strategy of Slovakia's development until 2030 - long-therm strategy of sustainable development of the Slovak Republic	2021	Approved, implementation, basis for the Partnership agreement	Ministry of Investments, Regional Development and Informatisation

Source: authors

Greener Slovakia – Strategy for the Environmental Policy of the Slovak Republic (2017-2030)

The Strategy serves as a basis for the Slovak National Energy and Climate Plan. Envirostrategy 2030 sets specific measurable targets, which should be met by 2030. The targets set in 2019 are to reduce greenhouse gas emissions in the sectors of emissions trading by 43%, and outside these sectors by at least 20%, compared to 2005. Since these goals were set before Slovakia committed itself to the more ambitious goal of 55% emission reduction, the whole Envirostrategy is under revision and actualization to adjust to the new targets. The Institute for Environmental Policy, the Analytical Unit of the Ministry of Environment of the Slovak republic is responsible for this revision. However, Envirostrategy does not set specific allocation for implementation, nor has it binding milestones for other responsible institutions as of yet.

Low-Carbon Development Strategy of the Slovak Republic until 2030 with a View to 2050 (2020)

This Strategy aims to overarchingly identify measures, including additional measures leading to climate neutrality in Slovakia by 2050[1]. It outlines options for a comprehensive long-term (30-year) plan with a basic strategic roadmap towards a low-carbon economy. The document sets sectoral targets for GHG emissions reductions to 2030 without modelling a carbon-neutral trajectory. Therefore, the strategy itself states that, due to the lack of data and necessary modelling, it needs to be updated at the latest in 2025.

Slovak National Energy and Climate Plan

The Slovak NECP was approved by the Slovak Government in 2019. The Slovak national target for GHG in non-ETS sectors is a 20% reduction compared to the 2002 level. The planned total share of RES for 2030 is 19.2%, which is lower than the common EU 2030 goal of 32%[2]. The share of RES in transport is projected to be 14% by 2030. On the other hand, to be able to secure additional RES introduction, the level of grid interconnection (electricity connectivity) is set to 52% in 2030, being higher than the 15% EU 2030 goal to overcome challenges of stabilization of the network.

Considering the new EU decarbonization target in 2050 and new European legislation related to more ambitious targets in GHG, RES, and energy efficiency, Slovakia has to prepare a draft update of this NEPC by 30 June 2023, and subsequently by 1 January 2033 and every 10 years thereafter, or shall provide the Commission with reasons justifying why the plan does not require updating [Article 14(1) of Regulation (EU) 2018/1999].

NECP contains many policies in different sectors. Approximate investments in the industrial sector in the 2021-2030 period were modelled at an amount of nearly 3.35 bil. EUR. Required costs for implementation of policies, which are part of NECP, will come from the national budget, EU funds, as well as from private sources.

Although NECPs were laid out before the COVID-19 crisis, their completion, confirmed in 2021, is linked to the implementation of national recovery measures. An intense revision of NECP is planned for 2023.

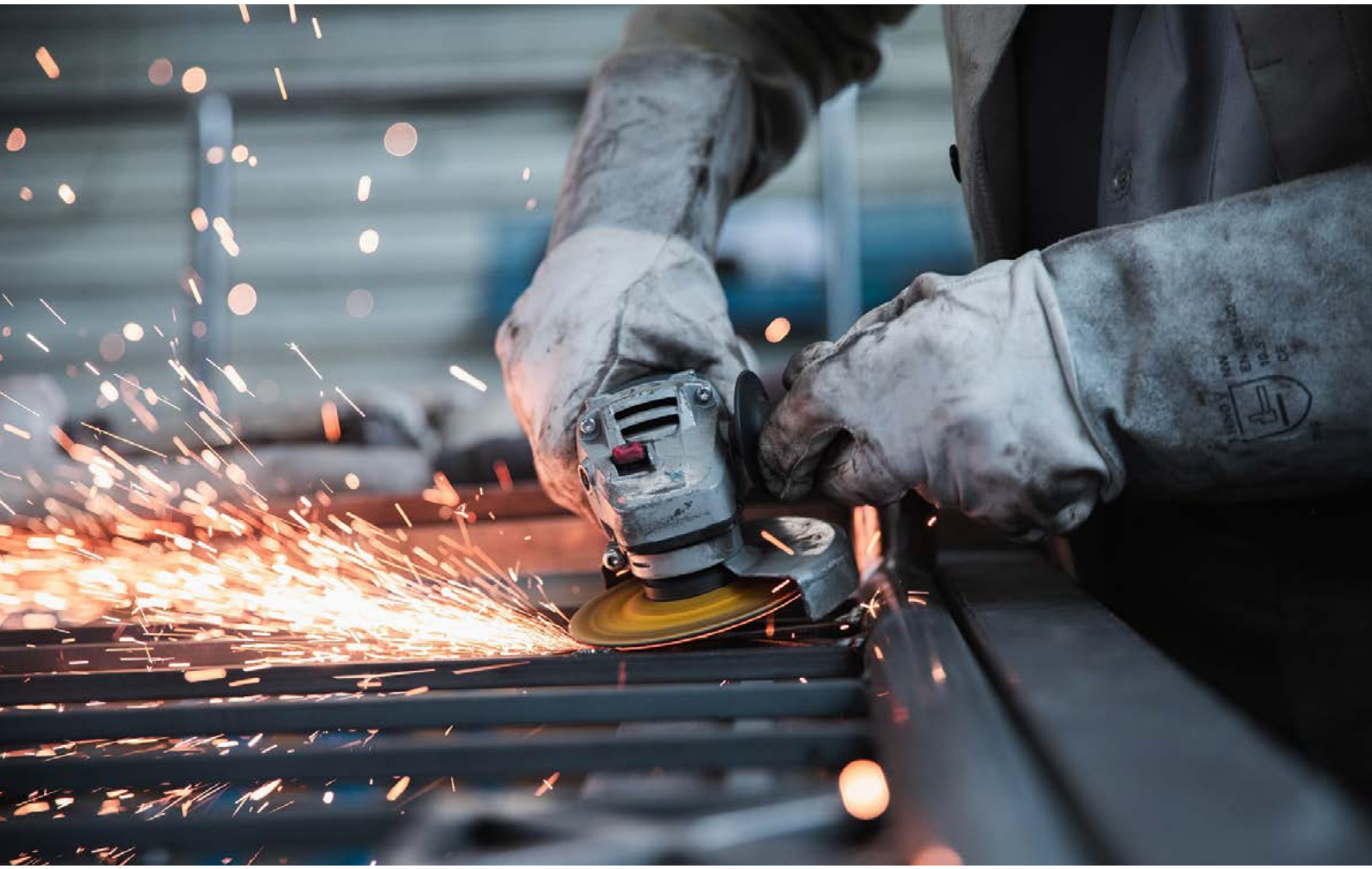
Vision and strategy of Slovakia's development until 2030

[1] https://ec.europa.eu/clima/sites/lts/lts_sk_sk.pdf
[2] https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2030-climate-energy-framework_en

Moreover, the topic of decarbonization touched the ground with another strategic document - Vision and strategy of Slovakia's development until 2030 - a long-term strategy for sustainable development of the Slovak Republic - Slovakia 2030 approved by the Government in January 2021, which describes the vision and strategy of Slovakia up to 2030. The document also serves as a basis for the Partnership Agreement for the years 2021 - 2027 and its implementation through the integrated Operational Program in Slovakia.

The central pillar of Slovakia 2030, in line with the Global Agenda 2030, as well as the European Green Agreement, is sustainability, placing emphasis on environmental protection in Slovakia, strategic planning and sustainable development, alignment of priorities with regional development potential, and development of industry based on green transformation and high added value, automation, market services, the digital economy, innovation, and research and development. This broad scope is translated into the ESIF Partnership Agreement for the years 2021 – 2027, setting priorities for ESF investment in Slovakia.

No financial allocation measures are described in the Strategy. In terms of monitoring, the Strategy outlines the set of outcome indicators, including data sourcing. It also includes in the Strategy that yearly performance reports will be approved by the Government and published on the website of the Statistical Office of the Slovak Republic. No performance report has yet been published, the website is not up to date and no data on performance has been published either.



Industry's current decarbonisation status

Industry's current decarbonisation status

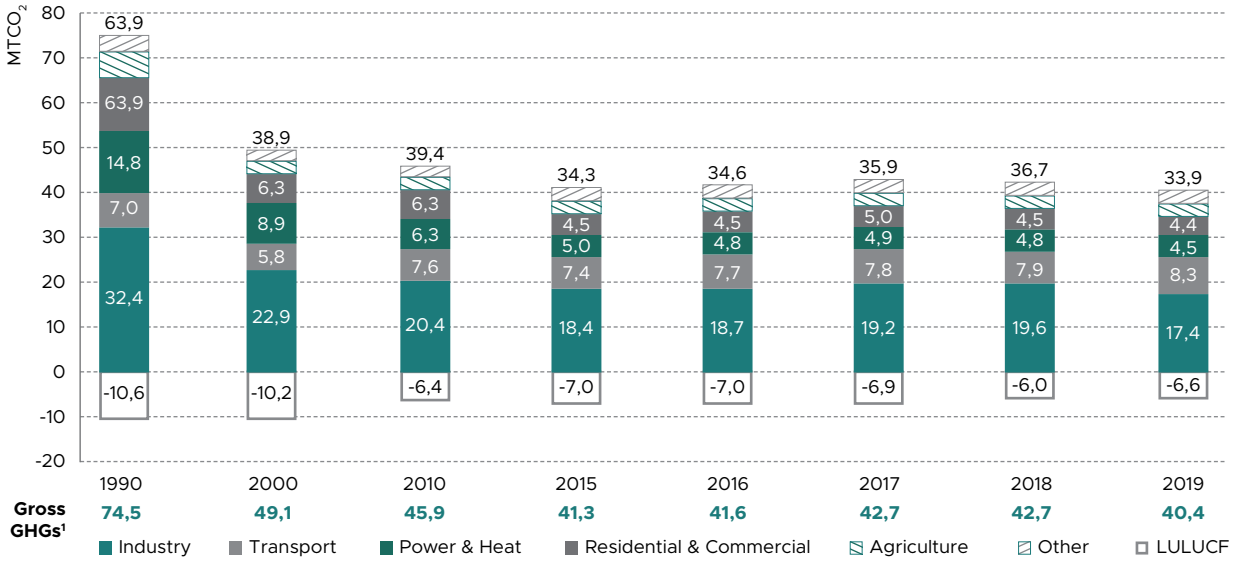
The Slovak economy has decarbonized significantly in the last thirty years. Between 2000 and 2015, substantial energy savings were made[3]. According to Eurostat data, Slovakia decreased its energy intensity by 50.8%[4] in this period. These positive results are an effect of industrial restructuring, implementation of low energy intensity technologies and improvement of energy efficiency in real-estate construction. Since 2015, total emissions have been more-or-less stable

Looking at the period of the first systemic implementation of cost-effective measures within the years 2005-2020, we can see it led to reducing energy intensity by approximately 48%[5]. Measures have had such a sufficiently acceptable payback period that it has been worthwhile for companies to implement them exclusively from their own resources without the support of public resources. Success for decarbonisation depends on addressing technological, policy and financial barriers.

Slovak industry has substantially reduced its GHG emissions, especially in the 1990 – 2000 period. Since 2010, emissions have plateaued. The latest consolidated data are available from the year 2021 (Slovakia. 2023 National Inventory Report - NIR[6]). These show the pandemic drop in 2020 to 37.2 GHGs, with a quick return to 41.2 GHGs in 2021. However, the rise in energy prices in 2020 shows a large drop in emissions in the preliminary data from 2022, with total emissions dropping 8% y-o-y and industrial emissions lower by 20 %[7].

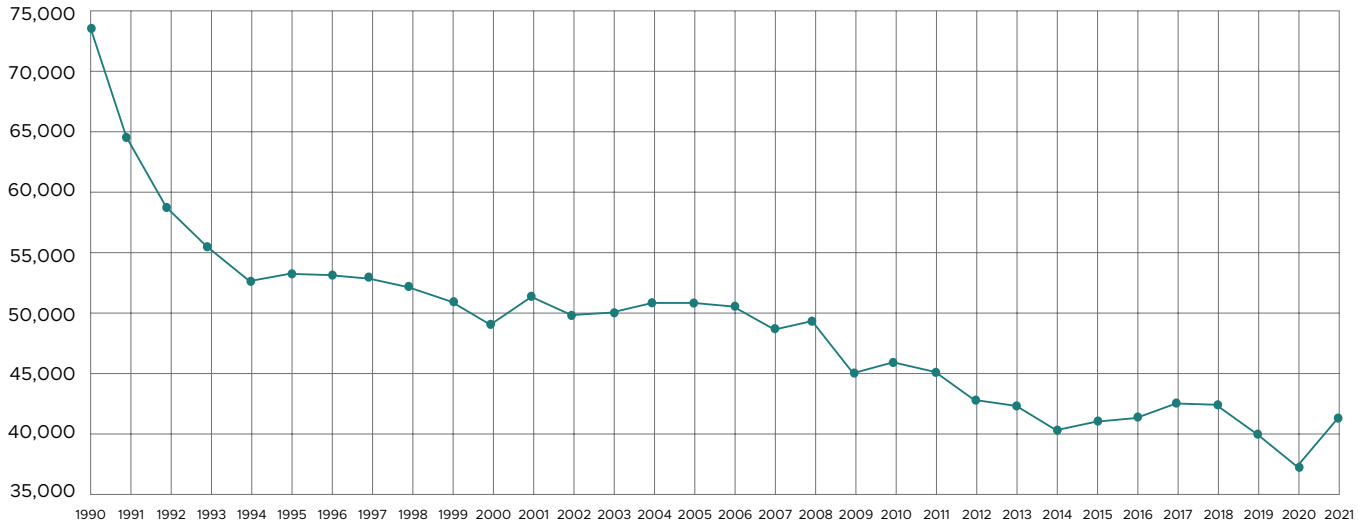
Figure 1 GHG emission production

1. Excluding LULUCF sinks, Source:Value for Money Department



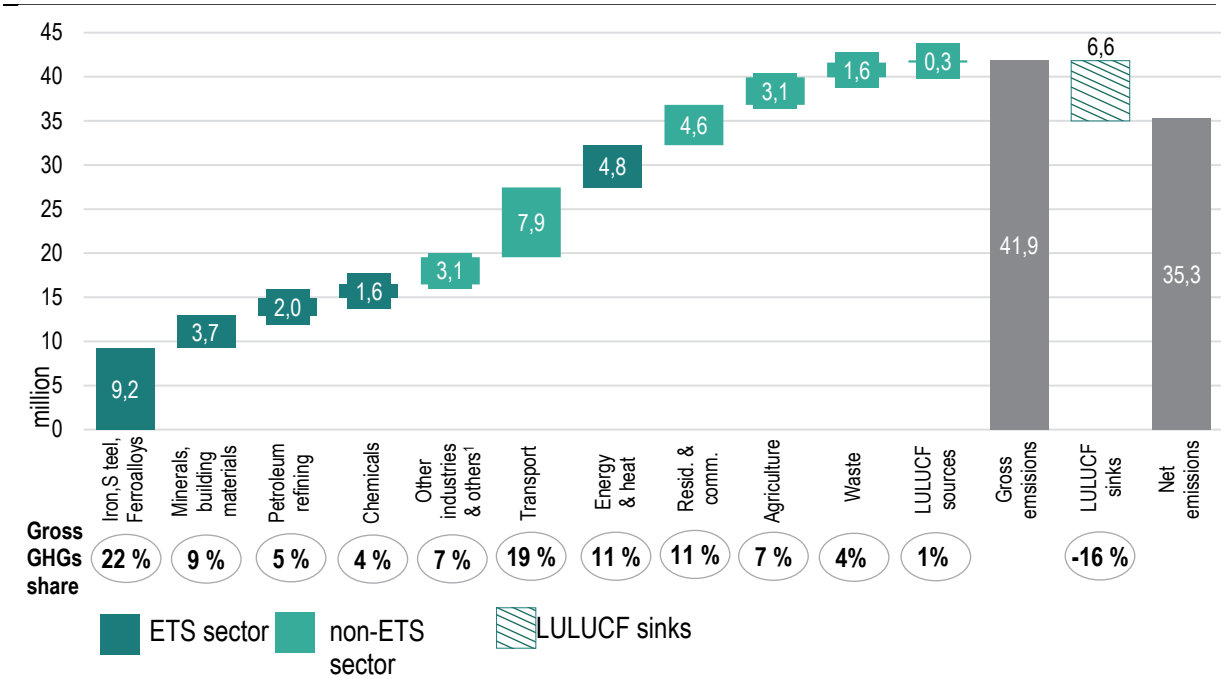
[3] Please see also the Barrier Report by MESA 10, which served as one of the sources for this publication
[4] https://energy.ec.europa.eu/system/files/2022-08/sk_final_necp_main_sk.pdf
[5] Slovak Statistical Office, 2022, data processed by the Slovak Environmental Agency: https://www.enviroportal.sk/indicator/detail?id=902
[6] https://unfccc.int/documents/627782
[7] https://e.dennikn.sk/3468825/prekvapenie-slovensko-minuly-rok-vyrazne-znizilo-emisie-sklenikovych-plynov/

Figure 2 GHG emission production (Slovak Hydrometeorological Institute) Source: Slovak Hydrometeorological Institute



Iron and steel production is (and has been in the past at least since 2000) the largest contributor to total greenhouse gas emissions. Construction materials and oil refining also play a significant role.

Figure 3 Slovak emission and sectorial split (2016-2019 average) Source: Value for Money Department



1. Including product uses as substitutes for ozone-depleting substances and fugitive emissions from mining, etc. *Source: EEA*
Resid. & comm. = residential and commercial sector (primarily includes heating, but not the heating plants).

Steel industry

The steel industry is one of the main pillars of Slovak industry. It employs about 8 500 people, which makes the U.S. Steel Kosice the biggest employer in Eastern Slovakia. The industry accounts for 3.8 % of total manufacturing GVA in Slovakia, compared to 1.3 % of total manufacturing GVA across the European Union.

The Iron & Steel Manufacturing in Slovakia industry is valued at 3.6bn EUR measured by revenue in 2022 and is ranked 11th in Europe in 2022 (of 18 total EU countries with steel production). The market size of Iron & Steel Manufacturing in Slovakia grew 2.5% per year on average between 2017 and 2022[8], with a rapid growth of 12.8% in 2022.

Steel production is strongly interlinked to other industries such as metallurgy, construction, engineering, energy and automotive.

There are two major steel making companies – U.S. Steel and ZELPO. However, ZELPO uses electrified process and produces circa 1% of the emissions of U.S. Steel. Therefore, we will consider U.S. Steel only in our analysis.

Steel - Financial analysis

U. S. Steel Košice, s.r.o. has an annual raw steel production capability of 4.5 million metric tons. In 2021, the company increased its total revenue to 3.5bn EUR, which represents a 110% increase on the 2020-2021 basis. Moreover, the company returned to a net profit level from its loss - 55 mil EUR in 2020 to 653 mil EUR in 2021 thanks to a record production year after overcoming a challenging period for the steel industry that caused declines in production and thus in sales in 2019 and 2020 due to the COVID-19 pandemic. The main territories in which the U. S. Steel Košice Group operates are Central and Western Europe, with a dominant export into V4 counties (62%), the rest of the EU (33%), and other (5%)[vvV], underlining the importance of U.S. Steel's production for the whole region.

Liquidity positions show mild deterioration on the back of a revenue slump. The company keeps its current ratio level slightly above 2 pointing at a higher proportion of accounts receivable which are directly linked towards the revenue swing. In 2015-2021 period, the company was successful in managing its current ratio by a 26% decrease, indicating more efficient use of its current assets. The last 6 years have influenced the company's liabilities to assets ratio, which increased by nearly 50% from 32% to 47% in 2021, with its peak in 2020 at 54%. This development was directly linked to the revenue shortage in the 2018-2020 period. The EBITDA margin rose to 25% in 2021, bringing the company's profitability back on track with a potential investment pipeline in its decarbonization efforts.

[8] IBIS raking 2022: https://www.ibisworld.com/slovakia/industry-statistics/iron-steel-manufacturing/1395/
[9] U.S. Steel Kosice Financial Report, 2021

Table 2: U.S. Steel financials

	2021	2020	2019	2018	2017	2016	2015
Total revenue	3 589 701 000	1 711 145 000	2 138 732 000	2 712 068 000	2 612 248 000	2 017 271 000	2 079 925 000
EBIT	827 238 000	-65 580 000	-87 163 000	164 683 000	566 296 000	349 796 000	70 381 000
EBITDA	912 503 000	177 000	-10 036 000	236 239 000	305 888 000	228 839 000	202 185 000
Net profit	653 163 338	-45 172 987	-59 261 381	128 443 929	450 809 410	271 420 297	50 553 307
Net cash flow	68 416 000	2 727 000	116 214 000	-210 649 000	185 815 000	-131 612 000	-78 044 000
Total debt	0	424 886 000	488 362 000	206 289 000			0
Long-term debt	0	422 239 000	483 523 000	2 00 000 000			0
Short-term debt	0	2 647 000	4 839 000	6 289 000			
Net debt	-285 651 000	207 651 000	273 854 000	107 995 000	-308 943 000	-123 128 000	-254 740 000
Source: FinStat data 2022, MESA 10 calculations							

Emissions from iron and steel production

Major sources of technological CO_2 emissions are pig iron and steel production in blast furnaces. Both pig iron and steel production in blast furnaces contribute to carbon emissions; however, their precise share is hard to calculate. Also, 1/3rd of the emissions came from the subsidiary Ferroenergy, which handled energy processes for the foundry (using hot gases from the foundry as the main energy source). Ferroenergy was legally created in 2017 and, since 2023, it is again an integral part of U.S. Steel without separate reporting. We will consider consolidated emissions for U.S. Steel in this analysis (U.S. Steel + Ferroenergy).

Decarbonisation status - steel

In April 2021, the United States Steel Corporation expanded its transformational commitment to sustainability by setting an ambitious goal targeting net-zero carbon emissions by 2050. U. S. Steel expects to leverage its growing fleet of electric arc furnaces (EAF) coupled with other technologies such as direct-reduced iron, carbon-free energy sources, and carbon capture, sequestration and utilization. Based on U.S. Steel's announcement in 2021, achievement of the neutrality goal also depends on public-private collaboration across industries and global stakeholders to develop supportive innovative breakthroughs. Improving the access to commercially-available carbon-neutral electricity sources is a must.

The first milestone is to reduce greenhouse gas emissions by 20% globally by 2030. U.S. Steel also scoped out the technological possibilities to create a portfolio of decarbonization projects.

The portfolio of the projects has three main pillars:

1. reducing carbon intensity of the blast furnace production route,
2. electrification of production, and
3. use of hydrogen.

Also, the group plans to promote new solutions with the aim of providing products with a low carbon footprint, making progress to create a lower-carbon, more circular economy.

Projects for reducing emissions - steel

Based on the "Roadmap to 2050" by U.S. Steel, the net-zero by 2050 pledge hinges on the U. S. Steel's interim goal to reduce greenhouse gas emissions intensity by 20% across the company's global footprint by 2030. It follows the company's acquisition of technologically advanced Big River Steel, the only LEED® certified steel mill in the United States. In 2021 the company introduced a new sustainable steel product line, verdeX™, and joined the ResponsibleSteel™ initiative.

These efforts strengthen support for customer and supplier implementation of their net-zero targets, to ensure process inputs and steel use conform to net-zero. Having already produced more than 14 grades of some of the most advanced high-strength steels at its Big River Steel subsidiary, the company is confident in its ability to use EAFs and other advanced technologies to achieve significant carbon emission reductions. The new green steel product portfolio will replace existing products to optimize the overall business footprint.

Past projects for increased de-dusting on U.S. Steel blast furnaces 2 and 3 have demonstrated their sustainability, leading to blast furnace particulate emissions being reduced by 90%[10]. This project used a subsidy of 6 million EUR from the EU, representing around 35 percent of the total investment costs, and U.S. Steel invested a further 11 mil. EUR plus into the project.

Energy consumption: USSK produces approximately 60% of the total electricity consumed at the plant. The energy efficiency of processes is one of the most important aspects ultimately affecting the final cost of production.

Throughout the year 2021, an increase in the prices of electricity, natural gas and CO_2 allowances led to motivation for savings.

Cement industry

All Slovak cement factories are among the top 20 largest emitters in Slovakia. Together, they are responsible for approximately 5-8 % of total Slovak emissions. Compared to producers in China (700kg CO_2 per 1 metric ton of cement); and in the United States (680 kg CO_2 per 1 metric ton of cement), Slovak producers keep moving to 552 kg CO_2 per 1metric ton of cement.

Cement – Financial analysis

Thanks to the geo-availability of raw materials, Slovakia can produce higher-quality white cement. Domestic consumption hovers at around 2.2 million tons of cement, of which approximately 500,000 are covered by imports. The total cement production capacities amount to four million tons.

The total cement production of Slovakia consists of 4 cement plants (3 producers), 45 ready-mix concrete plants, 8 gravel pits and 4 quarries with a total turnover 379 mil. EUR in 2021.

[10] https://www.usske.sk/en/article/blast-furnaces-particulate-emissions-reduced-by-90-percent

Table 3: Cement industry financials in EUR			
Danucem	2021	2020	2019
Revenue	230 219 000	240 611 868	235 385 419
EBITDA	45 212 000	33 460 267	27 038 855
Net Profit/loss	17 162 275	14 432 936	1 705 318
Považská cementáreň	2021	2020	2019
Revenue	92 589 441	80 356 301	76 309 268
EBITDA	9 961 719	10 351 493	10 041 387
Net Profit/loss	1 652 802	2 415 879	2 687 409
CEMMAC	2021	2020	2019
Revenue	56 218 108	48 286 798	46 313 537
EBITDA	6 132 932	6 416 746	6 389 083
Net Profit/loss	2 349 126	2 856 514	2 808 098
Source: Finstat			

Emissions from cement production

When considering the cement and lime industries in Slovakia as a group, the bulk of emissions stem from cement production. As can be seen in the table below, cement is responsible for 2/3rds of emissions. Therefore, this study will focus solely on the cement industry.

Table 4: Cement and lime emissions		
	2021 emissions (t)	
Danucem	cement	1 380 917
Považská cementáreň	cement	497 995
CEMMAC	cement	282 800
Dolvap	lime	106 062
Calmit	lime	154 871
Carmeuse	lime	511 845
TOTAL		2 934 490
Source: ICZ		

Decarbonisation status - cement

All the cement industry producers communicate actively about their climate goals on their websites as well as via their social media toolkit, both individually as well as jointly via the cement association.

The Slovak cement industry has publicly committed to a 55% decrease of emissions by 2030.

Continuous pressure is being made in formulating effective strategy and policy to achieve further reduction of emissions in the cement sector also. All cement producers publicly commit to the decarbonization goals with their own project pipeline, heavily marketed in media and social media posting. The EN 197-1:2011 norm[11] for Cement - Composition, specifications and conformity criteria for common cements have allowed two new cement types to be sold with almost 60% of substitutive materials involved. The product diversification program of all producers in Slovakia remains a driving force in the decarbonization initiative, but which might not be quite enough.

Projects for reducing emissions - cement

The year 2022 was strong for public messaging related to the decarboniza-

[11] https://normy.unms.sk/eshop/public/standard_detail.aspx?id=115007

tion strategy till 2050, mostly announcing projects till 2030 in the following areas:

Emissions

The emission strategies of cement producers are mostly focused on product diversification within cement production. Behavioural aspects have been also implemented to influence consumer behaviour using coloured labelling of products based on CO_2 emissions showing an environmental friendly attitude. All three-cement producers are transparent with their CO_2 emissions. They publish their monthly reports on their website, using the latest technologies for automatized calculations.

Alternative fuels

In June 2021, the Association of Slovak Cement Producers signed the Memorandum of Understanding with the Ministry of the Environment on the waste treatment used for cement production[12]. The main goal is to use the waste produced for energy recovery and cement production. The key challenge remains within the proper legislation to be implemented to fully uncover the opportunities for such an agreed mechanism. The program of waste management for 2021-2025 from the Ministry of the Environment was approved by the Government in November 2021. The fully uncovered opportunity has been identified in 2023 onwards with respect to EU funding sector opportunities[13]. The follow up evaluation and data publication has not been set though.

According to press releases, in 2021 all cement producers recovered almost 367k tones of produced waste. Their alternative fuel mix reached a 66.2% share. Based on their calculations, this step helped to stave off 200 kilo tonnes of coal, which contributed to a decreased CO_2 emission footprint[14].

Energy efficiency

The production of clinker as a basic component of cement demands a great portion of energy - heat and electricity. Production optimization includes reducing total heat consumption and using the residual heat to produce electricity.

CEMMAC publicly declares that more than 15% of its investment over the last 10 years was environment friendly and focused on decarbonization efforts, mostly in the energy efficiency area.

Chemical industry

Slovakia has a strong tradition in all major segments of the chemical industry, including production of chemicals, fertilizers, rubber and plastics. In 2021, revenues generated by all companies in this sector amounted to 8.4 billion EUR. At the same time, the Slovak chemical industry's output equated to 10% of total industrial production. The sector employs over 42,000 people in approximately 285 companies[15].

Companies' profile

The figures presented in the previous text represent the chemical industry in the broadest sense, as represented by the SARIO statistics. Our analysis will focus on companies with prevalent activity within NACE code 20 (Manufacture of chemicals and chemical products). We will also include data from the oil refinery Slovnaft, since besides refinery products it is also a major producer of plastics.

There are 5 chemical industry (NACE 20-) representatives in the ETS scheme and the refinery. However, the large majority of GHG emissions are concentrated in two companies.

[12] Press release on 18 June 2021: Cement factories in Slovakia prefer domestic waste to foreign waste. https://www.minzp.sk/spravy/cementarne-slovensku-uprednostnia-domaci-odpad-pred-zahranicnym.html
[13] Program of waste management for 2021-2025: https://www.enviroportal.sk/odpady/program-odpadoveho-hospodarstva-slovenskej-republiky-2021-2025
[14] Press release on 3 March 2022: Cement plants evaluated 367,000 tons of alternative fuels last year. https://www.enviroportal.sk/clanok/cementarne-vlani-zhodnotili-367-000-ton-alternativnych-paliv

Slovnaft

The only oil refinery in Slovakia and the 4th biggest company on a national level by turnover. The Slovnaft group represents almost the whole turnover of petroleum in Slovakia, but it also produces a range of petrochemical products, such as plastics, sulphur and others.

Total GHG emissions in 2021 were over 2.2 Mt. These emissions can be divided into three groups – from refinery processes, from petrochemical processes and from heat and power generation (which provides services both for the refinery and the petrochemical part).

Duslo

A fertiliser producer of European significance. Since 2005, Duslo, a.s. is a part of the AGROFERT group, an international holding of companies that operate in chemical, agricultural, food production, forestry, lumber, land and transport technology, renewable resources and media sectors.

Enviral

Enviral was established in 2004 as the first producer of bioethanol in Slovakia. The commercial production of bioethanol was launched in July 2007. Current annual production capacity is 175,000 m3 of bioethanol.

Fortischem

This company manufactures and sells products on the basis of manufacturing and processing of chlorine, calcium carbide, carbide mixtures and industrial gases, electrolysis products, and PVC products. FORTISCHEM a.s. also contributes to the production of basic and specialized low-tonnage chemicals.

Evonik Fermas

A company specialized in industrial fermentation - scale-up and manufacturing of microbial fermentation products.

Diakol Strážske

A manufacturing company which produces an extensive assortment of formaldehyde condensates based on the main raw materials - methanol, urea, melamine, and soda lye. The production of formalin, which is the initial phase of the technological process, is also part of the company. Products are sold as glues used in the wood-working industry in the production of chipboard, plywood, furniture and insulating materials.

Chemical industry – Financial analysis

The financial landscape of the chemical industry's representatives in our study is wildly different, with some companies showing stable results, while others are in deep financial trouble.

Table 5: Chemical industry financials, in EUR			
Slovnaft	2021	2020	2019
Revenue	4,200,682,000	2,668,460,000	3,647,904 000
EBITDA	424,912,000	78,721,000	190,153,000
Net Profit/loss	255,402,894	-79,475,748	19,166,590
Duslo	2021	2020	2019
Revenue	581,916,000	356,511,000	402,488,000
EBITDA	60,762,000	65,464,000	69,989,000
Net Profit/loss	6,689,452	11,263,766	11,236,966
Enviral	2021	2020	2019
Revenue	172,018,539	142,012,652	138,321,321
EBITDA	16,779,634	26,795,473	19,011,266
Net Profit/loss	6,749,801	18,553,886	7,820,469
Fortischem	2021	2020	2019
Revenue	149,846,976	77,596,337	121,042,807
EBITDA	-2,234,445	-9,896,745	-9,418,340
Net Profit/loss	-7,674,918	-17,562,038	-16,399,829
Evonik Fermas	2021	2020	2019
Revenue	38,045,858	28,718,733	30,066,946
EBITDA	8,408,671	5,675,061	5,835,802
Net Profit/loss	1,452,646	1,474,236	1,661,189
Diakol Strážske	2021	2022	2019
Revenue	74,251,578	44,082,040	28,753,455
EBITDA	-369,017	854,177	796,267
Net Profit/loss	-487,830	487,194	421,909
Source: Finstat			

Emissions from chemical production

The large majority of emissions come from ammonia production and petrochemical products (plastics). The emissions from Slovnaft heat production cannot be easily divided into refining and petrochemical processes, since the heat (and electricity) production serves both branches.

Table 6: Chemical industry emissions	
	2021 emissions
Slovnaft (total)	2,242,915
Slovnaft Petrochemistr	403,730
Slovnaft heat production	784,609
Duslo	1,074,361
Enviral	74,079
Fortischem	73,142
Evonik Fermas	11,251
Diakol Strážske	7451
TOTAL	**3,397,869**
Source: ICZ	

Decarbonization status - chemicals

Slovak chemical companies are part of the "Responsible Care chemical industry initiative" - commitment to align activities with the growing demands for safety, human health and the environment[16]. The main goals in the field of environmental protection are the gradual systematic reduction of environmental pollution directly at the source with a focus on streamlining the protection of groundwater, reducing wastewater pollution, reducing emissions from individual sources and greenhouse gas emissions and reducing waste.

Slovnaft

[15] Chemical & Plastics Industry in SLOVAKIA, SARIO, 2022 https://sario.sk/sites/default/files/sario-chemical-industry-in-slovakia-2022-09-23.pdf

Decarbonisation scenario description

Decarbonisation scenario description

We have briefly described the current status quo of the steel, cement and chemical industries in Slovakia with regards to decarbonisation. This chapter focuses on a description of emissions development in industry. We will utilize a model of greenhouse gas reduction applicable to these industries.

It has two parts. First, we will recall the statistics from the previous chapter and look at the 2050 Pathways Explorer model for Slovakia. We will also mention other models utilized to prepare decarbonisation scenarios in Slovakia and compare them.

In the second part, we will use data from the 2050 Pathways Explorer to focus on the steel, cement and chemical industries, look at the model assumptions and compare them with our assessment of current reality. The decarbonisation scenario will serve as an input for decarbonisation cost calculation.

2050 Pathways Explorer mode

To extrapolate future trends in carbon emission by industry in Slovakia, we will employ the 2050 Pathways Explorer (PE) model. It was developed in 2022 by Climact. PE is a web-based tool which enables the development of national energy transition scenarios based on realistic and transparent assumptions. The exploratory scope encompasses the energy system and its dynamics, all GHG emissions, and the associated resources and socio-economic impacts. The interface enables us to break the general trends into various subgroups, including industry.

The PE model uses Eurostat and IDEES (JRC 2018) databases as a source, amended with national statistics. An important part of the model is represented by "levers", which set the main parameters of the model and can be used to create scenarios.

PE offers a choice of several predefined pathways to 2050 emissions, depending on country. Slovakia has a choice of 4 scenarios (pathways). Slovak historical data were corrected and scenarios prepared by the science team[17] from The Institute for Forecasting (Centre of Social and Psychological Sciences – Slovak Academy of Science).

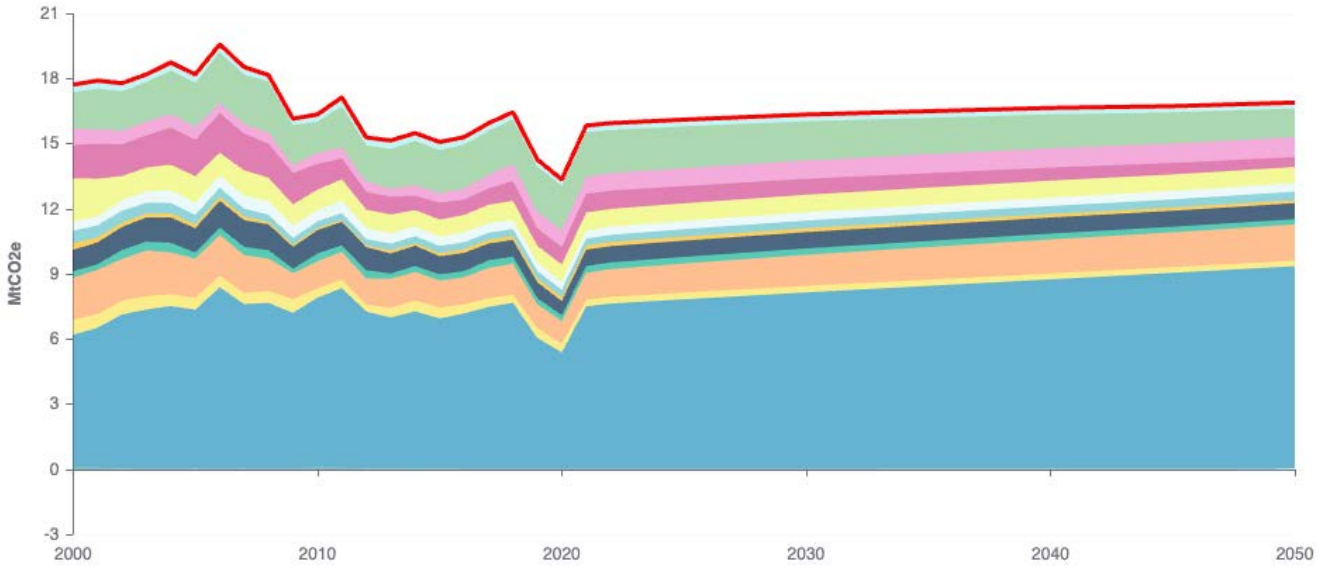
PE Scenarios

The first scenario (predefined pathway) to choose from is "WEM approx.". This is a reference scenario - "With Existing Measures". This scenario mirrors measures implemented until 2016 and it was used in the Integrated national energy and climatic plan for years 2021-2030 (published 2019) and in the Low carbon development strategy of the Slovak Republic until 2030 (published 2020).

This scenario predicts a slight growth in industrial emissions after 2019 up to 2050. The chart (and all the following charts) show the "Industry[18]" subsection of the model.

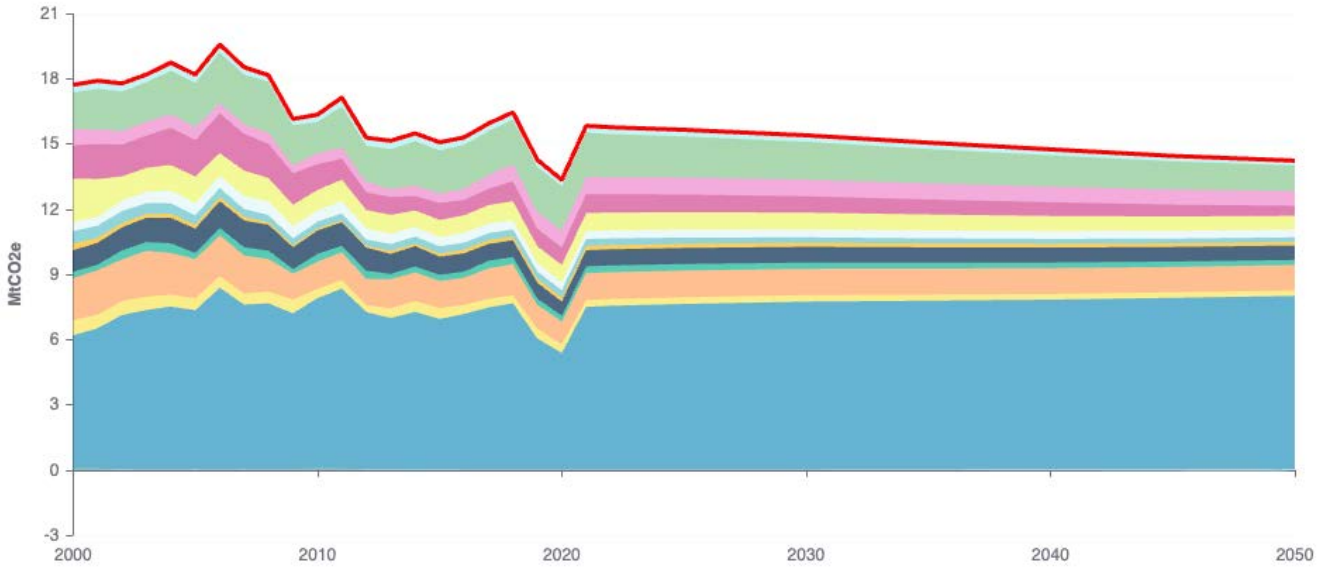
[17] RNDr. Dušana Dokupilová, PhD., Mgr. Richard Filčák, MSc. PhD., Ing. Katarína Korytárová, PhD., Ing. Eduard Nežinský, PhD.
[18] "Industry" does not include oil from refineries, which is included in the "Energy" part of the Pathways model.

Figure 4: PE WEM scenario Source: PE



The second scenario is “WAM approx.”. This model mirrors the “With Additional Measures” scenario introduced also in the previously mentioned Integrated plan and Strategy. The WAM model offers a slight decrease in industrial emissions.

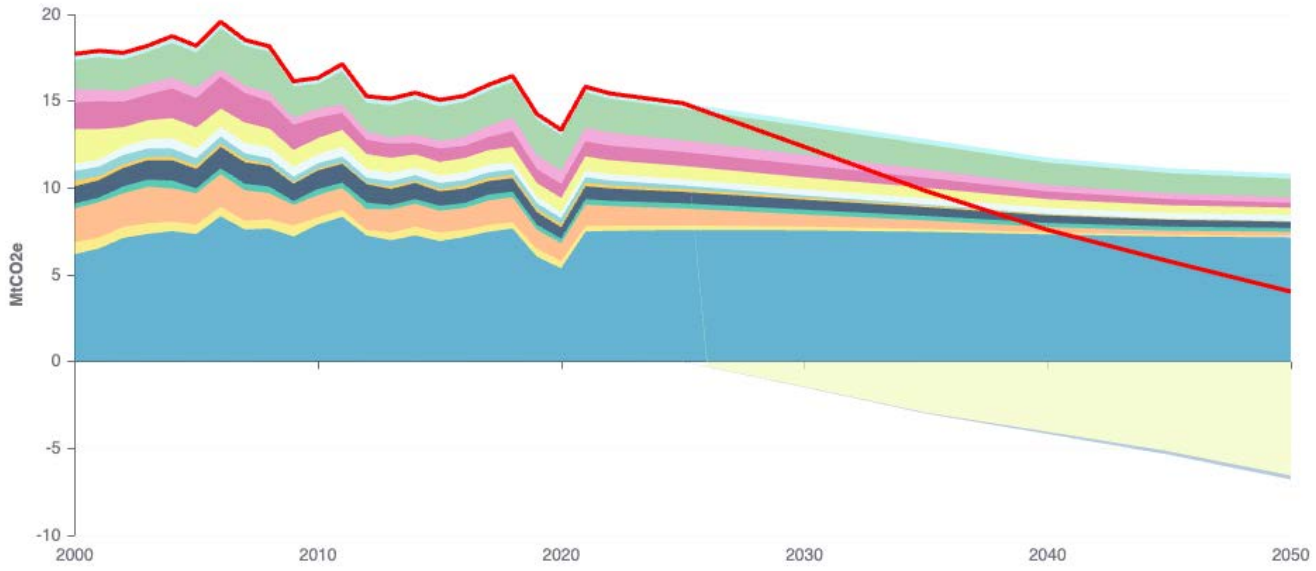
Figure 5: PE WAM scenario Source: PE



The “Zero Emission Scenario” (ZEM) was created by the CSPS team under the ECF project in 2022. The model aims to reach carbon neutrality in 2050. The ZEM scenario bets on faster decarbonisation of industry, buildings and transport, especially through more intensive electrification (in the case of industry and transport) compared to the WAM scenario.

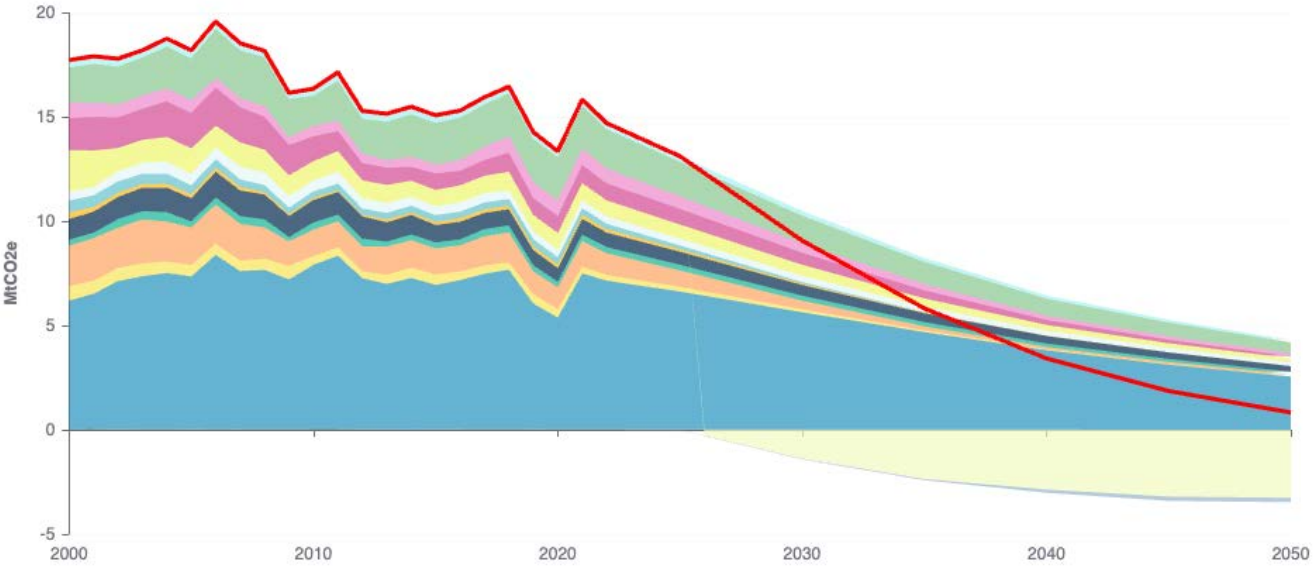
In this scenario, industry should come close to zero emissions in 2050.

Figure 6: PE ZEM scenario Source: PE



The "Ambitious" scenario moves carbon neutrality to the year 2040. Beside numerous other smaller amendments, the main focus is placed on land carbon sequestration.

Figure 7: PE Ambitious scenario Source: PE



There is also a fifth model in progress in Pathways Explorer (EU27 as sum – preliminary Net Zero 2040). We did not consider this model, since it is not finished and its carbon reduction for ETS sectors is less ambitious than the "ambitious" model.

The "Ambitious" scenario is the closest fit to the -62 % target.

Table 7: CO_2 Emissions – Pathways Explorer Scenarios (million tonnes)

		2005	2030	difference		2005	2030	difference
zero model	ETS total	26.4	14.1	-47%	ETS industry	14.7	10.8	2-27%
ambitious model	ETS total	26.4	10.6	-60%	ETS industry	14.7	8.3	-44%
Source: Authors								

It expects the following emission cuts (in million tons) in the sectors of our interest:

Table 8: Expected emission cuts (million tonnes)			
	2005	**2022**	**2030**
Steel	8.1	6.1	4.7
Chemical	2.4	1.3	1.1
other	0.3	0.3	0.3
olefin	0.7	0.4	0.3
ammonia	1.4	0.6	0.5
Cement/lime	2.5	2.6	1.8
cement	1.6	2	1.4
lime	0.9	0.6	0.4
Total	**13**	**10**	**7.6**
Source: PE, authors			

These sectors are also represented in the non-ETS part of the Pathways model. However, the emission decline in the non-ETS part between 2022-2030 is rather small, totalling only -0.3 Mt, all of it in the steel sector. This is important to note with regards of the CAPEX/OPEX numbers. These are not split between ETS and non-ETS sectors in the Pathways model, but we can assume all of them belong to the ETS sector.

PE model limitations

Every model comes with its limitations. These are based on chosen mathematical functions, quality of entry data and quality of assumptions made, when choosing levers. It is important to understand that any results coming from a model have to be taken with some imitations in mind.

We noticed several limitations connected to the PE model.

Linearity. Linear models are good representatives of the gradual implementation of new technologies, or process changes (like gradual introduction of EVs). However, some technological changes result in instant leaps. A good example is the switch of blast furnaces in steel making for a different technology, for example electric arc furnaces. It is not possible to gradually swap the furnace; it is all or nothing. Therefore, the emission change, especially in the case of the steel sector in Slovakia, will come in leaps, if 1, 2 or 3 of the BFs are swapped for a different one. The timing of this swap can substantially influence the entire timing of emission declines.

Technology switch. Cement and chemical industries' answer to decarbonization comes with a spectrum of technological and process changes. There is no "single solution" in these industries. Choosing the right mix of technologies for the model is subjective.

However, in the case of the steel industry it is slightly different. The decarbonisation future of the industry is based on the one technology chosen to replace blast furnaces. The PE Ambitious model scenario for steel expects that the majority of steel production will remain in BFs and

only a small part will be done with the Hisarna process and with Direct reduction with hydrogen. This scenario's assumption is improbable. Firstly, the main technology considered publicly for U.S. Steel is the electric arc furnace. Direct reduction with hydrogen is being alternatively considered for the more distant future. The Hisarna process is not on the table. Although, as mentioned above, this process cannot be gradual, since there are 3 furnaces.

Emission allocation. The model makes a distinction between industry and energy production sectors. In reality, there are some practical problems with allocating emissions to these two categories since there are practical connections between material and energy production at some facilities. There are two notable cases in Slovakia. First, U.S. Steel produces heat, electricity and compressed air utilizing gases generated by the metallurgical processes. If these were not diverted to generate heat and electricity, part of them would be counted towards steel production emissions. A similar situation can be seen at the Slovnaft oil refinery. The refinery has its own oil powered power-plant generating electricity, heat and steam for the whole refinery. The allocation of the power-plant's emissions towards energy generation, oil production and plastic production may not be exact.

Cost estimates. The model makes cost estimates about electricity, biomass etc. Over the past year we have been witnessing very high price variability on the energy markets, including electricity price. The real electricity price in 2030 may be very different from the approximately 70 EUR / MWh level the model assumes.

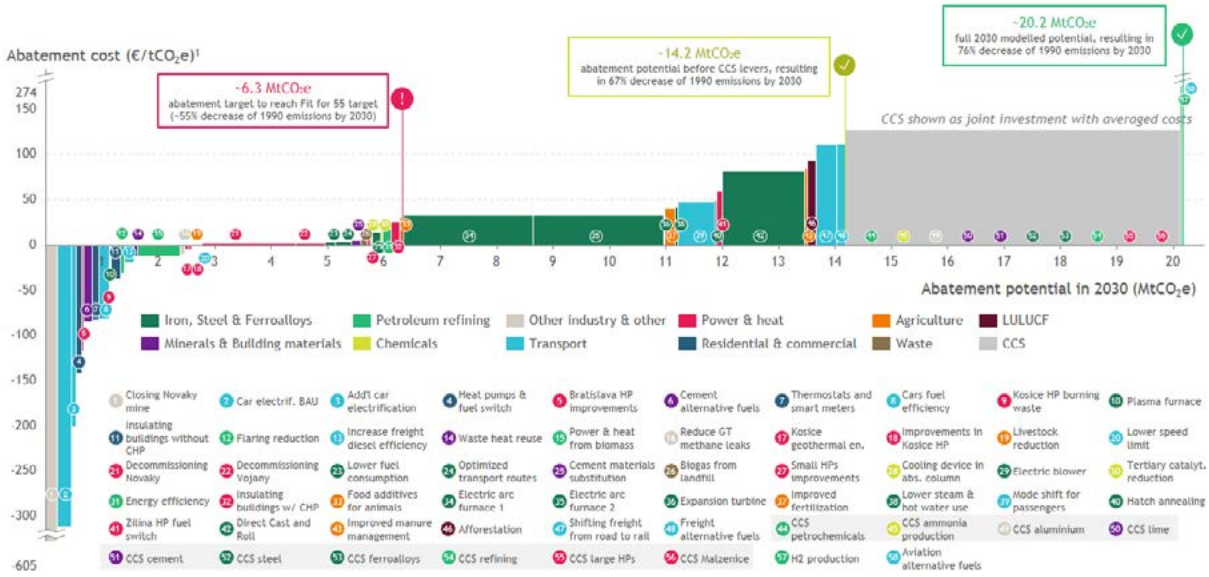
MACC decarbonisation model

Since the PE model presents some challenges, we will introduce one more decarbonisation model used in Slovakia – the MACC model.

To identify the most cost-effective decarbonization pathways, a marginal abatement cost curve (MACC) was constructed for the Slovak economy to 2030 by a team consisting of the Value for Money department (Ministry of Finance), the Institute of Environmental Policy (Ministry of Environment) and Boston Consulting in 2022. MACC compares various decarbonization measures from all sectors of the economy by their price for tCO2e abated, and their abatement potential in 2030. Three emission-reduction goals were identified – 55%, 67%, and 76% based on MACC.

Figure 8: MACC curve

Source: BCG and ÚHP



Note: HP = Heating Plant, CHP = Central Heating Plant (District Heating Plant)
1. NPV of abatement costs until 2030 / NPV of abatement until 2030. CAPEX only includes annualized costs until 2030.

This work contains a list of 58 levers, each with calculated abatements potential and societal cost of these abatements[19]. The net present value of the total cost was calculated as a year-by-year change in expenditure (sum of OPEX and annualized CAPEX), compared to a no technological change scenario. CAPEX was annualized based on the lifetime of the device or the technology (assumed to be 25 years for most industry levers). The change in ETS expenditures was not included in the OPEX.

The model expects the following emission declines in the sectors of our interest:

Table 9: Levers and abatement costs from MACC

Sector	Lever name	abatement (ktCO2e)
Cement	Cement alternative fuels	154
Cement	Waste heat reuse	71
Cement	Cement materials substitution	162
Cement	CCS lime	332
Cement	CCS cement	1559
	Non-CCS Total	387
	CCS	1891
	Total	**2278**
Iron & steel	Iron & steel Plasma Furnace	10
Iron & steel	Lower fuel consumption	194
Iron & steel	Optimized transport routes	285
Iron & steel	Electric blower	147
Iron & steel	Electric arc furnace 1	2039
Iron & steel	Electric arc furnace 2	2039
Iron & steel	Expansion turbine	18
Iron & steel	Lower steam & hot water consumption	51

[19] These can be even positive, for example when coal subsidies are cancelled.

Iron & steel	Hatch annealing	39
Iron & steel	Direct Cast and Roll	1464
Iron & steel	CCS steel	1092
	Non-CCS Total	6826
	CCS	1092
	Total	**7918**
Chemicals	Chemicals Cooling device for absorption column	37
Chemicals	Tertiary catalytic reduction	33
Chemicals	CCS ammonia production	876
	Non-CCS Total	70
	CCS	876
	Total	946
Non-CCS Total		**7283**
CCS		**3859**
Total		**11,142**
Source: UHP		

Even without CCS, the levers provide a -7.2 Mt reduction in emissions in the steel/cement/chemical industries. The overwhelming majority of the reduction is attributed to the steel industry.

It is important to note that emission allocation in this model among sectors is slightly different compared to PE, especially in the steel sector. It attributes around 9 Mt to the steel industry, while PE is only around 6 Mt. This is most probably caused by counting together the steel making process and in-site energy generation (via the Ferroenergy ex-subsidiary, see “PE model limitations” chapter).

Decarbonisation costs for the steel/cement/ chemical industries

Estimating decarbonisation cost is one of the necessary steps for any decarbonisation policy. However, it is an uneasy task. A researcher has to make many assumptions and cope with the number of limitations.

First, a model of decarbonisation is needed, explaining how emission reduction will be spread across sectors and which technologies will provide the decarbonisation. We introduced the PE and MACC models in the previous chapter.

Second, costs need to be assigned to the technologies. The level of technological readiness of these technologies may vary and the market price may be missing. Even when there is a mature market with a certain technology, changes in global demand may influence the existing price.

We will therefore not provide our own calculations, which would be out of the scope of this work, but use CAPEX estimations offered by the Pathways Explorer Ambitious model for Slovakia instead and compare it with CAPEX estimations from the NECP and MACC models.

This PE model provides continuous CAPEX data only up until 2022, then offers data-points in 2025 and 2030. The data did not show any large variations in between years, therefore we filled the missing years linearly, since there was no other way to estimate the data. In reality, CAPEX values would be externally dependent on technology switch timing (see chapter Pathways Explorer model limitations).

Table 10: CAPEX (million EUR) according to PE

	2023	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	
Cement (Dry-Kiln)	17.8	17.4	16.9	16.5	16.1	15.7	15.3	14.9	
Cement (Geopolym)	0.6	0.8	1.0	1.2	1.4	1.5	1.7	1.9	
Cement (Tech)	6.6	6.5	6.4	6.2	6.1	6.0	5.9	5.7	**cement**
Cement (Wet-Kiln)	1.5	1.4	1.3	1.2	1.1	1.1	1.0	0.9	**2023-2030 total**
Total	**26.5**	**26.1**	**25.6**	**25.2**	**24.7**	**24.3**	**23.8**	**23.4**	**199.6**
Chemical (Ammonia)	14.8	14.5	14.3	14.0	13.7	13.4	13.1	12.8	
Chemical (Chlorine)	6.5	6.4	6.3	6.2	6.1	6.0	5.9	5.7	
Chemical (Olefin chemical)	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	
Chemical (Olefin mechanical)	8.2	8.2	8.2	8.1	8.1	8.0	8.0	7.9	
Chemical (Olefin tech)	112.2	110.1	107.9	106.3	104.7	103.0	101.4	99.7	**Chemicals**
Chemical (Other)	53.5	52.5	51.6	50.7	49.7	48.8	47.9	47.0	**2023-2030 total**
Total	**195.3**	**191.8**	**188.3**	**185.3**	**182.3**	**179.2**	**176.2**	**173.2**	**1471.6**

Steel (BF-BOF)	32.3	31.5	30.8	30.1	29.3	28.6	27.9	27.2	
Steel (Hisarna)	0.5	0.7	0.8	0.9	1.1	1.2	1.3	1.4	
Steel (Hydrogen DRI)	0.6	0.8	1.0	1.2	1.4	1.6	1.7	1.9	**Steel**
Steel (Scrap-EAF	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.6	**2023-2030 total**
Total	**35.1**	**34.7**	**34.3**	**33.8**	**33.4**	**33.0**	**32.6**	**32.1**	**269.0**
									2023-2030 total
Total sum	**256.9**	**252.5**	**248.2**	**244.3**	**240.4**	**236.5**	**232.6**	**228.7**	**1940.2**
Source: PE / author calculations									

Total CAPEX for the three sectors is estimated at 1.94 billion EUR in the period 2023 – 2030. As can be seen in the table, 75 % of these costs are attributed to the chemical industry, especially olefin technology. Unfortunately, the model does not provide details for these costs.

Also, especially in the case of the steel industry, CAPEX is attributed to specific technologies. According to the PE model, these technologies are expected to be used mainly after 2030, therefore initial CAPEX is very low. As we explained previously, the expected technology switch path is quite different from the PE model scenario, with different technology (EAF) installed much sooner (before 2030). For these two reasons (disproportionally high share of chemical CAPEX and improbable technology switch in the steel sector), we will use two other sources for CAPEX to benchmark PE results. The first source can be found in the National Energy and Climate Plan - NECP.

Table 11: Investment expenditure according to NECP

Source: NECP/English table from Slovakia's Low Carbon Economy Pathways / GLOBSEC

INVESTMENT EXPENDITURE (IN EUR MILLIONS OVER 5-YEAR PERIODS)								
Industry	**2011-2015**	**2016-2020**	**2021-2025**	**2026-2030**	**2031-2035**	**2036-2040**	**2041-2045**	**2046-2050**
Steel industry	514.73	1114.75	820.15	872.17	914.30	1826.69	1501.54	2076.10
Metallurgy of non-ferrous metals	59.64	146.28	95.70	160.11	87.34	88.92	37.46	61.13
Chemical industry	53.66	489.76	58.15	87.02	81.75	100.48	117.40	138.23
Building materials	34.00	98.75	65.33	108.30	97.05	102.50	141.99	156.77
Paper industry	428.17	689.13	170.21	213.08	133.89	341.11	234.01	591.49
Manufacture of food, beverages and tobacco	25.61	66.85	68.32	129.03	76.25	135.45	93.01	129.17
Engineering	59.18	153.09	123.50	142.64	121.36	224.03	124.78	173.81
Textile industry	6.74	8.62	7.11	8.08	6.82	15.87	8.40	11.70
Other industries	54.46	155.62	87.78	140.17	92.63	100.91	93.43	155.92
Total	1236.18	2922.85	1496.23	1860.60	1611.39	2935.96	2352.02	3494.32

Interestingly, the NECP model assumes substantial investment for the chemical industry only in the 2016-2020 period (NECP was released in December 2019, so the data are partly historical). We will focus only on the sectors of our interest. To fit the starting year 2023, we divided CAPEX for the 2021-2025 period evenly in between the years. We also approximate "building materials" as cement.

Table 12: CAPEX according to NECP			
(million EUR)	**2023 - 2025**	**2026 - 2030**	**total**
Steel	492.1	827.2	**1319.3**
Chemical industry	34.9	87.0	**121.9**
Building materials	39.2	108.3	**147.5**
total	**566.2**	**1022.5**	**1588.7**
Source: NECP / author calculations			

This model arrives at the loosely similar CAPEX total (1.59 billion EUR versus 1.94 billion EUR in PE), albeit with very different CAPEX distribution among sectors. We must remind the readers that the NECP is older and does not include sufficient emission reductions, compared to the PE Ambitious model.

The third option for CAPEX benchmarking comes from the MACC model. It has two important advantages when it comes to cost calculation – it is relatively new (2022) and cost estimation was based on a per technology cost basis. The technology cost data was sourced in the projects, which these companies submitted to the Modernization fund, in media releases and in direct communication with the companies. Also, the total emission reduction in the MACC model is similar to the PE Ambitious model.

The (non-annualized) CAPEX does not include CCS (it is considered OPEX for the source company in the MACC model). The starting year in the study is 2022, but with our 2023 hindsight (no substantial investments from the list were announced in 2022) we can approximate the CAPEX to our period of interest 2023 - 2030.

We have included also the petroleum industry in the overview. The investments listed in the study are focusing mainly on heat/power production from biomass and green hydrogen production. These will be common both for the petroleum refining and chemicals production part of the Slovnaft refinery. Based on the share of plastics and chemicals production on the total production in the Slovnaft refinery (11% according to the 2021 annual report), we can make rough estimation on the chemicals' CAPEX share in the refinery. Important consideration – the refinery technologically cannot make partial investments, so the real CAPEX needs will have to be counted in total number, including the petroleum refining.

Table 13: CAPEX according to the Value for Money Department	
	2023 - 2030
Steel	1426.8
Chemical industry	6.9
Building materials	62.3
Petrochemical industry	487.6
- CAPEX chemicals share	50
total	**1983,6**
Source: CAPEX details from the study published in Impact Assessment of Fit for 55	

With three routes used to estimate CAPEX steel, cement and chemicals decarbonisation, we arrive at a similar total CAPEX for the 2023 – 2030 period:

Table 14: CAPEX comparison	
	2023 – 2030 CAPEX
PE Ambitious scenario	1.94 billion EUR
NECP	1.59 billion EUR
MACC	1.98 billion EUR
Source: Authors	

The PE scenario substantially differs in the sectoral cost share. As explained before, both NECP and MACC are more based on reality when it comes to steel industry cost and vice versa – neither of these two scenarios point to such a high CAPEX for the chemical industry, as suggested by PE. While the case of a higher steel CAPEX can be strongly argued, the case of the chemical industry CAPEX is more difficult. The chemical industry will incur a large CAPEX if it goes into green hydrogen production, especially via costly electrolysers. If green hydrogen is bought from external suppliers, it will influence OPEX. If it is not used at all (reaching the emission target is possible even without green hydrogen use in the chemical industry), the chemical industry's CAPEX will be much more moderate.

With the estimation of decarbonisation CAPEX needs at hand, we will look at the financial opportunities in the next chapter.

Financing available

Financing available

Decarbonisation of industry will require substantial investments. As we demonstrated in the previous chapter, in the case of the steel, cement and chemical industries in Slovakia, we are talking CAPEX in the realm of 2 billion EUR up to 2030.

The financial resources for these investments will come from two sources: public and private. We will have a look at the both possibilities in the following text.

Public resources

Public resources can be further divided into national and international. This division is more about decision-making than about the origin of the available finance, since also domestic public resources are often financed by European resources.

National resource

There have been two main national sources of funding for industrial decarbonisation and some smaller opportunities.

Recovery and Resilience Plan. RRF offers 368 million EUR for decarbonisation, or more precisely 357 million EUR after excluding some auxiliary expenses. The call was opened on 25 November 2022 and closed 20 January 2023. The RRF call asked for modernization or instalment of new technologies, electrification of industrial processes and other investments directly lowering emissions. In June 2023, the results of the call were announced with a total of 317 million EUR allocated to three companies for green investments. The money will be divided among U.S. Steel, receiving 300 million EUR, the cement producer Danucem Slovensko and bricks producer Wienerberger, both of the latter each receiving 8.4 million EUR[20]

Modernization fund. This is a programme from the European Union established in 2020 to support 10 Member States to meet 2030 energy targets by helping modernize energy systems and improve energy efficiency. Since the decision making is largely a national responsibility, we include it in national resources. The Modernization Fund (MF) is funded by the proceeds from emission allowance sales.

According to the Investment strategy of the Modernisation Fund for the years 2021 – 2030[21], the MF budget should reach 2.6 billion EUR. This is based on the assumption that the average ETS price will be 50 EUR per tonne. Given that ETS prices have been higher than 50 EUR for the past two years and reached 100 EUR at the beginning of 2023, the real budget could be substantially higher. Projects focusing on ETS industries should receive 70 % of the budget.

A state aid scheme focused on industry decarbonisation and with an expected budget of 750 million EUR was approved by the EU Commission in autumn 2022. As stated, "The intention of the scheme is to contribute to the reduction of greenhouse gas emissions by supporting industrial decarbonisation projects that will lead to primary energy savings, a reduction in final energy consumption and introduce the use of advanced environmental technologies in industrial production, thus directly supporting the achievement of national target[22]." The call's announcement should come in the first half of 2023. MF has already been

[20] https://spectator.sme.sk/c/23178492/us-steel-kosice-welcomes-300-million-from-recovery-plan-but-needs-more.html
[21] https://www.slov-lex.sk/legislativne-procesy/-/SK/dokumenty/LP-2022-219
[22] https://www.minzp.sk/klima/modernizacny-fond/modernisation-fund/

collecting project proposals and making an indicative list of projects since 2020[23].

MF represents the most direct public source of finance for decarbonisation of industry in Slovakia. Given the total size of its 2021 – 2030 budget, the current decarbonisation budget of 750 million EUR will probably be supplemented with more funds.

European Structural and Investment Funds for the 2021 – 2027 period. The Ministry of Investments, Regional Development and Informatisation of the Slovak Republic (MIRRI), as the manager of European funds, prepared the European Fund investment plan for Slovakia for the years 2021-2027. These are the Partnership Agreement and Operational Program Slovakia. These strategic documents determine how Slovakia will invest EUR 12.6 billion from European sources and the related EUR 3.5 billion of mandatory national co-financing (total EUR 16.3 billion) over the next decade[24].

Environmental objectives are listed within the scope of objective 2 "Green, low-carbon Europe" and are set to improve energy efficiency and RES with the allocation of 4.2 billion EUR from the European Regional and Development Fund (ERDF) and the Cohesion Fund.

However, the current schedule of calls[25] indicates only very limited decarbonisation opportunities for the industrial sectors of our interest. The calls are focusing on increasing energy efficiency and use of RES. Three identified calls focusing on the private sector are worth 130.8 million combined.

R&D tax super-deduction. The Slovak tax code allows a "super-deduction" (200 %) of expenses on research and development. This can be useful to some extent, if investment is connected to R&D.

International Resources

There are also numerous international funding opportunities, which we summarize in the table below[26]. As can be seen, great emphasis is placed on R&D and demonstration projects.

[23] https://www.economy.gov.sk/energetika/modernizacny-fond
[24] https://www.eurofondy.gov.sk/operacny-program-slovensko/index.html
[25] https://www.eurofondy.gov.sk/wp-content/uploads/2023/02/Harmonogram-pl%C3%A1novan%C3%BDch-v%C3%BDziev-Programu-Slovensko-2021-2027_verzia-1.pdf
[26] https://www.estep.eu/assets/Uploads/Funding-Opportunities.pdf

Table 15: International resources Source: GreenSteel

EU Programme	Scope and objective	Funding available in total	Estimation of funding available for decarbonisation of steel	Beneficiaries	Type of action	Blending with other instruments	TRL
Horizon Europe (HEU)	Driving economic growth and creating jobs	€100 B (2021-27)	€80 M (2021-30)	Undertakings and individuals	**R&D&I** RIA, IA, CSA	CSP, RFCS, IF, LIFE	1-9
Clean Steel Partnership (CSP)	Supporting the decarbonization of the steel industry	€700 M (2021-27)	€975 M (2021-30)	Undertakings and individuals	**R&D&I** small-scale demonstration projects	RFCS, HEU, IF, LIFE	5-8
Research Fund for Coal and Steel (RFCS)	Supporting R&I in coal and steel sectors. Projects cover: (I) production processes; (ii) application, utilisation and conversion of resources; (iii) safety at work; (iv) environmental protection; (v) reduction of CO_2 emissions from steel production	€ 40 M per year (€30 M for steel)	€300 M (2021-30)	Undertakings and individuals	**R&D&I** Research projects (up to 60%), pilot and demonstration projects (up to 50%) and accompanying measures (up to 100%)	HEU, CSP, IF, LIFE	3/5-7
Innovation Fund (IF)	Supporting the demonstration of innovative low-carbon technologies and promoting GHG emission avoidance	€10 B (2021-30)	€500 M (for 20 different sectors) (2021-30)	EII, renewable energy, IT	Demonstration & first-of-a-kind big (€>7.5 M) or small (€<7.5 M) projects. Big projects:	HEU, CSP, RFCS, LIFE	7-9
					up to 60% of additional costs related to innovative technologies; small projects: up to 60% of CAPEX		
LIFE	Promoting environment and climate actions	€5.4 B (2021-27)	€50 M (2021-30)	Climate, environment, nature	Demonstration & first-of-a-kind projects	HEU, CSP, RFCS, IF	6-9
European Green Deal Investment Plan (EGDIP)	Helping the most vulnerable regions deal with the socio-economic impacts of the green transition	€503 B (2021-27)	Currently under evaluation at EU level	Climate, environment	Demonstration & first-of-a-kind projects	HEU, CSP, RFCS, IF	7-9

LIFE Programme

The LIFE programme is the EU's instrument for funding environment and climate action, with sub-programmes focusing on, inter alia, climate change mitigation and adaptation, clean energy transition and the circular economy. The programme is not farther elaborated in the roadmap, being only marginally relevant for companies in hard-to-abate industries.

InvestEU

Through the InvestEU Fund, operational since 2022, the InvestEU programme provides guarantees that back implementing partners such as the EIB and the EIF in the direct and intermediated financing of private and public final recipients in targeted investment areas. A dedicated budget of EUR 10.5 bil. allows for providing guarantees of EUR 26.2 bil., which can be leveraged by financial partners to mobilise additional investments of at least EUR 372 bil., by attracting other private and public investors.

The InvestEU Fund targets economically viable projects in four investment areas where there are market failures

or investment gaps, where financing could not be obtained at all or not at the required terms without InvestEU Fund support, and also in higher risk projects:

» Sustainable infrastructure - sustainable energy, digital connectivity, transport, the circular economy, water, waste, other environment infrastructure;
» Research, innovation and digitalisation – taking research results to the market, digitisation of industry, scaling up larger innovative companies, artificial intelligence;
» SMEs - including innovative ones and those operating in the cultural and creative sectors;
» Social investment and skills - education, training, social housing, schools, universities, hospitals, social innovation, healthcare, long-term care and accessibility, microfinance, etc.

InvestEU also supports investments of strategic importance for the EU including Important Projects of Common European Interest, in particular with a view towards green and digital transition, enhanced resilience and strengthening strategic value chains.

Pan-European Guarantee Fund (EGF)

Following the endorsement of the European Council from 23 April 2020 supported by the Ministers of Finance of the EU member states, the European Investment Bank ("EIB") has established the Pan-European Guarantee Fund in response to COVID-19 ("EGF") in the overall volume of EUR 25 billion with expected mobilization of additional investments in a total amount of approximately 200 billion EUR. Mainly small and medium-sized enterprises are to be supported.

Aid is granted under the measures through credit institutions and other financial institutions as financial intermediaries selected by the EIB to provide the financing that is guaranteed by the EGF, including national promotional banks or institutions.

Private resource

The brunt of the decarbonisation investment will be, in most cases, carried by private financial resources, and only supplemented by public resources. In this chapter, we will try to estimate the general capacity for capital investments of the steel, chemical and cement industries.

Such an estimation is facing numerous constraints for obvious reasons. We are focusing on a relatively long term (up to 2030) and on industries which are often very volatile. We have to advise the reader to take our calculations for what they are – a very rough estimation, or rather one theoretical scenario out of several possible future developments.

Methodology

We are using financial data from official company statements, utilizing the business data tool finstat.sk. Since the work was done in March/April 2023 (most – but not all – companies submit their financial results by the end of March), some of the input data come from the 2019-2021 period and some from 2019 – 2022.

Our calculations focus on estimating EBITDA and cash flow for the period up to 2030. This is done by extrapolating financial data using inflation (HICP, industrial production, wage) forecasts. The ultimate goal is to assess the additional CAPEX capacity of each industry,

given as 3x EBITDA in 2026 and cumulative free cash flow in the 2023 – 2029 period.

We also estimated expenditures on emission allowances by extrapolating existing data and applying an assumed phase-out of free allocation and decarbonisation investment in 2026 (bringing emissions down by 50% in 5 years).

In the case of less volatile industries (cement and chemical) we have extrapolated the current trend in sales. In the case of steel, we have calculated a "drop" in the 2017 – 2022 average (based on average production multiplied by average steel price). In the case of the refinery, the sales average for 2019 – 2021 was used.

Companies were broken into several groups:

- Steel is represented by a single company;
- Cement is represented by all three cement producers;
- The chemical industry is sub-divided into three groups:
  a. The refinery (it is not possible to distinguish the financials of the refinery and chemical part);
  b. Chemical companies (NACE 20…) in the ETS scheme;
  c. 15 chemical companies representing 80% of NACE 20.. sales (this includes also the previous category).

Limitations

While some of the sectors (cement) show a certain amount of stability, the steel sector especially is highly volatile and susceptible to business cycles. Our calculation implements a "drop" in average values (as described above), since both 2021 and 2022 were successful due to very high steel prices. However, multiple external factors (recessions, energy crisis, tariffs…) may bring about a substantially different future.

To some extent the situation is similar in the case of the refinery. While its results are slightly less volatile, they are still highly dependent on global fuel market development. Moreover, its future financials may be influenced by any disruptions or sanctions on Russian crude. Therefore, in the case of these two companies, we provide the reader also with another, very simple calculation of debt capacity and cash flow, based on multiplying simple averages. One more important distortion is the "solidarity tax". The tax is in legislative process and it was not definitely approved as of April 2023, but its probability remains significant. If applied, the tax would represent between 400 – 600 million EUR per year.

While the chemical industry is bit more stable than steel or the refinery, there are also some specificities. Some of the companies have long term financial troubles, and their future is dependent on the success of restructuring. Some of the companies have a very narrow product portfolio, which can be influenced by market swings. However, the ETS group consists of 5 companies, which helps to smoothen the results. In the case of the Top 15 group we used only the very simple method of using 2019 – 2021 simple averages, due to its size.

On a more general note – one important question that remains is that of free

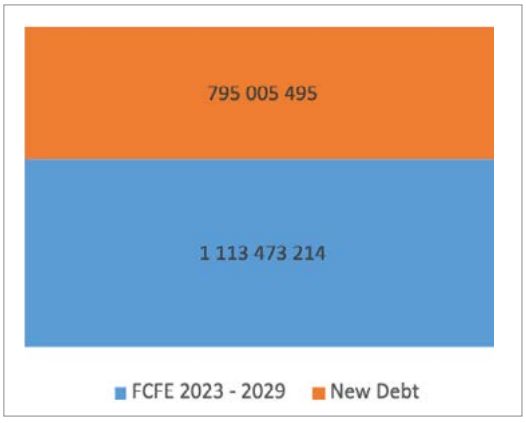
allowances. We have calculated the expected phase out with approximate global parameters. However, the biggest decline in free allowances comes late in 2029 – 2030. Assuming the start of substantial decarbonisation of the companies in 2026, this leaves them with generous savings in the 2026 – 2028 period. But it remains to be answered whether the free allocations will stay in trend on an individual company-by-company basis.

Also, our calculation assumes a constant ratio of operational expenses (purchased material, wages, services) to sales, influenced only by different inflation estimates up to 2025. In reality, each group of operational costs may behave differently.

Results – steel

Represented by a single company with the most volatile results. Our calculations show an almost 800 million EUR capacity for additional debt in 2026 and over 1.1 billion of free cash flow equivalent in the 2023 – 2029 period. This leaves space for some 1.9 billion CAPEX in that period.

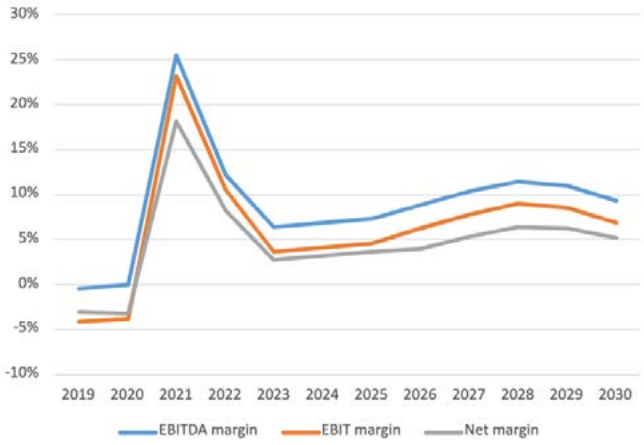
Figure 9: Steel CAPEX capacity Source: Authors



Using simple 5-year averages, the estimation is even more optimistic, resulting in 978 million debt capacity and 1.92 billion cumulative cash flow.

The effect of allowance savings due to investment and the consequent reduction of these savings due to free allocation phase out can be seen in the margin chart.

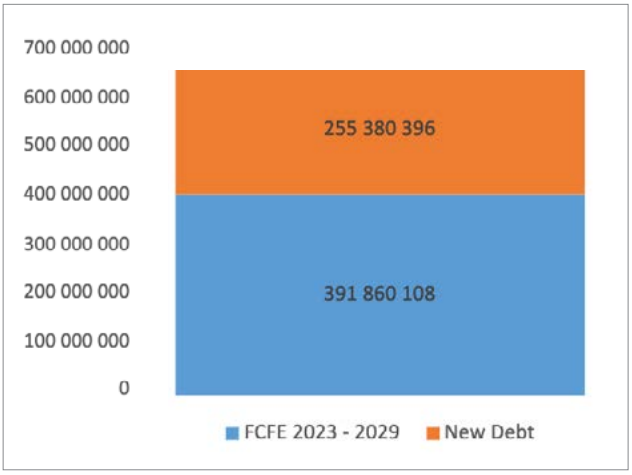
Figure 10: Steel margin Source: Authors



Results – cement

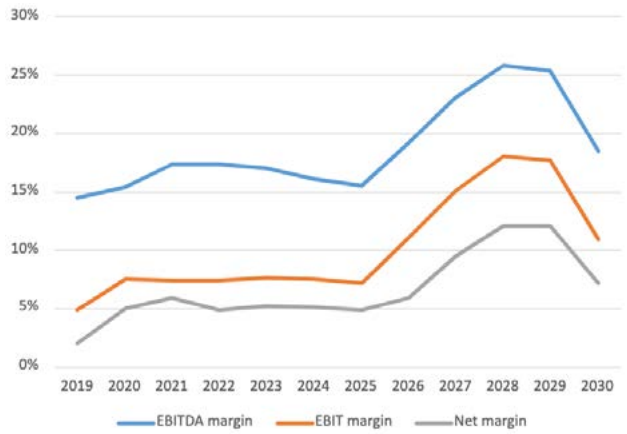
The most stable of the three sectors, all three cement companies reported sales growth even during the pandemic. Our calculations show a -250 million plus new debt capacity and around 390 million free cash flow.

Figure 11: Cement CAPEX capacity Source: Authors



In the case of the cement sector, the financial effect of decarbonisation investment and subsequent free allowances phase out is more pronounced.

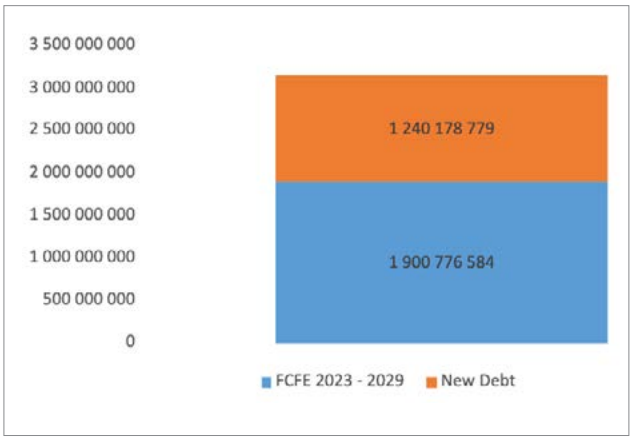
Figure 12: Cement margins Source: GreenSteel



Results – Refinery

As previously mentioned, the Slovnaft refinery was assessed independently as a whole (refinery + petrochemicals).

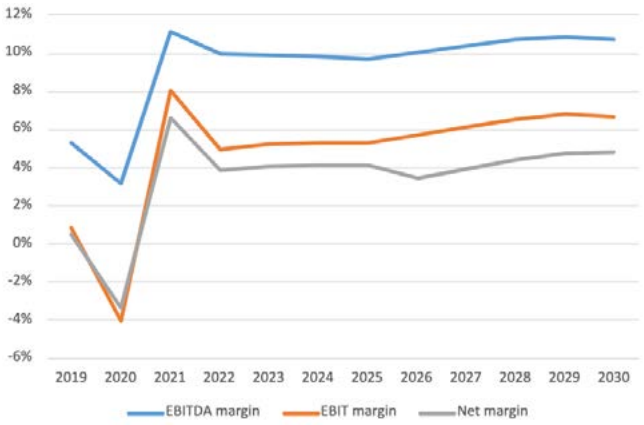
Figure 13: Refinery CAPEX capacity Source: GreenSteel



The result seems rather optimistic, with over 3 billion CAPEX capacity. However, as with the steel sector, the refinery business model is also highly volatile. There are also two uncounted distortions. One of them is the gradual phasing out of Ural crude, which will require substantial CAPEX into technology. The second distortion is the potential introduction of a "solidarity tax", which could eat up several hundred million EUR per year, massively reducing CAPEX capacity.

When using simple averages, debt capacity reaches 752 million EUR and free cash flow 1.75 billion EUR.

Figure 14: Refinery margins Source: GreenSteel

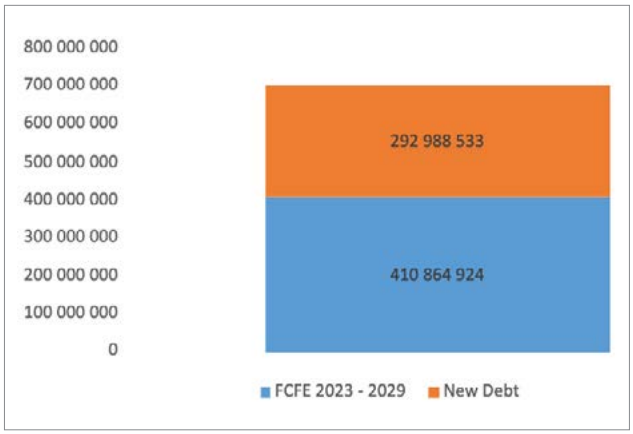


Results – Chemical industry

The chemical industry consists of more diverse companies, producing a wider selection of products. We have focused on those companies which state NACE 20... as their main production. The first group, consisting of 5 companies in the ETS, was studied in detail. A larger group of top 15 companies (with sales reaching over 80% of the NACE 20... companies in 2021) was analysed in a simple way, using 3-year averages. The top 15 group includes the 5 ETS companies.

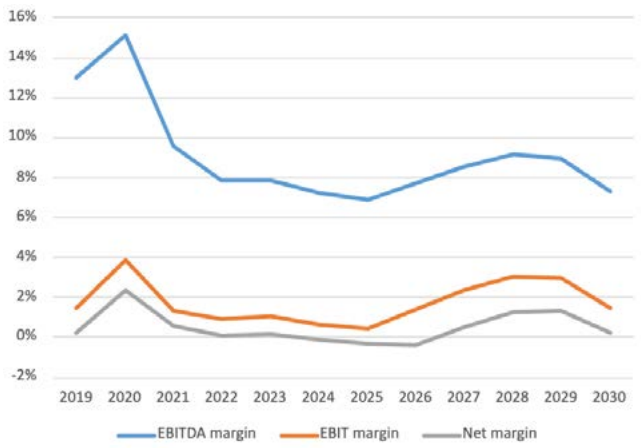
The ETS group shows 700 million CAPEX potential in 2023 – 2029.

Figure 15: Chemical industry CAPEX capacity Source: GreenSteel



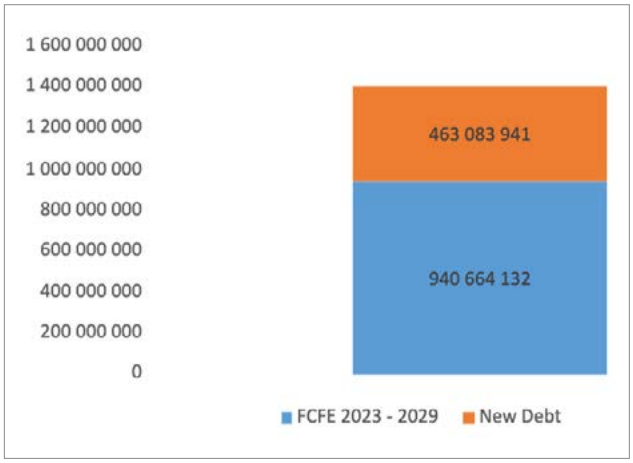
Several companies experienced a steep decline in margins after a successful 2020. It has to be noted that the variety of results in the group of 5 is very broad, with one company being in the negative for several years.

Figure 16: Chemical industry margins Source: Authors



A simple analysis of the Top 15 companies shows a 1.4 billion additional CAPEX capacity.

Figure 17: Chemical industry top 15 CAPEX capacity Source: Authors



Results – overall

In the table below, you can find a summarization of the results.

Table 16: Financing capacity				
Industry	**FCFE 2023 - 2029**	**New debt capacity**	**Total**	**Total (2022 prices)**
Steel	1,113,473,214	795,005,495	1,908,478,709	1,414,094,153
Steel - alternative	1,922,485,600	978,303,600	2,900,789,200	-
Cement	391,860,108	255,380,396	647,240,504	479,819,672
Refinery	1,900,776,584	1,240,178,779	3,140,955,362	2,348,970,906
Refinery - alternative	1,750,236,600	751,825,200	2,502,061,800	
Chemical (ETS)	410,864,924	292,988,533	703,853,457	525,534,490
Chemical (Top 15)	940,664,132	463,083,941	1,403,748,073	
Source: Authors				

We can compare it with the CAPEX table from the previous chapter:

Table 17: CAPEX comparison	
	2023 – 2030 CAPEX
PE Ambitious scenario	1.94 billion EUR
NECP	1.59 billion EUR
MACC	1.98 billion EUR
Source: Authors	

The results of our modelling show a scenario where sectors are financing CAPEX decarbonisation utilizing their free cash flow and debt capacity is a reasonable concept. However, we must remind the reader of all the limitations our work encountered: the financial model is relatively simple, does not account for potential business cycle fluctuations, differences between individual companies, CAPEX requirements for non-decarbonisation investments, and the local and technical feasibility of particular technological solutions. It shall be reiterated that industrial decarbonisation in such a short timespan remains a very ambitious goal, reaching over any industrial sector boundaries.

The ambition of the present work is thus not to provide exact answers, but to provide material for ongoing public discussion about the cost of decarbonisation for the steel, cement and chemical industries and the possible economic paths to reach such goal.

Conclusion

Conclusion

We have briefly described the current status quo in the steel, cement and chemical industries in Slovakia regarding decarbonisation, and we also presented a potential path towards decarbonisation with economic cost allocated.

The Slovak economy is relatively small, compared to other EU members. The majority of industrial emissions are represented by a very small number of companies. Therefore, decarbonisation solutions for industry in Slovakia literally rests on a few possible solutions (electronic arc furnace, biomass combustion, CCS…). This is both positive and negative, because the decarbonisation efforts (and funds) can be tightly focused on a few companies and a few solutions. On the other hand, tight focus creates an "all or nothing" situation, when failure to implement a specific solution will result also in the complete failure of decarbonisation.

The list of available public financial support and the results of our financial modelling for the three crucial industrial sectors allow for a rather optimistic conclusion. Decarbonisation goals seem achievable in these sectors. However, too many simplifications, assumptions and open questions remain in place. Therefore, we encourage all readers to think of this analysis as a stepping stone, which opens further avenues in public discussion about the economic and technical possibilities of industrial decarbonisation in Slovakia and across Europe. The model and calculations were done in early 2023.

When reading this, you probably have access to more recent data, but the year 2030 gets ever closer. Therefore, you can re-evaluate and update our conclusion.

Slovakia 2023