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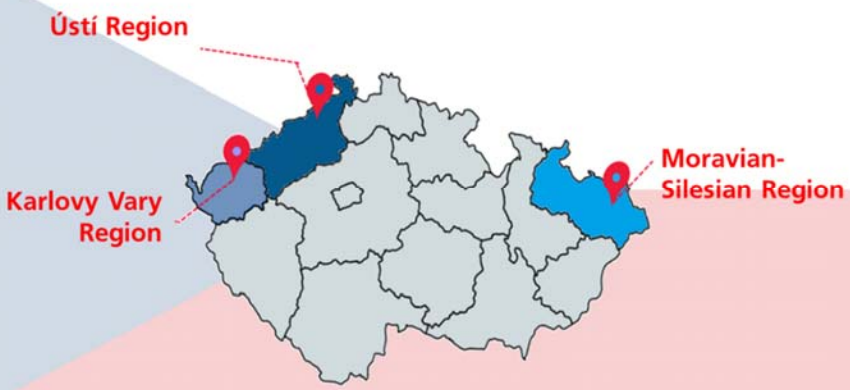

D3. REPORT ON THE TRANSITION PROCESS TOWARDS CLIMATE NEUTRALITY (FINAL)

01.06.2021

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ABBREVIATIONS

AI	Artificial Intelligence
AMECO	Annual Macro-economic database of the European Commission's Directorate General for Economic and Financial Affairs
ARIMA	Auto-Regressive Integrated Moving Average
ARIMAX	Auto-Regressive Integrated Moving Average with extra variables
BAU	Business-As-Usual
bn	Billion
BREF	Best Available Techniques Reference Document
CCGT	Combined Cycle Gas Turbines
CCS	Carbon Capture and Storage
CEDEFOP	European Centre for the Development of Vocational Training
ČEPS	Czech Transmission System Operator
ČEZ	Lignite Power Plants Operator
CF	Cohesion Fund
CGE	Computable General Equilibrium models
CHP	Combined Heat and Power
CMZRB	Czech-Moravian Guarantee and Development Bank
CO2	Carbon Dioxide
CSP	Concentrated Solar Power
CTU	Czech Technical University
CZ	Czech Republic, Czechia
CZ01	NUTS 2 code Prague Region
CZ02	NUTS 2 code Central Bohemia Region
CZ03	NUTS 2code Southwest Region
CZ04	NUTS 2 code Northwest Region
CZ05	NUTS 2 code Northeast Region
CZ08	NUTS 2 code Moravian-Silesian Region
CZ041	NUTS 3 code Karlovy Vary Region
CZ042	NUTS 3 code Ústí Region
CZ080	NUTS 3 code Moravian-Silesian Region
CZK	Czech Crown
CZSO	Czech Statistical Office
D	Deliverable
DH	District Heating
DG	Directorate General
DHW	Domestic Hot Water
DPO	Decarbonisation Pathways Optimizer
DSGE	Dynamic Stochastic General Equilibrium models
E3ME	Dynamic, computer-based, global macroeconomic model
EC	European Commission
EE	Energy Efficiency
EED	Energy Efficiency Directive
EIB	European Investment Bank
ERDF	European Regional Development Fund
ERO	Energy Regulatory Office
ESF	European Social Fund
ESIF	European Structural and Investment Funds
ETS	Emissions Trading System
EU	European Union
EUA	European Union Allowance
EUAA	European Union Aviation Allowance
EUR	Euro
EU-27	European Union Member States – United Kingdom
EU-28	European Union Member States
EV	Electric Vehicles

FEC	Final Energy Consumption
FTT	Future Technology Transformations
G20	Group of Twenty / International Forum
GD	European Green Deal
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GHG	Greenhouse Gas
GVA	Gross Value Added
GW	Gigawatts
ICE	Internal Combustion Engine
ICT	Information and Communication Technology
IEA	International Energy Agency
IGCC	Integrated Gasification Combined Cycle
ILO	International Labour Organization
IMF	International Monetary Fund
IROP	Integrated Regional Operational Programme
ITI	Integrated Territorial Investments
JAK	Jan Amos Komensky Operational Programme
JASPERS	Joint Assistance to Support Projects in European Regions
JTF	Just Transition Fund
JTM	Just Transition Mechanism
JTP	Just Transition Plan
KV / KVK / KVR	Karlovy Vary region
LCOE	Levelized Cost of Energy
LULUCF	Land Use, Land-Use Change and Forestry
MEYS	Ministry of Education, Youth and Sports
MF	Modernisation Fund
MFF	Multiannual Financial Framework
ML	Machine Learning
MoIT	Ministry of Industry and Trade
MoE	Ministry of the Environment
MoLSA	Ministry of Labour and Social Affairs
MoRD	Ministry of Regional Development
MS / MSK / MSR	Moravian-Silesian Region
MW	Megawatts
NACE	Statistical Classification of Economic Activities in the European Community
NECP	National Energy and Climate Plans
NGO	Non-Governmental Organisation
NPV	Net Present Value
NUTS	Nomenclature des Unités Territoriales Statistiques
OECD	Organisation for Economic Co-operation and Development
OP	Operational Programme
OPEC	Organization of the Petroleum Exporting Countries
OPZP	Operational Programme Environment
OPZ+	Operational Programme Employment Plus
PEC	Primary Energy Consumption
PG	Power Generation
PM10	Particulate Matter
PRIMES	EU Energy System Model
PV	Photovoltaic
PWC	Price Waterhouse Coopers
RCA	Regional Policy Common Result Indicators
RCO	Regional Policy Common Output
REP	Regional Energy Policies
RES	Renewable Energy Sources
RfS	Request for Service
RIS	Research and Innovation Strategy
RIS 3	Research and Innovation Strategy for Smart Specialisation

RRF	Recovery and Resilience Facility
RRP	Recovery and Resilience Plan
RTP	Regional Transformation Plan
SC	Steering Committee
SE	Senior Expert
SEP	State Energy Policy
SME	Small and Medium Enterprises
SRSP	Structural Reform Support Programme
START	Secretariat's Technical Assistance to Regions in Transition
TA	Technical Assistance
TACR	Technology Agency of Czech Republic
TJTP	Territorial Just Transition Plan
tn	Trillion
TW	Terawatts
UK	United Kingdom
ULK	Ustí region
US	United States
WEO	World energy Outlook

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EXECUTIVE SUMMARY

This report presents an assessment of the transition process towards climate neutrality in the Czech Republic. The report analyses the extent to which the transition towards climate neutrality has been incorporated into existing strategic documents at the national and regional levels. It evaluates existing documents that assess the investment needs to reach climate neutrality and the planned funding from national and regional programmes. The timeline for key transition steps is also being assessed. The report focuses on the impacts of the transition to climate neutrality both at the national and regional levels.

This report was developed using a mixed methods approach, combining desk research of key strategic documents and relevant literature, quantitative top-down and bottom-up modelling, and a qualitative assessment based on in-depth interviews with stakeholders. It builds on an analysis and recommendations from the Deliverable 2 report, which assessed stakeholder engagement and governance mechanisms. Deliverable 2 serves as a pre-stage for the Deliverable 4 report, which will support the drafting of the Territorial Just Transition Plan (TJTP) of the Czech Republic.

The report starts with introducing the country and is followed by Chapter 2, which examines the progress towards climate neutrality by analysing how climate neutrality is reflected in the main national strategic documents, the expected associated investment needs and the structure of funding to support the transition. Chapter 3 provides our assessment of key transition steps. Chapter 4 evaluates the impacts of the climate neutrality transition at the national level (and whether those impacts are also assessed in Czech strategic documents). Chapter 5 provides a regional analysis of the impacts, both in terms of modelling and qualitative analysis based on interviews with stakeholders. We also assess the regional policy framework. In Chapter 6, we extend the impact analysis to other Czech regions to assess effects on heat production and individual heating in residential sector. Chapter 7 concludes and makes recommendations in several fields.

The key strategic documents of the Czech Republic have not yet fully reflected the transition to climate neutrality. The National Energy and Climate Plan (NECP) was prepared in 2018 and finalised in 2019, i.e., before the EU-wide endorsement for the climate neutrality target. Although the Climate Protection Policy (CPP) aims at 80% CO_2 reduction by 2050, the CPP is an indicative, rather than binding, target. The current State Energy Policy was adopted in 2015 and has been linked to 2020 energy efficiency targets, but it does not incorporate greenhouse gas (GHG) emission reduction targets.

These documents were developed in different periods and have not been clearly interconnected with respect to climate neutrality. It can be reasonably expected that climate neutrality will become the main point of reference in the revisions of these documents. The State Energy Policy is undergoing a revision at the time of writing of this report; the NECP will be revised in 2023.

Investment needs for the climate neutrality transition remain to be fully assessed and tracked. The investment needs (reflecting pathways to decarbonisation) have not been entirely quantified in the main strategic documents. The Climate Protection Policy is the closest in assessing the total investment and operational cost of GHG emissions reductions by estimating the total costs of the GHG reduction scenarios. The scenario closest to climate neutrality estimates total costs of CZK 29–33 trillion (EUR 1.1 – 1.3 trillion) between 2010 and 2050. However, the analysis may have been skewed by the prices of low carbon technologies at the time of report creation. **The National Energy and Climate Plan** is less comprehensive and only assesses investment and operational costs for selected sectors (e.g., renewable and energy efficiency under article 7 of the Energy Efficiency Directive (EED)). The estimates relate to 2030 targets as set by the NECP. Analyses by various consultancies have examined the investment costs of the climate neutrality transition and/or coal phase-out. Investment estimates vary between CZK 1–6 billion (EUR 39-234 million) per year. However, the studies vary in scope and applied methods. Therefore, the comparability of the estimates remains low. The availability of funding to support the climate neutrality transition and the specific conditions of public support programmes are currently being negotiated. Importantly, a system that tracks both public and private sustainable investment in a systematic way should be established at the national level. The EU Taxonomy will be instrumental to develop such a system. Nevertheless, proper implementation in the analysis, evaluation, and decision-making processes will be key for its success at the national and regional level.

The transition steps towards climate neutrality are still to be defined. In December 2020, the Czech Coal Commission recommended the phase-out of coal by 2038. However, given the lack of supporting analysis, the Government has taken note of the date without approving it yet. Thus, it is possible that the final date for the coal phase-out could change to an earlier suggested date of 2033. An earlier phase-

out has also been highly recommended by civil society and environmental groups. The underlying analysis tends to omit some aspects, e.g., infrastructure costs. However, key sectoral players, such as those in the district heating sector, are likely to phase-out coal at an earlier stage due to other factors such as the unavailability of coal, the development of emission allowances, and other factors irrespective of the final governmental decision.

If the national climate transition is carried out in line with the NECP and coal-phase out expectations, it will have a positive impact on employment, the environment, and the economy. Within this context, much of the renewable energy deployment is expected to happen by 2026 and a significant reduction of final energy consumption will take place by 2030 (12% reduction compared to 2015) and an additional CO_2 reduction of 17% to baseline levels taking into account the climate transition of the NECP. This will be accompanied by increased economic activity through the coming decade, driven primarily by investments needed to make the transition inducing increased economic activity in the construction and manufacturing sectors and indirect gains through supply-chain linkages. Nevertheless, an important employment decrease in the energy and utilities sector (which includes coal mining and coal-based power generation) is projected, resulting in the loss of about 3,000 jobs in the sector by 2030. This will be counterbalanced by an employment increase in the manufacturing sector (peaking in 2027 and driven by fabrication of electric components and other components that are necessary to build up the renewable capacity; after 2027 the job growth will be driven by an increase in electromobility) and the construction sector (driven by demand for energy efficiency and related labour, as well as the transition and deployment of renewable sources). By 2030, the overall net effect of the climate transition will be the creation of over 50,000 jobs nationally (compared to the baseline). To realise these positive net effects, there is a need for people to transition to new jobs (by upskilling and re-skilling). However, these new types of jobs do not necessarily have the same value added as the jobs in energy and utilities, which needs to be considered.

The climate transition will have different impacts on the three transition regions. It will have to be borne in mind that existing differences in the socio-economic indicators of the three transition regions exist. For instance, there is a significant gap in R&D institutions, technological readiness, education and healthcare between the Moravian-Silesian, Ústí and Karlovy Vary regions, and the rest of the Czech Republic. However, some indicators in Moravian-Silesian are closer to the Czech average than for the other two regions (Ústí and Karlovy Vary).

Impact on Climate transition by 2030 (compared to the baseline scenario)

Indicators	Czech Republic	Moravian-Silesian region	Ústi region	Karlovy Vary region
CO_2 reduction	-17%	-27%	-28%	-28%
GDP/GVA (for regions)	2.9%	2.2%	0.3%	0.8%
Employment (jobs)	50,000	4,700	2,400	700
Employment in Energy and Utilities sector	-3,000	-900	-1,300	-400
Employment, jobs (baseline vs. 2018)	*0*	*-3,700*	*-12,800*	*-13,200*

Source: Cambridge Econometrics E3ME modelling (2021)

Modelling the regional impacts of climate neutrality to 2030 further illustrates the divergence between the regions. The Moravian-Silesian region is expected to converge with other regions by 2030, though still among the lowest performing regions. By contrast, the modelling shows that without a (properly implemented) Just Transition Mechanism, the Karlovy-Vary and Ústí regions would remain substantially below the Czech average in terms of employment and the gross value added (GVA). These trends are acutely visible for the energy sector, where employment levels are expected to decrease in both regions. Employment rates are expected to grow the fastest in the information and communication sector.

Regional development strategies have mostly reflected the coal phase-out at the technical level. The regional development strategies reflect the coal phase-out commitment and climate transition in the energy sector. They predominantly focus on technical aspects. Less attention is paid to the diversification of regional economies. There is limited attention paid to the social dimension of the Just Transition such as impacts on the job market (especially in older age cohorts and employees with lower qualifications) and the demand for different job profiles and qualifications.

Awareness and engagement can be strengthened. The in-depth interviews and workshops revealed that large companies operating in the region are generally well informed about the Just Transition and have been actively involved in the regional discussion platforms. However, the situation is different for other regional stakeholders. Interviewees and stakeholders from smaller municipalities, SMEs and NGOs generally lack sufficient levels of information on the process and plans of the Just Transition unless they take a proactive approach or are personally represented at the regional government platforms.

The interviewees further suggested that coordination capacities in terms of the transformation process should be substantially strengthened, especially (but not exclusively) in the Northwest region. Stakeholder engagement, activation and a participatory approach will be crucial for the success of the Just Transition. A clear strategic vision to guide the transformation processes and projects is equally needed.

The administrative burden of programmes is perceived as one of the prohibitive factors to deploying such programmes. The administrative burden of previous programmes is perceived as one of the prohibitive factors to deploying such programmes, especially for SMEs. The administrative burden can reach up to 25-30% of eligible project costs. Therefore, the future engagement of these stakeholders in the programmes may be largely influenced by the levels of administrative intensity and entry barriers of such programmes. The continuity and stability of the programmes, as well as clarity on their conditions, will be crucial to ensure full absorption capacity. The administrative intensity of the upcoming programmes should be carefully analysed.

Businesses lack qualified and/or requalified employees. The impact of climate neutrality and the coal phase-out depends on the type of industry. Businesses in the energy sector will be affected the most as demonstrated by the modelling results. All companies participating in interviews to date have expressed their continuous need for qualified and/or requalified employees to implement the new strategies, diversify and upscale the business. The lack of such employees is expected to be amplified by the climate neutrality transition and is perceived as one of the core priorities in the Just Transition, which is expected to increase high value-added business in the regions and possibly amplify this need even further.

The coal phase-out will affect the district heating sector and individual heating in other regions. In the district heating sector, which represents a significantly higher share of heat delivery for households than the EU average, coal phase-out will affect the structure of heat production across Czech Republic. Transformation of the heating sector creates a risk for potential discontinuation of cogeneration and heating plants. Coal plays a significant part in most regional district heating systems. However, according to the district heating companies, the heating systems will be transformed into new technologies and fuels rather than disrupted and discontinued. Therefore, we do not expect large employment impacts.

The effect to the price of heating could be attenuated by the expected investment support for these reconstructions from the Modernisation Fund. The Modernisation Fund has funds from the sale of emission allowances, a total of 193 million will be available for the period 2021-2030. The amount of funds will depend on the price of the emission allowance, currently a total of approximately CZK 150 billion (EUR 6 billion) is expected. Depending on the size of the company and the region, the amount of the subsidy will range from 45 to 80%.

However, companies have invested heavily in reconstruction of existing facilities in recent years comply with the emission limits of conventional emissions (not necessarily focusing on GHG emission reduction) and the depreciation of this type of investment could be an issue. These investments were made with an expected life of the heat source of about 15-20 years and a significant part of the investment has not been written off yet.

Additionally, a significant number of households (approximately 300-340,000) depend on coal used for local space heating despite the massive subsidies in boiler schemes. These subsidy schemes supported coal or coal/biomass boilers at the beginning of the programme.

To transform the heating industry, the Modernisation Fund is likely to be instrumental, together with other complementary sources of support (Recovery and Resilience Facility (RRF) and operational support). Avoiding the lock-in of fossil fuel (natural gas) will be the main challenge. While natural gas will most likely be the short-term solution, the district heating companies should seek to diversify their fuel base as much as possible, diversify the business (e.g., seek to provide energy services), and use modern technologies (e.g., PV, battery systems) to stay competitive and remain on the pathway to climate neutrality. The future of district heating will be the mix of highly efficient cogeneration and direct

electrification using Renewable Energy Sources (RES) (heat pumps, solar collectors). Combined Heat and Power (CHP) systems can also be used for energy storage (power-to-heat technology) to efficiently use surplus electricity from intermittent RES to generate and store heat using large heat pumps. Where possible these systems should be explored and piloted as soon as possible.

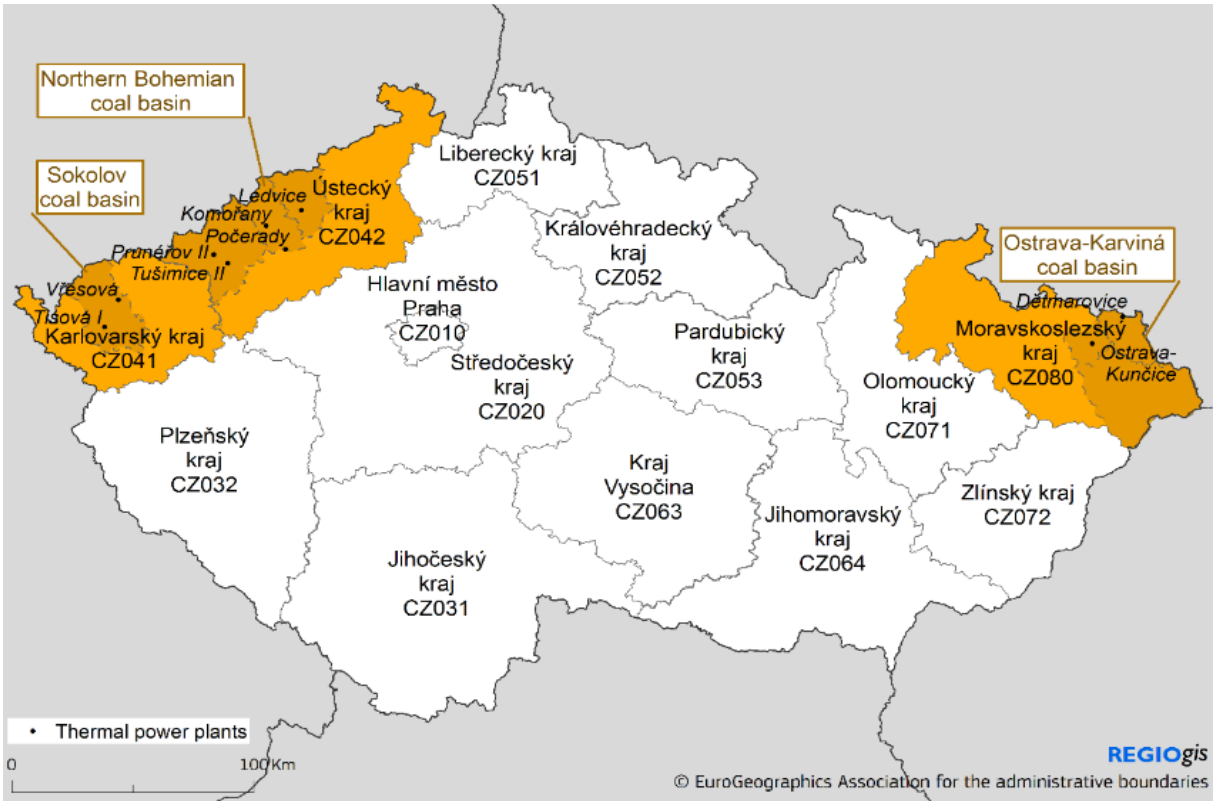
The Czech Republic still has a long way to go to achieve carbon neutrality. In the area of legislation and strategic plans, greater coherence is needed to reconcile future steps. Simultaneously, these steps must be based on specific needs and measures that are already implemented in the regions. The lack of a nationwide coal-phase out deadline creates an uncertainty. However, other factors, such as the prices of emission allowances, driven by strengthened climate and energy targets, will be among the main drivers of further decarbonisation. Socio-economic factors, such as demographic changes, social infrastructure, and enterprise structure differ between the regions, and often even within the regions themselves. The TJTP needs to carefully reflect these aspects and tailor the priority themes and operations accordingly, to form the well-grounded transformation story. The TJTP should emphasize the upskilling, re-skilling, and requalification of workers. Relatedly, the TJTP is encouraged to enhance community building and social infrastructure. Administrative burdens of the programmes should be carefully observed and minimized wherever possible. Providing technical assistance to create project pipeline especially for small stakeholders should go alongside the own preparation of programmes. Stakeholder involvement, activation and a participatory approach will be crucial for the success of the Just Transition.

Please note that this report has been updated after several rounds of comments by multiple stakeholders and contains the latest available quantitative data and information as of June 1, 2021, unless otherwise stated. The upcoming Deliverable 4 (Report on Challenges, Needs and Action Plans for the Most Affected Territories) Deliverable 5 (Final Report) will reflect any development of key issues happening after the cut-off date of this report.

1 COUNTRY INTRODUCTION

The Czech Republic, as a member of the European Union, is committed to the strategic goals set across the EU. The European Commission's annual Country Report under the European Semester is a central document to set the priorities of development reforms and evaluate progress with country-specific recommendations. The 2020 report[1] identifies environmental sustainability as one of five current priorities. Sustainability in the transport and energy sectors, which will soon be connected via electro-mobility, is a top priority. The common denominator of sustainable development is the shift away from fossil fuels, especially coal production. The Czech Republic is currently one of the highest greenhouse gas (GHG) emitters in the EU, in per capita terms, mostly due to reliance on coal.–Phasing out coal production will mainly affect areas where coal mining is a significant economic activity. In the Czech Republic, three regions are particularly reliant on coal mining and energy generation from coal (see Figure 1Figure 1). In order for the Czech Republic to move toward climate neutrality, these regions in particular will have to go through a socially fair transition.

Figure 1 The most affected coal regions in the Czech Republic[2]



The transition is also associated with workforce fluctuations and the required retraining to advance market penetration of more energy efficient and low-carbon technologies and economic activities. The coal mining regions of the Czech Republic include Moravian-Silesian and Severozápad "Northwest" (the latter includes Karlovy Vary and Ústí). Czech coal mining and coal-burning power plants directly employ around 21,000 people and more than 40,000[3] people in total with indirectly connected industries such as the metallurgical industry of iron and steel production in the Moravian-Silesian Region.[4]

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1 European Commission Staff Working Document. Country Report Czechia 2020. Accompanying the document Communication from the Commission to the European Parliament, the European Council, the Council, the European Central Bank and the Eurogroup 2020 European Semester: Assessment of progress on structural reforms, prevention and correction of macroeconomic imbalances, and results of in-depth reviews under Regulation (EU) No 1176/2011 SWD/2020/502 final: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1584543810241&uri=CELEX%3A52020SC0502

2 Ibid.

3 Vazquez-Hernandez, et.al, European Commission, & Joint Research Centre. (2018). EU coal regions opportunities and challenges ahead.

4 European Commission Staff Working Document. Country Report Czechia 2020. Accompanying the document Communication from the Commission to the European Parliament, the European Council, the Council, the European Central Bank and the Eurogroup 2020 European Semester: Assessment of progress on structural reforms, prevention and correction of macroeconomic imbalances, and results of in-depth reviews under Regulation (EU) No 1176/2011 SWD/2020/502 final: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1584543810241&uri=CELEX%3A52020SC0502

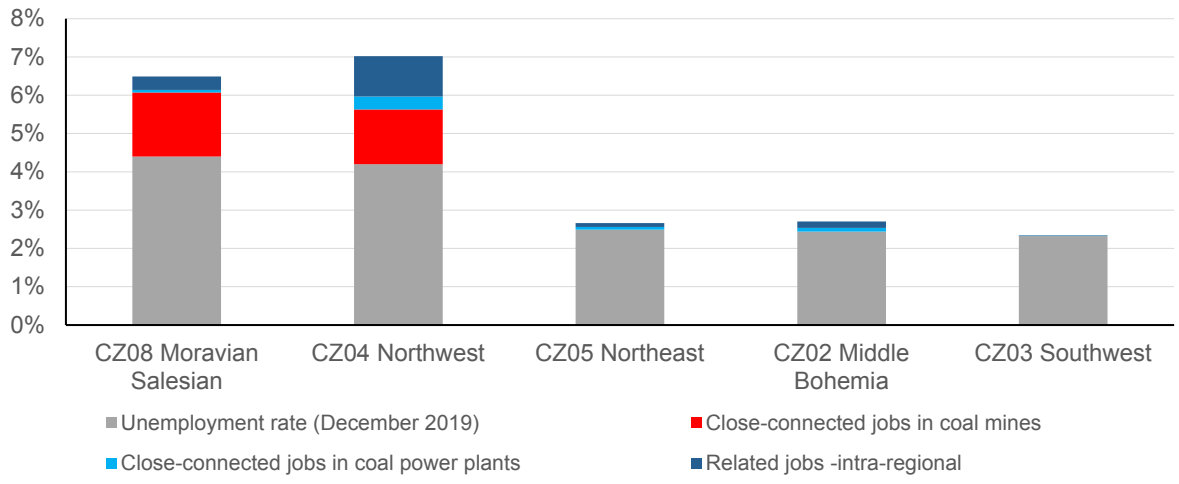
Estimation varies according to the methodology used. For 2018, the Department of Raw Materials Policy of the Ministry of Industry and Trade estimated 22,000 people were employed in total, of which around 4,700 were in the subcontracting sector[5]. The impact of coal phase-out on related jobs differs from each study. According to an EU study that estimates a greater impact on related sectors than MID, regional unemployment may increase by one percent (see Table 1). Exit or a transition from the coal industry is associated with a challenge in the form of retraining the workforce concerning technological progress. The coal regions already have higher levels of unemployment, poverty, indebtedness, and early school leaving than the national average (Graph 1).

Table 1 Assumption of total employees affected with phase-out of coal and increase in employment[6]

NUTS2		CZ02	CZ03	CZ04		CZ05	CZ08	Regional/ inter-regional Total
Region		Central Bohemia	South west	Northwest		Northeast	Moravian SilesianSilesian	
				Karlovy Vary	Ústí			
Unemployment rate (Dec2019)		2,4%	2,3%	4,2%	2,5%	2,5%	4,4%	x
Connected jobs	Jobs in coal mines	0	0	3 000	4 869	0	10 131	18 000
		+0,0%	+0,0%	1,9%	1,2%	+0,0%	+1,7%	
	Jobs in coal power plants	661	59	1 000	1 862	550	423	3 555
		+0,1%	+0,0%	0,6%	0,5%	+0,1%	+0,1%	
Related jobs	Regional jobs	1 213	85	5 843*		759	2 118	10 018
		+0,2%	+0,0%	+1,1%*		+0,1%	+0,3%	
	With inter-regional jobs	3 069	163	10 310*		1 847	3 840	19 229
Total regional impact		1 874	144	15 574*		1 309	12 672	31 573/ 40 784
		+0,3%	0,0%	+2,8%*		+0,2%	+2,1%	

* NUTS2 differentiation

Graph 1 Unemployment rates and jobs in coal mines[7]



Moravian Silesian is the largest region of hard coal mining in the Czech Republic (28% of the total area of the region is part of the Ostrava-Karviná Coal Basin and half of the regional inhabitants, some 600,000 people live there).

In the Karlovy Vary region, there are two lignite mines operated by the largest regional employer in the Sokolov district. The company creates 3,000 jobs in a region that has the highest number of Socially

[5] Ministry of Industry and Trade. 2019. Mining and quarrying in the Czech Republic and employment in the mining sector: https://www.mpo.cz/cz/stavebnictvi-a-suroviny/surovinova-politika/statni-surovinova-politika-nerostne-suroviny-v-cr/tezba-nerostnych-surovin-v-ceske-republice-a-zamestnanost-v-tezebnim-sektoru--248701/

[6] Vazquez-Hernandez, et.al, European Commission, & Joint Research Centre. (2018). EU coal regions opportunities and challenges ahead and Statistical Yearbooks of the regions 2020, Czech statistical data https://www.czso.cz/csu/czso/home

[7] Ibid.

Excluded Localities[8] and the lowest GDP per capita in the Czech Republic. Brown coal from the Sokolov area is mainly used for energy and heat production where another 1,000 jobs might be affected by the transition.

Nearly 80% of the Czech Republic's brown coal is mined in the Ústí Region (North Bohemian Coal Basin), where more than 5,000 jobs are related to coal mining. Direct employment in brown coal mining represents 11.4% of total employment in the Ústí Region. The Ústí region has four coal mines and the largest Czech coal-fired power plants (Prunéřov, Tušimice, Ledvice and Počerady), which provide about 20% of the total electricity produced in the Czech Republic. Ústí region is also specific to many related industries with high energy intensity (steam, heat, and electricity), the production of chemicals and preparations, the production of other non-metallic mineral products, and the production of paper and paper products.[9]

The transformation of energy-intensive industries, which are indispensable for the European economy, is also mentioned in the EU Green Deal Communication on Framework Measures for the Decarbonisation of Europe. Decarbonisation, modernisation, and maintenance of the EU energy sector is essential. Transforming the energy industry will change the composition of coal region economies and ways of life. In the national economy framework, transformation can be the subject of the search for new energy sources, new regulations that force companies into new strategies to a carbon-neutral economy. While all mentioned regions still strongly depend on the mining sector, they are at various stages of transition to a zero-emission economy. Since 2015, the transformation process has been supported by a specific government resolution called the Strategic Framework for Economic Restructuring (RE:START strategy) which outlines a wide variety of measures to prepare for the transition. To this end, the Coal Commission, an advisory body of the Czech government, was established in 2019.[10]

[8] GAC spol. s.r.o. Analysis of Socially Excluded Localities in the Czech Republic, May 2015
[9] Investment Guidance on Just Transition Fund 2021-2027 for Czechia_ Annex D
[10] Developed on further in Chapter 3 mainly.

2 PROGRESS TOWARDS CLIMATE NEUTRALITY

2.1 Policy framework

This chapter examines the key Czech strategic documents related to energy and climate to assess the progress towards climate neutrality. In addition, the Country Report on the Czech Republic 2020 and the report by McKinsey assessing the pathway to carbon neutrality in the Czech Republic[11] have been added to complement the analysis. The analysed documents are summarised in Table 2.

Table 2 Strategic and expert documents related to energy and climate

National strategic documents	European Commission report	Expert documents
National Energy and Climate Plan (NECP)[12] (2019) State Environmental Policy (SEP) of the Czech Republic 2030[13] (2021) State Energy Policy[14] (2015) Climate Protection Policy in the Czech Republic[15] (2017) Strategy of adaptation to climate change in the Czech Republic conditions[16] (2015)	Country Report on the Czech Republic 2020[17] (2020)	McKinsey report assessing the pathway to carbon neutrality in the Czech Republic[18] (2020)

It must be emphasised that neither the NECP, nor any of the other national strategy and policy documents (adopted or in draft stage) we revised envisage any clear target date for climate neutrality or coal phase-out. We therefore review the following strategic documents from the perspective of how they approach climate mitigation and what specific targets have been set.

The Czech Republic's **National Energy and Climate Plan (NECP)**[19] was prepared as required by Regulation 2018/1999 of the European Parliament and the Council on the governance of the Energy Union and climate action and contains objectives and policies in all five dimensions of the Energy Union for the period 2021-2030 with a view to 2050. An important part of the NECP is to set the Czech Republic's contribution to the European climate and energy objectives to reduce emissions, increase the share of renewable energy sources, and increase energy efficiency. The NECP proceeds from two

[11] McKinsey and Co. 2020. Pathways to decarbonize the Czech Republic: https://www.mckinsey.com/cz/our-work/pathways-to-decarbonize-the-czech-republic

[12] National Energy and Climate Plan of the Czech Republic, https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf

[13] Státní politika životního prostředí České republiky 2030 s výhledem do 2050 [State Environmental Policy of the Czech Republic in 2030 with the view to 2050]] (https://www.mzp.cz/C1257458002F0DC7/cz/news_20200710_statni_politika_zivotniho_prostredi_2030/$FILE/OPZPUR-statni_politika_zp_2030_s_vyhledem_2050-20210111SPZP_2030_pro_verejnou_konzultaci-20200710.pdf)

[14] Doplňující analytický materiál k návrhu aktualizace Státní energetické koncepce [Additional analytical material to the draft update of the State Energy Policy] https://www.mpo.cz/assets/cz/energetika/statni-energeticka-politika/2016/12/Doplnujici-analyticky-material-k-SEK.pdf

[15] Politika ochrany klimatu v ČR [Climate Protection Policy of the Czech Republic] (https://www.mzp.cz/C1257458002F0DC7/cz/politika_ochrany_klimatu_2017/$FILE/OEOK-POK-20170329.pdf)

[16] Strategie přizpůsobení se změně klimatu v podmínkách ČR [Strategy for Adaptation to Climate Change in the Czech Republic] (https://www.mzp.cz/C1257458002F0DC7/cz/zmena_klimatu_adaptacni_strategie/$FILE/OEOK-Adaptacni_strategie-20151029.pdf)

[17] Zpráva o České republice 2020 - Průvodní dokument k Sdělení Komise Evropskému Parlamentu, Evropské Radě, Radě, Evropské Centrální Bance A Euroskupině [Report on the Czech Republic 2020 - Accompanying document to the Communication from the Commission to the European Parliament, the European Council, the Council, the European Central Bank and the Euro Group]

[18] Hanzlík, V., Javůrek, V., Smeets, B.,Svoboda, D. 2020. Klimaticky neutrální Česko. Cesty k dekarbonizaci ekonomiky [Climate neutral Czechia. The paths towards decarburization of the economy]. McKinsey & Company. https://www.mckinsey.com/cz/~/media/mckinsey/locations/europe%20and%20middle%20east/czech%20republic/our%20work/decarbonization_report_cz_vf.pdf

[19] National Energy and Climate Plan of the Czech Republic, https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf

primary strategic documents: (1) the State Energy Policy of the Czech Republic, approved in 2015 and (2) the Climate protection policies in the Czech Republic approved in 2017.

To reduce greenhouse gas emissions, the NECP mentions a European-wide target of a 43% reduction in greenhouse gas emissions by 2030 compared to 2005 in sectors covered by the Emissions Trading Scheme (EU ETS) and 30% in sectors outside the EU ETS. The Czech Republic's aim is to reduce total greenhouse gas emissions by 30% by 2030 compared to 2005, which corresponds to a reduction in emissions of 44 million tonnes of CO_2eq. The NECP also contains long-term indicative targets for 2050 based on the approved Climate Protection Policy. According to the emission projections, greenhouse gas emissions will fall to 34% (compared to 2005) when the policies and measures contained in the National Plan are met. In terms of reducing greenhouse gas emissions, reducing health risks emissions to air is considered as a priority and consistent issue. Reducing greenhouse gas emissions includes reducing and ending the use of local heating plants and stoves in households that burn coal. Furthermore, the plan aims to reduce the emissions of risk substances (PAH) from burning wet wood and increasing buildings' energy efficiency.

Decarbonisation, which is also discussed by the NECP, also covers renewable energy sources (RES). A European-wide target of 32% RES in gross final energy consumption by 2030 has been established. The Czech Republic proposes a contribution to the European target of 22% by 2030, an increase of 9% compared to the Czech Republic's national target of 13% for 2020. The proposed average annual growth in the share of RES in the heating and cooling sector corresponds to 1%. The main policies to fulfil the proposed contribution include the policies enshrined in the draft amendment to Act No. 165/2012 Coll., on Supported Energy Sources, which sets a new scheme to support RES and supported sources after 2020. However, this proposal has not yet undergone a complete legislative process.

The NECP emphasizes carbon neutrality in the land use and forestry (LULUCF) sectors. Regarding the LULUCF sector and carbon neutrality, the NECP maintains that there will be a temporary increase in CO_2 from forestry in the coming years. The changes will come due to the unexpected felling of trees related to the elimination of the bark beetle calamity[20].

From an energy efficiency perspective for the period 2021-2030, the NECP mentions three objectives:

1) individual target for the size of primary energy sources, final consumption and energy intensity;
2) a required target for energy savings in public sector buildings; and,
3) a required annual rate of final consumption savings.

The Czech Republic's targets a level of 1,735 PJ for primary energy sources, with final consumption at a level of 990 PJ and energy intensity of GDP at a level of 0.157 MJ/CZK in 2030 (The Czech Republic has prioritised a goal expressed by the energy intensity of GDP). Based on the assumption of energy intensity of central institution buildings in 2020, the Czech Republic set a commitment by the Energy Efficiency Directive rules to achieve energy savings in institutional buildings in the amount of 124 TJ. Furthermore, a cumulative energy savings commitment of 462 PJ was established based on available EUROSTAT data and consumption forecasts for 2018 and 2019[21].

The **State Environmental Policy (SEP) of the Czech Republic 2030**[22] mentions that the Czech Republic aims to move towards a climate-neutral economy (see Table 3). The precondition for achieving a climate-neutral economy is the transition to low-emission and renewable energy sources and reducing overall energy consumption by increasing energy efficiency.

External influences such as socio-demographic development, economic development, and global pressures were considered in the SEP compilation. The SEP also considered the Environmental Protection Act, the principles of sustainable development stated in the "Strategic Framework of the Czech Republic 2030" legislative documents of the national and supranational level, and other strategic documents. Efforts to maintain sufficient legal protection of the environment are expected to continue in

[20] The bark beetle calamity (i.e. the bark beetle attacking the mainly spruce trees) began already in early 2000s. However, in 2019 in hit the Czech forests especially hard. Due to this, the Czech landscape will face its fundamental transformation in the next few years. According to the Czech Forest study, less than half of the original spruce forests will remain after 2021. This has vast implications at the ecosystems, water management, and also biomass for energy development. https://echo24.cz/a/SQjfD/kurovcova-kalamita-je-jiz-nezastavitelna-do-roku-2021-prijdeme-o-pulku-puvodnich-smrku, https://ekolist.cz/cz/zpravodajstvi/zpravy/kurovcova-kalamita-se-dale-siri.prichazi-cas-kdy-je-mozne-ji-zbrzdit.lesnici-radi-jak

[21] We then use the NECP as one of the main reference points for the assessment of investment needs to assess climate neutrality transition in Chapter 2.2.

[22] Státní politika životního prostředí České republiky 2030 s výhledem do 2050 [State Environmental Policy of the Czech Republic in 2030 with the view to 2050] (https://www.mzp.cz/C1257458002F0DC7/cz/news_20200710_statni_politika_zivotniho_prostredi_2030/$FILE/OPZPUR-SPZP_2030_pro_verejnou_konzultaci-20200710.pdf)

the future. The SEP provides information on long-term climate neutrality objectives to 2050, which was officially supported at the EU level by the European Council in December 2019.

The SEP document ascertains that the transition to a low-carbon economy brings several changes (technological, administrative, and legislative) that can have significant social and economic impacts. Society needs to be prepared for these changes. The development of new innovative industries should be reflected in the labour market and thus in education as well. From the objectives in the section on reducing emission production and the objectives of approaching climate neutrality point of view, the state environmental policy of the Czech Republic 2030 with a view to 2050 correlates with objectives defined in the document climate protection policy in the Czech Republic. To achieve climate neutrality, the documents acknowledge that it will be necessary to reduce greenhouse gas emissions in the public and the private sectors. In addition to changes in energy, industry and agriculture, a transformational change in society is also essential. Societal change can achieve a drastic reduction in the carbon footprint through responsible consumer behaviour.

The SEP also reflects the structure of Directive measures of the European Parliament and the 2012/27/EU Council, which was introduced to promote energy efficiency in the EU (The national target and the related values for reducing final energy consumption have already been mentioned in the NECP[23] section). The SEP document mentions that in addition to investments in research, development and product standards, subsidies for newly emerging environmentally friendly technologies and their implementation will play a key role in reducing greenhouse gas emissions. However, measures such as improving the efficiency of energy transformations of fuels, introducing new materials and other technical solutions will not be sufficient to meet the EU's emissions and sustainability targets.

Table 3 Strategic objectives 2030 State Environmental Policy (SEP)

Strategic Objectives 2030	Specific objectives	Priority
Reducing greenhouse gas emissions	reduction of greenhouse gas emissions	1
	increase energy efficiency	1
	increase in the use of renewable energy sources	2
Ensuring economic management of raw materials, products and waste in the Czech Republic	maximum waste prevention	1
	compliance with waste management methods	1
	reduce the economy material intensity	2

The Climate Protection Policy in the Czech Republic[24] reflects the views of the Czech government and determines the primary objectives of the Czech Republic in the field of climate protection by 2050. It therefore represents the long-term strategy for the low-carbon development of the Czech Republic. The climate protection policy takes a proactive stance, and concerns the following areas in particular: energy, final energy consumption, industry, transport, agriculture and forestry, waste management, science, research and voluntary instruments, and specific measures and tools for the gradual reduction of greenhouse gas emissions.

The climate protection policy proposes effective and efficient measures, including their contribution to reduce greenhouse gas emissions by 2030 and describes the trajectories that lead to a low-carbon economy by 2050. The policy does not replace other sectoral national policies and strategies. Rather, it complements and develops them appropriately.

[23] National Energy and Climate Plan of the Czech Republic, https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf

[24] Politika ochrany klimatu v ČR [Climate Protection Policy of the Czech Republic] (https://www.mzp.cz/C1257458002F0DC7/cz/politika_ochrany_klimatu_2017/$FILE/OEOK-POK-20170329.pdf)

The main purpose of the Climate Protection Policy is to determine a suitable mix of cost-effective measures and tools in key sectors that will lead to the achievement of the Czech Republic's greenhouse gas emissions objectives as follows:

- Reduce the Czech Republic's emissions by at least 32 Mt CO_2eq by 2020, compared to 2005
- Reduce the Czech Republic's emissions by at least 44 Mt CO_2eq by 2030 compared to 2005

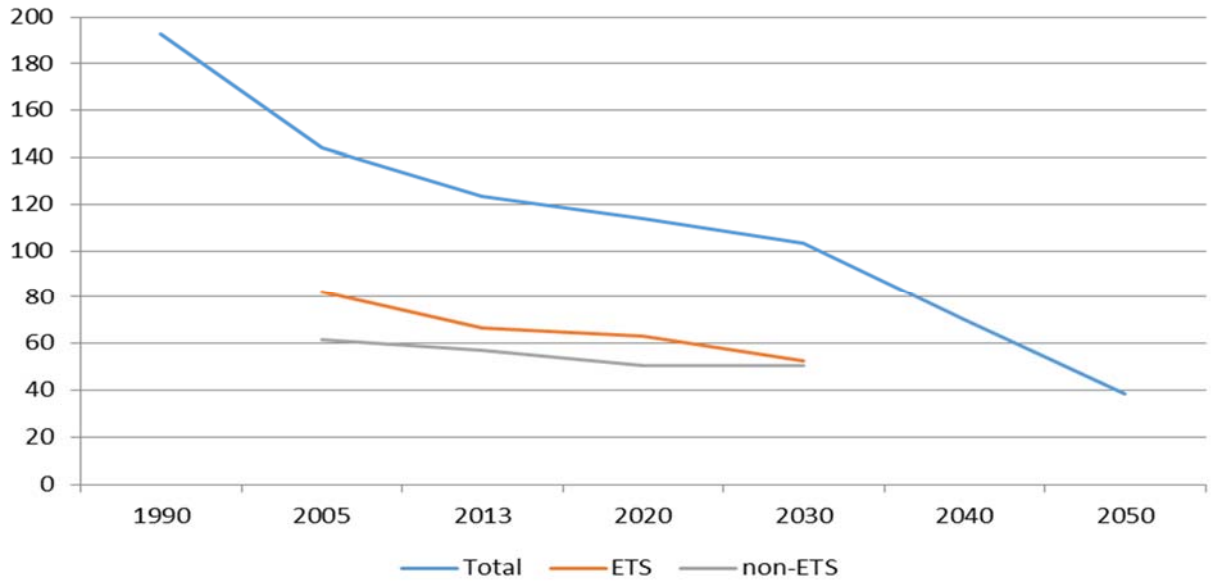
Long-term indicative goals of the Climate Protection Policy in the Czech Republic are:

- Move towards an indicative level of 70 Mt CO_2eq. emissions by 2040
- Move towards an indicative level of 39 Mt CO_2eq. emissions by 2050

The Climate Protection Policy considers existing commitments to the EU, which specify that greenhouse gas emissions need to be reduced by 20% by 2020, and at least 40% by 2030 compared to 1990.

Fulfilling the emission reduction targets for 2020 and 2030 is further implemented through European legislation for emissions covered by the EU ETS and sectors outside the EU ETS. In the long run, the EU plans to achieve the transition to a low-carbon economy. Achievement of the low-carbon economy also correlates with reducing greenhouse gas emissions by 80-95% by 2050 compared to 1990.The Czech Climate Protection Policy respects three basic levels of needs and requirements in climate protection, i.e., at the national level and in the context of European and international policy. Graph 2 presents illustrative trajectories of CO_{2eq} reduction as expected in the Climate Protection Policy[25].

Graph 2 Illustrative trajectories of reducing emissions (in millions of tonnes of CO2eq.) of greenhouse gases by 2050



The ***Strategy of adaptation to climate change in the Czech Republic conditions***[26] focuses on climate change benefits globally. However, it does not address climate neutrality, nor the steps and objectives that need to be taken to achieve it (see Table 4).

The Country Report on the Czech Republic 2020[27] is one of the key strategic documents of the European Commission towards Member States to assess their progress on structural reforms, and prevention and correction of macroeconomic imbalances. The report expresses doubts about the methods to achieve climate neutrality in the Czech Republic. The document indicates that it will be difficult for the Czech Republic to achieve climate neutrality and abandon solid fossil fuels. The Czech

[25] Politika ochrany klimatu v ČR [Climate Protection Policy of the Czech Republic] (https://www.mzp.cz/C1257458002F0DC7/cz/politika_ochrany_klimatu_2017/$FILE/OEOK-POK-20170329.pdf)

[26] Ministry of Environment. 2015. Strategie přizpůsobení se změně klimatu v podmínkách ČR [Strategy for adaptation to climate change in the Czech Republic conditions]: https://www.mzp.cz/C1257458002F0DC7/cz/zmena_klimatu_adaptacni_strategie/$FILE/OEOK-Adaptacni_strategie-20151029.pdf

[27] Zpráva o České republice 2020 - Průvodní dokument k Sdělení Komise Evropskému Parlamentu, Evropské Radě, Radě, Evropské Centrální Bance A Euroskupině [Report On The Czech Republic 2020 - Accompanying Document To The Communication From The Commission To The European Parliament, The European Council, The Council, The European Central Bank And The Euro Group]

Republic is still dependent on solid fossil fuels with high CO_2 emissions. It is expected that the diversion from coal in the Czech Republic will primarily have an impact on regions where the mining industry still plays an important role. The use of low-carbon technologies may facilitate this change, but ambitions to invest in them remain low.

Table 4 The Czech Republic's reducing targets of greenhouse gas emissions.

Czech strategic document	NECP[28]	SEP[29]	Climate Protection Policy in the Czech Republic[30]
reduction in greenhouse gas emissions by 2030 compared to 2005 (**EU ETS**)	**43%**	**43%**	**43%**
reduction in greenhouse gas emissions by 2030 compared to 2005 (**outside the EU ETS**)	**30%**	**30%**	**30%**
total greenhouse gas emissions by 2030 compared to 2005	**30%**	-	**30%** (Correlates with 44 million tonnes of CO_2)
total greenhouse gas emissions by 2030 compared to 1990	-	**40%**	**40%** (Correlates with 76 million tonnes of CO_2)
total greenhouse gas emissions by 2050 compared to 1990	-	-	**80%** (Correlates with 152 million tonnes of CO2)

The key to achieving climate and energy objectives and creating a new growth model will be to identify the necessary investments in green technologies and sustainable solutions and last but not least, to ensure adequate funding. The European Commission proposals for the Just Transition Mechanism included in the next Multiannual Financial Framework 2021-2027 and REACT-EU includes the Just Transition Fund, the special Just Transition Scheme under the InvestEU programme and a new public sector credit facility in cooperation with the European Investment Bank. The mechanism is designed to facilitate the transition toward climate neutrality in the EU. Therefore, it will help the most affected regions of the Czech Republic mitigate the social and economic consequences of the climate transition. The Just Transition Fund's key priorities established under the Just Transition Mechanism are based on a more comprehensive analysis of the Czech Republic regions facing severe socio-economic challenges arising from the transition to a climate-neutral economy.

The Czech Republic's high-carbon economy will have to deal with several challenges to achieve climate neutrality. As a transition country with a high share of industrial activities of GDP, the Czech Republic has one of the highest greenhouse gas emissions per capita in the EU. High per capita greenhouse gas emissions are mainly due to dependence on coal and low energy efficiency. Coal mining is a significant economic activity in the three regions, which will need to go through a socially just and cost-efficient[31] transformation.

[28] National Energy and Climate Plan of the Czech Republic, https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf

[29] Ministry of Environment. 2020. Státní politika životního prostředí České republiky 2030 [State Environmental Policy of the Czech Republic in 2030]: https://www.mzp.cz/C1257458002F0DC7/cz/news_20200710_statni_politika_zivotniho_prostredi_2030/$FILE/OPZPUR-SPZP_2030_pro_verejnou_konzultaci-20200710.pdf

[30] Ministry of Environment. 2017. Politika ochrany klimatu v ČR [Climate Protection Policy of the Czech Republic]: https://www.mzp.cz/C1257458002F0DC7/cz/politika_ochrany_klimatu_2017/$FILE/OEOK-POK-20170329.pdf

[31] i.e. using the private and public funds optimally used to deliver the objectives sought (https://ec.europa.eu/international-partnerships/system/files/evaluation-matters_en.pdf).

According to the recently published National Investment Plan, the document indicates that it will be necessary to invest EUR 25 billion (bn) (12% of GDP at 2018 prices) to achieve a complete transition from fossil fuels by 2050.

Additionally, the use of energy from renewable sources in the Czech Republic is below the EU average. The share of energy from renewable sources in final consumption is approximately 15%, which is below the EU average (18% in 2018). The document also mentions that the National Climate and Energy Plan, which sets 2030 goals, indicates that only 22% of gross final energy consumption will come from renewable energy sources, which is slightly below the 23% target recommended by the European Commission. It also aims to increase the share of nuclear energy. According to the 2015 energy policy, nuclear energy could account for a third of total primary energy sources (including primary heat and primary electricity[32]) and half of the gross electricity generation by 2040.

Apart from the strategic documents analysed above, we would like to mention the report developed by **McKinsey**, which specifically assesses the transition to **carbon neutrality in the Czech Republic** in 2050.[33] The report states that to achieve the Green Deal goals for Europe, to which the Czech Republic also contributes, it is necessary to significantly accelerate the economy's decarbonisation. McKinsey states that reducing the Czech Republic's greenhouse gas emissions by 55% by 2030 is realistic and will require an additional investment of CZK 500 bn over the next 10 years (i.e., 1% of Czech GDP annually). Simply reducing the share of coal in the production of electricity and heat would enable the Czech Republic to achieve three-fourths of the 55% emissions reduction target by 2030.

The achievement of the 55% reduction in greenhouse gas emissions by 2030 will require a significant reduction in coal mining and using coal for energy and heat production. Additionally, increasing the energy efficiency of buildings and replacing coal-fired boilers in decentralised heat sources with lower-emission boilers will also be required. McKinsey further elaborates the necessary steps to achieve full decarbonisation by 2050. A key measure is to construct natural and artificial carbon sinks to offset emissions, especially in the cement or agriculture sectors. The Decarbonisation Pathways Optimizer (DPO) is considered and used by McKinsey for the analysis. The DPO tool draws on more than 500 models from various sectors. It seeks a cost-optimal scenario for meeting the Green Deal objectives, considering available resources, expected technological developments and potential constraints. McKinsey argues that introducing more expensive low-carbon processes can be a competitive disadvantage for businesses affected by the changes, especially if all companies in the sector do not make similar changes.

2.2 Investment needs assessment

This section assesses existing analysis on the investment needs to decarbonise the Czech economy, both at the national and regional level. On the national level, we base our analysis on the main strategic documents - the Climate Protection Policy, National Energy and Climate Plan (NECP), and a selection of recently published studies that assess the coal phase-out and/or the transition to climate neutrality in the Czech Republic. The regional analysis is mainly based on the regional energy concepts that have been prepared in the three coal regions.

2.2.1 National investment needs analyses

The **Climate Protection Policy** of the Ministry of the Environment (MoE) aims to reduce greenhouse gas (GHG) emissions by 80% in 2050 compared to 1990 levels. Relatedly, it provides a rough estimate of the investments needed to achieve the GHG reduction targets. Of the defined scenario categories (see Table 5), only those identified as "C" meet the 80% GHG targets in 2050. All scenarios in category "C" foresee significant increases in energy efficiency and changes in consumer behaviour, mostly differing in the structure of renewable energy production and nuclear installations.

Total costs (expressed as net present value, NPV) range from CZK 29 tn to CZK 33 tn, approximately EUR 1.1 tn to EUR 1.3 tn, for the 2010-2050 period. The total amount translates to roughly EUR 30 bn[34] per annum.[35] Unlike the studies we analyse later in this report, estimates in the Climate Protection Policy

[32] Primary heat is heat at the output of nuclear reactor and primary electricity is the electricity produced in hydro power plant and PV power plant – definition used in the Czech statistics on primary energy sources.

[33] Hanzlík, V., Javůrek, V., Smeets, B.,Svoboda, D. 2020. Klimaticky neutrální Česko. Cesty k dekarbonizaci ekonomiky [Climate neutral Czechia. The paths towards decarburization of the economy]. McKinsey & Company. https://www.mckinsey.com/cz/~/media/mckinsey/locations/europe%20and%20middle%20east/czech%20republic/our%20work/decarbonization_report_cz_vf.pdf

[34] Investment costs may not be distributed equally across the time period.

[35] If not stated otherwise, assume an exchange rate of 25 CZK/EUR.

cover all costs, including discounted variable costs (e.g., fuel and other operating costs), fixed operating costs, and investment costs. It also includes investments in transmission and distribution network infrastructure, energy savings costs and the cost of importing primary energy sources.

Table 5 Total costs of scenarios in CZK (bn), expressed as net present value (NPV), for 2010-2050[36]

Category	A	B				C		
Scenario Sector	Reference	Extra-polation of SEP	Nuclear	Green	Economic recession	Import of electricity and biomass	CCS develop-ment	Develop-ment of RES, nuclear and savings
Fossil fuels	6 948	5 649	4 403	4 334	3 908	3 648	5 123	3 723
Bioenergy	3 105	3 610	3 610	3 669	3 669	3 939	3 105	3 669
Electricity	1 423	1 904	1 841	1 696	1 803	1 269	1 544	1 929
Buildings	1 718	2 195	2 111	2 317	1 987	2 317	2 037	2 244
Transport	10 969	11 888	11 427	11 186	9 741	11 186	11 427	11 186
Industry	304	709	6 780	6 780	508	6 780	6 780	6 780
CCS	0	0	0	0	0	0	2 986	0
Total	**24 467**	**25 955**	**30 171**	**29 983**	**21 616**	**29 140**	**33 002**	**29 532**

Note: SEP = State Energy Policy, CCS = carbon capture and storage.

The **NECP** also estimates some of the investment needs to reach the 2030 climate and energy targets (i.e., 30% reduction of GHG emissions compared to 2005, 22% of RES share, and 990 PJ of final energy consumption in 2030 corresponding roughly to 10% decrease compared to 2005).

According to the Czech NECP, the total investment needs for 2021–2030 to reach targets set by Art. 7 of the Energy Efficiency Directive[37] are CZK 634.5 bn (EUR 24.4 bn), of which CZK 157.8 bn (EUR 6.1 bn) shall be financed with public support using both EU and national sources.

In the renewable energy sector, an estimated total of CZK 511.2 bn (~EUR 19 bn) of public operational support (in the form of feed-in-tariffs and feed-in-premiums) and CZK 51.6 bn (~EUR 1.9 bn) in investment subsidies will be needed to reach the 2030 renewable energy targets (see Table 6). An additional CZK 335.7 bn of operating support is planned for current resources, maintenance support and new production in 2031–2059. The NECP does not specify the total (public *and* private) investment needs for RES.

Table 6 Public support for RES to meet the 2030 targets (in CZK bn)[38]

Source	Amount
Total operational support 2021-2030	**511.2**
Current sources (feed-in tariffs / feed-in premiums)	411.3
Maintenance	53.5
New facilities	46.4
Investment subsidies 2021-2030	**51.6**
Total	**562.8**

Note: Exchange rate of 27 CZK/EUR applies.

The Czech Republic has a well-developed district heating industry, which needs to be gradually transformed for the use of low-carbon energy sources, including energy from secondary sources and waste heat, and their transportation to consumers in urban agglomerations. The use of renewable

[36] Ministry of Environment. 2017. Enviros in Climate Protection Policy of the Czech Republic: https://www.mzp.cz/cz/politika_ochrany_klimatu_2017

[37] Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency

[38] National Energy and Climate Plan of the Czech Republic, https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf

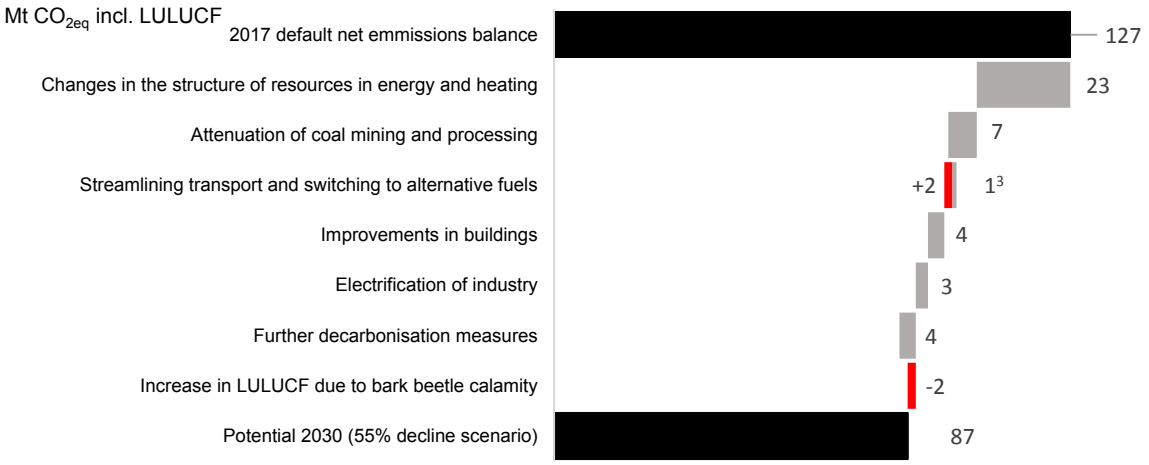
resources will also support thermal energy storage systems. According to data from the Confederation of Industry and Transport of the Czech Republic and the Heating Association of the Czech Republic, the necessary investments in the sector of combined heat and power generation and district heating are estimated at CZK 50–60 bn by 2030.[39]

The NECP further estimates that investments in the electricity system from 2021–2030 will reach a total amount of CZK 651 bn. Almost two-thirds of this amount are investments in power plants and accumulation, roughly 28% distribution and the rest transmission system. Investments in the gas system are not publicly available, but investments in the transmission system are expected to reach tens of billions of CZK. The updated version of the National Action Plan for Smart Grids (2019–2030) quantifies the costs for integrating decentralised resources by 2040 at CZK 45 bn[40].

Additionally, several studies have calculated the costs/investment needs of carbon neutrality in the Czech Republic. Below, we analyse the studies by McKinsey and Ember, which have estimated the investment needs of the low-carbon transition, and the study by the Czech Technical University in Prague that reflected the 2030 NECP targets.[41]

The report by the **McKinsey & Company**[42] presents a cost-effective scenario to carbon neutrality in the Czech Republic by 2050. It presumes a 55% reduction in emissions by 2030 (Graph 3). The 2030 reduction is driven by the decarbonisation of the energy sector (75% of the target) and other ambitious (but not unrealistic) assumptions such as 49% new registered cars to be EVs or plug-in hybrids (which are currently less than 1%).[43] The coal capacity would decrease from the 10.6 GW today to 4.2 GW in 2030. The study estimates that **CZK 500 bn (EUR 20 bn)** is the additional required investment to reach this target, roughly CZK 50 bn (EUR 2 bn) per year.[44]

Graph 3 Estimated CO_2 emission reductions from 2017 to 2030 according to activities[45]



[39] Current Draft for implementation of Modernisation fund: https://www.mzp.cz/C1257458002F0DC7/cz/modernizacni_fond/$FILE/OFDN-PDMdF-20201124.pdf Other studies (see also the Climate and energy investment in district heating, (https://ekonom.feld.cvut.cz/cs/katedra/lide/valenmi7/cic2030/index) estimate the costs up to around CZK 100 billion by 2030.

[40] https://www.mpo.cz/cz/energetika/strategicke-a-koncepcni-dokumenty/narodni-akcni-plan-pro-chytre-site/narodni-akcni-plan-pro-chytre-site-2019---2030---aktualizace-nap-sg--248894/

[41] There were also additional studies published by Blomberg and Energynautics that also analyse the impacts of coal phase out. However, they do not estimate the investment costs, therefore are not further discussed in this subchapter.

[42] Hanzlík, V., Javůrek, V., Smeets, B.,Svoboda, D. 2020. Klimaticky neutrální Česko. Cesty k dekarbonizaci ekonomiky [Climate neutral Czechia. The paths towards decarbonization of the economy]. McKinsey & Company. https://www.mckinsey.com/cz/~/media/mckinsey/locations/europe%20and%20middle%20east/czech%20republic/our%20work/decarbonization_report_cz_vf.pdf

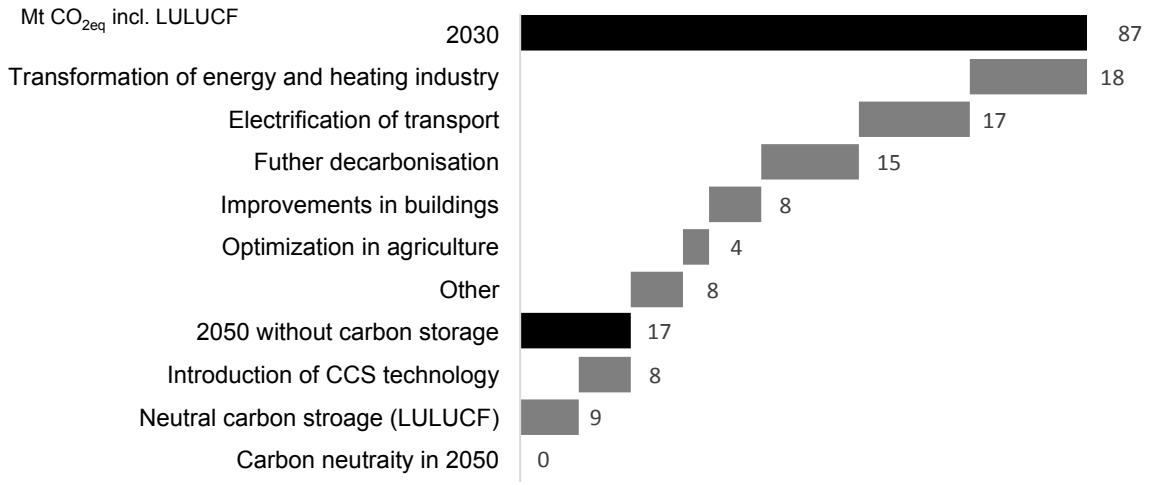
[43] To put the level of efforts needed into further perspective, the McKinsey report assumes the increase of PV installations to 4.6 GW_e by 2030, while the NECP assumes roughly an increase to 3.98 GW_e with the current (2020) installed capacity of 2.1 GW_e. By 2050, the report assumes an increase to 20.3 GW_e. Using the assumptions of the report on investment needs by 2030 for RES in Czechia, this would be e.g. installations of PV on every residential building in Czechia.

[44] We are aware that in reality, the investment will not be distributed evenly (even though the report does not elaborate on this further). It is presented here for comparison purposes.

[45] Hanzlík, V., Javůrek, V., Smeets, B.,Svoboda, D. 2020. Klimaticky neutrální Česko. Cesty k dekarbonizaci ekonomiky [Climate neutral Czechia. The paths towards decarbonization of the economy]. McKinsey & Company. https://www.mckinsey.com/cz/~/media/mckinsey/locations/europe%20and%20middle%20east/czech%20republic/our%20work/decarbonization_report_cz_vf.pdf

The 2050 decarbonisation scenario assumes, among others, a complete transformation of the industry sector, decarbonisation of the vehicle fleet and buildings with a high share of heat pumps, and also the development of Carbon Capture and Storage (CCS), which is assumed to cover the remaining 5% of CO_2 emissions (Graph 4). The scenario estimates that an additional **CZK 4 tn (EUR 160 bn)** of additional investment will be needed to reach the target, which is roughly CZK 200 bn (EUR 8 bn) per year.

Graph 4 Estimated CO_2 emission reductions from 2030 to 2050[46]

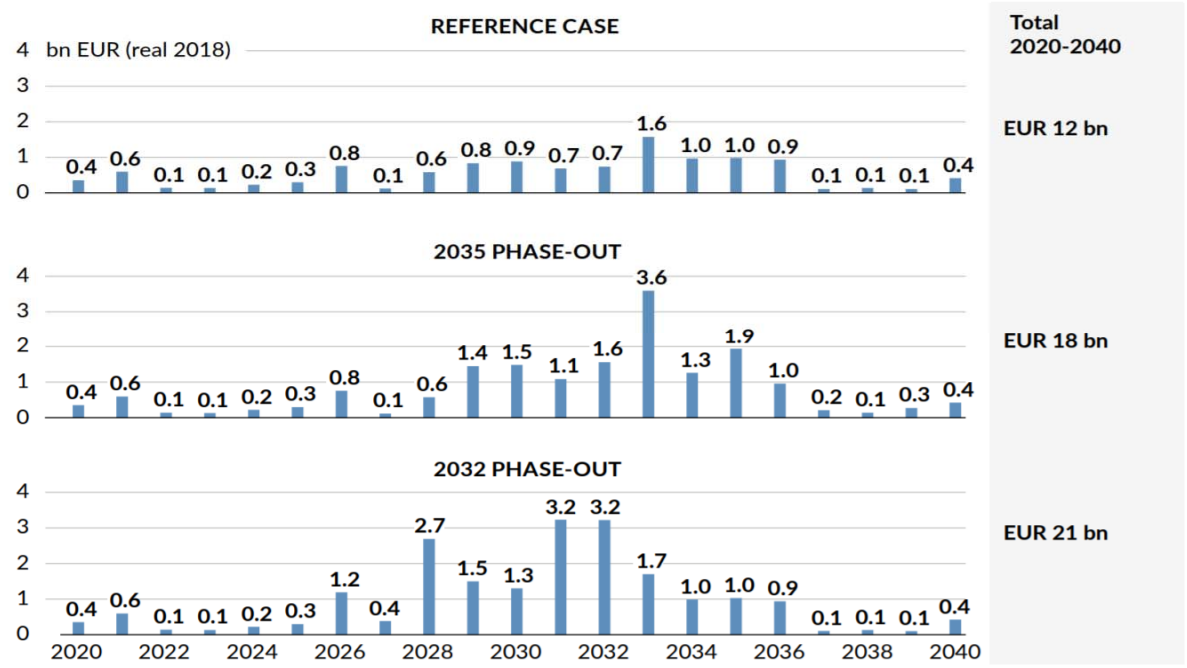


The study by **Ember**[47] took a slightly different approach and modelled the scenario of coal phase-out from electricity and heating in the Czech Republic by 2030 and compared it to a reference scenario, which follows assumptions by the NECP. The study estimates that the investment costs of the phase-out scenario in electricity production are "an order of magnitude higher than the reference scenario, due to the ambitious build-out of RES generation capacity" (p. 25). Investment costs amount to EUR 11 bn (~CZK 275 bn) from 2020–2030, of which 46% is attributed to PV and 31% to onshore wind. The estimates do not consider any additional infrastructure investment.[48] The study further estimates the marginal cost of electricity as a proxy for the wholesale price at the level of 54 EUR/MWh in 2030 compared to 44 EUR/MWh in 2020. Investment estimates for heat production are EUR 2.2 bn (61% of which is attributed to large heat pumps, followed by 28% for gas CHP). Again, additional infrastructure costs were not included. The total investment costs therefore amount to EUR 13.2 bn (~CZK 330 bn) from 2020–2030, or roughly EUR 1.32 bn (CZK 33 bn) per year.

Agora and Forum Energii[49] analyse the impact of coal phase-out on the power market in three countries: Germany, Poland and the Czech Republic. In the Czech Republic, the study assumes three scenarios: reference (slightly more ambitious than NECP), coal phase-out in 2032, and coal phase-out in 2035. The power generation investment cost ranges from EUR 12 bn in the reference scenario to EUR 21 bn in the 2032 scenario. This translates into an average of EUR 1.05 bn (CZK 26.3 bn) annually for the latter scenario. Generally, in both scenarios, the investment costs are the highest in the six-year period before the intended phase-out. The distribution of investment costs is depicted in Graph 5. The wholesale electricity price in the two phase-out scenarios vary between 47 and 53 EUR/MWh with a declining trend towards 2040, which is roughly at the level of the reference scenario, but lower by 2040.

[46] Ibid.
[47] Ember. 2020. Coal-free Czechia 2030. https://ember-climate.org/project/coal-free-czechia-2030/
[48] The study however also highlights the multiplier effect of the investment on jobs. We elaborate on this further in section 4 of this report.
[49] Agora and Forum Energii. 2020. Modernising the European lignite triangle Towards a safe, cost-effective and sustainable energy transition. https://www.agora-energiewende.de/en/publications/modernising-the-european-lignite-triangle/

Graph 5 Czech power generation investment[50]



The authors from the **Czech Technical University in Prague** also estimated the investment needs to reach the 2030 RES targets in the Czech Republic.[51] As stated above, the Czech National Energy Climate Plan[52] expects the RES share in gross final consumption to be **22% by 2030**. The breakdown of the RES contribution by sector for 2020 and 2030 are provided in Table 7. Based on the structure presented, the authors quantified the investment needs to meet the expected NECP values in the RES sector.

Table 7 RES by sector in 2020 and 2030 according to the Czech National Energy and Climate Plan [TJ]

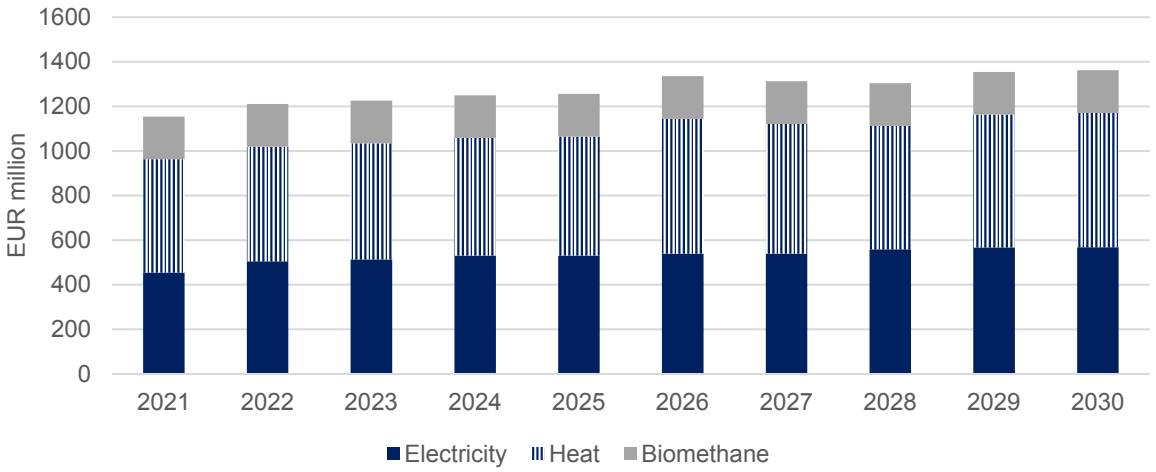
Final consumption RES	2020	2030
Electricity	33 512	44 540
Transport	20 399	30 577
Heating and cooling	120 222	164 600
Total	**174 133**	**239 717**

The Czech Technical University report first estimated the contribution of individual types of RES and technologies across electricity, heat, and biomethane, and consequently derived the specific investment costs for individual types of RES.

The results of modelling investment needs in the RES sector show that the total investment need is EUR 12.8 bn between 2021 and 2030. This is the sum of the values for the RES for electricity, heat, and biomethane (transport) segments. Total costs for 2021-2030 indicate 41.4% of the RES costs are for electricity generation, 43.2% of the RES costs are for heat generation, while the rest are attributable to biomethane (Graph 6).

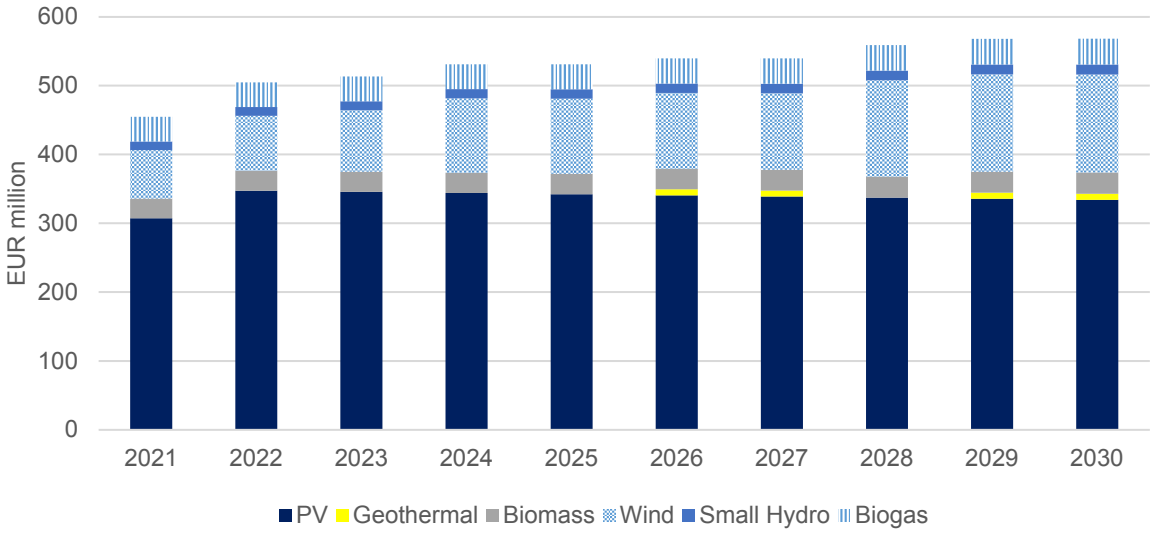
[50] Ibid, pp. 26.
[51] The following subsection takes after the main findings of the report by Valentová et al. (2020) which was carried out by the CTU expert team as part of the Climate Investment Capacity 2030 project. Full results of the project as well as the full report can be found here. The report can be downloaded here: https://ekonom.feld.cvut.cz/cs/katedra/lide/valenmi7/cic2030/index
[52] National Energy and Climate Plan of the Czech Republic, https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf

Graph 6 Investment needs for RES development in 2021–2030 (EUR million) [53]



Regarding electricity production from RES, photovoltaic power plants account for the largest share of investment needs, roughly 64% of the total (Graph 7). Wind power plants account for 21% of total investment needs. The remaining technologies (geothermal, small hydro power plants, biomass and biogas) account for 15% of total investment needs.

Graph 7 Investment needs – RES electricity production 2021–2030 (EUR million) [54]



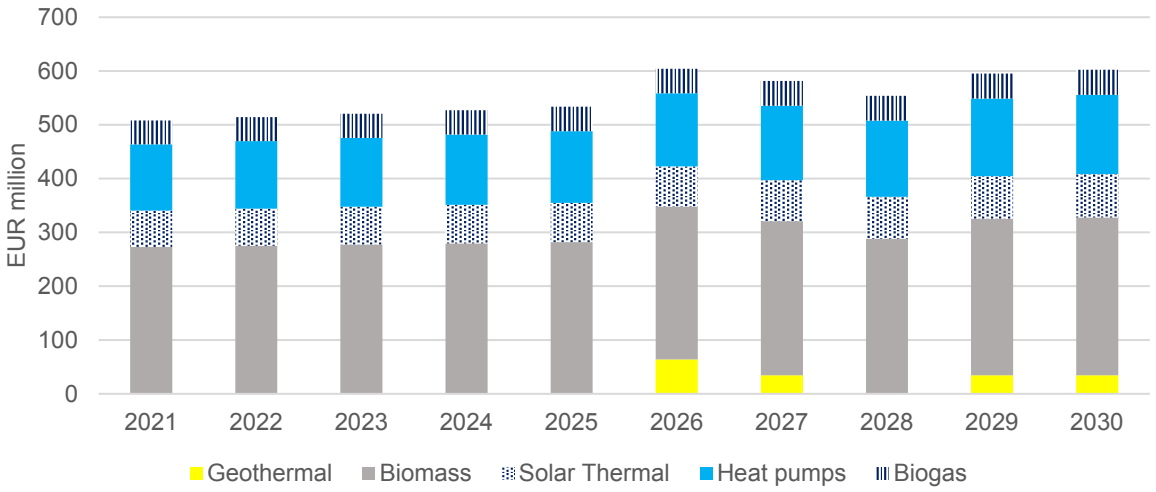
Regarding RES for heat production (Graph 8), the most important segment is the combustion of solid biomass, accounting for about 51% of total investment needs[55], followed by heat pumps with 24% of total investment needs, and solar thermal (13%).

[53] Valentová, M., Knápek, J., Mikeska, M., Vašíček, J. 2020. Investment needs for 2030 energy and climate targets in Czechia. Buildings and renewable energy supply sectors. Prague: Czech Technical University in Prague, https://ekonom.feld.cvut.cz/cs/katedra/lide/valenmi7/cic2030/index

[54] Ibid.

[55] The scenario is based on a detailed breakdown of the RES targets in the field of heat according to the targets and structure of the currently valid National Energy Climate plan (version from January 2020). The future real role of biomass will be affected by its real availability (in the case of forest biomass) and farming practices (higher pressure for sustainable management) and the development of energy crops. In particular, the impact of the bark beetle calamity can significantly affect the availability of residual biomass from the forest since the end of this decade. The point is that current logging is several times higher than the long-term average values and more or less responds only to calamities. More than 95% of the total mining site at present is calamity mining. The condition of forests is strongly influenced by the bark beetle calamity, which developed mainly between 2015-2019, as a result of a combination of large spruce monocultures and climate change manifested in long periods of drought and high temperatures. In a period of about 5-7 years, a significant decrease in forest harvesting can be expected, in many regions the priority will be forest regeneration and will leave the remaining forest stands as a basis for this renewal. Assumptions about biomass availability can be expected to be revised.

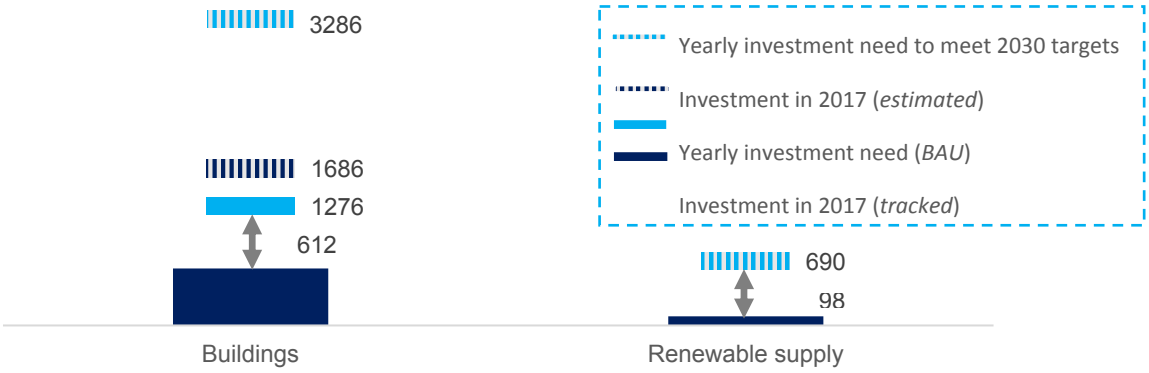
Graph 8 Investment needs – RES heat production 2021–2030 (EUR million)[56]



Graph 9 illustrates the estimated investment gap, i.e., the difference between the observed investment flows[57] and estimated yearly investment needs to reach the 2030 targets in the RES supply and building sectors. In total, the annual estimated investment needs in buildings are EUR 1,276 m, covering renovation and other energy efficiency measures (EUR 690 m annually) and RES integrated in buildings (EUR 586 m annually).[58]

The average annual amount of investment into renewable energy supply sector needed to meet the 2030 climate and energy goals, as defined in the NECP, is EUR 690 m. This excludes technologies integrated in buildings. As a comparison, the volume of investments flowing into the sector in 2017 reached EUR 98 m, including related infrastructure.[59] To reach the RES 2030 targets, annual investment in RES supply would need to increase by 7x. This figure shows that the current policy, regulatory and support framework does not lead to sufficient levels of investment to reach the NECP 2030 targets, let alone to transform the whole economy towards carbon neutrality.

Graph 9 2030 annual investment gap to reach 2030 targets (EUR million)[60]



[56] Valentová, M., Knápek, J., Mikeska, M., Vašíček, J. 2020. Investment needs for 2030 energy and climate targets in Czechia. Buildings and renewable energy supply sectors. Prague: Czech Technical University in Prague, https://ekonom.feld.cvut.cz/cs/katedra/lide/valenmi7/cic2030/index.

[57] The climate and energy investment flows in Czechia have been assessed in Valentová, M., Knápek, J., Novikova, A. 2019. Climate and energy investment map – Czechia. Status Report 2017: buildings and renewable energy supply and infrastructure. Prague: Czech Technical University in Prague, https://ekonom.feld.cvut.cz/cs/katedra/lide/valenmi7/cic2030/reports/cvut-mvalentova-et-al-2019-climate-energy-investment-map-czechia-2017-full-report.pdf.

[58] This amount does not meet the required parameters in terms of GHG reductions as set in the Czech Climate Protection Policy. The investment needs to reach the 2030 targets are marked by light-blue dash line in the Graph 9, i.e., EUR 3,286 m in case of the buildings sector. The dark-blue dash-line then marks the rough estimate of all investment in the building sector in 2017, including untracked investment.

[59] National Energy and Climate Plan of the Czech Republic, https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf

[60] Valentová, M., Knápek, J., Mikeska, M., Vašíček, J. 2020. Investment needs for 2030 energy and climate targets in Czechia. Buildings and renewable energy supply sectors. Prague: Czech Technical University in Prague, https://ekonom.feld.cvut.cz/cs/katedra/lide/valenmi7/cic2030/index

In addition, the Czech transmission operator ČEPS prepared a scenario analysis to aid the Coal Commission's decision making.[61] It calculates the impacts of coal phase-out in 2038 and provides three scenarios (conceptual, progressive, and ambitious), which differ in the speed of renewable replacement of coal, and also the development of battery storage capacities. Gas power plants are expected to cover any outstanding electricity needs. The study estimates that additional investment costs by 2038 are CZK 58 bn (EUR 2.23 bn) for gas plants under the conceptual and progressive scenarios and CZK 51 bn (EUR 1.96 bn) under the ambitious scenario. The progressive scenario further assumes an additional CZK 43 bn of investment costs in photovoltaics compared to conceptual scenario and up to CZK 260 bn under the progressive scenario, including battery accumulation (CZK 40-50 bn).[62]

In Table 8, we present a summary of all the analysed strategies and studies covered above[63]. It shows that the studies differ by targets, assumptions and goals, which range from the transition to carbon neutrality by 2050 to coal phase-out in specific sectors by 2030. Nevertheless, they show the magnitude of investment to reach these goals. Most of the analysed estimates are in the range of units of billion EUR per year, with the exception of the McKinsey study, which is, however, the broadest of the analysed studies both in terms of sectors covered (whole economy) and depth of the target (full decarbonisation by 2050).

Table 8 Summary of analysed strategies and studies on investment needs for decarbonisation

Analysis	Climate Protection Policy	*NECP*	McKinsey	Ember	Agora and Forum Energii	CTU
Target / assumption	80% GHG emission reduction (indicative)	*30% GHG emission reduction by 2030*	Carbon neutrality in 2050 Cost effective pathway	Coal phase out by 2030	Coal phase out by 2032/2035	Same as NECP
Sectors covered	All	RES	All	Electricity and large-scale heating	Electricity	Buildings and RES supply
Costs	Investment and operating costs Includes infrastructure	***Public** investment and operating **support*** Unclear about infrastructure	Additional investment costs	Investment costs Excludes infra-structure	Investment costs	Investment costs Includes infra-structure
Yearly investment costs (EUR)[64]	**30 bn [65]**	**2.2 bn**	**6 bn**	**1.32 bn**	**1.05 bn**	**1.97 bn**

[61] ČEPS. 2020. Podklad na jednání UK dne 20. října 2020 s ohledem na modelování možného útlumu uhlí [Background material for the meeting of the Coal Commission on 20 October 2020 with respect to modelling the possible coal phase-out].

[62] The multiple benefits of renewables compared to externalities of coal and potential energy security issues connected with reliance on gas have not been discussed in the document.

[63] The ČEPS study was deliberately excluded as it assesses the infrastrucutre costs, purely. However, we believe it is complementary to the other studies.

[64] This calculation simply serves as a general idea and comparison across different analyses.

[65] This value is the most comprehensive of all the studies. It covers total costs, including discounted variable costs (e.g., fuel and other operating costs), fixed operating costs, and investment costs. It also includes investments in transmission and distribution network infrastructure, energy savings costs and the cost of importing primary energy sources. The value represents the net present value of all costs. At the same time, the underlying data are the "oldest" (i.e. 2016/2017 compared to 2020). Therefore, arguably, some of the costs may have been overestimated to some extent and not reflecting the continuous technology cost declines in recent years. In comparison, e.g., the McKinsey report, which is the closest in terms of targets, only includes additional investment costs (as opposed to total investment and operational costs in the Climate Protection Policy estimates).

It is clear that the studies differ majorly in scope (30% reduction to carbon neutrality), in covered sectors (from RES and electricity only compared to an all-sector approach), and in the costs that they capture (e.g., most of the expert studies do not include infrastructure costs).

There are two main conclusions. First, while climate neutrality brings about huge opportunities, it also comes with substantial investment needs. However, secondly, we need much more data and also informed debate on the structure and levels of these investment costs in order to meaningfully inform the public policy decision making as well as sending a clear signal to private investors.

2.2.2 Regional investment needs analyses

The following subchapter examines the investment needs as specified in the Regional Energy Policies (REP)[66] of the three regions.

In the **Karlovy Vary region**, the REP identifies two main development scenarios of the energy system for the 2017-2042 time period: V1 – moderate development (conservative) and V2 – progressive. The scenarios differ in the assumptions about energy savings and development of RES. Both scenarios are further divided into (a) and (b) according to the expected development of two major (coal) energy sources in the region. In scenario (a), both energy sources remain in operation. In scenario (b), one of the sources (Tisová) is closed while the second remains in operation. Table 9 depicts some features of the four scenarios described above.

The REP recommends following the V1b scenario, which would require EUR 0.06 bn of investment and would lead to a 38% reduction in CO_2 emissions. However, it is not clear whether the scenario is in line with the transformative processes that have been agreed to since the writing of the REP in 2018. Scenario V2b seems to be more in line with the latest targets and recommendations of the Coal Commission. However, it does not appear to lead to a carbon neutral economy.

Table 9 Selected features of the Karlovy Vary region REP scenarios[67]

	V1a	V1b	V2a	V2b
Coal (share on PEC)	65% (-30%)	57% (-44%)	65% (-35%)	56% (-48%)
RES (share on PEC)				
Biomass	7% (+79%)	7.8% (+79%)	8.9% (+112%)	9.8% (+113%)
RES electricity	1.7% (+80%)	1.7% (+80%)	2.6% (+165%)	2.9% (+166%)
Heat pumps and solar thermal	1% (393%)	1% (393%)	1.6% (+625%)	1.8% (+625%)
Final energy consumption	-10%	-10%	-14 %	-14 %
Investment costs (total, EUR)	1.5 bn	1.5 bn	2.9 bn	2.9 bn
Investment costs (yearly)	0.06 bn	0.06 bn	0.12 bn	0.12 bn
CO_2 emission savings	-26 %	-38 %	-30%	-42 %

Note: numbers in brackets indicate a change in 2042 compared to 2017; PEC: Primary energy consumption

The REP in the **Moravian-Silesian Region** (MSR) considers three main development scenarios in the 2019–2044 time period: V1 – reference scenario, V2 – low-carbon scenario, V3 – decarbonisation scenario. The scenarios differ in the energy efficiency rate and the development of renewable energy sources. The reference scenario follows existing strategies and policies. Coal is phased-out gradually

[66] Karlovy Vary Region: Územní energetická koncepce Karlovarského kraje. Aktualizace 2017–2042. June 2018. Moravian-Silesian Region: Územní energetická koncepce Moravskoslezského kraje na období 2020 – 2044. March 2020. Ústi region: Aktualizace územní energetické koncepce Ústeckého kraje. September 2019.

[67] Karlovy Vary Region: Územní energetická koncepce Karlovarského kraje. Aktualizace 2017–2042. June 2018, chapter 14.

and replaced by gas, biomass and other RES. According to the REP, it is the "most probable" scenario. The low-carbon scenario assumes that the Czech Republic will reach its NECP targets and provide increased support to EE and RES to reach these targets. In addition to the measures of V2, the decarbonisation scenario adds coal phase-out due to legislative requirements and expects the end of coal by 2044 (sic!). Table 10 depicts some features of the scenarios.

The REP recommends the V2 scenario. However, V2 only reduces CO_2 emissions by 22% between 2014 and 2044 and does not lead to coal phase-out even by 2044. Nevertheless, the V2 scenario is the most economically effective (highest NPV) according to the analysts. However, it is not clear, whether items such as co-benefits and negative externalities have been accounted for.

Table 10 Selected features of the Moravian-Silesian region REP scenarios[68]

	V1	V2	V3
Coal (share on PEC)	57% (-19%)	55% (-25%)	40% (-51%)
RES (share on PEC)			
Biomass	8.2% (+2%)	9.8% (+18%)	11% (+18%)
Other RES	1.6% (+0%)	1.6% (+5%)	1.9% (+5%)
Final energy consumption	-8%	-7%	-17%
Investment costs (total, EUR)	7.3 bn	8.1 bn	9.5 bn
Investment costs (yearly)	0.3 bn	0.3 bn	0.4 bn
CO_2 emission savings	-18%	-22	-38%

Note: numbers in brackets indicate a change in 2042 compared to 2017; PEC: Primary energy consumption

The REP in the **Ústí Region** also considers three main development scenarios from 2019–2044: V1 – reference scenario, V2 – low-carbon scenario, V3 – decarbonisation scenario. As it has been prepared by the same consultation company, the assumptions are identical to the assumptions for the Moravian-Silesian Region (Table 11).

Table 11 Selected features of the Ústí region REP scenarios[69]

	V1	V2	V3
Coal (share on PEC)	60% (-47.4%)	59% (-49.2%)	23% (-86.7%)
RES (share on PEC)	13.5%	15.2%	24.6%
Final energy consumption	-	-	-
Investment costs (total, EUR)	-	Additional 1.08 bn	Additional 1.08 bn and other "units of billion"*
Investment costs (yearly)	-	Additional ~0,04 bn	-
CO_2 emission savings	-67%	-68%	-74 %

Note: * assuming compensations for thwarted investment in greening of coal sources

To sum up, all three REP are rather conservative in their assumptions. For instance, the progressive decarbonisation scenario in MSR assumes the end of coal in 2044. At the same time, the REPs do not assume more ambitious development of RES. Therefore, the question is what informational value these scenarios have considering the regional developments over the past two years. The underlying scenarios of the REPs should be updated to align with the climate neutrality/low carbon transition

[68] Moravian-Silesian Region: Územní energetická koncepce Moravskoslezského kraje na období 2020 – 2044. March 2020, chapter 8.
[69] Ústi region: Aktualizace územní energetické koncepce Ústeckého kraje. September 2019., chapter 7.

envisioned in the regions. By the same token, this would inevitably lead to an update of the investment cost estimates.

2.3 Funding overview

This section summarises the most significant available funding sources to support the climate neutrality transition and transformation in the 2021–2027 time period. The description of key priorities is followed by a summary table of all programmes. We focus on national programmes, which are the core support mechanism, but we also briefly assess the available regional schemes. Unless otherwise stated, all financial allocations are the result of the latest state of the approval process.[70]

2.3.1 National Programmes and EU funding

Successor programme to the new green savings programme (NZU)[71]

The programme of the Ministry of the Environment and administered by the State Environmental Fund of the Czech Republic is one of the most effective programmes focused on energy savings in family residences and apartment buildings. It supports the reduction of residential buildings' energy intensity (complex or partial insulation), the construction or purchase of houses with very high energy intensity, environmentally friendly and efficient use of energy sources and renewable energy sources. The programme's objective is to improve the state of the environment by reducing the production of emissions of pollutants and greenhouse gases (mainly CO2 emissions). The programme aims to achieve energy savings in final consumption and stimulate the Czech economy with other social benefits, such as increasing the quality of housing for citizens, improving the appearance of cities and municipalities, starting long-term progressive trends. The New Green Savings programme will be financed from the earnings EUA (European Union Allowance) and EUAA (European Union Aviation Allowance). The allocation of the programme's total budget is in the process of being approved by the Czech government. The budget approval is estimated for August to September 2021. The programme's funding will partially consist of money from the National Recovery Plan (CZK 19 bn) and CZK 4 bn from an annual sale of emission allowances. The total amount is estimated at CZK 59 bn (EUR 2.3 bn)[72].

The programme will support these areas:

- Renovation of family and apartment houses (insulation of facades, roofs, ceilings, replacement of windows and doors)
- Construction of family and apartment houses in the so-called passive standard (passive houses)
- Purchase of family houses and apartments with very low energy consumption
- Solar thermal and photovoltaic systems
- Green roofs, outdoor shading technology
- Use of heat from wastewater
- Recuperation - controlled ventilation system with heat recovery
- Replacement of heat sources for heat pumps, biomass boilers
- Acquisition and installation of charging stations for passenger cars in apartment buildings

Operational Programme Environment (OPZP)[73]

The OPE supports energy savings and renewable energy sources in public buildings and infrastructure, entrepreneurs, and households. The programme is financed from EU funds: European Regional Development Fund (ERDF) and Cohesion Fund (CF). About CZK 61.1 bn (EUR 2.1 bn) is allocated for 2021-2027.

The programme will be divided into several thematic areas:

- *Energy savings and renewable energy sources*: support for reducing the energy intensity of public buildings and infrastructure, increasing the use of renewable energy sources in the public sector and households;
- *Adaptation to climate change*: for example, support for measures to prevent and adapt to drought, floods and landslides in the countryside and cities and towns, and support for environmental centres;

[70] https://dotaceeu.cz/cs/evropske-fondy-v-cr/novinky/vlada-schvalila-rozdeleni-financi-mezi-operacni-pr
[71] NZU https://www.sfzp.cz/dotace-a-pujcky/nova-zelena-usporam/ NZU https://www.sfzp.cz/dotace-a-pujcky/nova-zelena-usporam/
[72] E15 https://www.e15.cz/byznys/reality-a-stavebnictvi/dotace-na-zateplovani-bytovek-vyschly-na-zadosti-za-vice-nez-miliardu-se-nedostalo-1377413
[73] OPZP https://www.opzp.cz/opzp-2021-2027/

- *Water management infrastructure*: support for the construction of water mains and feeders, sewers and wastewater treatment plants;
- *Circular economy*: support the prevention of waste generation and its material and energy use;
- *Biodiversity*: support for the restoration and care of natural habitats and species, removal of migration barriers, reduction of the spread of invasive species;
- *Air*: support for the replacement and reconstruction of stationary sources of air pollution and air quality monitoring systems;
- *Remediation*: support for remediation of contaminated sites.

The operational programme targeting overlaps JTF in fostering a circular economy, deploying renewable energy technology and infrastructure for affordable clean energy, in greenhouse gas emission reduction, by increasing energy efficiency and deployment renewable energy, particularly in non-residential sector. Decontamination and rehabilitation of landscape are only minor priority of the programme.

Operational Programme Employment Plus (OPZ+)[74]

The programme is managed by the Ministry of Labour and Social Affairs of the Czech Republic (MLSA). OP Employment covers the following areas:

- Employment promotion;
- Equal opportunities for women and men;
- The adaptability of employees and employers;
- Further education;
- Social inclusion and steps against poverty;
- Modernisation of public administration and public services; and,
- Support for international cooperation and social innovation in the fields of employment, social inclusion and public administration.

During the first quarter of 2021, OPZ+ will be finalised with data on financial allocations, a categorisation of interventions and target values of indicators, and possible inputs from the final version of the Partnership Agreement, final versions of the EU Funds Regulation for 2021-2027 and outputs from informal dialogue with the European Commission. Subsequently, OPZ+ will be submitted to the Czech Republic government in mid-2021 for approval and then to the European Commission for the start of official negotiations. The programme will be funded by the European Social Fund Plus (ESF +). MLSA will have in the Employment Operational Programme in total EUR 1.4 bn (CZK 36.4 bn) that can potentially support the regions in the transition process. Regarding the transformation process, the operational programme supports equality in education and the development of research centres. However, the JTF directs funding to the specific problems of the regions, especially the retraining of existing employees.

Operational Programme Technology and Applications for Competitiveness (OPTAK)[75]

The programme is managed by the Ministry of Industry and Trade of the Czech Republic (MIT). The OPTAK provides support to entrepreneurs to implement energy savings and the development of renewable energy sources in all regions except Prague. Around CZK 79.3 bn (EUR 3,1 bn) has been allocated for 2021-2027. The Modernisation Fund then complements the operational programme with identical interventions in the territory of Prague.

Subsidies can be obtained for items such as:

- Research, development and innovation;
- Starting a business and developing a business structure;
- Digitalisation, information and communication technologies;
- High-speed internet;
- Energy savings and the use of secondary raw materials.

This operational programme focuses on both sustainability and the transformation process, through innovation and the competitiveness of enterprises.

[74] OPZ+ https://www.esfcr.cz/documents/21802/11873914/OPZ%2B_03_2020.pdf/72756247-5437-4ada-a996-1563985d3e29 OPZ+

[75] OPTAK https://www.dotace-optak.cz/

Just Transition Fund (JTF)[76]

The Ministry of the Environment administers this fund. The purpose of the Just Transition Fund is primarily to mitigate the impact of the transformation process on the carbon-neutral economy in the regions where the impact has the most significant consequences.

Funding covers the following areas:

- small and medium-sized enterprises
- research and innovation
- digitisation
- clean energy and energy savings
- circular economy
- reclamation and new land use
- retraining and job search assistance

According to the last government proposal, the Czech Republic could receive EUR 1.6 bn (approximately CZK 42.7 bn) for 2021–2027.

Integrated regional operational programme (IROP)[77]

The Ministry of Regional Development administers this fund. IROP supports clean mobility in the public transport segment. Around CZK 122.7 bn (EUR 4.7 bn) is allocated for 2021-2027. It is expected that IROP will not have sufficient resources to provide support throughout the programming period, and therefore the funding will be covered by the Modernisation Fund.

IROP interventions are divided into five material priorities:

- ✓ *Improving the performance of public administration*: improving the performance of public administration through the implementation of eGovernment and cybersecurity measures at central, regional and local levels.
- ✓ *Development of urban mobility, revitalisation of cities and municipalities, protection of the population*: a set of measures in the field of sustainable multimodal urban mobility, revitalisation of municipalities and building of green infrastructure and adaptation to climate change and ensuring the protection of the population.
- ✓ *Development of transport infrastructure:* increasing the competitiveness of regions, improving the accessibility of economic development centres and interconnecting the main transport axes.
- ✓ *Improving the quality and accessibility of social and health services, educational infrastructure and the development of cultural heritage:* education and necessary infrastructure, socially-oriented infrastructure and facilities for the provision of health services
- ✓ *Cultural heritage and sustainable tourism* as areas with enormous development potential. The use of cultural heritage and the potential for the development of sustainable tourism will have a positive effect on employment growth and economic competitiveness of the region
- ✓ *Community-led local development:* community-led local development as a tool to address specific needs, increase the quality of life and mobilize local potential in rural areas.

The Operational Programme indirectly recognises investment support for the Czech Republic's developing regions through the following co-financing scheme:

- 85% for less developed regions (Northwest, Moravia-Silesia, Northeast, Central Moravia);
- 70% for transition regions (Central Bohemia, Southwest, Southeast); and,
- 40% for more developed regions (Prague).

To support low-carbon mobility (vehicles and filling stations), subsidy calls may focus on coal regions, i.e., the Ústí nad Labem, Moravian-Silesian and Karlovy Vary regions.

The IROP was chosen to help distribute the support that the Czech Republic will receive from the European Union in order to reduce the impact of the COVID-19 pandemic. The funds will be distributed through the new investment instrument, REACT-EU, where has been allocated an additional CZK 21.7 bn (EUR 834 million) for 2020. Funding can be used to recover from the crisis and prepare for a green, digital and resilient economic recovery within the EU.

[76] JTF https://www.mzp.cz/cz/opst_2021_2027 TF https://rskuk.cz/uhelne-regiony-fond-spravedlive-transformace
[77] MRD,IROP2021-2027 draft https://irop.mmr.cz/cs/irop-2021-2027/dokumenty

IROP interventions follow from the Operational Programme ("OP") Employment Plus and OP Jan Amos Komenský in individual, relevant topics and supplement the building and adjustment of necessary capacities, infrastructures, facilities and the acquisition of necessary equipment.

Modernisation Fund (MF)[78]

The Modernisation Fund is a separate budgetary instrument outside the EU budget. Under the Act on Emissions Trading, the State Environmental Fund of the Czech Republic was designated as a recipient of funds from the Modernisation Fund and acted as a mediator of this financial mechanism. In the industry sector, there is a clear funding gap from the current support programmes for 2021-2030, which the Modernisation Fund was expected to implement to help decarbonise industries. The Modernisation Fund is the only programme to cover companies of all sizes, even within the EU ETS and throughout the Czech Republic. There is currently no planned operational programme covering the decarbonisation of EU ETS facilities in the Czech Republic. The Modernisation Fund can help potential community energy projects overcome obstacles to raising capital, which is key to them, together with the administrative burden and the need for expertise. The Modernisation Fund could provide around CZK 140 bn (EUR 5 bn) (only indicative given the current price of emission allowances, the number of emission allowances intended for use within the Modernisation Fund for the Czech Republic).

The aim of financing this fund is to reduce emissions and transform energy in the EU-ETS area. It is a supplement to OPDF, IROP, and OPTAK.

Transport Operational Programme 2021-2027 (OP D)[79]

The draft Transport Operational Programme for the new programming period was created during 2019. The document has been discussed on the Platform for Preparation of OP Transport 2021–2027, in which all relevant partners are represented, e.g., the Confederation of Industry and Transport of the Czech Republic, Association for Transport Telematics, Net Mobility, Association of Regions, Faculty of Transport CTU, Railway Administration, Ministry for Regional Development etc.

The starting document for the creation of the Operational Programme Transport 2021–2027 is the National Concept for the Implementation of Cohesion Policy in the Czech Republic after 2020. As a strategic goal in this concept, the Czech Republic has set "Efficient, accessible and environmentally friendly transport." A clear priority for the Czech Republic is the development of backbone, suburban and urban transport infrastructure and sustainable transport, which will enable better connections between regions and between the Czech Republic and other EU countries.

The Transport Operational Programme 2021-2027 will have three substantive priorities and a fourth for Technical Assistance:

Priority 1 - European, national and regional mobility in road and rail transport

Priority 2 - National and regional mobility in road transport

Priority 3 - Sustainable urban mobility and alternative fuels

Priority 4 - Technical Assistance

The beneficiaries are the owners/managers of the infrastructure and means of transport. Around CZK 125 bn (EUR 4.8 bn) is allocated for 2021-2027.

The programme focuses on the development of sustainable transport. The OP Transport may complement the JTF by supporting investment into public transport and increasing the (sustainable) mobility of citizens in the regions.

The Jan Amos Komensky Operational Programme (OP JAK)[80]

The Jan Amos Komensky Operational Programme follows the Operational Programme Research, Development and Education. It aims to support the quality and availability of education at all levels - from pre-school to research and development. To achieve change, there is a need to focus on both equal opportunities and equity in education, and on modernising the content and methods of education that support access to highly skilled jobs, the transition of the economy. The programme can help with the qualification of students for the transformation of industry in the monitored regions.

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[78] Ministry of Environment, https://www.mzp.cz/cz/modernizacni_fond

[79] OP transport https://dotaceeu.cz/cs/evropske-fondy-v-cr/kohezni-politika-po-roce-2020/programy/list/op-doprava OP transport https://dotaceeu.cz/en/evropske-fondy-v-cr/kohezni-politika-po-roce-2020/programy/list/op-doprava

[80] OP JAK https://opvvv.msmt.cz/download/file5527.pdf

The programme will be funded by the European Social Fund Plus (ESF +) and European Regional Development Fund (ERDF). Around CZK 125 bn (EUR 4.8 bn) is allocated for 2021-2027.

With regard to the objectives of the JTF, the operational programme supports equality in education and the development of research centres. However, the JTF directs them to specific problems of the regions, especially the retraining of existing employees.

Recovery and Resilience Facility (RRF)[81]

In response to the expected effects of the COVID-19 pandemic, the Member States of the European Union (EU), the European Commission (EC) presented a proposal for a Regulation establishing a Recovery and Resilience Facility (RRF) in May 2020. The RRF proposal was based on previous discussions on the EC proposal to establish a new Reform Support Programme.

The expected allocation for the Czech Republic is approximately EUR 7.1 bn (current prices) in the form of grant financing and loans up to 6.8% of 2019 gross national income. No mandatory national co-financing is needed.

One of the Fund's transformation priorities is job creation and economic, institutional and social resilience. Furthermore, regeneration and restoration can be supported. The support is directly linked to national Recovery and Resilience plans.

Summary of national programmes

Table 12 summarises the key national programmes to be implemented in the next MFF 2021–2027.

Table 12 Government-approved allocation subsidy programme for the Czech Republic in 2021-2027[82]

Operational Programme Environment	MoE	Financing improvements of energy efficiency and use of RE in public buildings	2.3 bn EUR 61.1 bn CZK	2021-2027
Integrated Regional Operational Programme	MoRD	Financing the purchase of alternative fuels vehicles for public transportation	4.7 bn EUR 122.7 bn CZK	2021-2027
		React-EU	21.7 bn CZK 0.83 bn EUR	2020
Just Transition Fund	MoE	Mitigating the effects of the transition process to a carbon-neutral economy in the regions	1.6 bn EUR 42.7 bn CZK	2021–2027
Operational Programme Employment+	MLSA	Promoting employment, opportunities and social inclusion.	1.4 bn EUR 36.4 bn CZK	2021–2027
Operational Programme Transport	MoT	Promoting sustainable transport and removing bottlenecks in key network infrastructures, promotion of sustainable mobility with an emphasis on cities.	4.8 bn EUR 125.0 bn CZK	2021–2027
Operational Programme Jan Amos Komensky	*MEYS*	The programme also covers reducing educational inequalities, maximizing the development potential of everyone, and reducing academic failure. Reducing regional and intra-regional differentiation of the quality of the education system. Follow-up to the Operational Programme Research, Development and Education	2.5 bn EUR 64.1 bn CZK	2021–2027
Recovery and Resilience Facility		Reform support programme. Approximately half of this amount is fixed, the remaining part for the period 2023–2026 will be determined by June 2022. In addition, additional soft loans of up	7.1 bn EUR 171.4 bn CZK	2021–2026

[81] https://www.mpo.cz/cz/rozcestnik/pro-media/tiskove-zpravy/priprava-narodniho-planu-obnovy-vrcholi---259990/ , https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32021R0241&from=EN#d1e830-17-1 https://www.komora.cz/eu-rozpocet-vicelety-financni-ramec-na-obdobi-2021-2027-a-fond-obnovy-tzv-next-generation-eu/

[82] We have not included the research programmes, such as Czech Science Foundation and Technology Agency of the Czech Republic. This may be added at a later stage depending on the availability of information.

		to 6.8% of gross national income in 2019.		
New Green Savings Programme	MoE	Financing improvements in energy efficiency in households	2.36 bn EUR* 59 bn CZK*	2021-2030
Modernisation fund	MoE	Financing energy efficiency measures in non-residential buildings, industry, transport	5 bn EUR 140 bn CZK	2021-2030
		Total	**32.5 bn EUR 842.3 bn CZK**	

* Preliminary estimate, possible overlap with other sources of funding

Table 12 presents indicative targets and overlap with further operational programmes. **The CZ Government decided on the following allocation among the Operational Programmes of ESIF fund on 1 March 2021**.

This division does not indicate overcompensation, but rather areas that are already supported in a general transformation towards sustainability in line with the goals of the energy targets. The indicated overlaps serve as a general overview in the definition of JTF in relation to other operational programmes.

Table 13 Funds overview and indicative overlap for the Czech Republic from 2021-2027

Variables	JTF-Pillar I	JTF-NGEU	InvestEU JT Pillar II	EIB JT Pillar III	ERDF/CF	RRF	MF	IROP	OP E	OP JAK	OP TAK	OP Z+	OP D	NGS
EUA EAA							2 %							●
EFRR								●	●	●	●		●	
ESF+										●		●		
Cohesion Fund									●				●	
NUTS-level region	3		3	3	2	2	1	1	1	1	2	1	-	2
JTF - Investment areas (Art. 4) - CZ /Annex D														
SMEs, including start-ups, leading to economic diversification and reconversion	●									●	●			
Creation of new firms, including through business incubators and consulting services	●					●				●	●	●		
Research and innovation activities and fostering the transfer of advanced technologies	●						●			●	●			
Technology and infrastructures for affordable clean energy, in GHG emission reduction, EE and RES	●						●		●		●		●	●
Digitalisation and digital connectivity	●					●		●		●	●	●		
Regeneration and decontamination of sites, land restoration and repurposing projects	●					●	●	●	●					
Circular economy, including through waste prevention, reduction, resource efficiency, reuse, repair and recycling	●							●	●		●			●

Variables	JTF-Pillar I	JTF-NGEU	InvestEU JT Pillar II	EIB JT Pillar III	ERDF/CF	RRF	MF	IROP	OP E	OP JAK	OP TAK	OP Z+	OP D	NGS
Upskilling and reskilling of workers	●					●	●			●		●		
Job-search assistance to jobseekers	●						●					●		
Active inclusion of jobseekers	●											●		
Technical assistance	●													
Large enterprises	TBC						●							
EU ETS installations							●							

2.3.2 *Regional programmes*

Although emphasis should be on the national programmes outlined above, we have also assessed the main regional programmes that are connected to low-carbon transition. The level of decentralisation of the climate and energy support schemes has been low in the Czech Republic.

Moravian-Silesian region

There are two key support schemes in Moravian-Silesian Region: (1) *Support for disadvantaged areas of the Moravian-Silesian regio*n 2020 and (2) *Support for the renewal and development of the countryside of the Moravian-Silesian Region 2021*.

*Support for disadvantaged areas of the Moravian-Silesian regio*n 2020[83] is the main programme. It provides financing for construction, revitalisation or reconstruction of buildings, or other areas such as:

- residential premises;
- schools, kindergartens and sports facilities;
- cultural and hobbies facilities; and,
- medical facilities, facilities for social business.

The programme focuses on towns with less than 5,000 inhabitants, Microregion - Association of Municipalities of the Osoblažsko Region. The estimated budget of the programme for 2021-2022 is CZK 20 million. Support for an individual project is between CZK 0.3-3 million.

Secondly, there is the *Support for the renewal and development of the countryside of the Moravian-Silesian Region 2021*.[84] It supports building renovation (reconstruction, modernisation) and construction of selected elements of rural development, infrastructure and civic amenities. It also supports the construction of local roads, purpose-built roads, and water-permeable roads. It is a non-investment type of subsidy for associations of municipalities based in the Moravian-Silesian Region for the activities of managers/advisers of associations of municipalities (rural micro-regions) who provide activities aimed at education, counselling and exchange of experience in rural development and village renewal, exceeding the possibilities and needs of municipalities, usually of regional importance. The programme targets municipalities with less than 3,000 inhabitants and unions of municipalities. The estimated budget of the programme for 2021 is CZK 25 million. Support for an individual project is CZK 50,000-400,000.

[83] Moravian Silesian Region. 2020. Conditions of subsidy programme support for disadvantaged areas of the Moravian-Silesian region 2020: https://www.msk.cz/cs/podminky-dotacniho-programu-podpora-znevyhodnenych-oblasti-moravskoslezskeho-kraje-2020-3474/

[84] Moravian Silesian Region. 2021. Conditions of subsidy programme support for disadvantaged areas of the Moravian-Silesian region 2021: https://www.msk.cz/cs/podminky-dotacniho-programu-podpora-obnovy-a-rozvoje-venkova-moravskoslezskeho-kraje-2021-3488/

Ústí region

In Ústí region, the key programme is the *Rural Renewal Programme,*[85] which subsidises the municipality for modifications and repairs of civic amenities owned by the municipality and the purchase and repair of equipment and technology. It also supports improving the condition of transport communications of all kinds and increasing traffic safety, improvement of the environment, revitalisation and protection of the landscape, waste management, and administration of project application and documentation at the State Environmental Fund. The programme targets municipalities with less than 1,000 inhabitants. The estimated budget of the programme for 2020 was around CZK 20 million. and 2,107 projects were supported for a total amount of CZK 382 million in 2009 – 2020.

Karlovy Vary region

The *Rural Renewal Programme*[86] also exists in Karlovy Vary. The applicants are differentiated by size (e.g., municipalities with less than 3,000 inhabitants, etc.) and the supported activities include renovation and maintenance of rural buildings and civic amenities, reconstruction of roads, availability of services in the smallest municipalities, micro-region activities, among others. CZK 30 million was allocated for the subsidy programme from the budget of the Karlovy Vary Region in 2020.

Second, the region offers *co-financing of exchange of solid fuels boiler in family houses* in the Karlovy Vary region[87] for applicants who have submitted their applications under the OP E 2014-2020 "boiler support" scheme but have not been supported in previous years due to the insufficient volume of allocation. The total allocation in this programme was CZK 26 million.

2.4 Governance and public consultations

The core governance structures for the Just Transition Process (JTP) in the Czech Republic have been put in place with the Ministry of Regional Development (MoRD) as the main coordinating entity and the Ministry of the Environment (MoE) as the managing authority. The Transformation Platform was established in autumn 2020 as one of the main consultation bodies of the JTP. The working groups of the MoE are discussing the priority areas to be supported under the JTF. The specific settings of the structures and processes are yet to be detailed. The key remaining challenges include the involvement and mobilisation of small players (SMEs, small municipalities) and civil society. Additionally, the governance of Pillars 2 and 3 of the JTM are yet to be established.[88]

Consultations regarding the preparation of the JTP (and inherently the transition to carbon neutrality) have so far taken place under the umbrella scheme described above (namely during the Transformation Platform meetings), on a regional level through the Regional Standing Conferences of the three regions, and through a number of regional and national workshops organised by regional and national authorities. The local bureaus of CzechInvest have been instrumental in facilitating further stakeholder engagement.

In the current Technical Assistance project, we have been attending several stakeholder meetings organised by the Transformation platform and in cooperation with MoRD. In addition, we carried out a total of 50 in-depth interviews and 3 discussion workshops with 34 external participants from December 2020 to May 2021 including representatives of EU ETS sector, non-EU ETS (incl. SMEs), municipalities, policy makers, and NGOs. The stakeholders were identified based on an assessment in the previous report and in cooperation with the regional representatives of CzechInvest, who helped address the concrete stakeholders. In addition, the team has established regular working meetings with stakeholders involved in the JTP, including the regional authority representatives and representatives of MoRD. Additionally, initial interviews with other policy makers (MoIT, MoE) have been carried out. Results from the interviews and workshops are presented in Chapters 5.1.6, 5.4 and Annexes 3 and 4. As we outline further, the results of the workshops and interviews are not representative. However, given the number of stakeholders in each group[89], they do indicate potential directions and problem areas, which are further outlined in Report D4 of this project. The final report (D5) will provide an overview on all activities and interviews carried out with stakeholders.

[85] Ústi Region. 2020. Rural Renewal Programme: https://www.kr-ustecky.cz/program-obnovy-venkova/ms-265361/p1=265361
[86] Karlovy Vary Region. 2021. Rural Renewal Programme: https://www.kr-karlovarsky.cz/dotace/Stranky/dotaceKK/prispevky-region/pov.aspx
[87] https://www.kr-karlovarsky.cz/dotace/Documents/Dotacni_program_nzu.pdf
[88] The issue of governance has been developed in detail report D2 on governance mechanism and stakeholder engagement under the same contract.
[89] https://www.sciencedirect.com/science/article/abs/pii/S2352710214000023

3 TIMELINE OF KEY TRANSITION STEPS

The Czech NECP,[90] as the main strategic reference document, does not indicate a specific timeline of the steps to achieve the transition towards a low-carbon future. In accordance with the EU Energy Union Regulation,[91] the NECP establishes the key energy and climate targets to be achieved by 2030. In addition, with respect to the Czech Climate Protection Policy, the NECP sets targets for GHG emissions reductions by 2040 and 2050. The NECP then provides scenarios on how to achieve targets in time.

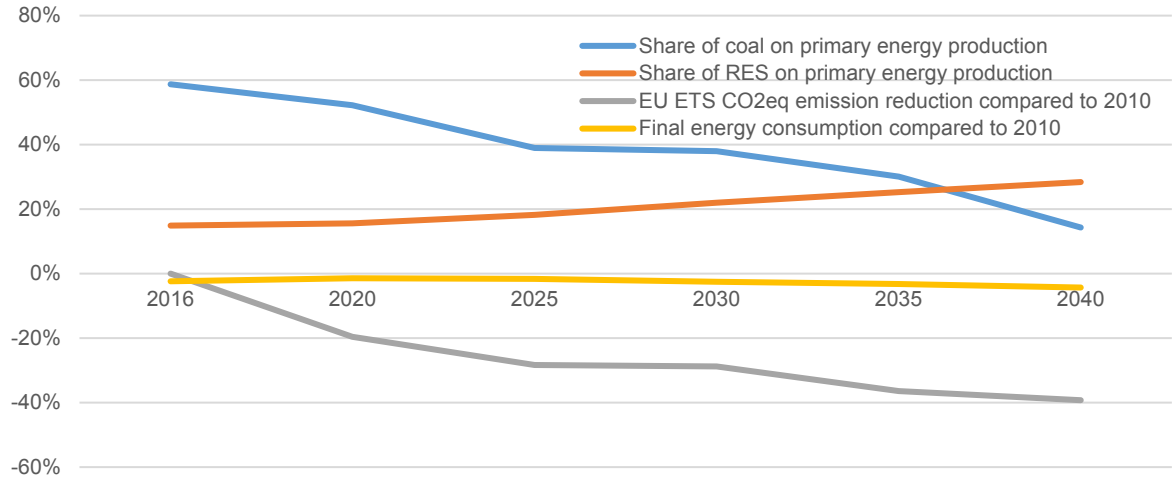
The targets are specified in Table 14. It illustrates the expected development of the key energy and climate indicators and shows the expected development of coal's share of energy production.

Table 14 Key targets of the Czech NECP

GHG emissions reductions	2030 – binding target of at least 44 Mt CO_2eq compared to 2005, corresponding to a reduction of **30%** 2040 – indicative GHG emission targets at 70 Mt CO_2eq 2050 – indicative target at 39 Mt CO_2eq for 2050 (80% reduction compared to 1990)
RES target	**22%** share of final energy consumption
Energy efficiency	Maximum final energy consumption in 2030 at 990 PJ and primary energy consumption at 1 735 PJ.*

*Note: This corresponds to the expected energy consumption reduction of 3% in PEC compared to 2005 values and 10% reduction of FEC compared to 2005 values.[92]

Graph 10 Key energy and climate statistics with respect to 2030 targets[93]



As depicted in Graph 10, the NECP assumes a fairly high share of coal in primary energy production in 2030 (roughly 40% of total energy production), which decreases to 14% by 2040. The values of 2030–2040 are deemed indicative in the NECP. The NECP further acknowledges potential developments that will influence the outputs and indicators. It specifically mentions the outputs of the Coal Commission, which can "potentially have a major impact on the structure of the energy mix in the medium and long term, respectively on the update of the State Energy Policy."

The MoRD started developing the Just Transition Plan in late 2020. The current version of the Territorial Just Transition Plan (version 1.5) sets the key targets and assesses the low-carbon transition with respect to the NECP. It further develops the specific impacts on coal related sectors. With respect to this

[90] Czech Government. 2019. National Energy and Climate Plan of the Czech Republic: https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf
[91] EUR-Lex. 2018. Regulation (EU) 2018/1999 of the European Parliament and of the Council. https://eur-lex.europa.eu/eli/reg/2018/1999/oj
[92] European Commission. 2020. JRC Science for Policy Report. National Energy and Climate Plans for 2021-2030 under the EU Energy Union: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC122862/jrc122862_national_energy_and_climate_plans_under_the_eu_energy_union_governance_final.pdf
[93] Czech Government. 2019. National Energy and Climate Plan of the Czech Republic: https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf

particular task (Timeline of key transition steps), the TJTP correctly follows the actual version of the NECP.

The draft version denotes that the transformation process stems from the obligations and needs of the Czech Republic and the goals and targets of the European Green Deal, which requires the transition to low-carbon energy and industrial activities. The draft plan further notes that this will require complex, vast changes "spread out in a longer time horizon and that will affect all areas of life and economy not only in coal regions, but in the whole Czech Republic."

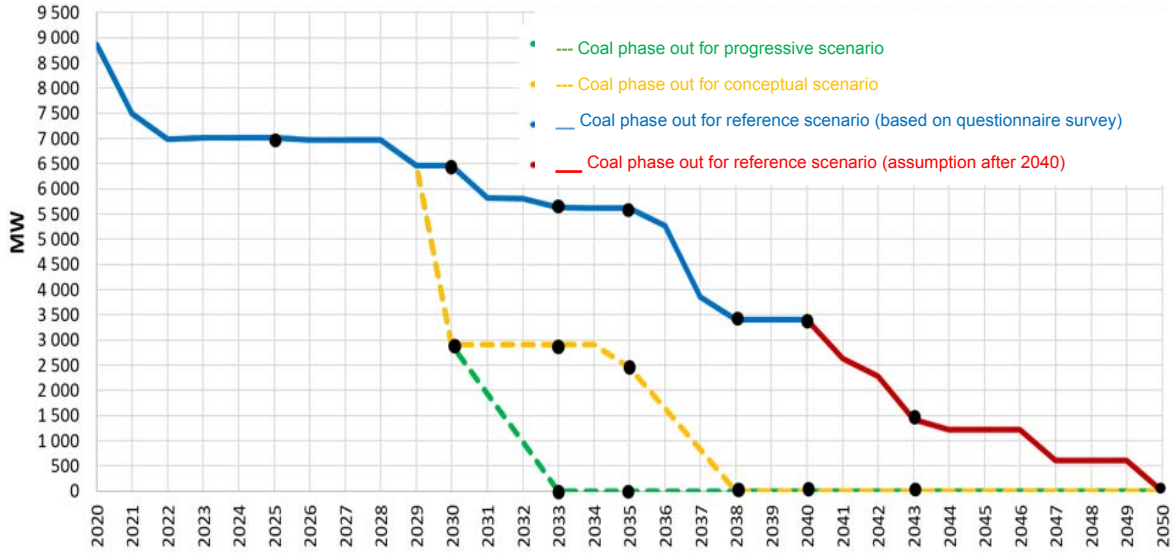
The draft JTP sets three main goals:

1) New productive investments supporting a change in the structure of the economy and reducing the effects of the energy transition, the coal phase-out.
2) Investments in the low-carbon economy, decontamination, revitalization and resocialisation of the territory and in the circular economy.
3) Investment in human resources in the context of the energy transition, the downturn in coal mining and the development of new economic activities.

These goals are in line with the recommendations of the European Semester Report for the Czech Republic.[94].

In the Czech Republic, the Coal Commission was established in July 2019 as an advisory body to the government with the goal of providing "maximum consensual inputs" on the coal phase-out, the timeline and related impacts and costs.[95] The Coal Commission first developed 24 scenarios of coal phase-out, taking into account energy, environmental and social impacts in the given regions and wider country. From the initial 24 scenarios for the future of Czech energy, with which the Coal Commission started at its inception, the selection was narrowed down to three dates for the end of coal use in the energy sector, namely: 2033, 2038, and 2043. The Czech transmission system operator ČEPS developed an analysis of the specific impacts of coal phase-out on the development of installed power plants and respective development scenarios (progressive, conceptual and reference). The three timeline scenarios are shown in Graph 11 and Graph 12.

Graph 11 Outlook of coal phase-out (net installed capacity) according to conceptual, reference, and progressive scenarios[96]

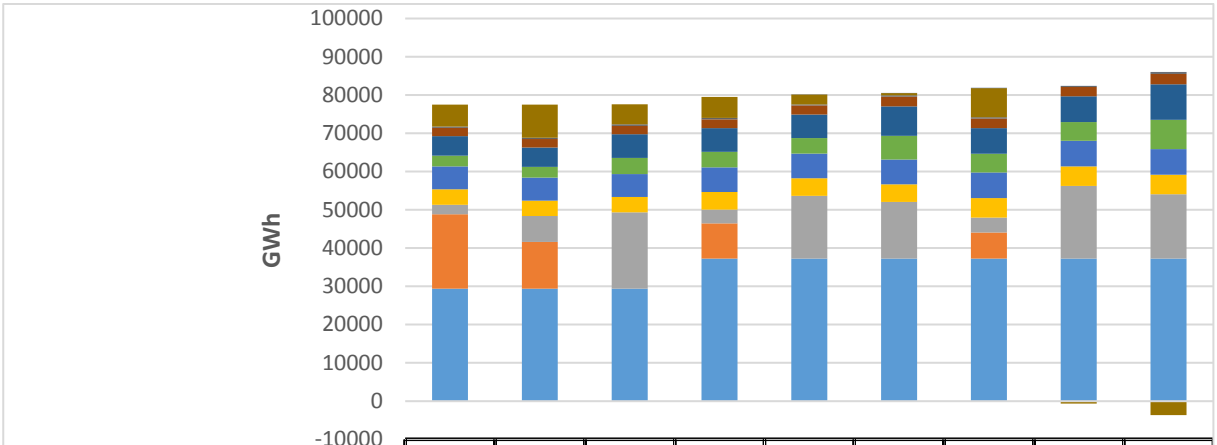


[94] European Commission. 2020. Communication from the Commission to the European Parliament, The European Council, The Council, The European Central Bank and the Eurogroup: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020SC0502&from=EN

[95] The coal commission has 19 members and is composed of representatives of the state administration (ministry), local government (Ústí, Karlovy Vary and Moravian-Silesian region), representatives of Parliament, academia, industry, as well as representatives of non-governmental non-profit environmental organizations. The statute and other information available (in Czech) at https://www.mpo.cz/cz/energetika/uhelna-komise/uhelna-komise--248771/

[96] As in the CEPS background documents for the Coal Commission meeting.

Graph 12 Electricity generation according to sources and scenarios for 2033, 2038 and 2043[97]



GWh	Reference 2033	Conceptual 2033	Prograssive 2033	Reference 2038	Conceptual 2038	Prograssive 2038	Reference 2043	Conceptual 2043	Prograssive 2043
Non delivery	0	0	0	0	1	1	61	1	2
Import and export balance	5726	8658	5213	5486	2617	563	7611	-656	-3681
Battery storage	350	366	404	368	256	349	349	280	490
Hydro and pumped storage power plants	2188	2179	2192	2306	2364	2538	2492	2427	2700
Photovoltaic power plants	5073	5073	6193	6157	6157	7716	6726	6732	9285
Wind power plant	2830	2831	4217	4059	4058	6195	4889	4892	7680
Heating plants and power plants	5986	5986	5986	6468	6468	6468	6678	6678	6678
Other RES	4046	4046	4046	4594	4594	4594	5103	5103	5103
Gas pover plants	2475	6751	19942	3607	16374	14806	3897	18986	16799
Coal power plants	19450	12240	0	9179	0	0	6805	0	0
Nuclear power plants	29371	29371	29371	37260	37260	37260	37260	37260	37260

In December 2020, the majority of Coal Commission members (15 out of 19) agreed on 2038 as the definitive deadline for the end of lignite combustion in the Czech Republic, even though the members of the commission had reportedly different views on these final scenarios.[98] The Coal Commission is an advisory body of the Czech Government, and therefore the Government must formally decide on the end of coal mining and usage in the Czech Republic. The decision was to be officially made on 1 February 2021. However, there has not been an agreement among individual ministers who expressed a need for further analysis (similarly to the members of the Coal Commission) to make a final decision.[99]

Therefore, even though the 2038 has been reported widely as the date for the end of coal in the Czech Republic, this may still change, possibly to the earlier date of 2033. The 2033 date would be more in line with the external studies that have been published to analyse the impacts of carbon neutrality and/or coal phase-out.[100] The studies by McKinsey, Agora and Forum Energii, and Ember[101] all show that coal

[97] As in the CEPS background documents for the Coal Commission meeting.

[98] Note of the consultants: The final meeting of the Coal Commission was accompanied by divisions among its members, with, for example, the MoE supporting the end of coal use five years earlier, in 2033. In a statement, he said that given that a fundamental change in Czech energy would occur by 2030, the end of coal at an earlier date would be possible in his view. The Minister of Industry and Trade stated that 2038 is not only a compromise for all groups in the Coal Commission but is based on both economic and environmental assumptions about building new resources. In the context of further expressions, he was referring not only to the assumption of the development of renewable energy sources, but above all to the issue of the construction of new nuclear resources (in the existing location of the Dukovany power plant), which is also foreseen by the State Energy Concepts in 2035.

[99] Euractiv. 2021. The end of coal in 2038? The government did not approve the recommendations of the coal commission, the ministers do not agree: https://euractiv.cz/section/energetika/news/konec-uhli-v-roce-2038-vlada-doporuceni-uhelne-komise-neschvalila-ministri-se-neshoduji/

[100] See also Chapter on investment needs for further discussion.

[101] McKinsey. 2020. Decarbonization Report Czech Republic: https://www.mckinsey.com/cz/~/media/mckinsey/locations/europe%20and%20middle%20east/czech%20republic/our%20work/decarbonization_report_cz_vf.pdf, https://ember-climate.org/project/coal-free-czechia-2030/ and Agora and Forum Energii.

phase-out by 2030[102] is possible and even desirable to be aligned with the goals of Paris Agreement. However, the studies also acknowledge that significant investments are needed to reach this goal. More importantly, they mostly disregard infrastructure costs[103], which, especially with a significant development of RES, may be a crucial component of the transition. Conversely, the studies do not calculate the externalities of coal burning, such as air pollution and health care impacts, which, when correctly priced, tend to bring net economic benefits for the society.[104] Similarly, they do not calculate the socio-economic implications of the low-carbon transition. The TA develops the specific regional implications in D4 of the project.

Additionally, the recent analysis of the district heating sector transition strategy shows that the coal phase-out is likely to happen in a small number of large steps, rather than continuously, with major decreases of coal use occurring until 2030. The report[105] shows that 85% of the transformation and restructuring of the sector will happen before 2030, with major reconstruction projects to be carried out in the period of 2025-2030. This is connected to the expectations of the energy sector, as described above, and the time needed to prepare such projects. With respect to the JT, the restructuring is not expected to have major implications on employment. The restructuring is to be mainly funded from the Modernisation Fund. Similar conclusions have been drawn by the impact analysis of coal-phase out in Moravian-Silesian Region[106], which assumes the "gradual or forced coal phase out" by 2035 but notes that it may happen even earlier.

Conclusions and suggested key transition steps

The NECP has not included a target for the climate neutrality transition. It can be expected that it will be updated in 2024 to reflect the new EU-wide climate neutrality targets. The official coal phase-out has been recommended for 2038, but an earlier coal phase-out is also likely since other (exogenous) factors (e.g., lending, increased GHG emission targets, "self-fulfilling" expectations[107], and public pressure) may contribute to the coal phase-out even sooner. While it is not within the scope of the consultant team to go beyond such a statement, a summary of the transition steps as they stem from the above analysis is provided in Table 15.

Table 15 Summary of transition steps

NECP	**Coal Commission**	**External analyses[108]**
2030 – binding target of at least 44 Mt CO_2eq compared to 2005, corresponding to a reduction of **30%** 2040 – indicative GHG emission targets at 70 Mt CO_2eq 2050 – indicative target at 39 Mt CO_2eq for 2050 (80% reduction compared to 1990) Coal phase-out not envisaged	Recommended coal-phase out in 2038	Coal phase out by 2030 – 2035 District heating – 85 % without coal by 2030

2020. Modernising the European lignite triangle towards a safe, cost-effective and sustainable energy transition: https://www.agora-energiewende.de/en/publications/modernising-the-european-lignite-triangle/

[102] In terms of diversion from coal, several factors play an important role in electricity generation: 1) the pressure of rising emission allowance prices, which is not fully offset by rising electricity prices, this leads to a decrease in profitability of these sources and may lead to economically sound decisions , 2) the ability of the electricity system to replace these sources, not only in terms of balance in terms of MW of installed capacity or TWh of electricity produced annually, but in terms of real coverage of the load diagram without the need to implement fundamental regulations on the consumption side. 3) the expected rapid shift away from the use of nuclear energy in Germany and the acceleration of the decommissioning of coal-fired power plants in Germany. There is a real risk of electricity shortages for certain periods of time, which could not be covered by imports. In this sense, the horizon for the phase out of coal use seems less realistic at this point in time.

[103] Clearly, even BAU scenarios will entail some level of infrastructure investment. However, the incremental infrastructure investment related to massive development of RES should be taken into account.

[104] https://www.irena.org/publications/2020/Apr/Global-Renewables-Outlook-2020; https://www.imf.org/en/Topics/climate-change/energy-subsidies

[105] Valentová, M., Knápek, J., Krejcar, R., Vašíček, J., Vecka, J. 2021. Klimaticko-energetické investice v teplárenství [Climate and energy investment in district heating sector]. ČVUT v Praze. https://ekonom.feld.cvut.cz/cs/katedra/lide/valenmi7/cic2030/index

[106] https://www.mskec.cz/data/storage/files/dopadova-studie-moravskoslezske-energeticke-centrum-web.pdf, Chapter 7

[107] See e.g., https://www.bennettinstitute.cam.ac.uk/blog/mind-over-matter-how-expectations-generate-wealth/ for more on conceptual background of how expectations shape development.

[108] See references above.

Based on the regulation of the Just Transition Fund,[109] the TJTP will include "a timeline for key transition steps that are consistent with the latest version of the NECP". In this respect, the draft version of the TJTP is in line with this obligation. However, we also recommend that the TJTP reflect the recommendation of the Coal Commission, the potential decision by the Government (if made within the timeframe of the TJTP), and possibly on other, external factors that could potentially speed up the coal phase-out, especially in the district heating sector.

Additionally, there are several important points that need to be solved and/or further assessed that are crucial to the successful phase-out of coal, which include:

- *Energy security*

The Czech Republic relies on nuclear power and natural gas as the main substitutes for the coal phase-out. However, especially in case of nuclear power, many uncertainties remain. The tender for a new nuclear block in Dukovany has so far faced much uncertainty.[110] Investment in nuclear power has seen major challenges in terms of significant cost increases and time delays across Europe and globally.[111]

- *Natural gas as transitional fuel*

Faster development of renewable energy sources will be needed. As stated above, the Czech Republic has pledged to increase the RES share to 22% of final energy consumption. However, this ambition has been assessed as modest.[112] The study by Ember calculates that to reach the phase out of coal by 2030, electricity generation by RES would have to be 2.5 times higher compared to the NECP scenario.[113]

- *A more inclusive Coal Commission*

Broader involvement of experts and civil society and widely shared and discussed impact analyses that form the background of the decision making of the Coal Commission would help to reach a broad consensus on the agreed coal phase-out and related transition steps.

- *Addressing the socio-economic impacts of the coal phase out*

Addressing the socio-economic impacts of the coal phase-out is indeed the purpose of the JT mechanism. However, it cannot be overstressed that the impact analysis, proper strategic planning and implementation of the financing schemes will be crucial to safeguard the Just Transition. This especially entails the coal regions, but as we show below, also includes nationwide impacts. The TA further develops the specific socio-economic impacts in the coal regions in the next sections (chapter 4 and 5) and provides even more detail in D4 of the technical assistance project.

[109] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020PC0022&from=EN
[110] https://denikn.cz/548354/vlada-kyvla-na-vyrazeni-ciny-z-dukovan-na-rosatomu-trva-opozici-ale-nepresvedcila/?ref=tema
[111] https://www.reuters.com/article/us-finland-nuclear-idUSKCN1QO1IC; https://www.neimagazine.com/news/newsflamanville-3-startup-pushed-back-to-2024-7853088
[112] https://ec.europa.eu/energy/sites/default/files/documents/staff_working_document_assessment_necp_czechia_en.pdf
[113] https://faktaoklimatu.cz/infografiky/srovnani-energetickych-scenaru-cr

4 IMPACTS OF THE TRANSITION TO CLIMATE NEUTRALITY ON CZECH ECONOMY AND SOCIETY

4.1 Identified impacts in strategic documents

This chapter examines the following main Czech national and regional strategic documents to assess the impacts of the transition to climate neutrality:

- National Energy and Climate Plan (NECP)[114]
- State energy policy (SEP)[115]
- State Environmental Policy of the Czech Republic 2030[116]
- Climate Protection Policy in the Czech Republic[117]
- Update of the Strategic Framework for Economic Restructuring of the Ústí nad Labem, Moravian-Silesian and Karlovy Vary Regions.[118]

The selected documents should be the key starting points for the transition to a low-carbon economy. However, not all strategic documents focus primarily on the transition to climate neutrality (see Section 2.1). We briefly discuss the key documents that touch on climate neutrality (or GHG emissions reductions targets and/or coal phase-out). We specifically focus on how the impacts of the climate neutrality transition are reflected in these documents. We also add supplementary analytical studies to these documents to identify the expected socio-economic impacts of changes in the Czech Republic.

The **National Energy and Climate Plan (NECP)**[119] from 2019 does not reflect directly on the impacts of the transition to climate neutrality on the Czech economy and society. However, it provides information on the long-term declining energy intensity of the Czech economy where energy intensity decreased by almost 18% during 2010-2018. It further mentions the Czech Republic's national targets, which include reducing carbon emissions.

The section of the NECP on reducing carbon emissions (greenhouse gas emissions and their absorption) refers to the Ministry of Industry and Trade analysis[120] - Assessment of social impacts for individual municipalities and the region concerned in view of the considered options for breaking the limit of coal mining in Northern Bohemia (from 2015), which focuses on the social impacts of GHG mitigation, which include, among others:

- Direct effects on unemployment and the labour market and living standards due to the elimination of primary jobs in mining companies
- Impacts on jobs related to mining activities in both quarries within the Ústí region
- Impacts on the inhabitants of municipalities directly affected by mining activities.

The study served as an analytical basis for the government's decision to break the mining limits and was thus prepared in the form of alternative variants. The study provides predictions of social and economic impacts in the Ústí regions related to the coal phase-out up to 2050. Although the report is from 2015 (and is thus based on different legislative frameworks and the continuation of mining over 2050, even 2038, to the specified extent is unrealistic), it provides valuable information on the expected impacts on regional employment associated with the cessation of lignite mining in the region. Thus, similar impacts can be expected, but on a much earlier timeline.

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[114] National Energy and Climate Plan of the Czech Republic, https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf

[115] Doplňující analytický materiál k návrhu aktualizace Státní energetické koncepce [Additional analytical material to the draft update of the State Energy Concept] https://www.mpo.cz/assets/cz/energetika/statni-energeticka-politika/2016/12/Doplnujici-analyticky-material-k-SEK.pdf

[116] Státní politika životního prostředí České republiky 2030 [State Environmental Policy of the Czech Republic in 2030] (https://www.mzp.cz/C1257458002F0DC7/cz/news_20200710_statni_politika_zivotniho_prostredi_2030/$FILE/OPZPUR-SPZP_2030_pro_verejnou_konzultaci-20200710.pdf)

[117] Politika ochrany klimatu v ČR [Climate Protection Policy of the Czech Republic] (https://www.mzp.cz/C1257458002F0DC7/cz/politika_ochrany_klimatu_2017/$FILE/OEOK-POK-20170329.pdf)

[118] Strategický rámec hospodářské restrukturalizace Ústeckého, Moravskoslezského a Karlovarského kraje (https://restartregionu.cz/content/uploads/2016/10/Strategicky_ramec.pdf)

[119] National Energy and Climate Plan of the Czech Republic, https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf

[120] Posouzení sociálních dopadů u jednotlivých obcí a dotčeného regionu z pohledu zvažovaných variant prolomení limitu těžby uhlí na území severních Čech [Assessment of social impacts for individual municipalities and the region concerned in view of the considered options for breaking the limit of coal mining in Northern Bohemia], https://www.mpo.cz/assets/dokumenty/53569/61119/636798/priloha001.pdf

The study assesses social impacts caused by the change in coal mining limits in North Bohemian basin (Bílina and Czechoslovak Army - ČSA mines) and is based on data provided by two mining companies (SD, a.s. and Sev.EN Energy, a.s.). They define the number of employees in operations directly related to the mining activities of the Bílina and ČSA mines. Together, the two companies provide approximately 5,000 jobs directly related to lignite mining.

The study uses a multiplication factor of 0.75 and 1.5 to determine the number of jobs in related fields. Based on the performed analyses, in 2005, the mining activity in the Bílina and ČSA quarries generated a total 7,000 jobs (11,000 jobs using the 1.5 factor) in the Ústí region for primary mining and related fields that focus on coal processing.

The study presented four scenarios:

- Scenario 1: maintain the limits of lignite mining in northern Bohemia according to established limits (at that time);
- Scenario 2: shift the boundaries of brown coal mining at the Bílina quarry;
- Scenario 3: shift the limit of brown coal mining at the Bílina quarry and also partially break the limits on the ČSA quarry;
- Scenario 4: shift the boundaries of lignite mining at the Bílina quarry and break territorial ecological limits at the ČSA quarry within the second phase.

Scenario 1 expected a loss of up to 1,000 jobs, which would have occurred between 2015 and 2019. By 2020, the study predicted a decrease of more than 1,200 jobs (approximately 30% of jobs in 2015) and the peak of employment decline was predicted between 2030 and 2034 when coal mining is expected to reach its limit. Consequently, the study predicts a continuous decrease in coal extraction from 12.8 m tonnes per year from 2016-2019 to 3 m tonnes per year in 2038 (cumulatively 163.9 m tonnes).

Scenario 2 considered postponing the limits on lignite mining at the Bílina mine to 2055 and closing mining activities at the ČSA mine between 2015 and 2019. A continuous reduction in jobs would thus occur only from 2030. Consequently, the study predicts a continuous decrease in coal extraction from 12.8 m tonnes per year from 2016-2019 to 4.65 m tonnes per year in 2050-2055 (cumulatively 263.9 – 283.9 m tonnes).

Scenario 3 included the relocation of part of the population in Horní Jiřetín. The relocation would necessarily be associated with mining extension (850 inhabitants). A significant drop in the number of jobs would occur in the ČSA mine between 2035 and 2039 (almost 2,000 primary jobs). The gradual reduction in employment at the Bílina mine would occur from 2030. Consequently, the study predicts a continuous decrease in coal extraction from 12.9 m tonnes per year from 2016-2019 to 4.65 m tonnes per year in 2050-2055 (cumulatively 310.9 – 330.9 m tonnes).

Scenario 4 predicted the extension of coal mining until 2050 and would require relocation of Černice and Horní Jiřetín (2,200 inhabitants). In 2015, the Czech government approved breaking the limits at the Bílina mine and did not allow breaking the limits at the ČSA mine (Scenario 2). A plan is currently being prepared by SD, a.s. for the mine's opening, preparation and mining. Consequently, the study predicts a continuous decrease in coal extraction from 12.9 m tonnes per year from 2016-2019 to 6 m tonnes per year up to 2072 (cumulatively 550.9 – 570.9 m tonnes).

The four scenarios expose the sociological impacts after closing mining in the ČSA or Bílina mines. A similar effect can be expected in the transition to carbon neutrality in the Czech Republic.

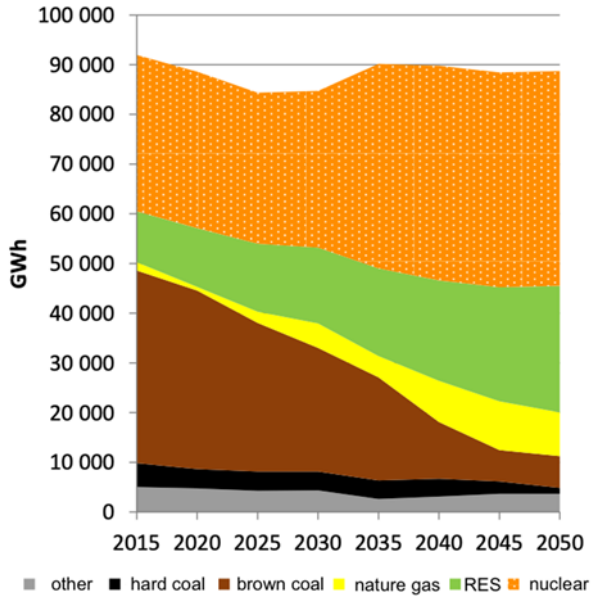
The conclusions of modelling the above-mentioned four variants from the point of view of coal mining can be summarised as follows[121]:

1) The structure of Brutto electricity production does not differ significantly between the four scenarios.
2) Brown coal consumption decreases significantly in all four scenarios.
3) Scenario 2 leads to a slight increase in the part of brown coal in electricity generation from 2030: on average, 2.2 TWh more electricity produced from brown coal compared to Scenario 1.
4) Scenario 3 leads to the same increase in brown coal as Scenario 2 but 5 years earlier.
5) Scenario 4 does not have any change in the energy mix of electricity generation compared to Scenario 3.

[121] Quantification of environmental and health impacts (external costs) from surface lignite mining in the North Bohemian brown coal basin in the mining localities of the Bílina and ČSA large quarries and extracted brown coal in combustion processes for electricity and heat production in the Czech Republic. https://www.mpo.cz/assets/dokumenty/53560/61109/636769/priloha002.pdf

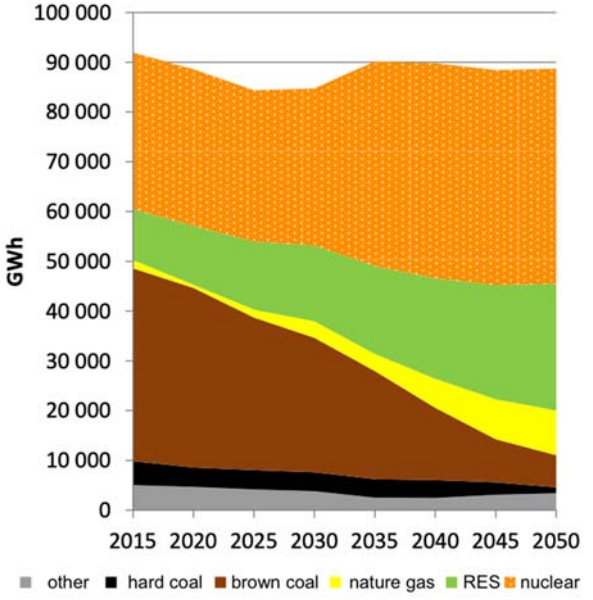
In the period 2013-17, 38.75 TWh (Brutto) of electricity was produced from brown coal per year, representing 42.1% of total electricity production. In Scenario 1, brown coal gradually decreased to 35.9 TWh (40.5%). In 2020, brown coal will continue to fall to 24.88 TWh (29.4%). By 2030, brown coal falls to 11.4 TWh (12.7%), and finally, in 2040, brown coal reaches 6.38 TWh (7.2%). Hard coal also declines, from 5% (4.8 TWh) to around 4.5% (3.8 TWh) from 2018-2032. A more significant decline in hard coal consumption for electricity production occurs after 2040 when it reaches 2.8% (2.5 TWh) in 2045 and 1.3% (1.2 TWh) in 2050. The predicted results for Scenario 1 are shown in Graph 13.

Graph 13 Improvement and structure of *Brutto* electricity production in Scenario 1



In Scenario 2 (Graph 14), there is a slight increase in brown coal in electricity generation mix, at the detriment of natural gas. However, around 2025, the difference between Scenario 1 and Scenario 2 is only 0.75 TWh of electricity produced from brown coal (i.e., 2.5% more than Scenario 1), and brown coal represents a negligible part of the total electricity produced (84.4 TWh). The difference in electricity produced from brown coal in Scenario 2 and 1 Scenario increases to 1.5 TWh during 2030-39 and around 2.7 TWh in 2040-49. However, this difference is small compared to the total volume of electricity produced at approximately 2.5-3.5%.

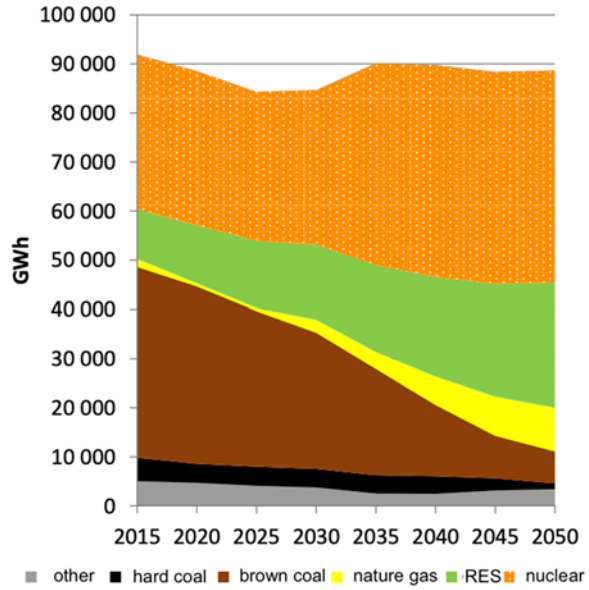
Graph 14 Improvement and structure of *Brutto* electricity production in Scenario 2



The only effect of Scenario 3 is an increase in the share of lignite-produced electricity between 2023 and 2032 when the share of lignite increases by 0.9 TWh compared to Scenario 2. This represents

approximately 3% of an increase in lignite production compared to Scenario 2, but in total volume, this increase is only about 1%. In the remaining period, the share of brown coal in the electricity mix is the same as Scenario 2. The energy mix in Scenario 4 is identical to that of Scenario 3 (see Graph 15).

Graph 15 Improvement and structure of *Brutto* electricity production in Scenario 3 and 4



The **State Energy Policy (SEP)** is the underlying strategic document for the energy sector. The objectives of the energy concept are based on the EU energy strategy (valid from its adoption in 2015) and provide a long-term vision of the Czech energy sector. The strategic document of the State Energy Policy mostly deals with the impacts of the transition to climate neutrality on Czech society and the employment of the population from the regions that will be most affected by the transition.

The expected increase in these regions' unemployment will be associated with the interruption of coal mining and coal processing. The planned closure of coal mines in 2023 would cause up to 16% unemployment in the Most region. After coal mining limits in the Vršany quarry around 2054, the coal mining limits will stop the Most district's mining activity. The cessation of mining activities in this region will also result in an employment loss of approximately 1,808 jobs. The end of mining activities would increase the Most district unemployment rate to 17.5% (estimated with a multiplication coefficient of 0.75). With a 1.5 multiplication coefficient, the unemployment rate in the Most district would exceed 19%.

According to the SEP, a significant increase in unemployment can also be expected in the event of the ending mining at the Jiří and Družba mines in the Sokolov region, where the Sokolovská uhelná, a.s. is with the largest employer. In 2020, there were already significant redundancies in the region (800-1,000 employees in mining) due to rising allowance prices. The pressurized gas plant Vřesová was closed, which in turn led to a reduction in lignite mining and processing.

The SEP is currently undergoing an official update, which should reflect the current developments in the energy sector and related climate targets. It is likely that the SEP will change substantially, especially in terms of coal phase-out predictions. Based on data from the Czech Statistical Office[122] around 24,000 employees in 2020 worked in the mining and quarrying sector across the three coal regions: 11,000 in Moravian-Silesian; 9,000 in Ústí; and 4,000 in Karlovy Vary.

The **Country Report on the Czech Republic 2020**[123] is not a strategic document per se but provides important guidance for the country. Hence, we feel it is important to include it in the analysis. The report provides analysis of the transformation impacts of the expected Transition Mechanism. As part of the Sustainable Europe Investment Plan, the EC proposes the Just Transition Mechanism, which includes the Just Transition Fund. Significant structural changes are expected from the Transition Mechanism

[122] ČSÚ (2021): Statistické ročenky krajů. [cit. 2021-03-30]. Retrieved from: https://www.czso.cz/csu/czso/katalog-produktu.

[123] European Commission Staff Working Document. Country Report Czechia 2020. Accompanying the document Communication from the Commission to the European Parliament, the European Council, the Council, the European Central Bank and the Eurogroup 2020 European Semester: Assessment of progress on structural reforms, prevention and correction of macroeconomic imbalances, and results of in-depth reviews under Regulation (EU) No 1176/2011 SWD/2020/502 final: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1584543810241&uri=CELEX%3A52020SC0502

with respect to business models, skills requirements and relative prices. Impacts on individual citizens are also expected. However, the JTM impact on inhabitants will significantly depend on their social and geographical conditions.

The report expects that the transformation process will affect inhabitants of the "coal regions" (Moravian-Silesian and the Northwest, which consists of Karlovy Vary and Ústí nad Labem), which are dependent on coal and coal energy. These sectors employ more than 21,000 people and represent more than 19,000 indirect jobs in the country. According to the report, there are over 10,000 jobs indirectly related to coal mining in the Northwest Region. In the Moravian-Silesian Region, there are approximately 4,000 workplaces and more than 5,000 in other Czech regions. The report further warns that the impact of the coal transformation could worsen these regions' situations because they are already among the poorest regions in the country. Moravian-Silesian is the region with the largest hard coal mining sector in the Czech Republic (28% of the total area is part of the Ostrava-Karviná Coal Basin). In 2020, there were three active mines that accounted for more than 10,000 direct jobs in the coal industry. However, in February 2021, the company OKD closed two mines, so only one mine is currently being operated (ČSM-sever and ČSM-jih). In the Ústí Region, where 80% of brown coal is mined in the Czech Republic (Severočeská uhelná pánev), there are over 5,000 coal-related jobs. There are four coal mines and the largest coal-fired power plants in the Czech Republic (Prunéřov, Tušimice, Ledvice and Počerady), with a high concentration of chemical companies.

In Karlovy Vary (with two brown coal mines and the lowest GDP per capita in the Czech Republic), the mining company located in the Sokolov district (which has the highest number of socially excluded areas in the Czech Republic) is the largest employer with approximately 3,000 jobs[124]. Another 1,000 jobs or so are related to energy production and related industries. Based on this preliminary assessment, the Just Transition Fund will definitely focus on these regions. The Moravian-Silesian, Ústí and Karlovy Vary regions expect significant job losses, which would not necessarily be offset by the creation and development of small and medium-sized (SMEs) companies. If necessary, the implementation of the regional transformation plan will support productive investment in large enterprises. The social challenges posed by an efficient and JTF will require the diversification of regional economies, the creation of new business opportunities, the upskilling or retraining of workers, and enhanced support for renewable energy, energy efficiency and the removal of environmental burdens from contaminated sites.

The **State Environmental Policy of the Czech Republic 2030,**[125] currently under preparation, mentions the goal of moving the Czech Republic to a climate-neutral economy. The document also mentions the social and economic impacts related to the transition to a low-carbon economy (e.g., technological, administrative and legislative changes). Similarly, the document states that companies need to "prepare for these changes." Measures should be taken to encourage the development of new and innovative industries. These measures should be reflected in both the labour market and education. In addition to these measures, which are intended to prepare society for changes to a climate-neutral economy, it is also necessary to ensure a reliable, affordable and long-term sustainable energy supply for both households and the market. However, the document does not quantify or develop specific impacts.

There is no mention of the impact of the transition to climate neutrality in the strategic document of **Climate Protection Policy in the Czech Republic.**[126] It focuses on the possibilities of reducing emissions in the field of energy and heavy industry, such as metallurgy or engineering. The document does not quantify or further develop these impacts.

From the point of view of our assessment, the document **Update of the Strategic Framework for Economic Restructuring of the Ústí nad Labem, Moravian-Silesian and Karlovy Vary Regions (July 2020)**[127]offers the most elaborate analysis of the impacts, albeit only at the regional level. The Strategic Framework was developed by the RE: START executive team in cooperation with the Regional Permanent Conferences of the Ústí, Moravian-Silesian and Karlovy Vary Regions and represents an important document that expresses the government's long-term strategy on how to support, facilitate and accelerate the restructuring of the economy in structurally disadvantaged regions. Although the

[124] The TA team develops on this in detail in D4.

[125] Státní politika životního prostředí České republiky 2030 [State Environmental Policy of the Czech Republic in 2030] (https://www.mzp.cz/C1257458002F0DC7/cz/news_20200710_statni_politika_zivotniho_prostredi_2030/$FILE/OPZPUR-SPZP_2030_pro_verejnou_konzultaci-20200710.pdf)

[126] Politika ochrany klimatu v ČR [Climate protection policy of the Czech Republic] (https://www.mzp.cz/C1257458002F0DC7/cz/politika_ochrany_klimatu_2017/$FILE/OEOK-POK-20170329.pdf)

[127] Aktualizace Strategický rámec hospodářské restrukturalizace Ústeckého, Moravskoslezského a Karlovarského kraje (červenec 2020) [Update of [Strategic framework for economic restructuring of the Usti, Moravian-Silesian and Karlovy Vary regions (July 2020)]] (https://restartregionu.cz/content/uploads/2021/03/Aktualizace-Strategického-rámce2016/10/Strategicky_ramec.pdf)

document does not contain a proposal for specific measures, it identifies the basic principles common to all regions, and according to it, the relevant regions will take measures in all key areas in cooperation with the government. This strategic document divides the strategic framework for economic restructuring into the seven pillars (five of which are directly related to financial restructuring). The objective of these pillars, besides restructuring the economy, is to reduce energy intensity and transformation of the production method of energy forms while reducing the production of CO_2. The seven pillars are:

- Entrepreneurship and innovation;
- Foreign direct investment;
- Research and development;
- Human resources;
- Social stabilisation;
- Environment;
- Infrastructure and public administration;
- Energy transformation (added in 2020).

This strategic document mentions that the changes made in energy production and consumption will positively or negatively affect the economy of individual regions. In particular, the changes caused by the transformation to climate (carbon) neutrality are expected to have negative impacts such as increased heating costs for residents of the Ústí nad Labem, Moravian-Silesian and Karlovy Vary and other regions. This document thoroughly quantifies the economic and social impacts that a transition to climate neutrality would cause in regions strongly associated with coal mining and processing.[128]

The strategic document further states that the transition to climate (coal) neutrality can easily estimate the extent of negative impacts in the energy production chain. Conversely, estimating the positive consequences is more difficult because it depends on the strategies of companies, the potential of new technologies and the speed of their development, and the ability of individual companies (regardless of strategy) to enter new markets.[129]

To quantify the positive and negative impacts caused by the transition to climate (coal) neutrality, the strategic document relies on the JRC study,[130] which was developed to investigate the possible impacts of the transition to climate (carbon) neutrality.

The JRC study estimates direct and indirect negative effects in the regions at about 50,000 endangered jobs (i.e., for the energy and coal mining sectors and related industries such as the metallurgical industry of iron and steel production). Furthermore, the study estimates the threat to jobs in the chain of suppliers who supply inputs to mining companies and power plants. The metal, engineering and construction sectors will be most at risk. However, impacts can also be expected in other sectors (activities), such as various outsourced services (IT, PR, security, logistics, development and research, maintenance, etc.).

One impact of the transition to climate neutrality in the energy sector is the expected rise in the price of electricity for consumers, which may have implications on the broader economy. It is expected that the coal and industrial regions will be most sensitive to rising electricity prices. A summary of the impacts related of rising prices of energy suggests:

- Increasing the price of energy for consumers, both for households and companies (producers whose production is energy-intensive).
- Structurally affected regions (i.e., coal regions in the Czech Republic) have a greater concentration of energy-intensive industries for historical and economic reasons. Therefore, coal regions are much more vulnerable to rising prices of energy than other regions.
- The increase in energy prices will be reflected in the broader economy. Rising energy prices and more expensive energy raw materials or energy production methods will have a significant impact on other companies in the production chain in the coal regions and beyond.
- The increase in energy prices will also have an impact on transportation (rail transport is an important consumer of electricity in the Czech Republic).
- The consequences of rising energy prices will also be significant for households. Structurally disadvantaged regions, i.e., coal regions are more vulnerable to rising prices than other regions in the Czech Republic since there is a greater concentration of socially vulnerable groups, which includes those with lower levels and quality of education, as well as stagnation and decline in

[128] Ibid.
[129] Ibid.
[130] EU coal regions: opportunities and challenges ahead, JRC for the European Commission, 2018, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/eu-coal-regions-opportunities-and-challenges-ahead

living standards and general well-being[131]. The effects of rising energy prices will vary from region to territory (the effects will be more severe in peripheral areas, on average, than in cities).
- Due to higher transportation prices, whether fuel prices for individual transport or public transport prices, the willingness of people to commute to work could be lower.
- Increasing the extent of brownfields (especially in energy operations) and increasing the area after mining.

Table 16 summarises the analysed strategic documents and the impacts of climate neutrality transition as assessed by these documents. However, as mentioned in the assessment above, the quantification and level of depth of the assessment varies among the documents.

Table 16 Impact assessment in Czech national strategic documents

<table>
<tr><th></th><th>NECP[132]</th><th>SEP[133]</th><th>Country report on the Czech Republic [134]</th><th>State Environmental Policy of the Czech Republic 2030[135]</th><th>Strategy of adaptation to climate change in the Czech Republic conditions [136]</th><th>Climate Protection Policy in the Czech Republic[137]</th><th>Update of the Strategic Framework for Economic Restructuring of the Ústí, Moravian-Silesian and Karlovy Vary regions[138]</th></tr>
<tr><td colspan="8">Impacts of the transition to climate neutrality / GHG mitigation on:</td></tr>
<tr><td rowspan="3">Key Impact Categories</td><td>Unemployment and the labour market</td><td rowspan="3">Society and the Employment of the population from the Ústí, Moravian-Silesian and Karlovy Vary regions</td><td>Structural changes in business models, worker skill requirements, and relative prices</td><td rowspan="3">Society and economy</td><td>Climate change benefits for the population from a global perspective</td><td>Possibilities of reducing emissions in the field of energy and heavy industry</td><td>Entrepreneurship and innovation</td></tr>
<tr><td>Living standards of inhabitants</td><td>Society and the employment of the</td><td rowspan="2">The document does not develop or</td><td rowspan="2">The document does not develop</td><td>Foreign direct investment</td></tr>
<tr><td></td><td></td><td>Research and development</td></tr>
</table>

[131] It is expected that the consequences of rising energy prices will be socially and spatially different. There are more socially excluded groups and groups at risk of poverty in structurally disadvantaged regions than in other parts of the Czech Republic. Therefore, the consequences in these regions will probably be more challenging, not only for the socially excluded but also for the public administration, which spends public funds to support social cohesion. Another possible impact will be a growing number of people who are at risk of poverty with already tight family budgets. An increase in the prices of forms of energy for some of them will mean a move closer to the poverty line and for a further fall into the so-called energy poverty. Certain groups of people may be unable to bear the cost of forms of energy while maintaining a minimum decent standard of living. With the growth of prices of forms of energy, structurally affected regions, i.e. coal regions, are more vulnerable than other regions in the Czech Republic because there is a greater concentration of socially disadvantaged people. More in D4.

[132] National Energy and Climate Plan of the Czech Republic, https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf

[133] Doplňující analytický materiál k návrhu aktualizace Státní energetické koncepce [Additional analytical material to the draft update of the State Energy Concept] https://www.mpo.cz/assets/cz/energetika/statni-energeticka-politika/2016/12/Doplnujici-analyticky-material-k-SEK.pdf

[134] European Commission Staff Working Document. Country Report Czechia 2020. Accompanying the document Communication from the Commission to the European Parliament, the European Council, the Council, the European Central Bank and the Eurogroup 2020 European Semester: Assessment of progress on structural reforms, prevention and correction of macroeconomic imbalances, and results of in-depth reviews under Regulation (EU) No 1176/2011 SWD/2020/502 final: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1584543810241&uri=CELEX%3A52020SC0502

[135] Státní politika životního prostředí České republiky 2030 [State Environmental Policy of the Czech Republic in 2030] (https://www.mzp.cz/C1257458002F0DC7/cz/news_20200710_statni_politika_zivotniho_prostredi_2030/$FILE/OPZPUR-SPZP_2030_pro_verejnou_konzultaci-20200710.pdf)

[136] Strategie přizpůsobení se změně klimatu v podmínkách ČR [Strategy for] (https://www.mzp.cz/C1257458002F0DC7/cz/zmena_klimatu_adaptacni_strategie/$FILE/OEOK-Adaptacni_strategie-20151029.pdf)

[137] Politika ochrany klimatu v ČR [Climate Protection Policy of the Czech Republic] (https://www.mzp.cz/C1257458002F0DC7/cz/politika_ochrany_klimatu_2017/$FILE/OEOK-POK-20170329.pdf)

[138] Strategický rámec hospodářské restrukturalizace Ústeckého, Moravskoslezského a Karlovarského kraje (https://restartregionu.cz/content/uploads/2016/10/Strategicky_ramec.pdf)

	NECP[132]	SEP[133]	Country report on the Czech Republic [134]	State Environmental Policy of the Czech Republic 2030[135]	Strategy of adaptation to climate change in the Czech Republic conditions [136]	Climate Protection Policy in the Czech Republic[137]	Update of the Strategic Framework for Economic Restructuring of the Ústí, Moravian-Silesian and Karlovy Vary regions[138]
	and municipalities		population from the Ústí, Moravian-Silesian and Karlovy Vary regions		quantify the impacts	or quantify the impacts	Human resources
	Termination of jobs related to mining activities						Social stabilization
							Environment
							Infrastructure and public administration
							Energy transformation

4.2 Assessment of the climate neutrality impacts

4.2.1 General assessment of the national transition progress

Overall, between 2008 and 2018 the Czech Republic has managed to decrease its per capita greenhouse gas emissions (in tonnes of CO2 equivalent) from 14.3 to 12.2 (translating to a 15% decrease, with largely stagnating total population), and while this decrease is on par with the EU-27 average change over the same period (15.5%), the 2018 absolute figure is still much higher than the EU-27 average (8.7 tonnes of CO2 equivalent) and is the fourth largest GHG emitter per capita in the EU-27.[139]

This metric is only a headline figure but underscores that there is still huge room for improvement for the highly industrialised country towards the transition to climate neutrality. A recent McKinsey[140] report concluded that reaching net-zero for the Czech Republic by 2050 would require additional investments amounting to CZK 4 tn (EUR 150 bn) between 2031 and 2050, which is equivalent to 4 percentage of the GDP over the same period.

4.2.2 Modelling national impacts with E3ME

The assumptions used for modelling a transition scenario are described in more detail in this section:

(1) a business-as-usual (BAU) case is described,
(2) a brief description of the E3ME macroeconometric model and its connected submodules (e.g., FTT:Power) is provided,
(3) the assumptions used for modelling a transition scenario are described.

4.2.2.1 Business-as-usual scenario

The E3ME model builds on data collected and maintained by Cambridge Econometrics.[141] Economic, energy, environmental and auxiliary time-series are sourced from various data providers including:

- Eurostat national accounts for economic data in European countries (e.g., nama10 series)
- AMECO database for macroeconomic figures
- PRIMES/Eurostat data for energy figures in European member states
- IEA WEO energy balances (for energy auxiliary energy data and data outside Europe)
- Additional data sources, for more detailed discussion see the E3ME manual[142]

139 Eurostat (2020) Greenhouse gas emissions per capita. Available at: https://ec.europa.eu/eurostat/databrowser/view/t2020_rd300/default/table?lang=en
140 McKinsey and Co. (2020) Pathways to decarbonize the Czech Republic. Available at: https://www.mckinsey.com/cz/our-work/pathways-to-decarbonize-the-czech-republic
141 Cambridge Econometrics. 2019. 'E3ME Technical Manual v6.1'. https://www.e3me.com/wp-content/uploads/2019/09/E3ME-Technical-Manual-v6.1-onlineSML.pdf.
142 Cambridge Econometrics. 2019. 'E3ME Technical Manual v6.1'. https://www.e3me.com/wp-content/uploads/2019/09/E3ME-Technical-Manual-v6.1-onlineSML.pdf.

Historical time-series are used for parameter estimations and calibration of the model (more discussion on this in the next section) as well as starting point for the forecasted data. Exogenous long-term projections are used for calibrating the long-term forecast of the model, sources for these are the Ageing Europe report (Eurostat 2019), the IEA WEO (IEA 2018) or IMF WEO. All of these data are used for building a general baseline, which, if needed, is then calibrated to the match pathways for individual countries more precisely.

Therefore, the first step of this modelling exercise is to establish a BAU scenario (or baseline) in line with the proposal. In energy terms the BAU scenario is based on the PRIMES EU Reference Scenario 2016 (Capros et al. 2016), but it includes subsequent modifications, such as taking COVID-19 effects into account. See Table 17 for a comparison of relevant indicators between the baseline and the PRIMES energy figures.

Table 17 Major indicators, Czech Republic in the BAU scenario compared to PRIMES 2016[143]

	PRIMES	Baseline
CO2 reduction in energy by 2030, compared to 2005	23%	21%
RES share in power generation by 2030	11%	10%
Change in final energy consumption (FEC), by 2030, from 2015	+1.2%	+0.4%
Power generation (GWh) share of technologies in 2030		
Nuclear	32%	35%
Solids	45%	44%
Gas	12%	10%
Solar	3%	3%
Wind	1%	1%
Hydro	3%	2%
Mean annual GDP growth (2021-2023)**	1.55%	4.00%
Mean annual GDP growth (2024-2030)**	1.87%	1.71%

Note: * The impacts of COVID-19 are assumed to decrease FEC by -3.7% from 2019 to 2020; the decrease is permanent, leading to an overall slower growth of energy consumption ** GDP is an input / assumption in the PRIMES energy modelling

In economic terms, however, the baseline scenario takes the impacts of COVID-19 into effect. It uses estimations from the EC's Summer Economic Forecast (European Commission 2020) for European member states, including the Czech Republic. Estimated impact of COVID-19 results in -7.8% GDP annual decrease compared to 2019 in 2020 according to the forecast. This impact was factored into the E3ME baseline (see again annual growth rate differences in Table 17, in 2021 a rapid recovery leads to an increased average rate in 2021-2023).

The resulting BAU case (baseline scenario) will be used as a starting point to model the transition scenario and serve as a point of comparison to understand the impacts of the transition.

4.2.2.2 The E3ME macroeconometric model

E3ME is a macroeconomic model built on post-Keynesian economic theory and on econometric estimations of macroeconomic relationships. It was originally built by an international research team and has since been maintained by Cambridge Econometrics. It has been used in high-profile scenario-based policy analysis, including assessing the EU's 2030 environmental targets,[144] EU skills projections[145] or in the 2018 New Climate Economy Report.[146]

E3ME is a national level model, which features detailed modelling for each EU member state, including a granular treatment of economic sectors and household consumption categories. Its behaviour is different from CGE type of models often used in macroeconomic modelling. E3ME works with a 'bounded rationality' approach, as it uses estimated behavioural relationships, rather than optimisation

143 PRIMES 2016 Ref Scenario[143](left), E3ME (right)

144 European Commission. 2020. 'Commission Staff Working Document SWD/2020/176: Impact Assessment on Stepping up Europe's 2030 Climate Ambition Investing in a Climate-Neutral Future for the Benefit of Our People'. Brussels. https://ec.europa.eu/clima/sites/clima/files/eu-climate-action/docs/impact_en.pdf

145 CEDEFOP and Eurofund. 2018. 'Skills Forecast: Trends and Challenges to 2030'. 108. Cedefop Reference Series. Luxembourg: Publications Office of the European Union. http://data.europa.eu/doi/10.2801/4492

146 New Climate Economy and World Resources Institute. 2018. 'Unlocking the Inclusive Growth Story of the 21st Century'. Washington, D.C. https://newclimateeconomy.report/2018/

assumptions. E3ME also features an endogenous treatment of money supply[147] and works with a demand-driven approach. This means that the supply side will try to adjust to demand, subject to constraints. Capacity constraints are one of those constraints and they feed back to prices and investment decisions in the model.[148] However, in the model, there is usually spare capacity in the economy, therefore policies may lead to increased output and employment.[149]

In this modelling exercise, the 'Future Technology Transformations' (FTT) suite of models is also used. FTT models are bottom-up technology models integrated with E3ME. FTT:Power is used in the modelling and simulates investment decisions through discrete choice modelling while assuming technology diffusion and learning effects for individual technologies.[150] In the modelling, FTT:Power determines a technology mix by region given a scenario of detailed energy policy such as carbon prices, subsidies and regulations by technology. Changes in the power technology mix result in changes of production costs, reflected in the price of electricity. The model takes electricity demand from E3ME and feeds back a price, fuel use and investment for replacements and new generators. Through E3ME linkages, this trickles through supply chains and reflected in gross output and investment for the electricity sector. For further details, please see Annex 1 or refer to https://www.e3me.com/.

4.2.2.3 Assumptions in the modelled transition scenario

The NECP was used as the base to create a transition scenario. Two tasks were carried out simultaneously: (1) important policy aspects of the NECP were collected and considered, (2) it was considered how NECP targets differ from results from the baseline scenario (PRIMES 2016 calibrated).

Table 18 shows the differences between the baseline, the simulated NECP scenario and the targets stated in the NECP. The NECP scenario is calculated with slightly higher ambitions than the actual NECP targets, this is partially due to spill-over effects from impacts in the other member states as the scenario assumes an illustrative Green Deal scenario outside of Czechia and partially from model mechanics (i.e., the scenario is calibrated to the target numbers, but to maintain internal consistency it does not necessarily report the exact same numbers, e.g. while both solar and wind gains in the NECP, wind gains more in the model and solar has a higher share in the NECP projections).

Table 18 Major energy indicators, comparing baseline, NECP targets and NECP E3ME scenario[151]

	Baseline	Target NECP	NECP scenario*
CO2 reduction in energy by 2030, compared to 2005	**19%**	**30%**	**34%**
RES share in power generation (GWh) by 2030**	**10%**	**16%**	**18%**
Change in final energy consumption (FEC), by 2030, from 2015	**+0.4%**	**-8.0%**	**-12.1%**
Power generation (GWh) share of technologies in 2030			
Nuclear	35%	39%	37%
Solids	44%	41%	40%
Gas	10%	5%	5%
Solar	3%	6%	5%
Wind	1%	2%	3%
Hydro	2%	3%	4%
EU28 CO2 reduction in energy by 2030, compared to 2005	**34%**	**55%**	**55%**

Notes: * The impacts of COVID-19 are assumed to decrease FEC by -3.7% from 2019 to 2020; the decrease is permanent, leading to an overall slower growth of energy consumption; illustrative Green Deal scenario (55% emission target) outside CZ in EU27 ** RES share in power generation is calculated based on expected installed capacity in the NECP (p 34) and load factors from historical data and E3ME assumptions; it is not to be confused with RES-E or share of energy from RES in gross final consumption of energy

147 Pollitt, Hector, and Jean-Francois Mercure. 2018. 'The Role of Money and the Financial Sector in Energy-Economy Models Used for Assessing Climate and Energy Policy'. *Climate Policy* 18 (2): 184–97. https://doi.org/10.1080/14693062.2016.1277685

148 Pollitt, Hector, Leonidas Paroussos, Kostas Fragkiadakis, and Panagiotis Fragkos. 2017. *Case Study-Technical Analysis on Capacity Constraints and Macroeconomic Performance*. European Commission. https://doi.org/10.13140/RG.2.2.24621.95205

149 Mercure, Jean-Francois, Florian Knobloch, Hector Pollitt, Leonidas Paroussos, S. Serban Scrieciu, and Richard Lewney. 2019. 'Modelling Innovation and the Macroeconomics of Low-Carbon Transitions: Theory, Perspectives and Practical Use'. *Climate Policy* 19 (8): 1019–37. https://doi.org/10.1080/14693062.2019.1617665 and Cambridge Econometrics. 2019. 'E3ME Technical Manual v6.1'. https://www.e3me.com/wp-content/uploads/2019/09/E3ME-Technical-Manual-v6.1-onlineSML.pdf.

150 Mercure, J. -F., H. Pollitt, U. Chewpreecha, P. Salas, A. M. Foley, P. B. Holden, and N. R. Edwards. 2014. 'The Dynamics of Technology Diffusion and the Impacts of Climate Policy Instruments in the Decarbonisation of the Global Electricity Sector'. *Energy Policy* 73 (October): 686–700. https://doi.org/10.1016/j.enpol.2014.06.029

151 PRIMES 2016 Ref Scenario (Capros et al. 2016), NECP of the Czech Republic (2019)

The NECP scenario was designed to mimic important structural aspects of the NECP such as energy system transition (power generation mix targets), energy efficiency actions and the transformation of road transport.

First, the share of EVs in new car sales is assumed to be in line with the NECP assumptions. To this end, three measures are considered: (1) differences in registration fees, (2) direct government EV purchases (e.g., through municipal purchases or public transport purchases), (3) direct regulation (mandate) increasing the share in new sales. These measures do not necessarily result in an increase in consumption, nor do we assume a change of input-output (IO) structures. The share of EVs does, however, have a relevant impact on emissions, transport technology and power demand.

Second, energy efficiency improvements are introduced in the scenario. The NECP aims for an 8% reduction of FEC from 2015 to 2030. The scenario assumes an annual 0.5% efficiency gain (demand decrease) for the main energy sources, such as electricity, gas, coal and heat. Based on financing and expected energy savings in the NECP, investment of ~ CZK 2.7 m is assumed to generate 1 GWh in energy savings.

Finally, it is assumed that outside of the Czech Republic, EU member states act in accordance with the goals of the European Green Deal (GD). This means that high-level policies (energy efficiency, EV mandates, RES support) are consistent with the GD and lead to a 55% reduction in CO_2 emissions for the EU27.

For the Czech Republic, this induces spill-over and price effects (i.e., technology matures faster, therefore it becomes cheaper to adapt). Another direct effect is the increase of ETS prices. As Table 19 shows, a gradually increasing ETS price was assumed, which reaches a 34% increase by 2030. Furthermore, as the EU has been considering the extension of the ETS system to the buildings and transport sectors[152] the scenario also considers this extension, thus ETS prices are levied on the buildings and transport sectors in the scenario.

Table 19 ETS price assumptions in the scenarios

EUR / tonnes CO_2	Baseline	NECP scenario
2020	**19.2**	**19.2**
2025	**25.6**	**32.6**
2030	**34.3**	**45.9**

Furthermore, budget balancing is assumed in the scenario. This means that ETS revenues are recycled towards required investments (energy efficiency investment, compensating early scrapping of power equipment if needed and power generation subsidies) while the residual amount is used to reduce income tax and social security contributions.

4.2.3 Key results of the national modelling

The chapter is structured by the model outputs, which include:

(1) National GDP
(2) Output and
(3) Employment with sectoral detail
(4) CO_2 emissions by source (fuel users).

In line with the modelling approach presented above, results have been calculated and are presented for the baseline scenario and the NECP target scenario. For the sake of comparison across variables, and with the aim of providing insights in terms of what the NECP scenario, if met, would mean *compared to* the baseline scenario, most of the following figures present the NECP results in percentage difference from the baseline scenario over the forecast horizon.

If the national climate transition is carried out in line with the NECP and coal-phase out expectations, it will have a positive impact on employment, the environment, and the economy. Within this context, much of the renewable energy deployment is expected to happen by 2026 and a significant reduction of final energy consumption will take place by 2030 (12% reduction compared to 2015) and an additional CO2 reduction of 17% to baseline levels considering the climate transition of the NECP. This will be

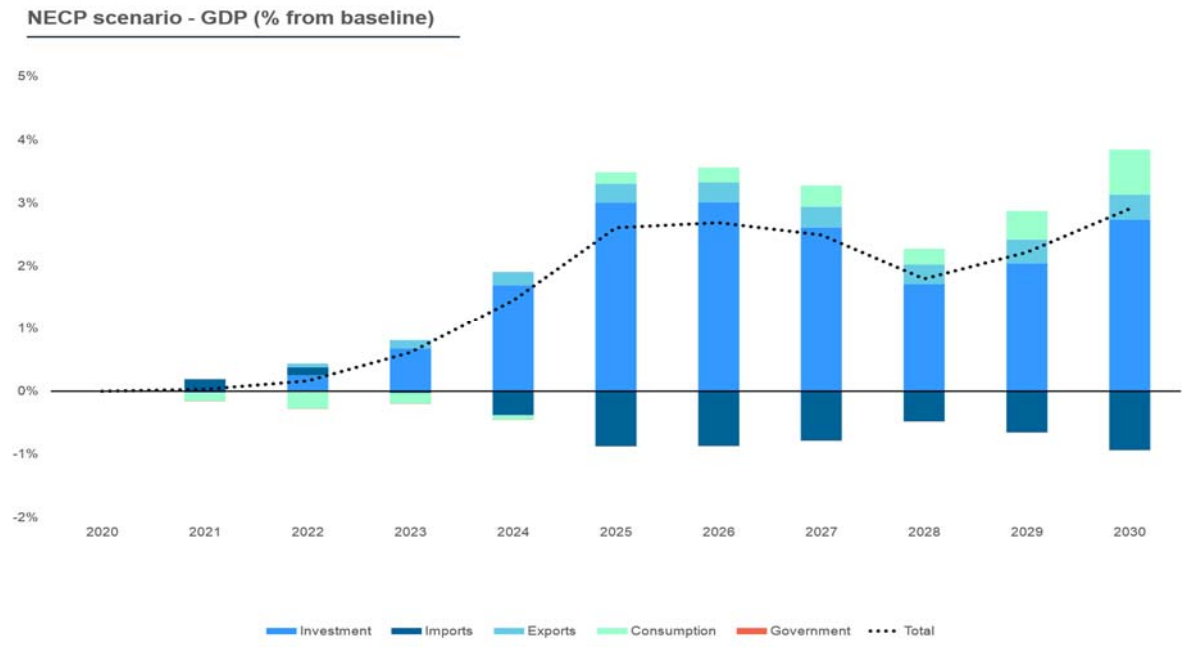
[152] Cambridge Econometrics (2020): Decarbonising European transport and heating fuels - Is the EU ETS the right tool?, Cambridge Econometrics: Cambridge, UK. https://www.camecon.com/wp-content/uploads/2020/07/Decarbonising-European-transport-and-heating-fuels.pdf

accompanied by increased economic activity through the coming decade, driven primarily by investments needed to make the transition inducing increased economic activity in the construction and manufacturing sectors and indirect gains through supply-chain linkages. Nevertheless, an important employment decrease in the energy and utilities sector (which includes coal mining and coal-based power generation) is projected, resulting in the loss of about 3,000 jobs in the sector by 2030. This will be counterbalanced by an employment increase in the manufacturing sector (peaking in 2027 and driven by fabrication of electric components and other components that are necessary to build up the renewable capacity; after 2027 the job growth will be driven by an increase in electromobility) and the construction sector (driven by demand for energy efficiency and related labour, as well as the transition and deployment of renewable sources). By 2030, the overall net effect of the climate transition will be the creation of over 50,000 jobs nationally (compared to the baseline). To realise these positive net effects, there is a need for people to transition to new jobs (by upskilling and re-skilling). However, these new types of jobs do not necessarily have the same value added as the jobs in energy and utilities, which needs to be considered.

Economy-wide results

The headline results of the national modelling exercise indicate that the NECP scenario, compared to the baseline, is expected to have 2.6% higher GDP in 2025 and 2.9% higher GDP in 2030 (Graph 16). Overall employment is estimated to be 0.9% higher (or about 50,000 jobs) under an NECP scenario compared to the baseline in 2030 (Graph 17). Economic results are mainly driven by increased investment levels due to the energy system transition and energy efficiency investments. Impacts on consumption are negative until 2025 due to price increases (ETS prices are increasing prices through supply-chains and directly through extension effects), but this is offset by an overall employment and gross wage growth by 2025. The scenario has an overall negative effect on trade balance: imports, primarily imports in basic metals and electrical equipment (sectors that are suppliers for renewable energy deployments), grow while export growth is more limited. Growth of machinery exports drive the increase in the first half of the modelling period, while exports in vehicles, electronics and rubber & plastics drive the increase in the second half.

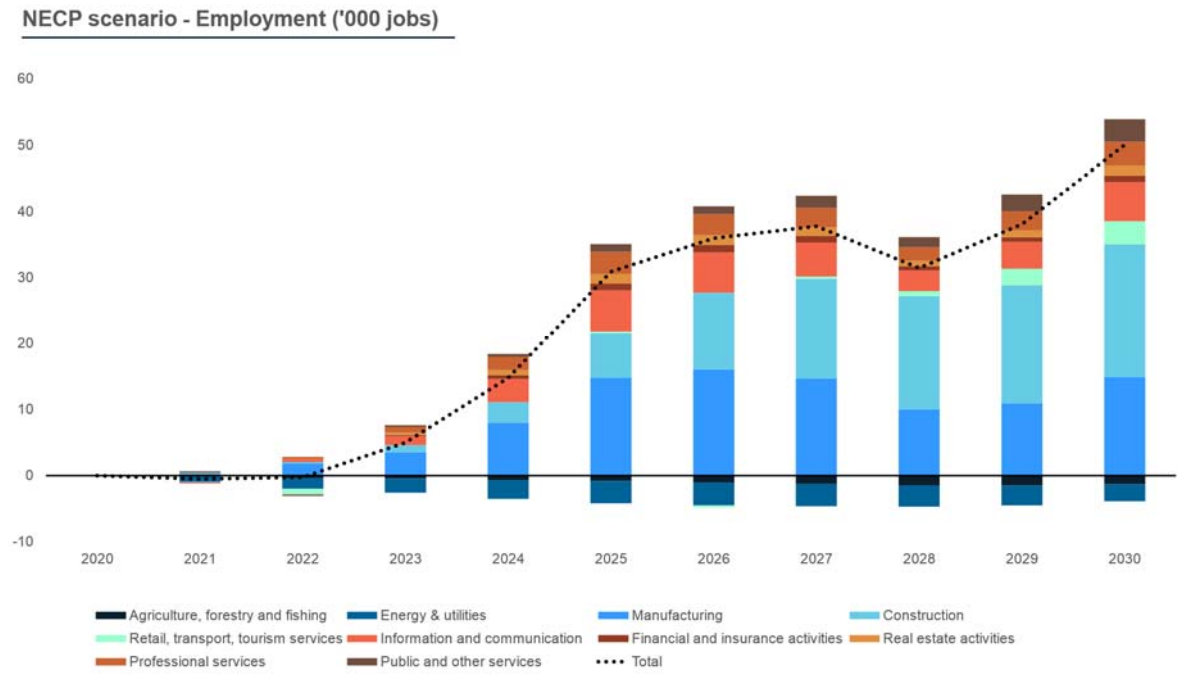
Graph 16 GDP in the NECP scenario, % difference from baseline scenario[153]



Nevertheless, due to the transition process, the coal sector is expected to see substantial losses, which dominates the employment results and causes a loss through supply-chain impacts in other sectors. However, jobs connected to investments in power generation, energy efficiency and manufacturing outpace losses in the coal sector, and thus we see a positive impact in the overall economy. It is important to note that the modelling assumes a semi-flexible labour market where the take up or losses in employment are driven by the supply-chain effects and relationships estimated on the historical data.

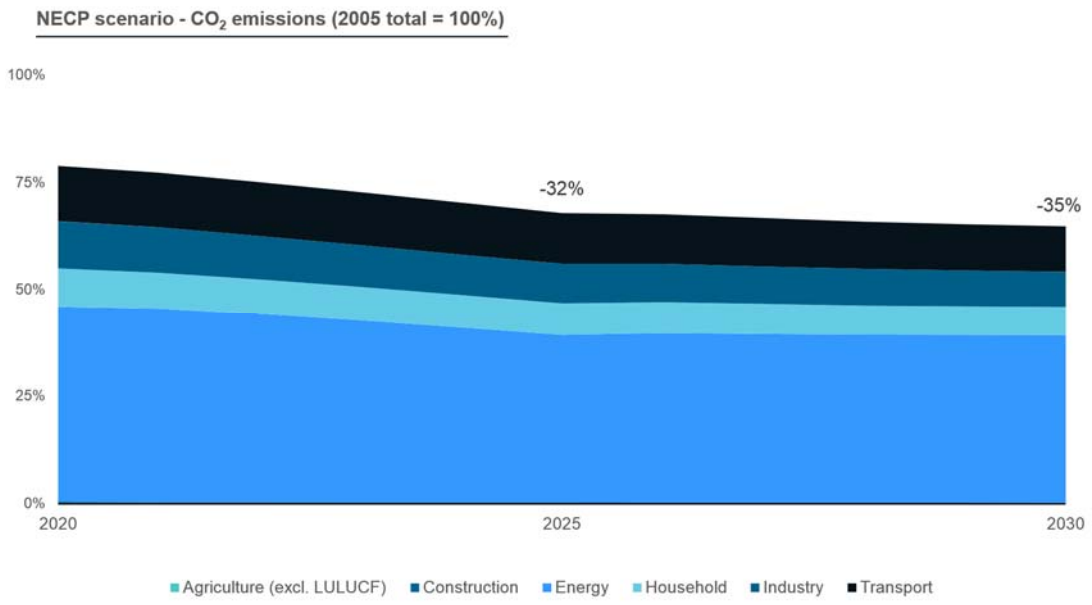
[153] E3ME modelling results

Graph 17 Employment in the NECP scenario, '000 jobs difference from baseline scenario[154]



In line with the CO_2 emission-reduction assumptions of the NECP scenario (30% CO_2 energy-related emissions by 2030 compared to 2005), the modelling shows that the NECP scenario would result in a 34% CO_2 emissions reduction compared to 2005. The reduction is driven by a strong reduction in the energy sector (in the first period of the modelling) but is further supported by the electrification of the road transport sector.

Graph 18 CO_2 emissions in the NECP scenario, compared to 2005 emission levels[155]

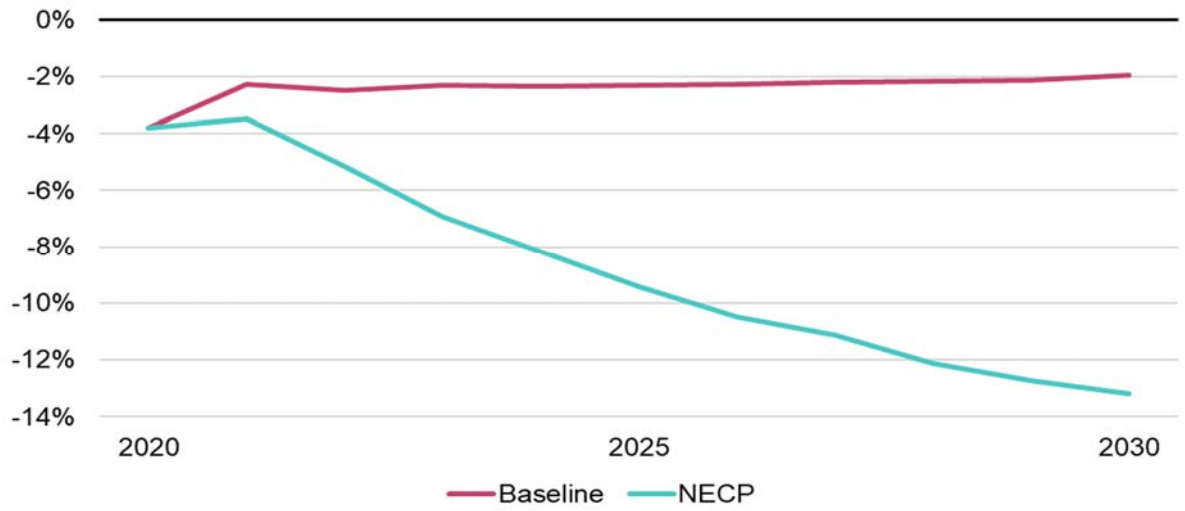


The NECP scenario is expected to substantially lower the total final energy consumption across the economy. The total final energy consumption is expected to be 13% lower than consumption was in 2019 under the NECP scenario. At the same time, it is expected to be about 2% lower in the baseline

[154] Ibid.
[155] E3ME modelling results

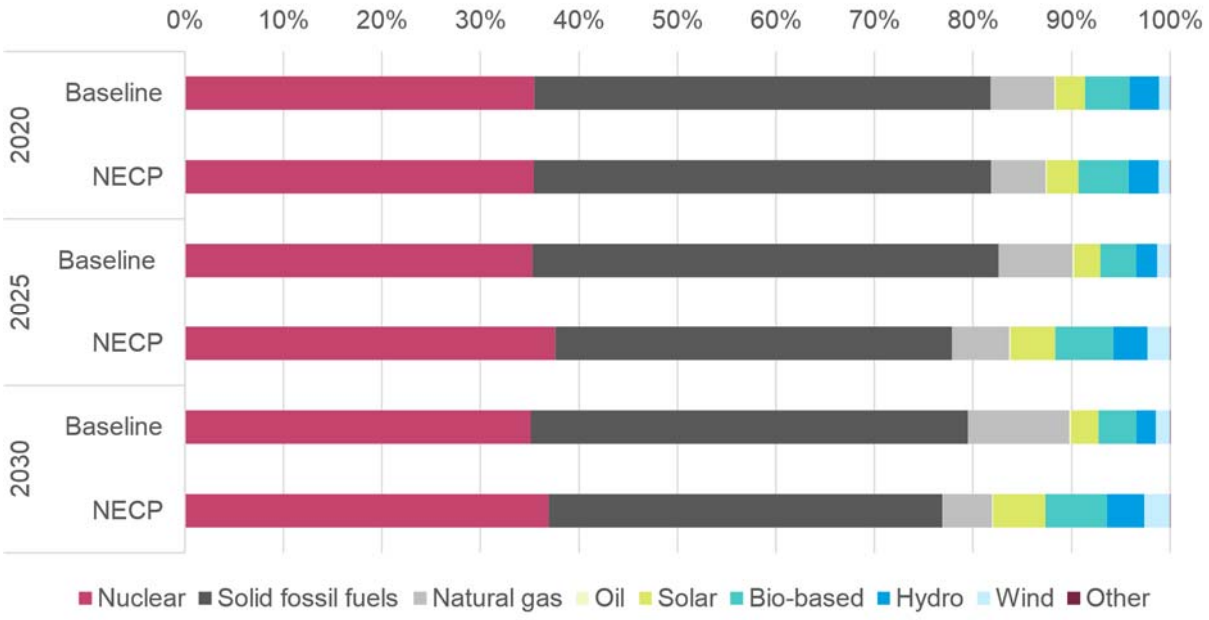
compared to 2019. The reduction is driven by energy efficiency gains in industry, but also in transport sectors (e.g., the electrification of road transport also means substantial efficiency gains).

Graph 19 Total final energy consumption, baseline and NECP scenario, % difference from 2019[156]



There are also considerable differences in the power generation mix under the NECP and the baseline scenario. While the share of nuclear is relatively similar across the scenarios and time period (35-37% in both scenarios over the forecasted time period), the ratio of renewables is expected to increase from 12-13% in 2020 to 18% by 2030 under the NECP scenario (while in the baseline it decreases to 10%; total generation is growing in the baseline scenario and the share of natural gas in power generation is quickly increasing). Consequently, the share of solid fossil fuels is expected to shrink from 46% in 2020 to 40% by 2030 in PG.

Graph 20 Power generation mix (MWh) in selected years, baseline and NECP scenario, % of total[157]



4.2.4 *Results by sector*

With respect to gross value added (GVA), economic output and employment in various economic sectors under the two scenarios, trends are expected to be negative and substantial in the energy & utilities sector. Compared to the baseline, the NECP scenario would result in lower output in the early years of

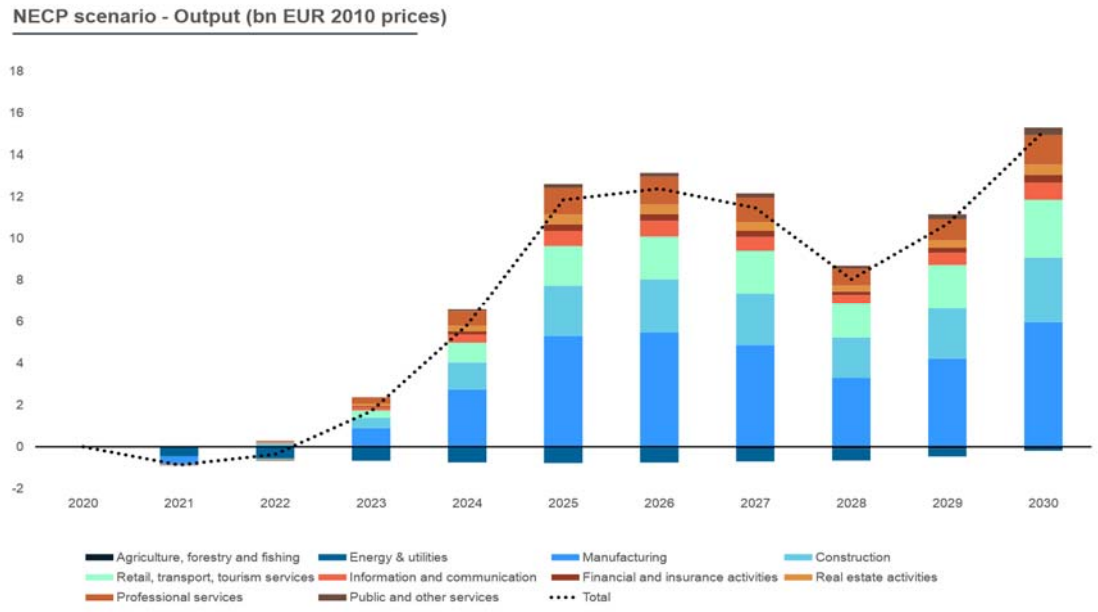
[156] Ibid.
[157] Ibid.

the scenario (around EUR 1 bn lower than baseline output in total), with the energy sector dominating the results. However, this is quickly offset by gains in other sectors, primarily in the manufacturing, construction, retail and services sectors. The growth in manufacturing and construction is a direct result of the measures in the scenario: energy efficiency investments benefit both sectors (e.g., retrofitting, more efficient machines), and the deployment of renewable energy (e.g., deployment creates demand for construction). Additionally, the electrification of transport creates positive impacts for manufacturing (i.e., manufacturing of EVs and components).

While gains in construction and retail are relatively stable throughout the period, two peaks can be observed in manufacturing, one in 2026 and another in 2030. The first peak is the result of the deployment of renewables, machinery and components since these can be supplied domestically, which substantially boost the sector. However, as the deployment of renewables slows, there is a noticeable dip in the increase compared to the baseline (it should be noted that, from 2026, coal-based power generation shrinks in the baseline as well which accounts for some of the difference – the sectors are also stronger in the baseline, hence the smaller difference). The second peak comes is driven by other manufacturing sectors, namely the manufacturing of vehicles contributes to the upward trend since ICE cars are increasingly replaced by EVs (sale of EVs in new car sales are up to 16% by 2030 in the scenario compared to 1.2% in the baseline).

Sectoral employment results are presented in Graph 17 and discussed in Section 4.2.3. In contrast with the results presented earlier, there are a number of important points. First, in terms of output, by 2030 the energy sector largely regains its economic levels. However, this is not the case in terms of employment. Employment in the sector stays below the baseline by 2030. This is because the RES replacing existing PG technology is expected to be less labour intensive.

Graph 21 Economic output in the NECP scenario, by sector, bn EUR (2010 prices) difference from baseline scenario[158]



Another important insight is the difference between the proportion of construction and manufacturing in terms of output and employment. While in output terms, the most prominent contributor to economic gains is manufacturing, the primary contributor for employment is construction. This highlights the different nature of the two sectors and their individual contributions through the transition. Construction is labour intensive and can create a large number of generally lower skilled jobs, while manufacturing (especially advanced manufacturing) is more capital intensive. CO_2 emissions are expected to drop substantially in all sectors, with considerable differences between the NECP and baseline scenarios (see Graph 18 and the corresponding section for the discussion).

[158] E3ME modelling results

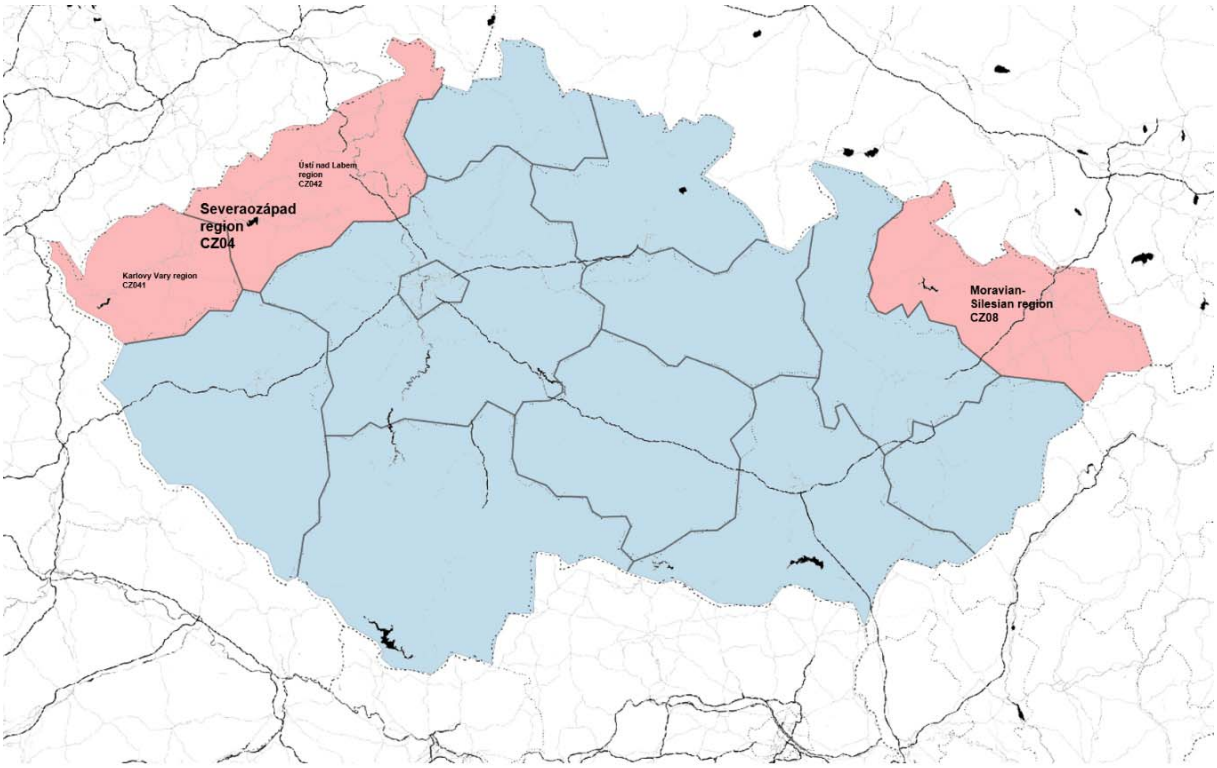
5 REGIONAL ANALYSIS FOR THE TRANSITION REGIONS

The regional modelling builds on the results of the E3ME scenario, as well as further historical data at the NUTS-3 regions of the country, collected during the preparation phase of the modelling exercise. The regional analysis has been carried out to provide results for the three NUTS-3 regions:

- CZ041 (Karlovy Vary)
- CZ042 (Ústí)
- CZ080 (Moravian-Silesian)

Figure 2 illustrates the location of the target regions in the Czech Republic (highlighted in red).

Figure 2 Location of target regions in the Czech Republic[159]



5.1 Identification of the main impacts and mostly affected regions and industries

5.1.1 Historical transition progress in the target regions

A recent study[160] investigated the transformation experiences of some of the most coal-dependent regions across Europe, including those in the Czech Republic. The study highlighted that the Czech Republic currently has the third highest share (after Estonia and Poland) of coal in its total primary energy supply (almost 37% in 2017), with its mining industry concentrated in the three focal regions: Ústí nad Labem, Karlovy Vary, Moravian-Silesian.

The coal industry in these regions has a shrinking, but still considerably large, share of total employment. In Ústí nad Labem, mining contributes to 2.35% of total employment, while in the Karlovy Vary region it is 3.91% (as of 2018).[161] Combined with the relatively high unemployment figures in these areas (4.7% in Ústí and 3.2% in Karlovy Vary), compared to a national average of 3.1% in 2018, these regions are considered to be highly vulnerable to the transition process in employment terms.

159 Cambridge Econometrics
160 Ecoaction – Germanwatch – Luhansk Oblast Alternative Human Rights Center (2019) Transformation Experiences of Coal Regions: Recommendations for Ukraine and other European countries. Available at: https://germanwatch.org/sites/germanwatch.org/files/Study_Transformation_Experiences_Coal_Regions_EN.pdf
161 Ibid.

Coal-based power generation, which is expected to be adversely affected by the transition, is also concentrated in these regions. Figure 3Figure 3 illustrates the location of major power plants in the Czech Republic by power plant type as of 2017 (target regions are highlighted in red). The map is based on the JRC Open Power Plants Database[162] (which is also used for the energy sector modelling part of the regional analysis). Coal based and CCGT power generation is largely present in the target regions.

Figure 3 Location of major power plants across the Czech Republic, by plant type[163]

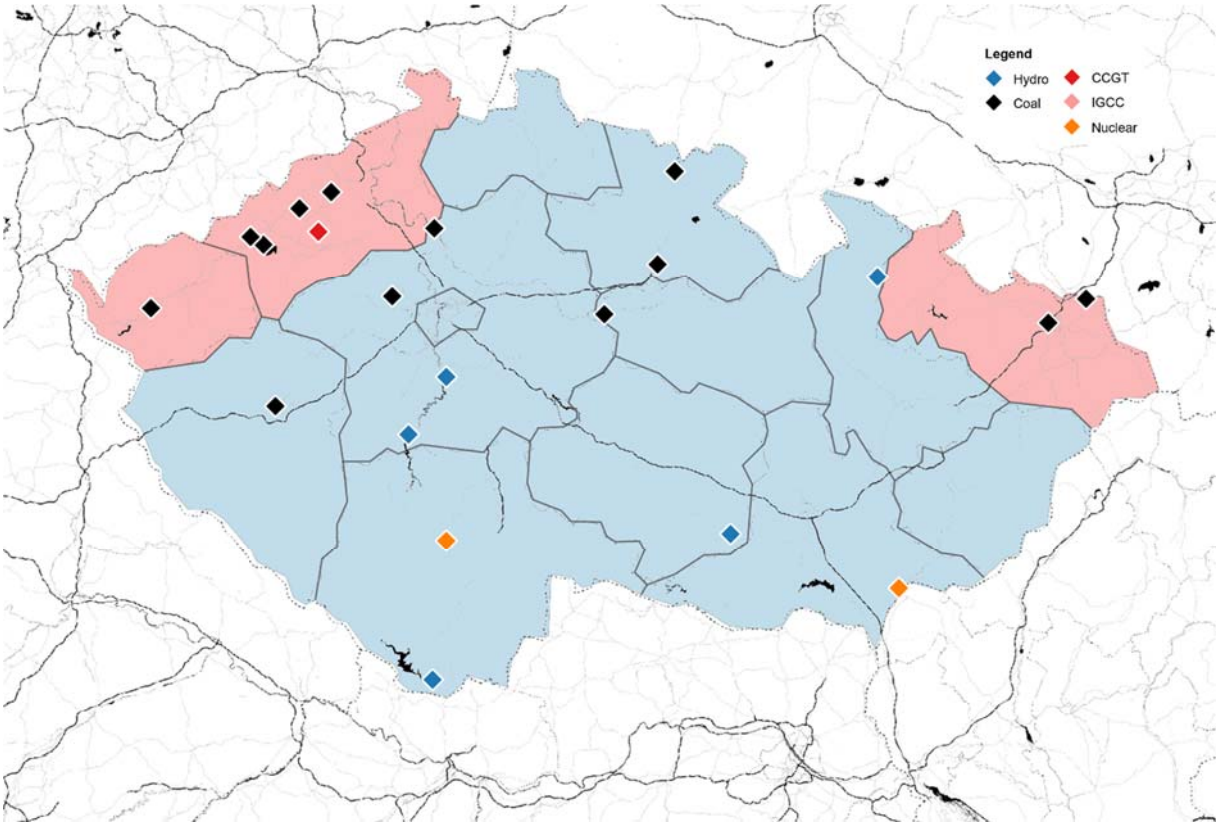


Table 20 shows stocks and production of coal fuel in the Czech Republic. Since 2010, both recoverable stocks and production of coal went down. In the case of production, the level went down to 39,000 thousand tonnes. Between 2017 and 2018, the production of coal fuel did not change substantially.

Table 20 Recoverable stock and production of brown coal fuel in the Czech Republic (thousands of tons)[164]

Stock and production of brown coal	2010	2017	2018
Available stocks of coal (recoverable)	915,100	669,166	634,154
Production of coal fuel	43,774	39,306	39,191

Graph 22shows the total volume of brown coal mining from 1988-2018. Between 1988 and 1999, there was a sharp decline of brown coal extraction. Since 1999, the decline slowed, ending with less than 40,000 million of tons in 2018.

[162] See Annex 2.
[163] JRC Open Power Plants Database, mapping: Cambridge Econometrics.
[164] TZB-info. Uhlí v České republice. Retrieved from https://energetika.tzb-info.cz/19810-uhli-v-ceske-republice Note: The energy content of brown coal is roughly 17 MJ/kg.

Graph 22 Volume of brown coal mining in years 1988-2018 in Czech Republic (million tons)[165]

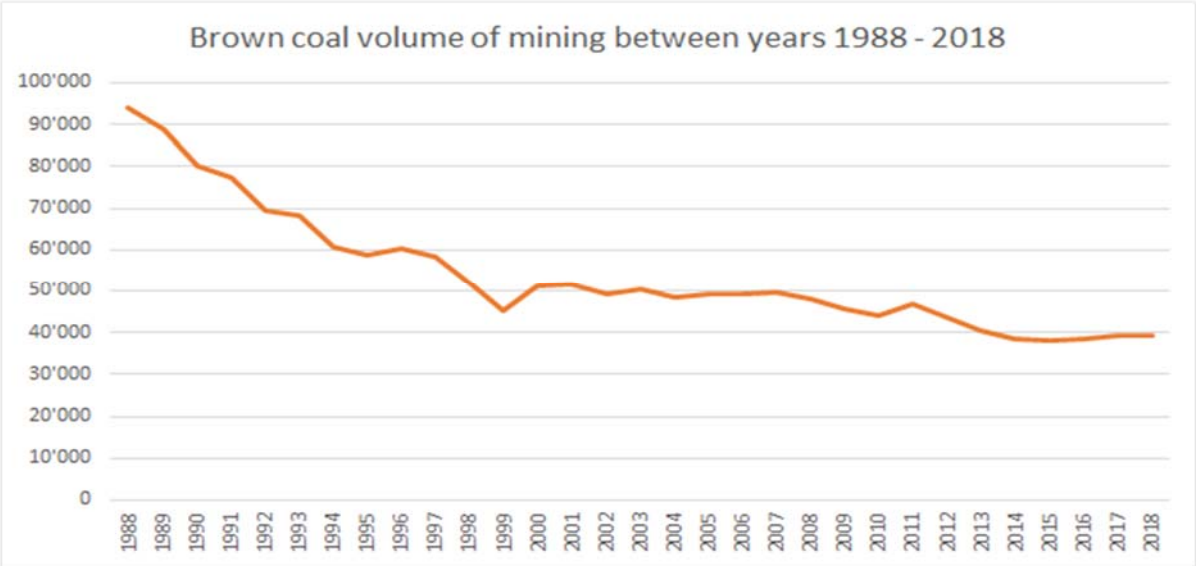


Table 21 shows how brown coal utilisation was distributed in 2017.

Table 21 Division of disposable volume of brown coal for utilization in 2017 (thousands of tonnes)[166]

Electricity production	29,785
Heat production	3,449
Operating consumption in energetics	138
Transformation into other fuels	147
Heat production in companies	117
Heat production in households	1,333
Total	38,57

The most recent development in the coal industry is the end-2020 decision[167] of the Czech Coal Commission, which recommended coal to be completely phased-out in the country by 2038 (which would ultimately concern the target regions).

[165] Rozhlas. 2019. Těžba uhlí v Česku od revoluce klesla o desítky procent. Výrazný útlum zaznamenaly i rudy [The coal mining in Czechia decreased by tens of percent since revolution]. Retrieved from https://www.irozhlas.cz/ekonomika/tezba-uhli-v-ceske-republice-ceska-geologicka-sluzba_1908111344_kro

[166] Ministry of Industry and Trade. 2020. Energetická statistika. Uhlí v České republice [Energy statistics. Coal in the Czech Republic]. Retrieved from https://www.mpo.cz/assets/cz/energetika/statistika/tuha-paliva/2020/3/Uhli-v-Ceske-republice-2010-2018.pdf

[167] Euractiv. 2020. Czechs eyes out coal phase-out by 2038: https://www.euractiv.com/section/climate-environment/news/czechs-eyes-coal-phase-out-by-2038/

5.1.2 Regional differences of the transition in the Czech Republic

Regarding the most challenging themes for regional development, the recently published strategic document, the Regional *Development Strategy of the Czech Republic 2021+*[168] classifies the three focal regions (Ústí, Karlovarský and Moravian-Silesian) as "structurally affected regions." The same document discusses the differences in the economic development of the Czech regions over the past years, a few highlights of which discussion[169] are listed below:

- Prague persists in its dominant position across regions in terms of economic development. However, growth is accelerating in other regions such as Pilsen, South Moravian and Zlín.
- There is a significant acceleration of R&D funds in Moravian-Silesian, Pilsen and Olomouc.
- In terms of labour productivity, Prague and the South Moravian are prominent regions, while the region of Karlovy Vary is lagging behind.
- Regarding incoming foreign direct investment, Prague's dominant position is starting to be complemented by an inflow of investments in other regions, such as in Pilsen and the Moravian-Silesian region. However, Olomouc and Ústí are lagging behind in this metric.
- The regions with less diverse and less balanced economic bases (in terms of the dominance/ representation of selected industries) and that have long had a highly specific and concentrated economic structure can be considered as economically problematic. The transition will likely be the most challenging task for these regions.

According to a 2018 OECD[170] review, overall regional economic disparities are not substantial in the Czech Republic and are in line with the OECD average. However, the country shows large regional disparities in terms of job availability across regions (compared to other OECD countries), which further stresses the importance and the need for well-designed regional policies in the process of green transition.

To make a valid analysis of the impacts we first need to present and describe the current state of development within regions as far as production and utilisation of coal goes.

Table 22 shows the consumption of brown coal in 2015 by households. Brown coal is primarily used in the Středočeský region and Ústí region.

Table 22 Household Consumption of brown coal in 2015[171]

Czech Republic, region	Number of households using brown coal	Total consumption	Share of regions on total consumption
	Number	tonnes	%
City of Prague	(1 504)	4'897	0.3
Středočeský	102'534	401'306	28.4
Jihočeský	37'979	118'433	8.4
Plzeňský	30'599	112'055	8
Karlovy Vary	(6 926)	23'839	1.7
Ústí	38'809	193'347	13.7
Liberecký	17'289	76'270	5.4

[168] Ministry of Regional Development CZ. 2020.Regional Development Strategy of the Czech Republic 2021+: https://mmr.cz/getmedia/a9985cb6-b672-4a97-a92c-c4c68bea2925/EN-III_ma_SRR-prac_doplneni-schemat-a-map_kontrola.pdf.aspx?ext=.pdf

[169] Ibid.

[170] OECD (2018) Regions and Cities at a Glance 2018: Czech Republic: https://www.oecd.org/regional/CZECH-REPUBLIC-Regions-and-Cities-2018.pdf

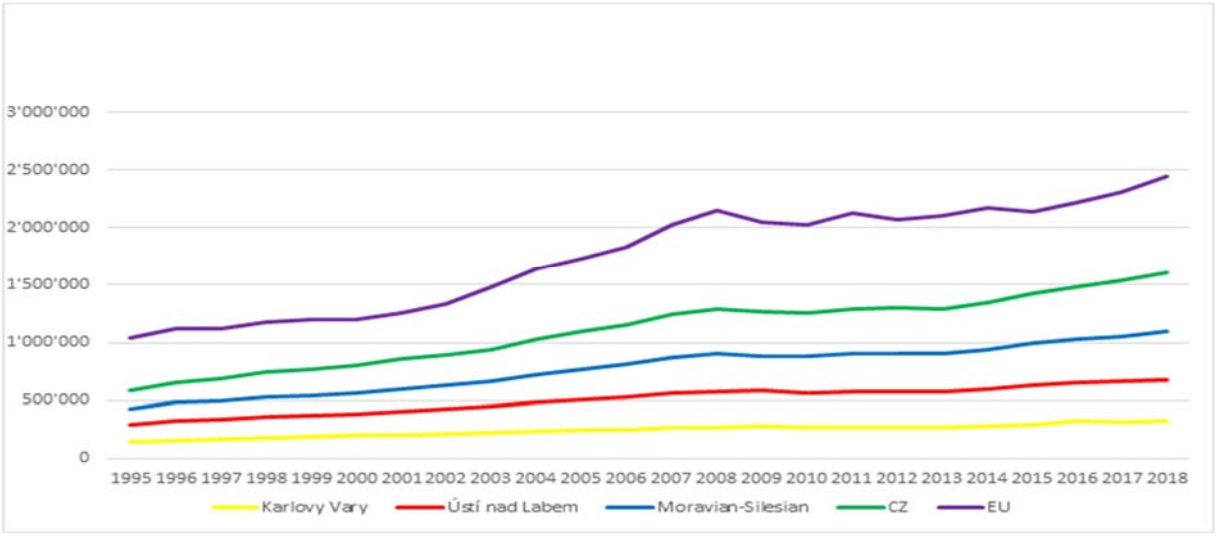
[171] Czech Statistical Office. 2017. Spotřeba paliv a energií v domácnostech [Fuel and energy consumption in households]: https://www.czso.cz/csu/czso/prumerne-rocni-spotreby-a-penezni-vydani

Czech Republic, region	Number of households using brown coal	Total consumption	Share of regions on total consumption
	Number	tonnes	%
Královéhradecký	36'576	119'130	8.5
Pardubický	27'901	84'253	6
Vysočina	32'264	113'508	8.1
Jihomoravský	(11 424)	41'427	2.9
Olomoucký	(11 022)	38'008	2.7
Zlínský	(7 002)	18'425	1.3
Moravian-Silesian	15'651	64'290	4.6

To make a valid comparison of the socio-economic environment in the coal regions, we selected a number of indicators referring to the areas. Although the Ústí and Karlovy Vary regions are marked as one region “Severozápad” (Northwest), we present the selected characteristics of both sub-regions.

Below we present a series of figures referring to different socio-economic indicators and characteristics of the regions. This is done to shed light on how socio-economic indicators develop in the coal regions compared to the Czech average.

Graph 23 GDP per capita (CZK)[172,173]

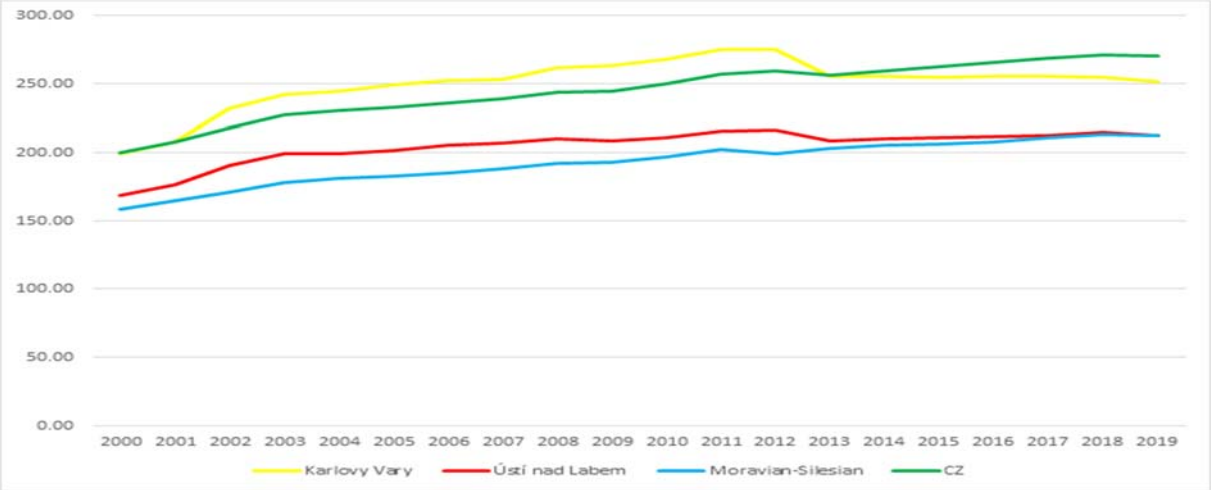


GDP per capita (Graph 23) clearly shows the general difference between the coal regions: all three regions lag behind the EU and Czech Republic average, with a better pattern of development in Moravian-Silesian.

[172] CZSO. 2020. Development of the number of inhabitants in the Czech Republic, Karlovy Vary, Ústí and Moravian - Silesian regions in the years 1989 – 2019. Retrieved October 24, 2020, from https://www.czso.cz/, https://data.worldbank.org/, Gross domestic product in Karlovy Vary, Ústí and Moravian - Silesian regions in the years 1989 – 2018. Retrieved October 24, 2020, from https://www.czso.cz/

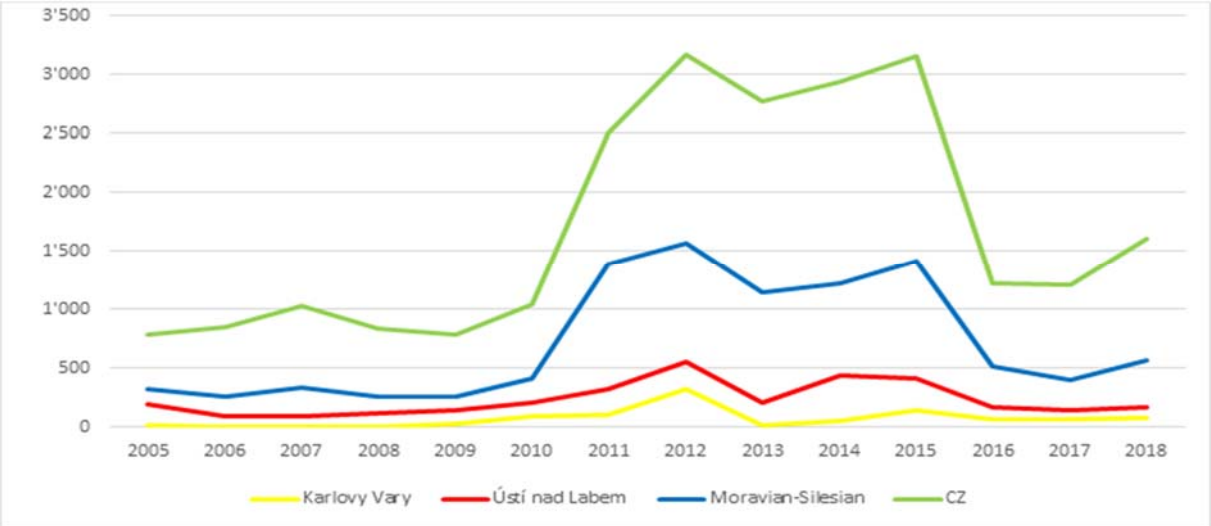
[173] The CZ statistics include Prague. Given the unique position of the Prague region, the overall national statistics could be skewed by this. However, as most statistics at the national level do include Prague, we choose to cover it as well.

Graph 24 Companies per 1,000 inhabitants[174,175]



The economically weakest region of Karlovy Vary shows the highest values of companies per 1,000 inhabitants. Yet even this region remains below the national average (Graph 24). However, the difference between Karlovy Vary and the other two coal regions may imply a different economic structure of the region, which could result in different economic development pathways in the future.

Graph 25 Investment into science and research per capita (CZK)[176]



Investment in science and research per capita in CZK shows that since 2010 there has been a large difference in trends between the three coal regions. While the investment rate in Ústí and Karlovy Vary remained very low, Moravian-Silesian started to allocate more funds into science and research (although still lower than the Czech average). This change may have resulted in different development trends across the three coal regions. However, a more detailed analysis is still required to investigate the efficiency of the funds implemented by the Moravian-Silesian (see Graph 25).

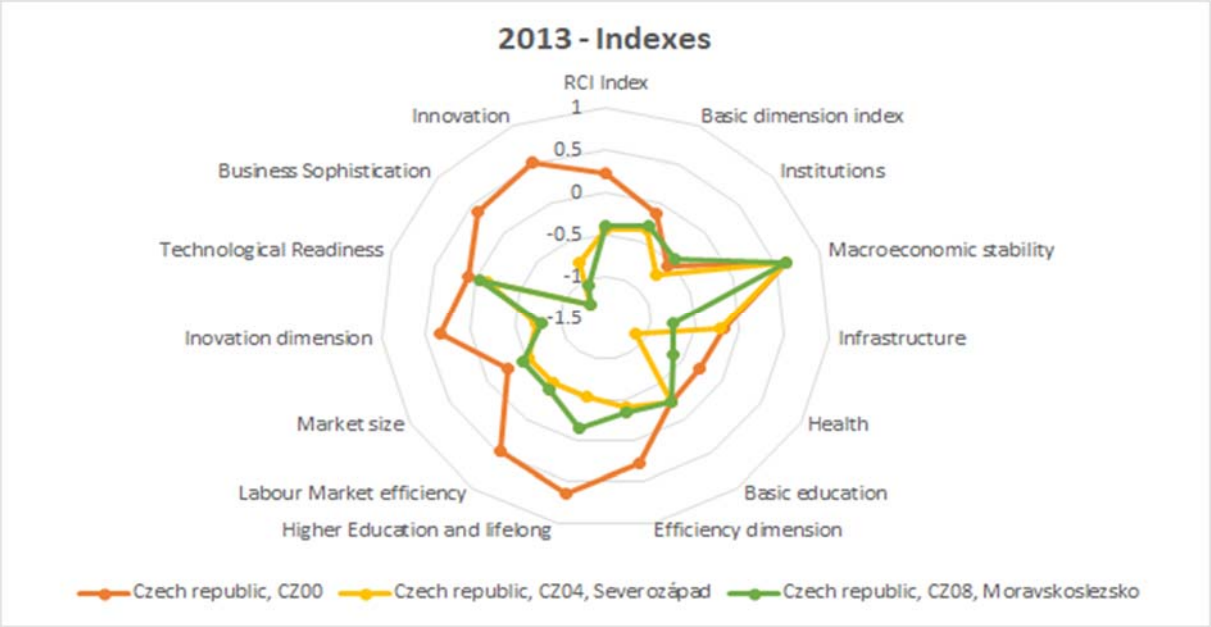
Graph 26 - 28 display the key characteristics of the two Czech coal regions alongside the reference "region" (Czech Republic national average). To capture trends, we present figures for 2013, 2016 and 2019 respectively. For each index, higher values imply better performance. Corresponding explanations are provided. The Karlovy Vary and Ústí regions are captured together as the Northwest region.

[174] The TA team is aware that this indicator may not be giving the full picture by omitting further granularity in the enterprise environment in the regions. The D4 elaborates on this by adding a detailed analysis of the enterprise envirnoment in the three regions, including the analysis of e.g the corporate structure and the size structure of companies at the regional level. CZSO. 2020. Development of economic entities in the Czech Republic, Karlovy Vary, Ústí and Moravian-Silesian regions in 2000–2019. Retrieved October 24, 2020, from https://www.czso.cz/, https://cfuc.vse.cz/pdfs/cfu/2014/04/15.pdf

[175] CZSO. 2020. Development of economic entities in the Czech Republic, Karlovy Vary, Ústí and Moravian-Silesian regions in 2000–2019. Retrieved October 24, 2020, from https://www.czso.cz/, https://cfuc.vse.cz/pdfs/cfu/2014/04/15.pdf

[176] https://vdb.czso.cz/vdbvo2/faces/cs/index.jsf?page=vystup-objekt&f=TABULKA&pvo=VAV02&z=T&katalog=30851&str=v183

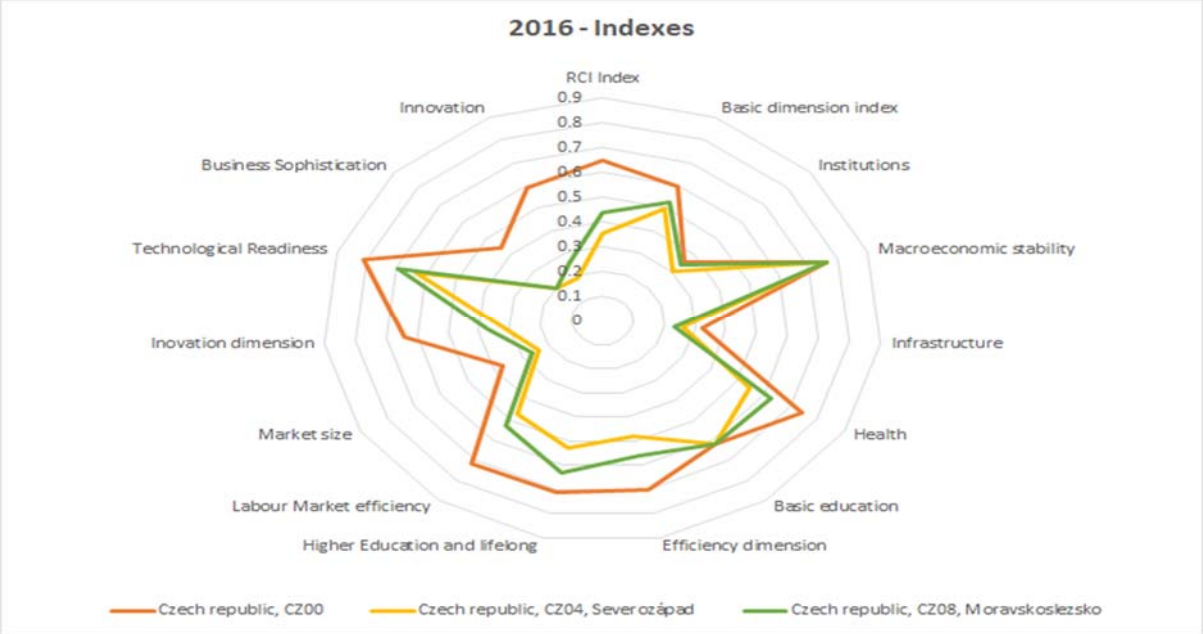
Graph 26 Indices for 2013[177]



Severozápad = Northwest, Moravskoslezsko = Moravian-Silesian

A first observation that can be drawn from the figure is that both coal regions lag behind the Czech average across almost all areas. The greatest differences relate to innovation, business sophistication and labour market efficiency.

Graph 27 Indices for 2016[178]

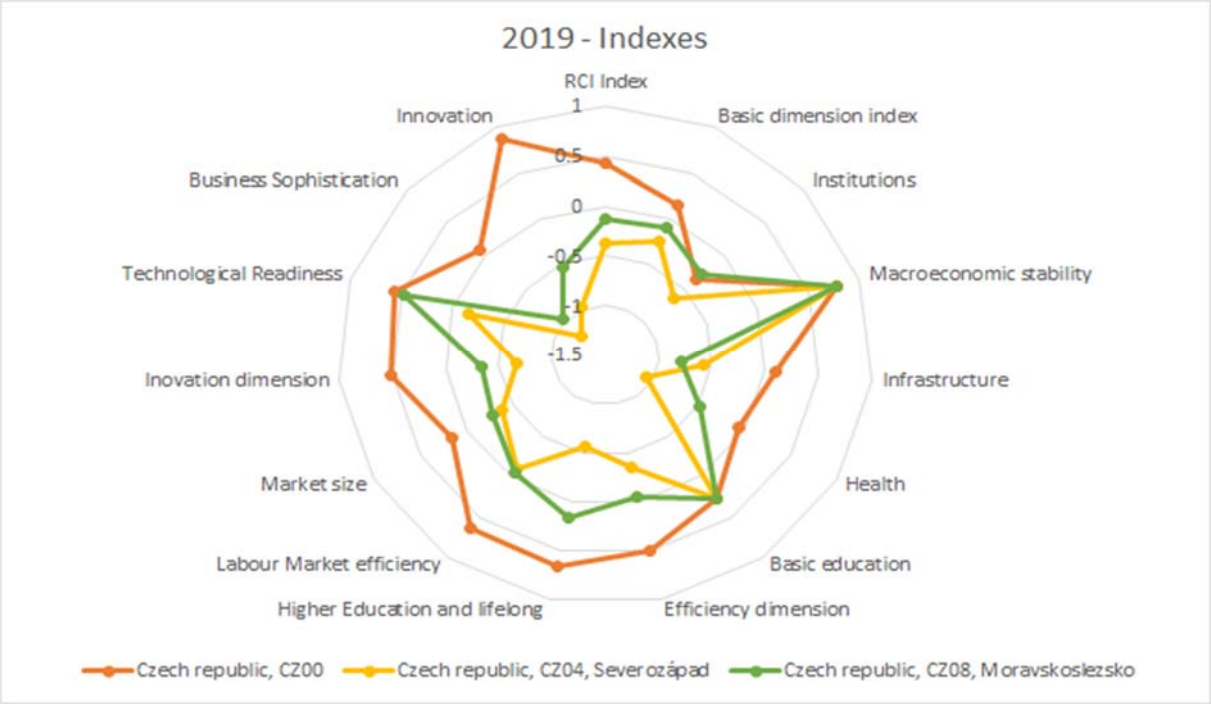


In 2016, there is still a significant gap between the coal regions and the Czech average. However, the gap is lower than 2013. We expect that this is the consequence of both government interventions and the natural development tendency of the regions.

[177] European Commission (2019). European Regional Competitiveness Index. (Scorecards). https://ec.europa.eu/regional_policy/en/information/maps/regional_competitiveness/

[178] Ibid.

Graph 28 Indices for 2019[179]



For 2019, large gaps remain between the coal regions and the Czech average. Severozapad also lags behind the other coal region of Moravian-Silesian. This is mostly attributed to the areas of technological readiness and higher education. These two areas are key elements in the economic transformation of the regions so it can be expected that this trend will continue, and the Moravian-Silesian region will generate greater economic development than the Northwest (consisting of two sub-regions). The TA team further elaborates on these aspects in the D4 report.

5.1.3 Modelling regional impacts: Top-down approach in the regionalisation of national results

This section explains the "regionalisation" of E3ME forecasts using dynamic shift-share decomposition and ARIMAX modelling. The method consists of two main elements:

1. a top-down approach where we use shift-share decomposition and ARIMAX modelling to forecast components of the variables of interest
2. a bottom-up method focusing on power generation to assess regional impacts of the transition.
3. The combined regional modelling method has been developed by Cambridge Econometrics outside of the current project.

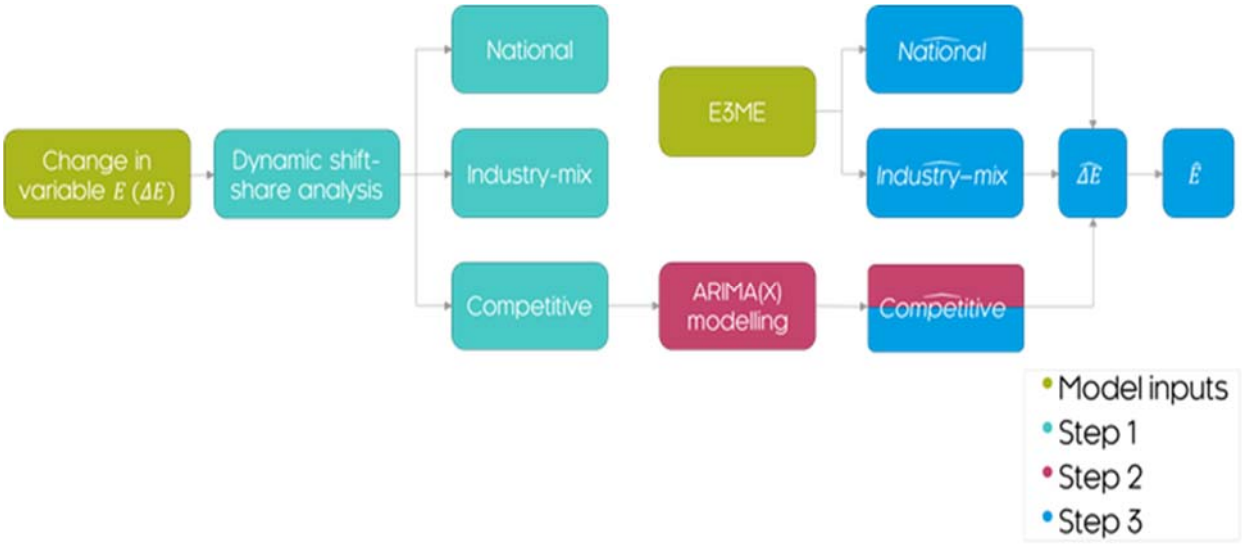
Cambridge Econometrics' regionalisation method builds on the solution proposed by Mayor, López, and Pérez (2007). Regional estimates from E3ME national forecast are obtained by combining dynamic shift-share analysis with ARIMA forecasting. More specifically, the process followed (as suggested by the authors) involves the following steps:

1. Applying the dynamic shift-share approach to an economic variable and obtaining the competitive effect by sector and year
2. Forecasting future competitive effect trends by fitting the appropriate ARIMAX model
3. Recursively obtaining values for the variable for each year of the forecast horizon by
   a) Using available national-level forecasts to compute the national and industry mix effects for the given year
   b) Aggregating the three components to obtain estimates of the change in the economic variable of interest relative to the previous year
   c) Adding predicted change to previous year value.

[179] European Commission (2019). European Regional Competitiveness Index. (Scorecards). https://ec.europa.eu/regional_policy/en/information/maps/regional_competitiveness/

This methodology was adopted to obtain GVA and employment forecasts by sector at the NUTS-2 level for the Czech Republic based on forecasts produced by the E3ME model.

Figure 4 Overview of top-down approach steps[180]



The shift-share model can be used to decompose regional growth in three components: (see Figure 4)

1. **National effect:** change in the region if it changed at the same rate as the national economy.
2. **Industry-mix effect:** change in the region attributable to differences in sectoral structure between the region and the country. It captures the impact of relative regional specialisation (positive or negative).
3. **Competitive effect:** change in the region attributable to unique local factors. It essentially captures how a region's industries has grown compared to the national level and attributed to a local comparative (dis)advantage.

See **Appendix B** for detailed steps on this methodology and data requirements.

5.1.4 Modelling regional impacts: Bottom-up approach in the regionalisation of national results

This section explains how national power generation capacity results are regionalised based on bottom-up modelling methodology.

In the bottom-up modelling, results from the E3ME national level modelling and capacity results from the FTT:Power submodule are used to estimate power sector employment and economic output at the regional level.

A summary of the process is provided below:

1. Determine 2017 national power plant capacity and plant age for different technologies.
2. Use E3ME national results to determine annual decommissions and new commissions.
3. Allocate national decommissions to each region.
4. Allocate national commission to each region
5. Estimate employment and economic output using the capacity of each region and combine with results from the shift-share model.

See Annex 2 for a detailed description of each step and data requirements.

[180] Cambridge Econometrics

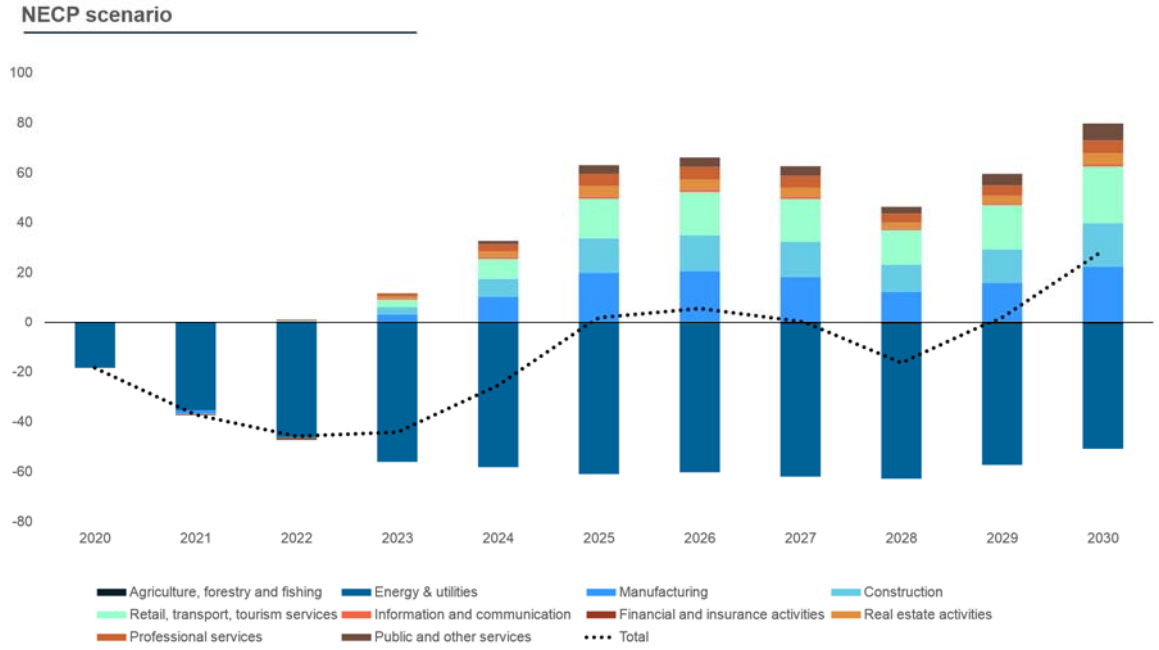
5.1.5 Key results of the regional modelling exercise

Outputs from the regional modelling exercise are GVA, employment on the regional level with sectoral disaggregation and upon requests made by the project team, CO_2 emissions by region and emitter[181] (see Graph 29-31).

Regional results: Karlovy Vary (CZ041), by sector

The analysis above illustrates that large differences exist across the regions. The Karlovy Vary Region has the least GDP per capita, a relatively high unemployment and the highest share (4%) of employment still in the coal industry in the target regions. Karlovy Vary also has the lowest population among the target regions (about 300,000) and the highest old age dependency ratio (29.6% in 2018). Furthermore, net migration is negative in the region, and thus population projections predict a substantial population decrease in the region in the coming decades. Over the past decade, the region has shown slower economic growth than the national average, which (in PPS terms) has led to it falling behind. GDP per capita in the region (in PPS terms) was below 60% of EU average (in 2017) with a decreasing trend. The Czech Republic average for same figure was 89%[182].

Graph 29 Karlovy Vary (CZ041) GVA in the NECP scenario, by sector, million EUR (2010) difference from baseline[183]

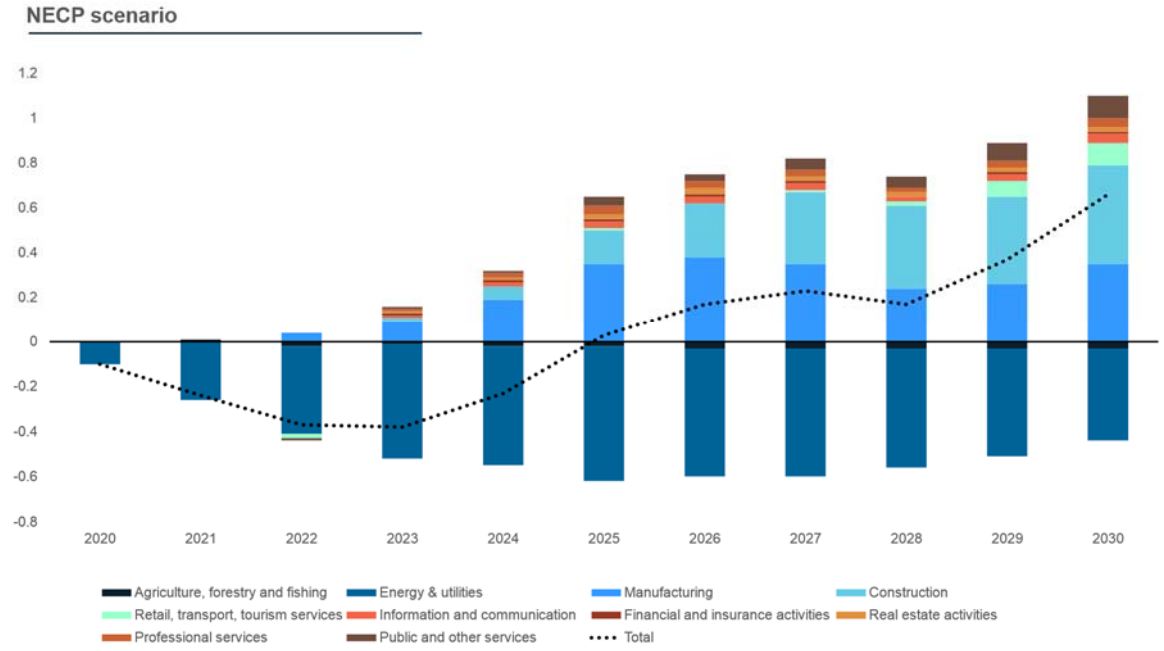


[181] As regional historical data on CO_2 emissions is unavailable in the regional disaggregation, estimated GVA impacts are used as a proxy for CO_2 emission changes. In this process national level, sectoral (fuel user) CO_2 emission changes are disaggregated between the regions, using their GVA changes in important emitting sectors as a proxy variable.

[182] https://urban.jrc.ec.europa.eu/#/en/my-place?context=Default&territorialscope=EU28&level=NUTS3&nutsid=CZ041

[183] E3ME modelling results

Graph 30 Karlovy Vary (CZ041) Employment in the NECP scenario, by sector, '000 jobs difference from baseline[184]



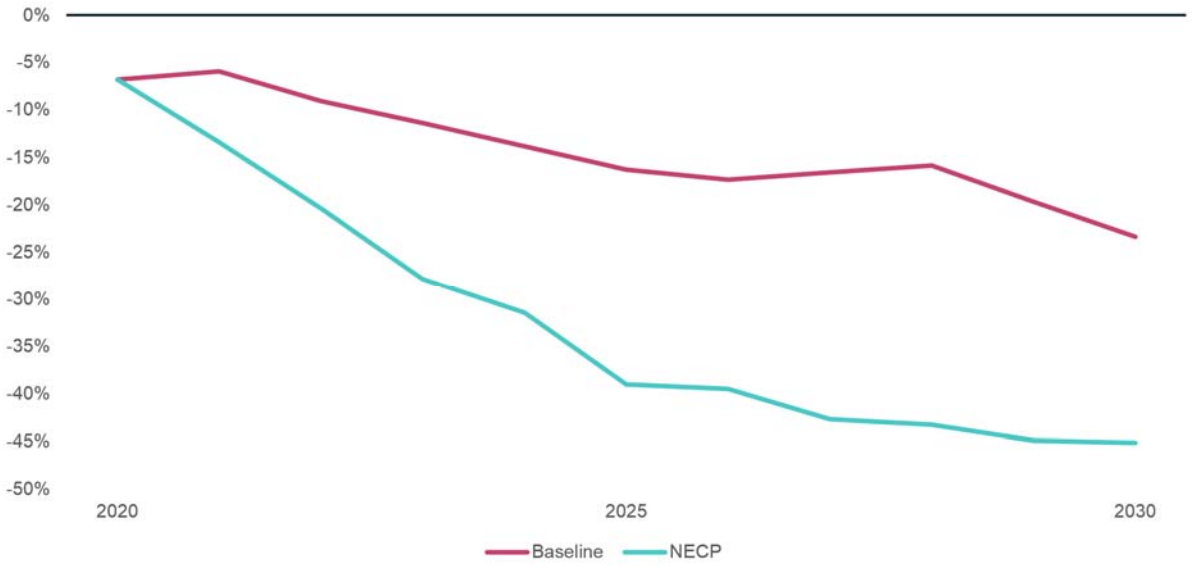
Against this backdrop, the modelling shows that the transition, especially in the first half of the modelling period, can depress local GVA (Graph 29) and employment (Graph 30). The transition in the energy & utilities sector, which contains both coal mining and processing and coal-based power generation, suffers substantial losses (compared to the baseline). Other sectors, similar to national trends, gain from the impacts of the transition (e.g., manufacturing, construction). However, as discussed earlier, since the coal industry is a major employer in the region, these gains are unable to offset the losses through much of the decade. GVA effects in energy are fairly stagnant from 2023 onwards, resulting in a EUR 50-60 million (1.4-1.7% of projected 2030 baseline total) decrease compared to the baseline, while positive effects gradually increase over time and lead to an EUR 80 million increase (2.3% of projected 2030 baseline total) by 2030.

Comparing these estimates with the employment results (Graph 30), further insights can be derived. Employment impacts turn positive (compared to baseline) faster than GVA, largely due to the labour-intensive nature of the construction sector. However, this highlights an important aspect of the transition effects. Both the construction and the manufacturing (to a lesser extent) sectors create jobs that have, on average, lower value-added than the lost energy sector jobs. Meanwhile, the retail and tourism sectors create jobs that have a higher GVA impact, but a smaller employment impact.

Graph **31** presents the decrease of CO_2 emissions in the region from 2018 values. In 2015, Karlovy Vary was responsible for about 5% of total CO_2 emissions in Czechia.[185] Emissions in the baseline decrease by 23%. In the NECP scenario, emissions decrease by 39% by 2025 and then decrease an additional 6% to 45% by 2030, which is largely in line with the national trends (the national figure for the same time frame is a 43% reduction compared to 2018).

[184] Ibid.
[185] https://urban.jrc.ec.europa.eu/#/en/my-place?context=Default&territorialscope=EU28&level=NUTS3&nutsid=CZ041

Graph 31 Karlovy Vary (CZ041) CO_2 emissions in the NECP scenario, % difference from baseline (2018 values)[186]



Regional results: Ústí (CZ042), by sector

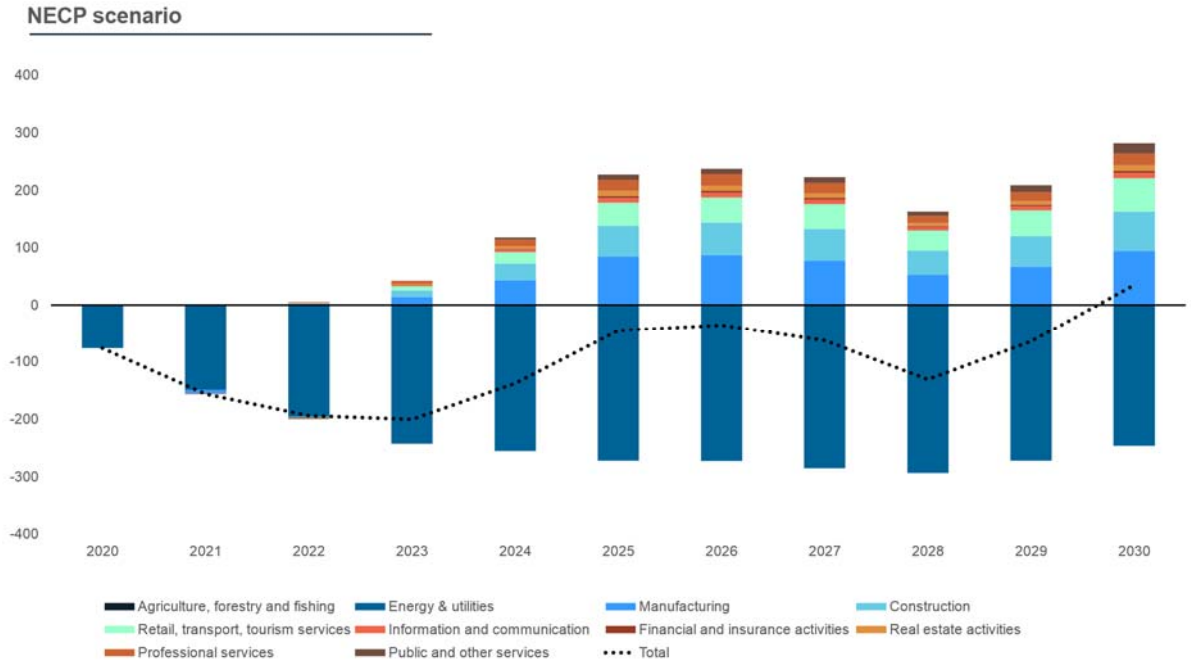
Ústí is the second largest target region in terms of population with more than 820,000 estimated inhabitants in 2021. Nevertheless, its population has decreased over the last decade. In economic terms, similarly to Karlovy Vary, the region has seen slower GDP per capita growth (in PPS terms) than the national average. GDP per capita (in PPS terms) has been 64-66% of the EU average since 2010 (compared to the Czech national average of 89% in 2016)[187].

Similar to Karlovy Vary, a large share of the population is dependent on the coal industry: about 2.4% of total employment is linked to coal mining. Due to the differences in population and total employment, this means that employment in the coal industry (about 9,000 jobs), in absolute terms, is about twice that of Karlovy Vary (about 5,700 jobs). As most coal-based power generation capacity is located in Ústí, the region is responsible for about 25.5% of national CO_2 emissions. Ústí has the highest per capita emissions in the country[188]. Most emissions are concentrated in coal-based power generation plants such as Prunéřov and Počerady[189]. Therefore, the region shows both tremendous potential to contribute to the low-carbon transition while at the same time, it faces a significant challenge because of the dominance of coal in its economic structure.

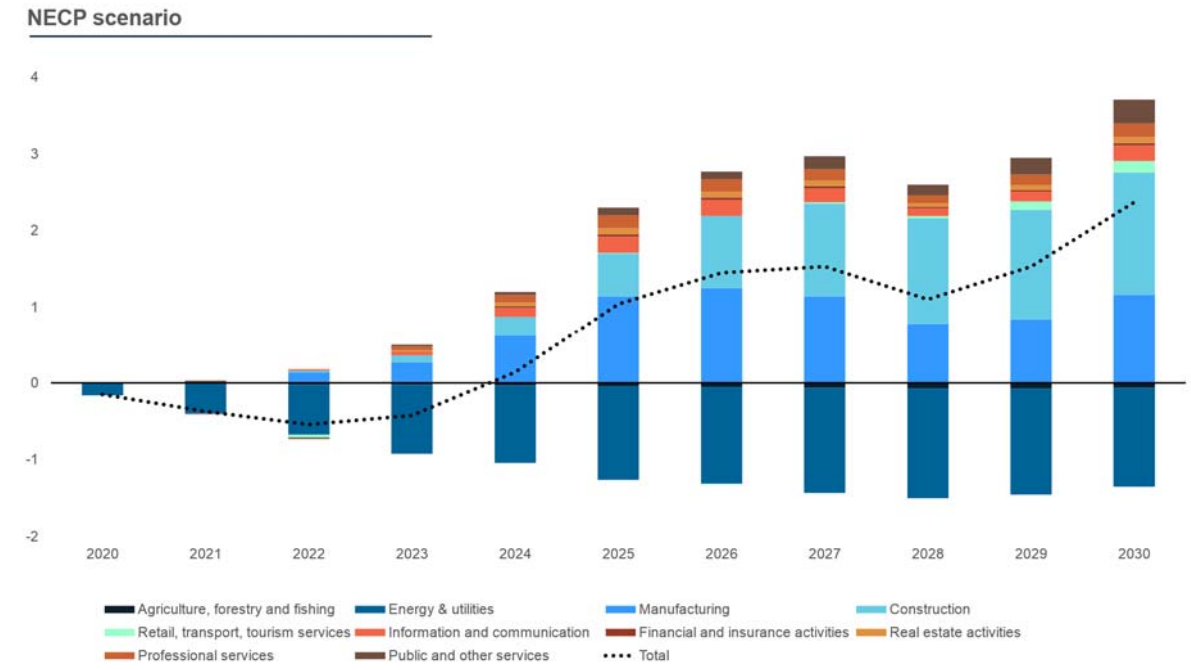
Modelling results underscore this phenomenon. Graph 32 shows declining GVA due to losses in the energy & utilities sector compared to the baseline. The net impact is negative throughout the period (with the exception of a small positive net effect in 2030) as gains in sectors such as construction, retail and manufacturing (EUR 240 million at its peak, 2.1% of 2030 baseline GVA total) fail to offset the high losses (EUR 150-300 million, 1.3-2.7% of 2030 baseline GVA total) in the energy sector. Employment, as illustrated by Graph 33, paints a similar picture. However, the net effect is positive as the manufacturing and construction sectors create a higher number of jobs. This echoes the case of Karlovy Vary: new jobs gains are expected to have lower value-added, and therefore a lower GVA increase can lead to higher gains in employment.

[186] E3ME modelling results
[187] https://urban.jrc.ec.europa.eu/#/en/my-place?context=Default&territorialscope=EU28&level=NUTS3&nutsid=CZ042
[188] https://www.oecd-ilibrary.org/urban-rural-and-regional-development/oecd-regions-at-a-glance-2013_reg_glance-2013-en
[189] https://portal.cenia.cz/irz/unikyPrenosy.jsp

Graph 32 Ústí (CZ042) GVA in the NECP scenario, by sector, million EUR (2010) difference from baseline [190]



Graph 33 Ústí (CZ042) Employment in the NECP scenario, by sector, '000 jobs difference from baseline[191]



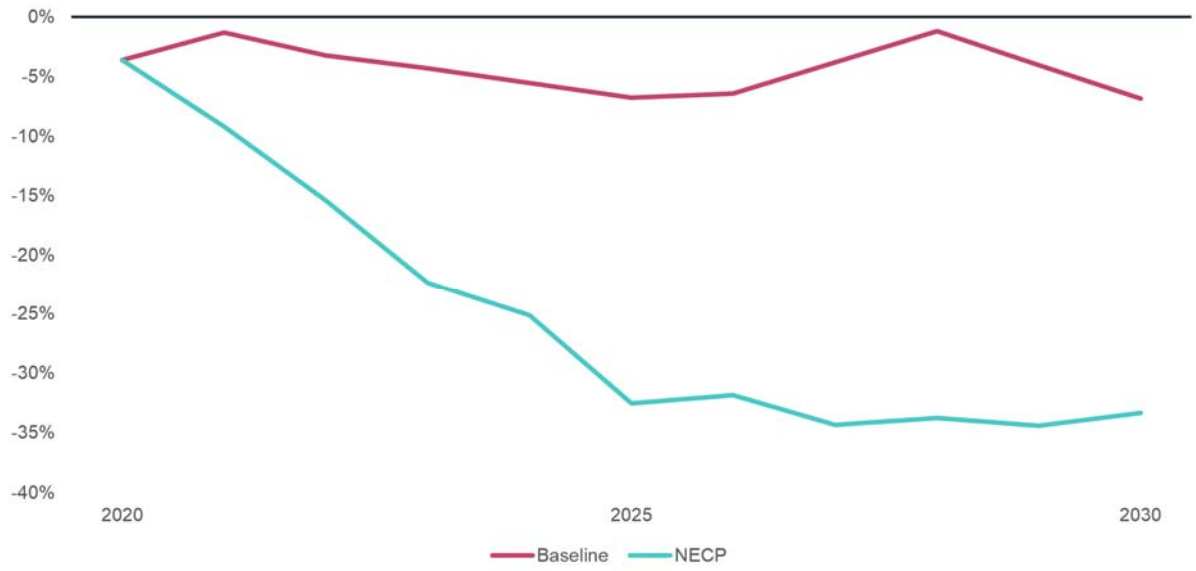
The absolute level of the employment impact – in line with the size of the region and total employment figures – is higher than in Karlovy Vary. The modelling shows that up to 1,500 jobs could be lost in the energy sector as an outcome of the transition, while other sectors, such as the construction sector, could show comparable gains. Nevertheless, these employment impacts are taken as net impacts, and while E3ME calculations consider some labour market-rigidity, to actually make this transition (i.e., employees

[190] E3ME modelling results
[191] Ibid.

transitioning from the energy sector to manufacturing), further support such as reskilling and retraining might be needed.

Finally, Ústí is responsible for a large share of national CO_2 emissions. In the baseline scenario, emissions from the region are largely unchanged compared to 2018. Nevertheless, in the NECP scenario the reduction is substantial. By 2025, the reduction is 32.5%, which continues at a slower pace to reach 33.3% by 2030. In the NECP scenario, the reduction of coal-based PG mostly happens from 2020-2025, while it is fairly stagnant between 2025 and 2030 (see Graph 34). Given that the decarbonisation is more muted in Ústí compared to the national average (-43%) this means that under the NECP scenario, other regions have higher than average emission reduction rates. Nevertheless, it should be also noted that the level of reduction compared to the baseline is the highest among the target regions (27% by 2030).

Graph 34 Ústí (CZ042) CO_2 emissions in the NECP scenario, % difference from est. 2018 values[192]



Regional results: Moravian-Silesian region (CZ08), by sector

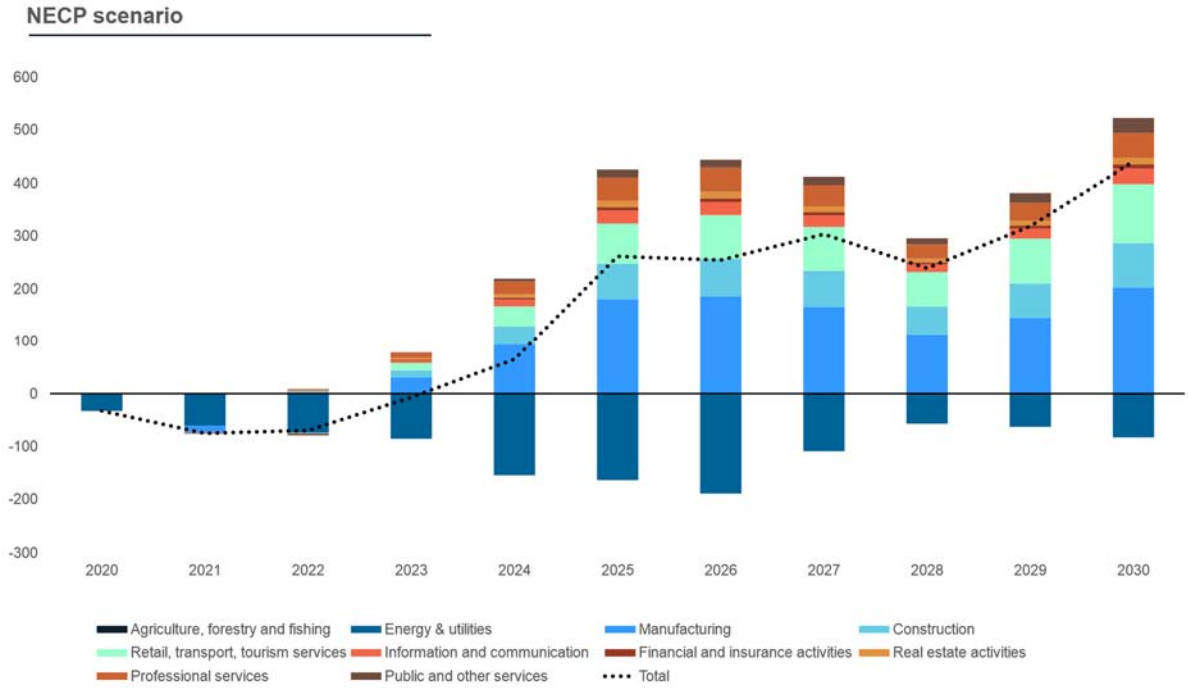
The Moravian-Silesian (MS) Region is the largest transition region in terms of population (1.2 million people). While the region is below the national average in terms of GDP per capita (PPS terms), 73% of the EU average in MS compared to 89% of EU average nationally, it is the most active economically across the target regions. The growth of regional economic activity is comparable to that of the national growth, and GDP per capita (market prices) is only slightly below the national average (EUR 16,700 nationally compared to EUR 13,900 in MS in 2016). There has been continued growth in the last decade. While both the natural change and net migration have been negative since 2010, there is a projected employment growth in the region[193].

The region is home to both coal-based heat and power generation, primarily used by heavy industry and coal mining in the Ostrava-Karviná Basin. Industry use, such as steel production in Třinec or Ostrava, alongside the power it uses, is therefore responsible for a substantial part of CO_2 emissions in the region. Nevertheless, due to its larger overall economy, positive trends (economic and employment growth) and its lower direct reliance on coal-based power generation, MS is relatively (compared to other target regions) resilient to the impacts of the transition.

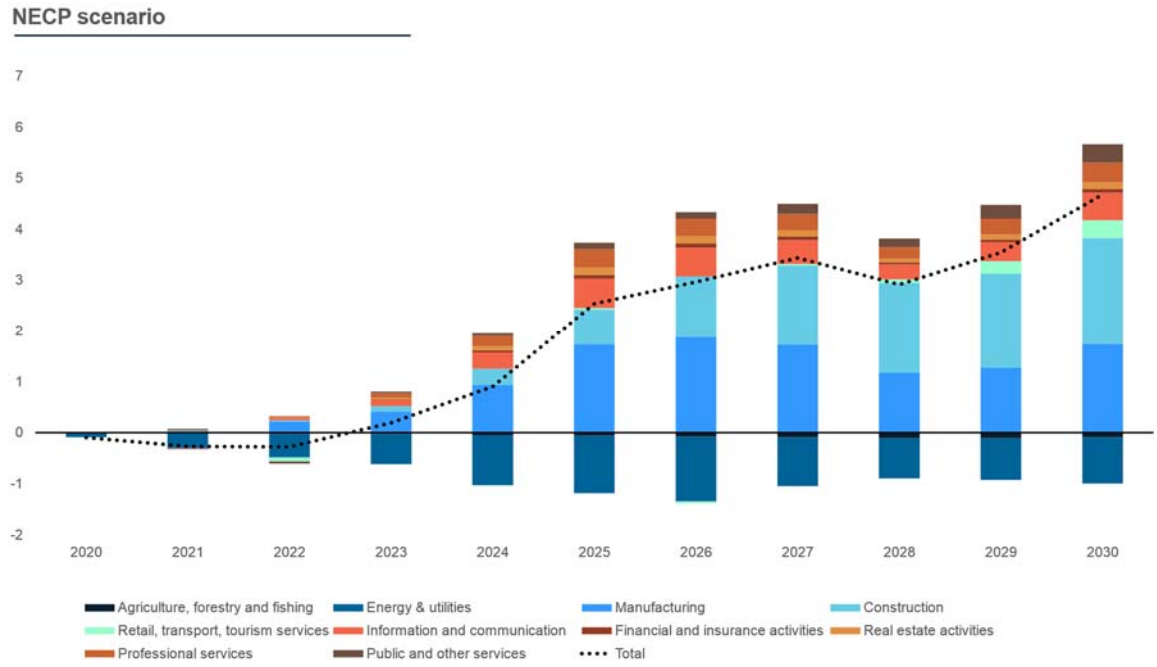
The results of the modelling, shown in Graph 35 and Graph 36, present a similar picture. While the overall pattern in both GVA and employment follows the national trends, the net effect is positive in both cases. Contrasting results from Karlovy Vary and Ústí, results in MS turn positive as early as 2023.

[192] E3ME modelling results
[193] https://urban.jrc.ec.europa.eu/#/en/my-place?context=Default&territorialscope=EU28&level=NUTS3&nutsid=CZ042

Graph 35 Moravian-Silesian (CZ08) GVA in the NECP scenario, by sector, million EUR from baseline[194]



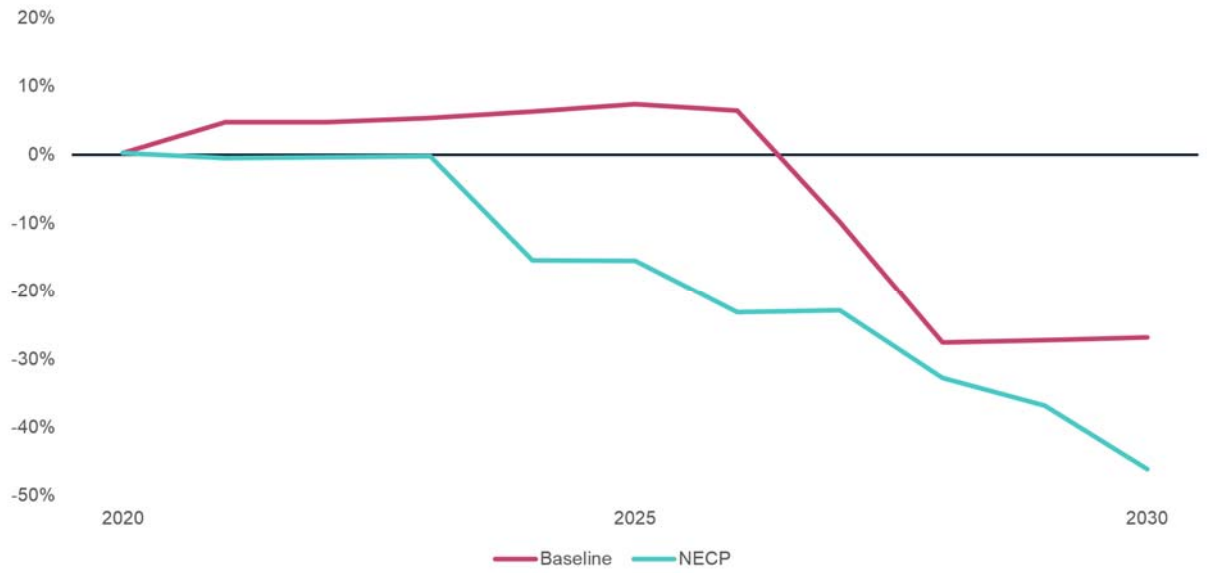
Graph 36 Moravian-Silesian (CZ08) Employment in the NECP scenario, by sector, '000 jobs from baseline[195]



A strong decrease (comparable to Ústí in absolute terms) of the energy sector (up to EUR 190 million lower GVA; up to 1,300 less jobs) is offset by an even stronger positive response in the manufacturing and construction sectors, coupled with supply-chain effects. Positive impacts range between EUR 80 to 520 million (0.3% to 2.6% of 2030 baseline total GVA) or 200 to 5,700 jobs (0.04% to 1% of 2030 baseline employment). These gains offset losses from the energy & utilities sector.

[194] E3ME modelling results
[195] Ibid.

Graph 37 Moravian-Silesian (CZ08) CO_2 emissions in the NECP scenario, % difference from baseline[196]



Meanwhile, emissions are substantially reduced by 2030 under both the baseline and the NECP scenarios. Overall CO_2 emissions end up being 46% lower than 2018 in the NECP scenario. However, even though E3ME, coupled with the FTT:Steel submodule, can simulate technology switching impacts and trajectories within the steel sector, this module is not yet adapted for use in regional level modelling. Therefore, the results presented here do not take advantage of the bottom-up modelling in FTT:Steel. It also should be noted that the baseline scenario already has a noticeable decrease in emissions from 2025 to 2028, which is caused the baseline itself including the reduction of coal-based power generation and, as the regionalisation simulates decommissioning based on estimated plant lifetime and age, coal-based capacities in MS are decommissioned in the simulation (see Graph 37).

5.1.6 Qualitative assessment of impacts of low carbon transition

In addition to the quantitative modelling of the regional impacts, the consultant team carried out stakeholder interviews, survey and workshops with regional and national actors who have been identified throughout the previous stages of the project (especially through the stakeholder engagement report).

The key takeaway messages based on the qualitative assessment of "small stakeholders[197]" are:

- The **awareness** on the JTM among small stakeholders (municipalities, SMEs, NGOs) can be perceived as i**mproving**. However, the general levels are still low, and the stakeholders would welcome some regularity in the information processes, tailored to their specific needs and including specific examples. While many of these platforms exist (such as the Transformation Platform or the Regional Standing Conferences), the flow of information has not been perceived as sufficient and, therefore, exploring potential bottlenecks could be highly useful.
- The debate at the time of writing this report was perceived as largely pulled by strategic projects as opposed to other schemes. This is likely to develop over time, but could have shaped the awareness and interest of some actors for the time-being.
- Public financial support has been perceived as crucial for both the climate neutrality transition and the Just Transition. However, the administrative burden in the existing programmes has been highly demotivating for some actors (especially among enterprises and SMEs). Flexibility in the mechanisms will be (one of the) key(s) to their success and absorption capacity. By contrast, the level of co-financing and cooperation with regional and local authorities are the decisive factors for NGOs, who lack the co-financing power.
- The programmes should be prepared and announced in time to allow for preparation of good projects by the stakeholders. At the same time, technical assistance is absolutely indispensable

[196] E3ME modelling results
[197] We elaborate on the findings for EU ETS stakeholders in the section on Key economic operators.

for “small” stakeholders (SMEs, NGOs). Existing governance structures could be successfully used.

- Relocation of production to the third countries is generally not considered as an impact of climate neutrality transition. However, the already existing unavailability of skilled and qualified workers (and the qualification mismatch) is expected to be deepened by the climate neutrality transition.
- Building and focusing on social infrastructure and community development has been perceived as the focal point both by municipalities and NGOs to address the negative demographic trends in all three regions.

In total, we have carried out a total of 50 in-depth interviews and 3 discussion workshops with 34 external participants from December 2020 to May 2021, including representatives of the EU ETS sector, non-EU ETS (including SMEs), municipalities, policy makers, and NGOs. Table 23 provides a summary of interviews by the type of actor. The full list of interviewees is provided in Annex 4.

Table 23 Stakeholder interviews and workshops

Actors	Number of stakeholders
Enterprises **under** EU-ETS	9
Enterprises **outside** EU-ETS (including SMEs)	14
Municipalities and regional authorities	23
NGOs	17
Policy makers and other	21
Total	**84**

The interviewees and workshop participants evenly covered all three regions, with 14 representatives in Moravia-Silesia, 27 in Ústí, 16 in Karlovy Vary regions, and 27 stakeholders representing nation-wide organizations, but in most cases with a regional focus. The interviews and workshops were stratified according to the type of stakeholder, i.e., different sets of questions and topics were asked for companies, municipalities, etc. However, some questions are common to all stakeholders (such as awareness). The following Table 24 provides an overview of the topics addressed by the interviewer for each type of stakeholder. The workshops then mainly focused on awareness, needs and preparedness of projects. The full structure of the interviews is provided in Annex 3.

Table 24 Structure of the interviews

Company under EU ETS	Awareness about JTM EU ETS – impact of regulatory framework Economic context Impact of climate neutrality Strategy of the company Investment and financial instruments, and Technical Assistance
Company outside EU ETS	Awareness about JTM Economic context Impact of climate neutrality Strategy of the company Investment and financial instruments, and Technical Assistance
Municipality	Economic context Awareness about JTM Climate neutrality transition Investment and financial instruments Technical Assistance

NGO	Awareness about JTM Climate neutrality transition Governance

The following section draws qualitative, exploratory conclusions from the interviews and focuses mainly on the results of the interviews and workshops with the non-EU ETS companies, municipalities, and NGOs. The results of interviews with companies under the EU ETS are developed separately in Section 5.4, as they are the central points in the low-carbon transition processes and transformation needs.

Companies outside EU ETS (including SMEs)

Table 25 Companies outside EU ETS

Awareness about JTM and role in JTM	- They are aware of their economic role in the transition process - The companies make use of their membership in the professional associations to gain insights on the upcoming activities, strategies, policy framework - The interviewed companies have generally good perceived knowledge on the Just Transition, but mostly thanks to personal links, informal meetings, and activities of local actors (e.g., the municipality where the company resides). The general knowledge especially among smaller companies (and micro-companies) is lower, but can be effectively improved through the existing channels, together with a uniform, clear "signpost" platform according to areas of support is a useful tool. - They would welcome more strategic discussion on the smooth transition of the employees, which will enter the market due to the coal phase out.
Economic context	- The companies generally do not expect major changes to the value chain of their business. - The structure of the suppliers and customers is generally wide and diversified among the interviewed companies. - In general, the interviewed companies have not so far included sustainability criteria in their supplier chains, nor have they been required to incorporate them by their customers. - However, especially with companies that are owned by European "mothers," the trend in sustainability has been somewhat more apparent. - All companies recognise the importance of digitalisation and are at various stages of development, from exploring the digitalisation options to advanced stages of digitalisation of all company processes. - Machine learning was only mentioned once as something being actively explored by the company.
Impact of climate neutrality	*Changes in business of the company* - The impacts of low carbon transition mainly depend on the specific sector of business of the given company. - The interviewed companies are mostly sensitive to general economic development and lately to the impacts of Covid-19 pandemic. - However, some interviewed companies acknowledged they would shift at least some of the business to third countries depending on demand. - This was also somewhat connected to the availability of loans for coal-connected products. *Employment* - All the companies expressed concerns about the availability of qualified employees. They all have to employ foreign (agency) workers or are in a constant shortage of employees, especially for engineering/technical/operator positions.

	- Each company has its own qualification procedures and often have a special qualification/training centre for new employees. - They sometimes also cooperate with external companies on specific training skills, mainly in the soft skills area, rather than in the core of the business. - Most of the companies have also an established cooperation with local actors (municipalities, local schools) and an effective cooperation with universities (both from the region and elsewhere) to cooperate of research, innovation and development. - The idea is to also support the employment process and connect with and form relations with potential employees.
Strategy of the company	- The strategic decisions are usually developed top down - As stated above, the state of development of own low-carbon strategies depends largely on the owner/mother/general directorate. - Either there is a clear GHG mitigation target (and other sustainability and corporate responsibility), or there is virtually none.
Investment and financial instruments	- The companies are used to using various public policy programmes to finance their strategic investment. - The companies used public programmes to invest especially in research and development projects (specifically through the operational programme enterprise and innovation, and also the programmes under the Technology Agency of the Czech Republic), and energy efficiency and renewable energy projects through the same operational programme. They have partially used other programmes for minor projects in OP Employment. - However, the administrative intensity of the programmes has also had a demotivating effect in some cases. The requirements of the programmes are too demanding, especially with respect to any changes in the project, public tender procedures, and reporting.[198] - The interviewees generally said they do not feel the need of programmes focusing on soft loans and guarantees as they are usually larger companies who are able to negotiate the terms of the loans themselves. By contrast, the SMEs welcome such instruments and are in favour of them compared to administratively intense investment grants. - Word-of mouth plays an important role and can be the main (de)motivating factor for SMEs. - In the near future, due to Covid-19 economic impacts, the companies expect a shortage of cash-flow to invest in new projects and will be considering more carefully the projects they invest in.
Technical Assistance	- The interviewed companies generally use external companies to help in administering the projects supported by public programmes. They may rely on them as a source of information as well. - Otherwise, the need for Technical Assistance has not been emphasized by the companies.

[198] See also https://www.sciencedirect.com/science/article/pii/S0301421520305875 and https://www.sciencedirect.com/science/article/pii/S0301421518302714?via%3Dihub on administrative intensity of these programmes.

Municipalities

Table 26 Municipalities

Economic context	- The interviewees generally stated that so far, they have not been substantially economically affected by the Covid-19 pandemic. - More importantly, the pandemic has impacted the prioritisation of the topics to deal with (the pandemic obviously gaining priority over other matters). - They stressed that other municipalities which are, e.g., more reliant on tourism, will be much more affected. - They are aware of their economic role in the transition process. - The interviewees report on capital raising strategy.[199] However, interviewees revealed that due to expected tightening of state, regional, and municipal budgets, the investment will need to address its priorities, with potentially energy efficiency and RES projects dropping down the line.
Awareness about JTM	- The stakeholders stated they think the general level of awareness has been improving. However, they do not see clearly how the needs of the municipalities can be met by the Just Transition priorities. - They would highly welcome a "reservoir" of typical projects to get a better picture on the JTM and to get a better picture on "what should they be prepared for." - Some of the interviewees said that they had enough information, but mainly stemming from their other roles in various committees (regional) and leading roles in associations. - They generally agreed that the information flow within the associations and top down from the regional authority has not been largely developed and could be substantially improved. The debate on JT(M) so far has been steered by the strategic projects and, therefore, navigating it back towards higher inclusiveness of small players will now be crucial. - A clear message on the time horizon and steps in the JTM preparation will be highly welcomed by the stakeholders. - With this respect, they also mentioned the need to strengthen personal capacities at regional authority levels to support the awareness, strategic leadership, and project management. - There were suggestions also aimed at introducing an "official communication channel with municipalities". - Generally, where available, the Local Action Groups are considered a good source of both informal and formal information sharing.
Climate neutrality transition	- The municipality representatives see the major **risk** in the lack of strategic vision, focus on a mere "upgrade", rather than "real transformation" of the regions, and narrow focus and lack of diversity of the regions (e.g., high share of spa and tourism), and lack of interest in the brownfields after mining for further development. - The connected **challenges** mentioned by the respondents include the potential lack of needed skills of the people made redundant by the transformation

[199] Available at https://ekonom.feld.cvut.cz/cs/katedra/lide/valenmi7/cic2030/index

	process, and the challenge to attract young people to stay in the region. - The main **opportunities** and the role the municipalities see is to create a "good environment" for living, i.e., provide such conditions that the population builds a relationship to the area (region and city), creating and enhancing local community life. The municipal representatives agree that most of the challenges can be turn into opportunities with an example of a flooded mine turn into a large heat pump, notwithstanding the diversification of the use of brownfields with the existing infrastructure. - The municipalities offered a diverse perspective on the **alternatives in employment/entrepreneurship** in their area. This is obviously very much dependent on the specific area and cannot be generalized. Some municipalities complained there is only one major employer in the area. In other cases, especially if a business area is nearby, the opportunities are clearly much more diverse.
Investment and financial instruments	- The municipalities are fairly used to the public policy (investment grant) programmes, especially the Operational Programme Environment to support energy efficiency in buildings, also for other projects, e.g., water management. - Much less so is the renewable energy support used, due to lack of willingness, but also appropriateness of the buildings typically owned by municipalities (schools, administrative buildings). - Only some of the interviewed municipalities have used other programmes, such as Operational Programme Employment and have established a continuous cooperation with NGOs. - They tend to use own funds to co-finance the subsidy and have complained about the administrative intensity of the programmes and the insecurity cause by changing conditions of the programmes. - One of the interviewees expressed major concern about the prepared OP Just Transition (and JTF in general) stating that "the conditions for supportable projects are still changing as it goes" and they were afraid that the "grant money will go to bigger cities and businesses." - Consistency and continuity are the crucial factors for success and absorption capacity of the projects. Similarly, adequate timing and sufficient time to respond to the call is vital to allow the preparation of good projects.
Technical Assistance	- The Technical Assistance to develop (pools) of projects is absolutely crucial to the municipalities, especially the smaller ones. The project preparation is a complex and costly process that the municipalities do not have the money nor personal capacities to carry out on their own. - Preparation of the projects needs to be financially supported (e.g., Operational Programme Environment, energy savings) - The interviewees agreed on the need for the regional authority to play great and more strategic role in assisting the municipalities in developing projects, by guidance and direct technical assistance. - Specifically, "advisers" and "apolitical infrastructure" connecting municipalities, companies and helping with

	evaluating existing projects and preparing new ones. Again, Local Action Groups are seen as good platform for technical assistance. - A form of transformation agency with specialists in the given areas to explain and guide through the transformation process would be highly appreciated.

NGOs

Table 27 NGOs

Concept of Just Transition	- The concept of a Just Transition is very broad and can be perceived in an empty way. At the same time, it is a deep and complex topic. - Transformation and improvement of the situation in the regions seems to be key. It is seen as a unique opportunity that will not be repeated. - Digitalisation, which was relatively well represented in the small sample, can be perceived as both problematic and as an opportunity (but at the same time, could cause further widening of the gap in access to services and opportunities). - At the regional level, several transformation processes are underway - digitalisation, post-covid and Just Transition. These can be complementary, but also risk interacting negatively (see also above).
Awareness	- Awareness processes are gradually improving at the county level. - However, NGOs generally still lack information on the timetable and plans of the just transformation programmes. - There is a lack of a systematic and broad process of informing about what the programmes will look like, what the conditions will be and what the timeline of the programme will be. - According to a survey of environmental NGOs200, only 15% of respondents have an idea of the concept of Just Transition. - The process lacked a broader initial strategic discussion at the level of the RSC and the general public ("strategies are made from the table" without participation and involvement of civil society). - Communication was and is perceived as focused on strategic projects (which are "likely to dominate" large enterprises), but which should not form the "gross" of a Just Transition, rather only complement it. - MoRD will implement an information workshop for NGOs on 19 May 2021. This is likely to have a positive impact on awareness among NGOs. However, it is important that the multiplier effect and the "umbrella" approach as described in the D2 Stakeholder Engagement report also works in the non-profit sector. **Clarity of wording** - The need for clear information without formal designs clearly emerged from the workshop. Participants generally agreed that the information is scarce, is not comprehensively written or accessible, and appears chaotic. - The information is often very technical and not easy to understand. - Information often flows through "customary channels" in a relatively narrow corridor. The broad format of information (the 'umbrella' approach) does not always work - representative members of panels and platforms do not ensure the flow of information onwards to their members. **Platform for discussion and information sharing**

[200] https://www.hnutiduha.cz/aktualne/dve-tretiny-lidi-podporuji-vysluhove-davky-pro-uhelne-horniky-energetiky-odbory-ekologicke

	- NGOs would welcome deeper use of participatory processes, including roundtables, comment procedures, etc. - It also seems highly desirable to set up a long-term system of regular meetings, sharing information and good practice. A “newsletter” form of information would be welcome. - A suitable platform could be, for example, regional innovation centres or regional development agencies. - Alternatively, greater coordination between the regional authority and the administration could be used.
Project preparedness	**Changing the story of the regions and modern social infrastructure** - The objectives of support for Just Transition programmes should be based on clearly set development priorities for the regions concerned. - Two main 'themes' emerged from the discussion: changing the story of regions and modern social infrastructure and community. - The supporting themes then emerge, among other things, from the focus of the NGOs participating in the event, but at the same time map well onto the needs of the regions. Thus, appropriate forms of retraining, comprehensive solutions for excluded localities, social housing with modern technologies (and densification of the city centre), community projects, the institute of community manager, appropriate transport infrastructure were identified as the main needs. - The link to transformation will be important, or equitable transformation programmes are "bonus" funds over and above standard, national and regional support programmes. Thus, they should ideally not substitute for government services. **Critical project funding for NGOs** - NGOs are critical of the requirement for co-financing of projects supported by (not only) Just Transition programmes. This requirement can significantly reduce the absorption capacity of a given fund for these organisations and activities. - Cities or regions play a very important supporting role in the issue of co-financing. It can be expected that the possibilities for this cooperation may be limited due to the impact of the pandemic on public administration budgets. - At the same time, municipal support can make project administration more complex if it contains additional or different conditions and requirements. **Timely access to information and technical assistance** - Timely access to information about the programmes is very important for NGOs to prepare for the calls or to prepare projects. - Basic technical assistance seems to be highly desirable and should include in particular the systematic provision of ongoing information and consultation on the calls and basic administrative assistance. - The structure of regional ICs or Regional Development Agencies could be used.

5.2 Regional analysis of relevant policies towards climate neutrality

This chapter presents regional analysis of relevant policies that deal with aspects of the low-carbon transition and the mitigation of potential negative impacts of this transformation. Specifically, we analyse the three main types of relevant regional documents: (1) the regional energy concepts, (2) the regional innovation strategies and (3) the regional development strategies.

Table 28 provides a structured assessment of regional innovation and regional development strategies.

Moravian-Silesian has undergone significant development of its innovation potential over the last decade (the fastest growth of all NUTS II regions in the Czech Republic), while the Northwest Region (Karlovy Vary and Ústí Regions) has stagnated over the same period and lags significantly behind other regions.

The main findings based on the assessment of regional RIS3 strategies include:

- The RIS3 documents aim to become important frameworks to support the innovation potential of the regions and local actors. They aim to improve the position of the regions in the supplier-customer chains by providing goods and services with higher added value thanks to cooperation with research institutions and among each other.
- The topic of energy transition is present in all documents and is a supported priority.
- The strategic documents do not reflect topics such as climate change or coal phase-out as cross-cutting themes that will be connected with extensive investments across sectors (with potential in forms of diversified eco-innovations) and disruptive changes of the regional job market.
- The focus is partially oriented on the digitalisation (industry 4.0) and diversification by support of new emerging industries and the development of the current specialisations of the regions.
- The RIS3 strategic documents cover human resources development, but on a general level (using language such as “need to support,” “improve,” etc.). There is a lack of clear targeting of specific needs regarding education, reskilling and upskilling and the design of their systematic support based on the expected future job market needs.

The main findings based on the assessment of regional development strategies include:

- All three regions have developed a Territorial Energy Concept, which is based on the State Energy Policy of the Czech Republic. These concepts are not explicitly mentioned in the regional development strategies but are coordinated with them. However, the dynamic development of energy and job markets driven by the coal phase-out and innovative projects needs to be reflected in the development strategies as basic documents to be aligned with Territorial JTP.
- The regional development strategies of all three regions identify some potential of coal phase-out and specific trajectories of change in the energy sector, but they do not deal with challenges and risks of the transformation on topics such as diversification, loss of jobs, unemployment of specific age and professional groups, the need for special qualifications (IT experts), potential deterioration of quality of life and migration of young and/or qualified people out of the region.
- The regional development strategies include some specific actions and measures, mainly related to the energy sector, but almost no specific action toward upskilling and reskilling is mentioned.
- The Moravian-Silesian region identifies challenges and the potential of the coal phase-out with a focus on technology changes in the energy sector. The issue of unemployment and specific upskilling and re-skilling needs is not further developed.
- The Ústí region does not reflect the coal phase-out and energy transition (e.g. emissions reductions, job losses, changes in energy and restructuring). No specific measures directly related to the transition process are identified.
- The Karlovy Vary region devotes extensive space to the strategy of transformation within the section “Attenuation of coal mining and transformation of energy.” The strategy deals with coal mining and processing with exclusive focus on Sokolovská uhelná, a.s., which is the smallest lignite mining company in the Czech Republic and the largest business entity in the region. It is already affected by the process of energy transformation and the decline in coal mining.

Table 28 Assessment of regional innovation and regional development strategies

Category	RIS 2020-2027		
	Ústí Region	Karlovy Vary Region	Moravian-Silesian Region
Regional innovation Scoreboard – European Commission 2019	Regional Innovation Index 2019 = 0.279 Moderate innovator (for NUTS II Northwest – Ústí + Karlovy Vary Regions) *Strengths (compared to the EU):* ● Low-R&D innovation expenditures *Weaknesses:* ● R&D expenditures public sector ● R&D expenditures business sector ● International scientific co-publications ● Public-private co-publications ● Patent applications ● Design applications ● Tertiary education With overall decreasing score (-1% between 2011 and 2019)		Regional Innovation Index 2019 = 0.365 Moderate Innovator *Strengths (compared to the EU):* ● Low-R&D innovation expenditures ● SMEs innovating in-house ● Lifelong learning *Weaknesses:* ● Public-private co-publications ● Trademark applications ● PCT - patent applications With overall increasing score (+8.7% between 2011 and 2019)
Innovation vouchers programme	Yes – open from 2020	Yes - Programme of Development of the Competitiveness of the Karlovy Vary Region – opened in 2020	Yes open 2010
RIS3 strategy	https://www.kr-ustecky.cz/assets/File.ashx?id_org=450018&id_dokumenty=1749678	https://www.ris3kvk.cz/download/documents/RIS3_KVK_final.pdf	https://www.rismsk.cz/upload/files/RIS3_MSK_krajska_priloha_CZ_FINAL_aktualizace%2030052018%281%29.pdf
Vertical priorities: Traditional specialisation	● Energy, resources, related fields ● Organic and inorganic chemistry ● Production of glass and porcelain	Domains of specialization: ● Traditional industries - ceramics, porcelain and glass ● Energy transformation and new challenges ● Spa, balneology and tourism	● Mining industry ● Steel production ● Machinery ● Energy production

Category	RIS 2020-2027		
	Ústí Region	Karlovy Vary Region	Moravian-Silesian Region
Vertical priorities: New-developing industries	• Mobility • Digitisation, including smart cities and industry 4.0 technologies • Cultural and creative industries	Domains of specialisation: • Mechanical engineering, electrical engineering and mechatronics • Automotive industry and autonomous transport	• Advanced materials and materials with low energy intensity • Special machines, equipment and technology processes of industrial automatisation
Horizontal/ cross-cutting priorities	• People for innovation, research and development • Innovative and competitive companies • Quality research and its applications • Innovation in the public sphere • Promoting an innovation ecosystem	• Private (Private Sector) • Public (Public Sector) • People (Human Resources) • Promotion (Attractive region)	• Transfer of technologies • Human resources • Internationalisation • Coordination and implementation of the innovation strategy • Mechatronics systems and equipment • Regenerative medicine, genomics and new methods of data analysis • Processing and use of secondary resources and waste • Intelligent energy – smart grids and smart cities • Integrated security systems • Supercomputer methods
Innovation platforms and working groups	• Hydrogen platform of the Ústí Region • European Chemical Regions Network • Working group for autonomous driving¨ • Connected, Automated and Autonomous Mobility Single Platform	• Spa and balneology innovation platform • Innovation platform Traditional industries • Innovation platform for strategic opportunities	6 platforms • Klastrnet • Start ups • Modern control systems • Advanced materials • Modern energy and waste processing • Regenerative medicine, genomics and bioinformatics
Supporting organizations	Innovation centre of the Ústí Region, J.E. Purkyně University	Karlovy Vary Business Development Agency	Moravian-Silesian Investment and Development Intensive cooperation with local universities
Actualizations Update	Actual version from 2020	Actual version from 2020	RIS strategy elaborated for 2014-2020, for 2021+ updated updated in 2019

Category	RIS 2020-2027		
	Ústí Region	Karlovy Vary Region	Moravian-Silesian Region
Vision	Inhabitants can develop their talent and apply it to their own business, the implementation of their ideas in progressive companies or research. The emergence of growth companies, internationally competitive thanks to their ideas and products and services with high added value. Research organizations cooperate with the application sphere and help the development of the region. There is a system of organizations and services that support the growth of companies and connect their cooperation	Karlovy Vary Region - a region friendly to innovation, entrepreneurship and international cooperation, which creatively develops local human potential, knowledge and economic traditions.	Vision up to 2020: MS region to become one of the 40 most innovative regions in Europe
Regional project to support the innovation environment (Call for proposals Smart Accelerator II)	March 2019 – September 2022: Basic team (strategic project developers), Education and competence development, Mapping and analysis, Assistance (programme of assistance vouchers), Twinning (TU Dresden), Pilot verification, Marketing and communication strategy of the region https://rskuk.cz/podpora-a-rozvoj-inovacniho-prostredi-v-usteckem-kraji-ii-smart-akcelerator-ii	August 2019 – December 2022: Basic team (strategic project developers), Education and competence development, Mapping and analysis, Assistance (programme of assistance vouchers), Pilot verification, Marketing and communication strategy of the region https://www.ris3kvk.cz/smart-akcelerator?lang=cs	The Moravian-Silesian Region did not submit a project proposal to the Smart Accelerator II call
Action plans	Yes	Yes	Yes
Indicators of success	• Number of employees working in research and development • Share of IT professionals in employment	• GDP per capita incl. comparison with the average of the Czech Republic without Prague	• Global goal: gross added value per employee MSr/gross added value per employee in the CR = 110% of the CR average until 2020

Category	RIS 2020-2027		
	Ústí Region	Karlovy Vary Region	Moravian-Silesian Region
	• Proportion of population with tertiary education • University students in the fields of natural sciences, mathematics, computer science, technology, production and construction • Expenditure on science and research • Granted patents • Revenues of companies for innovated products.	• Median gross monthly wage, total incl. comparison with the average of the Czech Republic without Prague • Indicators defined for specific priorities	• Indicators defined for specific priorities
Evaluations	Ongoing Regional semi-annual implementation reports Mid-term evaluation 2018-2019 (of the previous document), another evaluation planned for 2021 (as well as ex-ante-for the current)	Ongoing Regional semi-annual implementation reports Mid-term evaluation 2018-2019 (of the previous document), another evaluation planned for 2021 (as well as ex-ante-for the current)	Systematic, evaluation documents published set of documents published at the: https://www.rismsk.cz/ke-stazeni/studie-a-analyzy Last document Evaluation of contractual research, published 2019
Main challenges identified in RIS3:			
Climate change	No (only indirectly in relation to new developing industries)	No (only indirectly in relation to energy transition)	Not mentioned
Energy transition	Yes (as a part of vertical priority)	Yes (as part of specialization domain)	Yes (as one of the priorities)
Coal phase-out	Not (only indirectly in relation to traditional industries)	Yes (as part of specialization domain and innovation platform)	Not mentioned Value chain coal – steel – machines mentioned
Diversification	No (only indirectly in relation to new developing industries)	No (only indirectly in relation to new developing industries)	not explicitly mentioned

Category	RIS 2020-2027		
	Ústí Region	Karlovy Vary Region	Moravian-Silesian Region
Digitalization	Yes (as a part of vertical priority)	Yes (as a challenge and part of horizontal priorities)	Yes (as one of the priorities)
Development strategy of the Region	https://www.kr-ustecky.cz/assets/File.ashx?id_org=450018&id_dokumenty=1748791	http://www.kr-karlovarsky.cz/region/Stranky/EU2014-2020/PRKKaSRKK.aspx	https://www.msk.cz/cs/temata/cestovni_ruch/strategie-rozvoje-moravskoslezskeho-kraje-2019_2027-1291/
Vision 2030	No (sub-regional, not thematic division of strategy)	The Karlovy Vary region, an economically prosperous region, open to European challenges and impulses, providing its inhabitants with a space for a quality life based on attractive natural conditions and a socially friendly environment.	The transformation will be finished, the region will no longer have the image of a coal region
Identified potential of post-coal period	Pelvic coal area – priorities: ● P.1: Increase the social capital of the territory ● P.2: Improve living space ● P.3: Increase economic competitiveness ● P.4: Complete landscape restoration and revitalize the physically deprived ● buildings and premises and ensure their effective use	A new opportunity for the region will be the availability of public funds aimed at supporting the transformation of energy sector - to support new economic activities or to support the transformation of existing economic activities.	Post-coal landscape (brownfields)
Post-coal energy system			
Goal	Not directly targeted, only indirectly: elimination of the impacts of emissions from large stationary	Introduction of energy management of the region	Transformation from coal-based energy system to a low-carbon/zero carbon energy system

Category	RIS 2020-2027		
	Ústí Region	Karlovy Vary Region	Moravian-Silesian Region
	sources of pollution from industry, energy and mining,	Reduce the consumption of non-renewable energy sources and increase the use of renewable energy sources, improve air quality, secure water resources, increase the share of waste that is still used and preserve or restore the cultural landscape and natural environment of the region that is part of it.	
Challenges	Development challenges for the future are the creation of an "energy mix" in the electricity and heating industry, including greater use of renewable energy sources, the gradual settlement of the consequences of the decline in lignite mining on electricity and heat production (from analytical part)	Transformation of the region's supply of electricity and heat (obstacle in the development of industrial production, security of energy systems, dependence on supplies from other regions or abroad). Restoration of the landscape after mining. Integration of redundant labour into the labour market.	The region will be probably dependent on the energy import from other regions. The region has no energy concept/ strategy in place
Measures/ actions	● Support of energy savings in the household sector (education and counselling of households, maximization of subsidy resources, implementation of user-friendly administration of subsidies, etc.) ● Support for the use of geothermal energy in district heating and domestic heating systems ● Elaboration of the Territorial Energy Concept of the Ústí Region and its fulfilment	● Introduction of energy management of the region ● Promoting the use of renewable energy sources for heat and electricity production ● Promoting energy savings and reducing the energy intensity of public buildings ● Elaboration and fulfilment of the Energy Concept of the Region	a) Action plan for the transformation to a new energy system in the region, impact assessment of the EU Commission Winter Package b) Platform for the dialogue about the new energy system of the region c) Support networking of firms producing energy d) Support research activities focused on modern energy systems e) Identification and development of alternatives for coal replacement by new energy sources

Category	RIS 2020-2027		
	Ústí Region	Karlovy Vary Region	Moravian-Silesian Region
	• Preparation of the subsequent energy focus of the region with the transition to more environmentally friendly energy sources (pumped storage power plants, geothermal potential of mine waters, etc.) • Implementation of solutions in connection with the concept of Smart Regions / Smart Cities in the field of energy savings, use of renewable energy sources, etc.		

5.3 Priority investment needs

We present the full analysis of the investment needs and potential areas for investment related to the impacts of the climate neutrality transition in Deliverable 4. It is clear, however, based on our econometric analysis, that some areas will experience growth under all scenarios. As a result, investment in these areas (including worker qualifications and horizontal value chains) should be considered as a need: construction (including retrofitting work), (low carbon) manufacturing, renewable energy (including construction, operation and maintenance).

The priority areas stem from Annex D of the Country Report for the Czech Republic[201] and are diversified by region. The Regional Transformation Plan (RTP) of the **Moravian Silesian Region**[202] identifies eight priority thematic programmes, which include new energy, new land use, green industry, new enterprise, competent people, innovation ecosystem, digitalisation, and circular economy. In the earlier stages[203], projects potentially falling under the JTF umbrella have been presented and were structured into energy savings/RES/transport, employment, circular economy/recultivation, and enterprise/research/digitalisation. In **Ústí Region**, four main areas of interest have been proposed by the Regional Transition Plan[204], including (1) Enterprise, research and innovation, (2) Competent people, smart region, (3) New energy and efficient use of resources, and (4) Revitalised areas of 21st century. In **Karlovy Vary**, the draft RTP[205] identified six priority areas, which include: (1) Tradition, (2) Innovation, (3) Knowledge, (4) Cooperation, (5) Regeneration, and (6) Energy.

In addition, the regions also identified preliminary investment needs to support the absorption capacity in the regions. Table 29 considers the preliminary assessment of investment needs in the three regions, which are being continuously collected and evaluated. Table 29 therefore presents the expected investment needs as they were presented at the meeting of the Working Groups of the Operational Programme Just Transition in December 2020. These projects represent the pool of projects that the regions see as supporting the Just Transition. Some of the proposed projects may (or must) be supported by other programmes than the OP JT, especially the Modernisation Fund and other operational programmes.

Table 29 Initial assessment of priority investment needs for the Czech Republic, to prepare OP JT[206]

Region	Identified projects
Karlovy Vary region	Number of projects: 150+ Investment needs: CZK 67 bn
Ústí region	Number of projects: 180 Investment needs: CZK 277 bn
Moravian-Silesian Region	Number of projects: *Large companies: 161* *Other: 51* Investment needs: Large companies: CZK 151 bn Other: CZK 61 bn

While the projects above represent an iterative process and will be further refined, it is interesting to compare the levels of identified investment needs for coal phase-out/carbon neutrality as identified by regional energy concepts. The total investment costs (for a period of 25 years) are drastically lower than the investment

[201] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1584543810241&uri=CELEX%3A52020SC0502
[202] Draft version as of 10 March 2021.
[203] Based on the meeting of the Working Groups of the Operational Programme Just Transition on 14-15 December 2020.
[204] Draft version as of 22 March 2021
[205] Draft version as of 7 April 2021
[206] Based on the meeting of the Working Groups of teh Operational Programme Just Transition as of 14–15 December 2020.

needs currently identified to support the transformation. While we are aware of the different scope of the exercises, the difference is nevertheless quite large. The projects currently gathered will have to undergo thorough scrutiny with respect to their transformational potential and alignment to sustainability criteria.

The strategic projects transformation projects that have already been financed in the regions are quite difficult to assess, especially with respect to the still developing definition of such projects. However, the Regional Innovation Strategies and related evaluation of action plans can serve as one source of information (although not exhaustive). The same applies to the summary action plan of the restructuring strategy of the Ústi, Moravian-Silesian and Karlovy Vary regions.[207] These strategies would typically not present full statistics, but rather showcase examples and good practice case studies, which can be used for further assessment.

Similarly, there is a full list of projects that have been supported within the operational programmes in the previous MFF. However, the selection criteria of the "transformative" projects would have to be clearly identified to allow for meaningful analysis, which goes beyond the scope of the current project.

The priority investment needs as they are presented in the RTPs are analysed in detail in D4, where the investment needs identified by the regions are critically assessed vis-à-vis the investment gaps identified by the TA team.

5.4 Transformation strategies of key economic operators and status quo of EU ETS

We specifically focused our analysis on the main CO_2 emitters under the EU Emissions Trading System (EU ETS) as they also belong to the group of key economic operators with expected specific socio-economic impacts of transformation to low-carbon economy.

The key economic operators in the Czech coal regions represent large companies that are registered under the EU Emissions Trading System (EU ETS). It is expected that the transformation to a low-carbon economy will significantly influence current businesses of these companies, i.e., the coal mining companies and power plants, main heating operators, chemistry, manufacturing or steel producers, and thus makes them develop transformation strategies in compliance with EU policies, timing with respect to their potential for economic development.

In the following section, we first present the situation of the key operators with respect to coal in the three regions. This assessment is followed by analysis of their strategic planning based on in-depth interviews (see Section 5.1.6 for more details on the interviews).

Key economic operators are already involved in the economic transformation and energy transition. Thus, it is necessary to understand their initial situation, their current needs and future development strategies. Based on the analyses, the key messages include:

- Large companies across sectors are very closely following current developments about the Just Transition, have enough information and in the vast majority are actively preparing to move away from coal.
- Key economic operators are adjusting their strategies for coal phase-out. While large energy companies are preparing new projects not only in the field of energy to diversify their business, including new use of reclaimed land, companies operating in other sectors are preparing projects, especially in the areas of new technologies to reduce emissions. However, the sector experiences a significant degree of uncertainty about external factors (mainly the price of allowances and the governmental decision about the date of the coal phase-out).
- The question of employment is a sensitive issue, as most of the companies do not yet expect a significant reduction in the number of employees (except mining), but they anticipate the need for newly qualified employees. Thus, the need for retraining/up-skilling of current employees or their replacement by newcomers with higher professional qualifications is expected.

[207] https://restartregionu.cz/strategie-a-cile/

Mining of lignite and hard coal

There are currently four coal companies involved in coal mining:

- Severní energetická, a.s.: Czechoslovak Army (ČSA) mining site, including homogenization crushing plant and Komořany Coal Treatment Plant. The company Důl Kohinoor a.s. which carries out deep mining in the side slopes of the ČSA quarry, deep mining of the DW[208] finished in 2020. The decline in mining at the ČSA mine has already begun in 2021. Its continuous operation will soon end, and approximately 250 workers will be laid off. Approximately 1,770 employees should gradually leave the quarry. At present, about 12 million tons of coal are available and ready for mining. Mining at this mine is expected to end by 2024-5.
- Vršanská uhelná, a.s.: operates the Vršany mine and is closely linked to the operation of the Počerady power plant with an installed capacity of 5x200 MW. The power plant was sold by ČEZ, a.s. to Vršanská uhelná from the Sev.en Energy group. This connects the owner of the mine and the power plant. The declared intention of the new owner is to modernise the power plant and operate it for a long time.
- Severočeské doly, a.s.: belongs to the ČEZ, a.s. and operate the Libouš and Bílina mines.
- Sokolovská uhelná, a.s.: operated by the Jiří mine. The company began a gradual shift away from coal in 2019, and in 2020 it ended the operation of the gas part of the Vřesová fuel plant (gasification of coal for a combine cycle power plant with an installed capacity of approximately 2x200 MW). Sokolovská uhelná, a.s. operates in the Karlovy Vary region, others in the Ústí region.

Hard coal is mined by only one company, OKD Nástupnická, a.s, in the Czech Republic. Since 2010, there has been a sharp decline in coal mining, also due to the economic problems of the mining company. The end of hard coal mining has already begun, and as of 1 March 2021, mining at the Darkov and ČSA mines will cease. A decision on the termination of mining at the remaining ČSM - North and ČSM - South mines has not yet been decided. However, even here a rapid cessation of activities is expected (2022 at the latest). The cessation of coal mining and OKD's mining areas into the property of the state-owned company DIAMO, including workers, is also related to the cessation of coal mining. Subsequently, part of the workers will be used for remediation, liquidation and reclamation work, the remaining workers will be offered a retraining and social programme.[209]

The mining of lignite and hard coal is gradually declining (see Table 30).

Table 30 Development of lignite and hard coal production ('000 tonnes)[210]

	2010	2017	2018	2019
Brown coal	43 774	39 306	39 191	37 466
Hard coal	11 435	5 415	4 470	3 433

Lignite coal currently has three basic groups of customers:

- Large coal-fired power plants, usually owned by ČEZ, a.s.
- Cogeneration plants, partly also heating plants, on coal producing and delivering heat either for business (industrial) consumers or non-business consumers
- Households use brown coal for local heating

[208] Coal in the Czech Republic. Energy statistics, MIT 2020. https://www.mpo.cz/cz/energetika/statistika/tuha-paliva/uhli-v-ceske-republice--251855/

[209] OKD. 2020. Těžba v dole CSA a v dole Darkov skončí na konci února. [Mining at the CSA mine and at the Darkov mine will end at the end of February]: https://www.okd.cz/cs/media/tiskove-zpravy/tezba-v-dole-csa-a-v-dole-darkov-skonci-na-konci-unora-

[210] Coal, coke and briquettes. Results of statistical surveys for 2020. https://www.mpo.cz/assets/cz/energetika/statistika/tuha-paliva/2020/11/Mesicni-statistika-uhli-2020.pdf

Importance of coal for the electricity and heat generation sector

Currently, lignite power plants significantly contribute to electricity production in the Czech Republic. In 2019, coal production amounted to 35.2 TWh of a total production of 87 TWh (40.5% of production)[211]. Production from brown coal has been consistent since 2014 (a peak of 37.7 TWh in 2017 and a low of 35.2 TWh in 2019). The share of hard coal in electricity production mainly comes from one Dětmarovice coal-fired power plant in Moravian-Silesian. In 2019, the production of electricity from hard coal amounted to 2.1 TWh, down from peaks of 4.9 TWh in 2014 and 5.7 TWh in 2016.

The production of electricity from lignite coal is mainly concentrated in the Ústí region, where large system lignite power plants are located. In 2019, the production of electricity from lignite in this region accounts for 20.3 TWh of the total 35.2 TWh. Other regions with high concentrations of electricity production from lignite include the Pardubický region (5.1 TWh from coal) and Středočeský region (5.9 TWh from coal). The Karlovy Vary region contributes a total of 2.1 TWh to electricity production using lignite, although this production is negligible as a percentage of total electricity production in the region. However, approximately 92% of all electricity production from hard coal is concentrated in the Moravian-Silesian region. The share from other regions is negligible.

The production of electricity from coal also corresponds to the size of installed capacity in steam power plants (which are predominantly based on coal combustion). This output amounted to 10,729 MW in 2019 (out of a total installed capacity of 21,987 MW). The distribution of the installed capacity in the regions mimics the production of electricity from coal in the regions. The largest share of installed capacity in steam power plants is in the Ústí region (4,443 MW). The second largest share is in the Central Bohemian region (1,652 MW), followed by the Moravian-Silesian region (1,513 MW).

The dominant operator of lignite power plants is ČEZ, a.s., which currently (as of 2020) operates coal-fired power plants with a total output of approximately 6.2 GW. ČEZ has already started to phase-out the operation of some obsolete units, for which further operation is not economically viable. Specifically, in 2019-2020, the operation of two 110 MW units at the Ledvice power plant, one 200 MW unit at the Dětmarovice power plant and 440 MW at the Prunéřov power plant were terminated. According to publicly available plans from the company, a gradual decrease in installed capacity of coal fired power plants from 6.2 GW to 0.7 GW in 2040 is expected in the coming years[212].

CEZ's conventional fossil fuels (coal-fired power plants) accounted for only 10% of total operating profit in 2020. For 2021, a further decline to approximately 3% is expected. The rising price of emission allowances is no longer fully reflected in the price of electricity. This may speed up the closure of some (i.e., least economical) coal-fired power plants compared to the original assumptions[213]. CEZ plans to publish decarbonisation targets by the end of May 2021. In general, CEZ is trying to diversify its portfolio of activities and increase the efficiency of the operation of existing nuclear power plants and prepare for the construction of a new nuclear unit in Dukovany.

In August 2021, the operation of the 500 MW coal-fired power plant Mělník III is expected to end, with the coal-fired power plant Dětmarovice expected to close by the end of 2021/2022. The decommissioning of some coal-fired power plants is complicated by the fact that they also supply heat to the Dětmarovice district heating systems (e.g., the power plant). At the same time, ČEZ is considering the construction of a large waste incinerator at the Mělník III power plant site.

The Czech Republic is a significant exporter of electricity. In 2019, the net export of electricity was 13.1 TWh. With the gradual decommissioning of coal-fired power plants (according to the State Energy Policy from 2015), it is assumed that electricity exports will gradually decline to balance production and consumption. Currently, the question is how the sites will be used after coal-fired power plants are decommissioned. It is likely that most sites will be used for purposes other than electricity generation. As a result, there is a risk of

[211] Annual report on the operation of the electricity system for 2019. ERO. http://www.eru.cz/documents/10540/5381883/Rocni_zprava_provoz_ES_2019.pdf/debe8a88-e780-4c44-8336-a0b7bbd189bc

[212] See https://www.pse.cz/en/news/cez-pres-dopady-covidu-dal-odstavuje-uhli-letos-vypne-prunerov-i, these plans were published before the recommendation of the Coal Commission to end coal mining to in 2038.

[213] Communication of CEZ financial directorMay 11, 20211, https://byznys.ihned.cz/c1-66923450-dopad-rustu-povolenek-je-pro-cez-porad-pozitivni-podil-uhli-na-provozni-zisku-ale-letos-klesne-na-tri-procenta

losing a significant number of jobs that require highly qualified workers (either directly employed by the resource operator or indirectly in companies within the value chain).

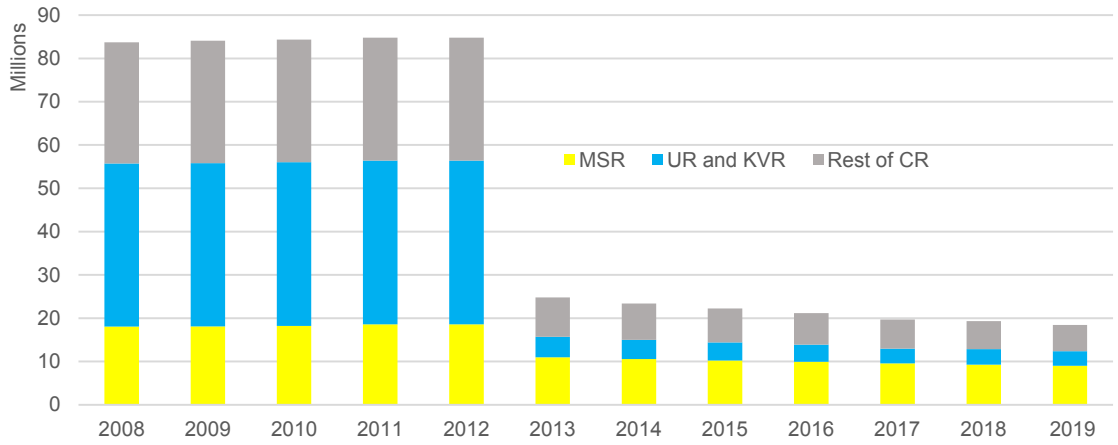
EU ETS in the transformation regions

In the Czech Republic, there were 269 installations under EU ETS in the 14 regions at the NUTS 3 level in 2020. Nearly one-third of these installations are located in the three coal regions: 36 installations in Ústí nad Labem, 8 installations in Karlovy Vary (together at NUTS 2 level Northwest Region with 44 installations) and 41 installations in Moravian-Silesian. Together, these three coal regions are responsible for almost two-thirds of CO_2 emissions under the EU ETS.

Graph 38 shows that around two thirds of emission allowances were allocated to installations in the Northwest region (UR and KVR) and the Moravian-Silesian Region (MSR), with the dominant representation of the Northwest Region installations until 2012. This is mainly due to the location of the heavy industry and coal power plants in these regions, when EU ETS Czech installations were significantly overallocated in the pilot and the first phases (compare Graph 38 and Graph 39). Furthermore, the vast majority of the price of emission allowances is reflected in electricity prices. Thus, all electricity producers with free allocations of CO_2 allowances received double compensation (in the free allocation and at the same time in higher electricity prices for final customers)[214], which is absolutely crucial for the Ústí and Karlovy Vary Regions, where the majority of emissions comes from coal-fired power plants.

Since 2013, emission allowances were allocated in a different scheme under the third phase of emissions trading (e.g., no free allocations for the energy sector and a preference of the auction system). This led to a significant drop in the allocation of free allowances in Czech regions, especially in the three coal regions. The drop was more significant in the Northwest Region due to new rules for energy sector. Nevertheless, Czech Republic was among the countries with the highest share of the free allowances for the modernisation of electricity generation[215] under Article 10c (Directive 2003/87/EC). In the Moravian-Silesian Region there is emission-intensive industrial production and thus many allowances are allocated to local companies (e.g., Třinecké železárny, a.s.; Liberty Ostrava, a.s.) and the drop between free allocations of emission allowances under EU ETS phases 2 and 3 was not so significant.

Graph 38 Northwest Region (UR and KVR), Moravian-Silesian Region (MSR) and the rest of the Czech Republic - emission allowances allocation to particular regions

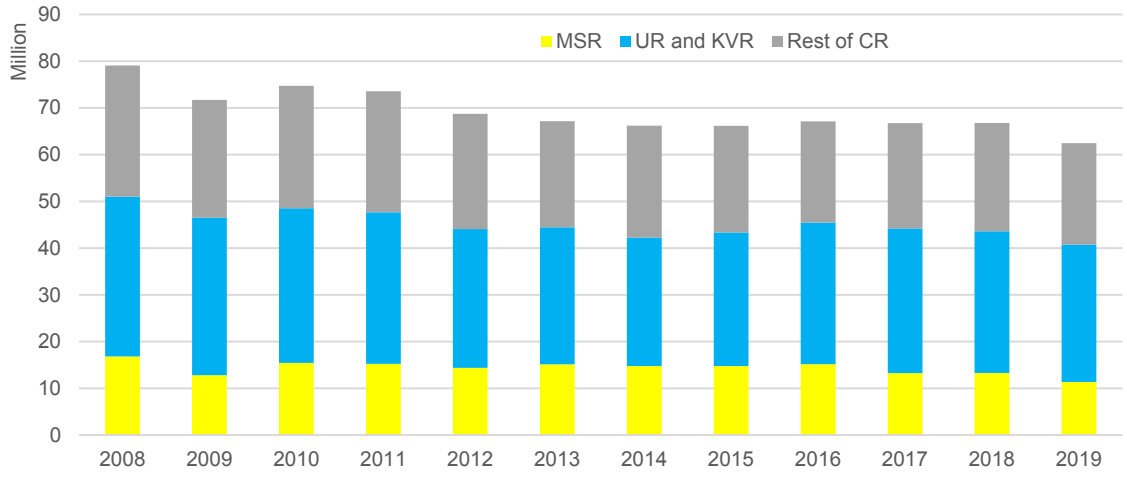


Graph 39 shows that around two-thirds of verified emissions come from installations in the Northwest and Moravian-Silesian regions. Verified emissions decreased through observed years: from 100% of emissions

[214] EC, 2015. EU ETS Handbook. Available online at: https://ec.europa.eu/clima/sites/clima/files/docs/ets_handbook_en.pdf
[215] European Court of Auditors, 2020. The EU's Emissions Trading System: free allocation of allowances needed better targeting. Available online: https://www.eca.europa.eu/Lists/ECADocuments/SR20_18/SR_EU-ETS_EN.pdf

(79,069,707) in 2008 to 79% in 2019 (62,474,755). The proportion of verified emissions between the regions has remained similar with no substantial changes. Installations in Moravian-Silesian produced 18% of emissions while the Northwest produced 47% emissions of all verified emissions under EU ETS in the Czech Republic in 2019

Graph 39 Northwest Region (UR and KVR), Moravian-Silesian Region (MSR) and the rest of the Czech Republic - verified emissions



Decarbonisation and the economic transition will presumably have large impacts in the Northwest and Moravian-Silesian regions due to the large number of installations in these two regions and the smaller allocation of free allowances. The number of verified emissions has not changed substantially. There is also a difference between the regions in allocated allowances compared to verified emissions. The Northwest region receives nearly one-fifth of freely allocated emission allowances but produces one-half of total emissions due to significant representation of the energy sector with no free allocation and high CO_2 emissions. The Moravian-Silesian is the opposite situation since main local CO_2 emitters are from the metallurgic industry, which is under free allocation of the free allowances.

Qualitative assessment of the strategic plans of the organizations under EU ETS

The qualitative results below were obtained from seven interviews with representatives of key economic operators in all three coal regions and with experts from Ministry of Environment. Interviews were conducted with the company's executives or managers. Table 31 summarises their responses and is followed by a summary of the results by topic.

Table 31 Overview of respondents' answers

Selected questions of the implemented questionnaire with overview of respondent´s answers	
How are you involved / prepared for the transformation / decarbonisation process?	- communication in progress on national level - have solution in long term, more than 3 years - systematic emission reducing - projects preparations - perception of changes, no image of final form

Selected questions of the implemented questionnaire with overview of respondent´s answers	
Do you feel that you have enough information about the just transition processes and related funding instruments / options (JTF, etc.)? In which areas do you feel that you would benefit from more knowledge about JTF?	- 5 respondents have sufficient information / 1 has lack of information Respondents moreover stated that: - there is need to define clear rules - it is unnecessarily complicated process for grant applying and administration of the public support- there is need of proper support and realization parameters - need of support in every aspect - there is a lack of time to prepare the projects rather than a lack of information
Do you expect any major changes in the structure of your suppliers and customers?	- Yes 3 respondents / No 3 respondents
When selecting suppliers, do you evaluate suppliers according to sustainability criteria? Or do your customers require such an assessment?	- Yes 0 respondents / No 6 respondents Respondents moreover stated that: - There is pressure from the European bank which does not want to finance activities connected with coal mining and processing. There is expected similar access in the insurance sector.
What regulatory intervention affects you the most in the current framework?	- EU ETS - Emission restrictions - Environmental charges - Strict environmental regulation - Decarbonisation - Water consumption
How do you perceive changes in the price of the EU ETS? How will this affect your company?	- strong influence 5 respondents / not able to assess 1 respondent Respondent moreover stated that with the current rise in the prices of emission allowances, they see the future very negatively.
What changes do you expect in the functioning of your company / sector with regard to decarbonisation?	- increase of costs - preparation to non-coal business - do not expect essential changes, rather some modifications - transformation to gas usage - no respondent answered that the relocation of its business or part of it to the third countries would be probable - 4 respondents stated that they use digitalization to the transfer / 2 respondents are not sure
Do you expect any changes in the structure of employment in your company with regard to decarbonisation?	- Yes 3 respondents / No 3 respondents - Respondents have considered the social and economic impact of these changes on employees - Respondents prepared or plan social programmes in connection with these changes even with help of external programmes for retraining

Selected questions of the implemented questionnaire with overview of respondent´s answers		
Do you need further education / training / skills to be prepared for future challenges? If so, in which areas?	- Yes 5 respondents / Not relevant question 1 respondent	
Do you expect enough qualified employees in your transformation plan in the region?	- Yes 0 respondents / No 6 respondents	
What led to your strategic decisions? What diversification (and decarbonisation) strategies and measures do you plan to implement in the future?	- Fuel supply - Necessity to survive - Pressure on implementation of alternative sources - Economical aspect - Environmental aspect	
Types of investment: • Business diversification • Upskilling and retraining of employees • Digitisation and digital connectivity • Research and innovation activities • Regeneration, decontamination, soil restoration	in past 3 years - Yes 5/ No 2 - Yes 5/ No 2 - Yes 4/ No 1 / Not sure 2 - Yes 7/ No 0 - Yes 3/ No 4	in future -Yes 7/ No 0 -Yes 5/ No 2 -Yes 4/ No 1 / Not sure 2 -Yes 7/ No 0 -Yes 4/ No 3
Have you used any financial instruments (grants, soft loans, etc.) to finance the above investment? Do you plan to use these financial instruments to transform activities? If you used investment grants, how did you invest in co-financing	- all respondents stated that public sources are necessary and vital in financing transformational activities in the past and so do the plan it in the future - to public financing respondents use other sources like own financing and bank loans - all respondents see public financing as motivational	
Technical support Do you need Technical Assistance in the development of the above projects?	- all respondents are able to manage Technical Assistance either on their own, through consultancy subjects, co-partners, research organization or public university with which do they cooperate	

Just Transition

Respondents from key economic operators generally stated that they are already involved on some level in transformation processes and have enough information about the Modernisation and Just Transition Fund. Large companies are often actively involved in discussion platforms at the regional level; however, they often also use unofficial information sources and are active in lobbying at the regional and national levels. It seems that key economic operators in the Czech coal regions are prepared for decarbonisation processes in the long-term (strategic) rather than the short-term (operational) run. Companies prepared project fiches that were often vague and relatively general. Only some of the project proposals have clear parameters currently. Most respondents have sufficient information about the Just Transition. Nevertheless, many expressed reservations to the Just Transition since the final rules are not yet clear. Companies pointed to problems with the dynamic process of preparing programmes and their specifications. During the formulation of requirements for submission of project proposals by the Ministry of Regional Development and regions, there were several changes in the conditions for documents to be submitted, and these were gradually modified.

This brought uncertainty and made the conditions for submitting projects sometimes confusing. However, on the basis of questions raised towards regional authorities and ministries, key questions were answered and clarified. It is a complicated process and thus that there is a lack of time for project preparation. Information flow is generally good. Some firms already contracted consultancies to help them prepare project proposals for the programmes.

Economic context

Expected changes in the value chains of the key operators differ significantly by sector. Companies with business activities directly connected with coal and lignite obviously expect significant impacts on their businesses and have prepared diversification strategies for their business, e.g., usage of recultivated land for renewable energy production, recreation, industry zones as other development projects. Other companies do not expect such significant changes in their customer base or suppliers and will focus investments in relation to the energy transformation and decarbonisation. They focus on reduction of CO_2 emissions and energy saving by investments into new local energy systems (e.g., gas, renewable energy sources) and new production technologies. For example, ironworks and construction companies do not expect fundamental changes in the structure or suppliers and customers but rather in production technologies. Some companies, e.g., chemistry sector, expect changes in their inputs from fossil fuels (oil, gas, etc.) to greener alternatives (waste recycling, etc.) as well as in their outputs due to the EU regulations. However, most companies expect that they will run their business as usual in the current model for some more years and key investments are expected rather in the second half of the decade.

Impact of the current regulatory framework

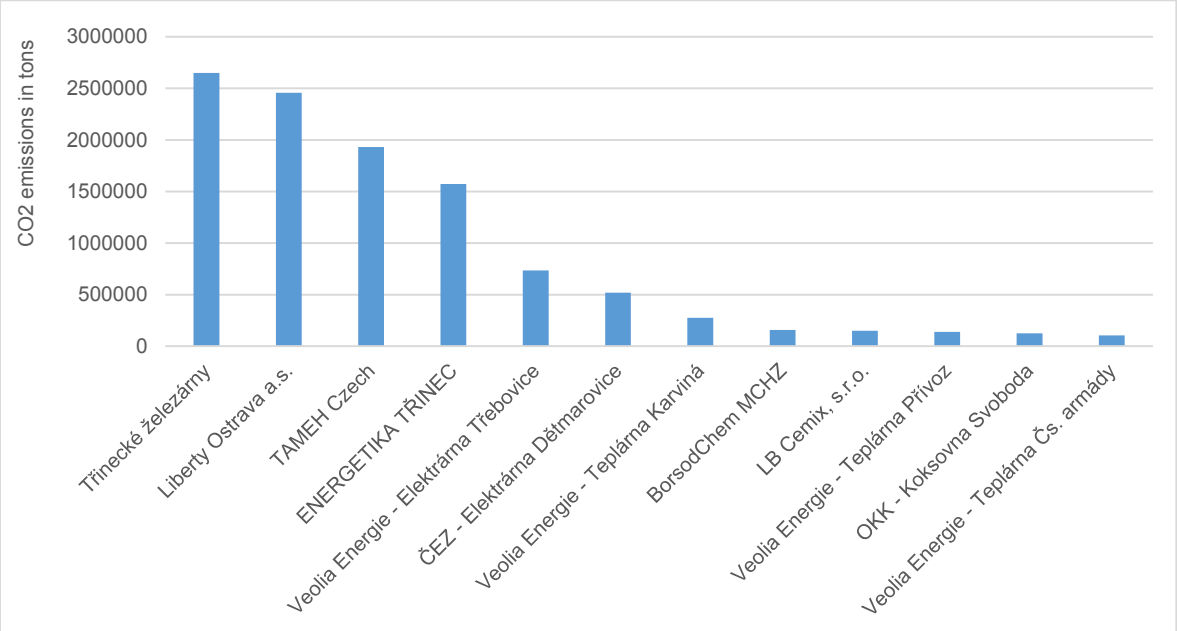
Almost all respondents stated that the strongest regulatory intervention is emission allowances and the EU ETS. However, regional key economic operators also criticize the current system for its artificial creation in the context of frequent political interventions, and in particular its unpredictability (thanks to various speculative purchases, etc.). Respondents perceive the current system as given and adapt their strategies to it. The rising prices of emission allowances have severe impacts on the viability of companies, and they mentioned it as an important factor to speed up the preparation of projects to reduce emissions. If the price of allowances continues to increase significantly, which can be expected in the next decade, it will threaten the economic performance of companies. As a result, companies will likely rely on the new programmes to help them accelerate the transition process and remain competitive in the European and global markets.

Manufacturer respondents strongly emphasised the significance of market protection against cheap products from countries outside of the EU where environmental regulations are weak. Respondents stated that the transition should consider inter-market protection and stabilisation. Manufacturers and energy producers often have to pass input prices through to their product.

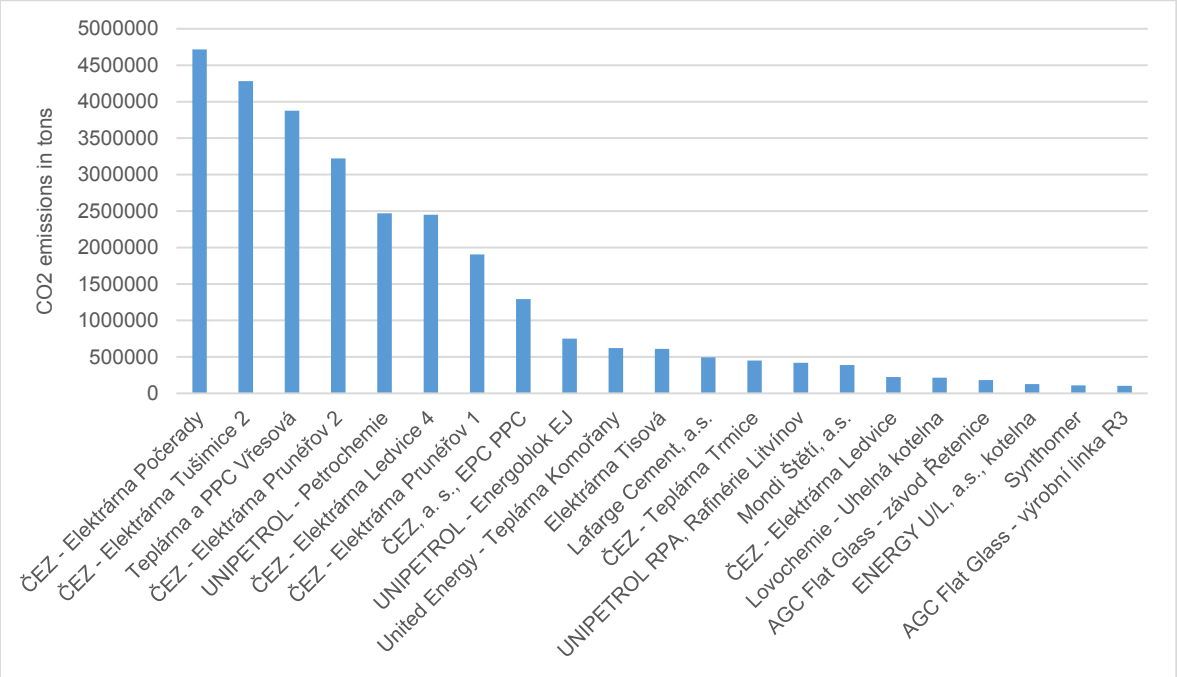
It seems that financial instruments could also be important for companies directly connected to lignite mining and traditional energy production since they already experience disadvantageous funding or the eliminating of their sectors for bank financing, albeit aimed at greening their activities. There are also specific regulations for sectors and companies, which is reflected by compliance in their strategies.

The volume of total emissions of large companies ventures into the millions of tonnes of CO_2 – see Graph 40 and Graph 41. The difference between allocations and actual emissions must be paid by the companies and/or customers. Regardless of the differential financial impacts, all respondents uniformly consider the EU ETS system as a very powerful instrument with significant impacts.

Graph 40 Verified emissions 2019 – main CO_2 emitters in NUTS 2 Moravia-Silesia



Graph 41 Verified emissions 2019 – main CO2 emitters in NUTS 2 Severozapad (Ústí and Karlovy Vary regions)



Impact of climate neutrality

Structural changes for firms related to the carbon neutrality transition varies considerably. One respondent stated that they do not expect structural changes, but simply some modifications. For others, the changes will be substantial. The transfer of the production to other countries is not an option for any of the responded

companies. Only one respondent considered this option to close a part of their business and subsequently purchase semi-finished products. Some respondents have doubts about the technological possibilities of the transition for their companies since there are either no feasible technologies or they are disproportionately expensive and therefore unprofitable.

Nevertheless, most respondents do not expect impacts on the number of employees related to the transition to a carbon neutral economy (with exception of mining companies). Nearly all respondents expect changes in employment structure since they need employees with a higher or completely new qualification.

Strategy of the companies

Economic aspects, firm viability, fuel supply and environmental aspects are the key drivers of strategic decisions. Respondents will soon implement diversification measurement in their energy mix such as the transition from traditional coal-based solutions to solar energy, gas, waste heat, biomass. Plans in diversification also relate to changes in the supply chain.

There are significant differences between companies directly focused on the mining and energy industry and companies from other sectors. Large energy companies are preparing new projects not only in the field of energy to diversify their business but also in the new use of reclaimed land. Companies operating in other sectors are preparing projects particularly in the areas of new technologies to reduce emissions and improve their existing products since the diversification of fuel source is not usually a core business feature of these companies. Energy and mining companies are preparing new strategies to create a new “non-coal” business. Among the diversification activities, there are opportunities across the so-called "new energy" areas such as charging electric cars, providing energy services, building RES or development projects like lithium mining or battery production projects. Additional opportunities exist outside the energy sector, such as new use of industrial buildings (e.g., underground mines or power plants) or development projects on the reclaimed land (e.g., housing or new industrial zones).

Companies also focus on the continuous training and qualifications of their employees, their digitisation and digital connectivity to improve energy efficiency, among other reasons. Some firms also cooperate on the development of new low-carbon technologies and pilot their implementation. However, most companies do not expect projects that focus on regeneration and decontamination of sites, land restoration and repurposing projects (with exception of the mining sector).

Each company has prepared strategic documents related to the transition to a low-carbon economy. Generally, they are feasibility studies, energy concepts, grant proposals, along with many others.

Investments and financial tools

Large companies quantify the necessary investments in billions of CZK in upcoming years. To finance these investments, they expect to use a combination of private sources, bank loans and subsidies (up to 50 or 60%). These companies perceive the Modernisation and Just Transition Fund as motivating factors and plan to submit project proposals to the funds. According to the respondents, the additional public financial support is essential to speed up implementation of their development projects related to carbon neutrality.

Technical support

Key economic operators usually expect to cover technical support from private sources, by their own experts or by contracting external experts and consultancies. They also often cooperate with internal research and development departments or external research institutions. Some companies also rely on consultancies with the suppliers of new technologies. At the moment, most companies have already started to prepare analytical studies to explore potential solutions and feasibility studies.

6 IMPACTS OF TRANSITION REGION ACTIVITIES ON OTHER REGIONS IN THE CZECH REPUBLIC

In this section, we assess the impacts of activities in the transition regions on other regions in the Czech Republic. The cessation of coal mining will not only have impacts in three regions with mining activities, but also in most other regions of the Czech Republic. The main reason is that coal is an important fuel for heat production in all regions of the Czech Republic.

As mentioned in previous chapters, the rapid rise in the prices of emission allowances is having a strong impact on coal-fired heating and heating plants and is forcing the whole sector to switch quickly to other fuels. Natural gas is the dominant fuel currently replacing coal in heat production for district heating systems. Biomass (approximately 20%) will play a smaller role, up to 14% for energy use of waste and alternative fuels. From the principle of operation of district heating systems, from the need for rapid transformation (estimated 80-85% of heat sources still burning coal) should be transformed to other fuels by 2030. The role of biomass is limited by its potential (see discussion in previous chapters), energy use waste in turn by seeking its primary separation and recycling. In addition, the construction of waste incinerators is complicated in terms of permitting procedures and the consent of municipalities and the population. The significant role of natural gas in the current transformation is also due to the need for its speed, especially given the time needed for project preparation and permitting procedures. The concentration in terms of time may also be the concentration of heating plant reconstructions in a relatively short period of time and a possible lack of supply capacity. It is also necessary to consider that, until 2019, the operation of heating plants and coal-fired plants up was planned up to 2040. This is also why there are currently only a few resources with transformation plans. Most reconstruction projects will not take place until 2025.

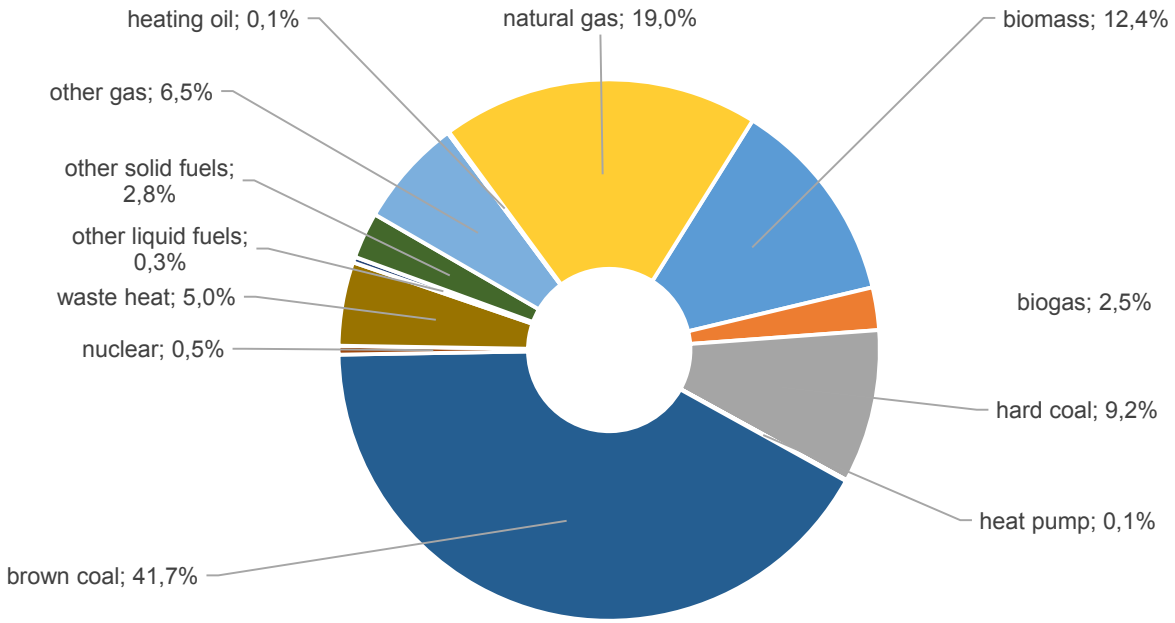
We have identified two major areas where we see “spill-over” effects of coal phase-out. These are the heating sector and individual space heating, especially in households, which are covered in more detail below.

6.1 Importance of coal for the heating sector

Coal, and especially brown coal, currently plays a significant role in the heating sector. A significant part of heat production and supply is provided through coal combustion. According to ERO statistics,[216] total gross heat production was 161.7 PJ in 2019. The share of brown coal in total gross heat production was 42%, and the share of hard coal was 9%. Natural gas accounted for 19% and biomass accounted for 12% (Graph 42).

[216] Annual Report on the Operation of Heating Systems in the Czech Republic, ERO 2019, http://www.eru.cz/documents/10540/5391332/Rocni_zprava_provoz_TS_2019.pdf/a4d8e72d-4f7b-4d02-b464-201bf1648479

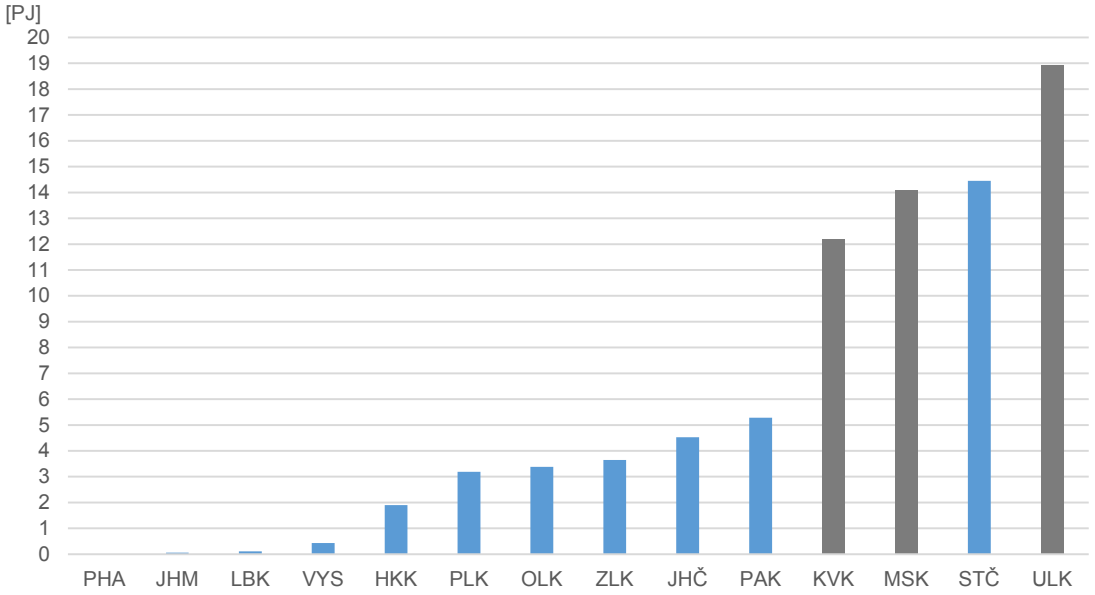
Graph 42 Share of fuel types in gross heat production, Czech Republic, 2019[217]



The share of coal in gross heat production by region is shown in Graph 43. Roughly 32% of the heat produced by coal was consumed directly in the plant itself - usually the so-called plant heating plants or heating plants, which supplied heat for technological production purposes. Heat supplies to final consumers amounted to approximately 87.5 PJ. The structure of heat production by fuel type to final customers is similar to the structure of fuel type in gross heat production with a slightly higher share of coal - brown coal 46%, hard coal 11% and a significantly higher share of natural gas (25%). The share of biomass in the heat supply was 7%.

[217] www.eru.cz

Graph 43 Volume of coal in gross heat production (PJ) by region[218]



Note 1: Regions are denoted as: PHA:Prague, JHM:Jihočeský, LBK: Liberecký, VYS: Vysočina, HKK: Královéhradecký, PLK: Plzeňský, OLK: Olomoucký, ZLK: Zlínský, JHČ: Jihočeský, PAK: Pardubický, KVK: Karlovy Vary, MSK: Moravian-Silesian, STČ: Středočeský, ULK: Ústí

Note 2: Heat is produced for two purposes: (1) own consumption – typically in the case of industrial companies producing process (technological) heat for their own purposes and (2) heat supplied to final customers, which can be both businesses and households.

The heating sector is currently facing a transformation caused by economic pressure, mainly from the rising prices of emission allowances. The transformation of the heating industry (deviation from coal) is addressed by the current proposal (as of January 2021) of the Ministry of Industry and Trade.[219]

Coal will be replaced by natural gas and biomass, as well as waste (ZEVO) and sources burning solid alternative fuels (TAP). Natural gas will have about 66% share, biomass 20%, with ZEVO and TAP making up the remaining 14% or so.

According to available information, a substantial part of modernisation in the heating industry will take place by 2030 (about 85%), with the remaining 15% by 2035. According to current estimates, the cost of modernising the heating industry is estimated at CZK 87-96 bn).[220]

If these costs were to be fully passed on in the price of heat to final customers, it would mean an enormous increase in heat prices and increase the burden on customers. As mentioned in the introduction, district heating companies have invested large sums in the last decade in the reconstruction of coal-fired plants to comply with the emission limits of conventional emissions (NO_x, solid fly ash, etc.)[221].

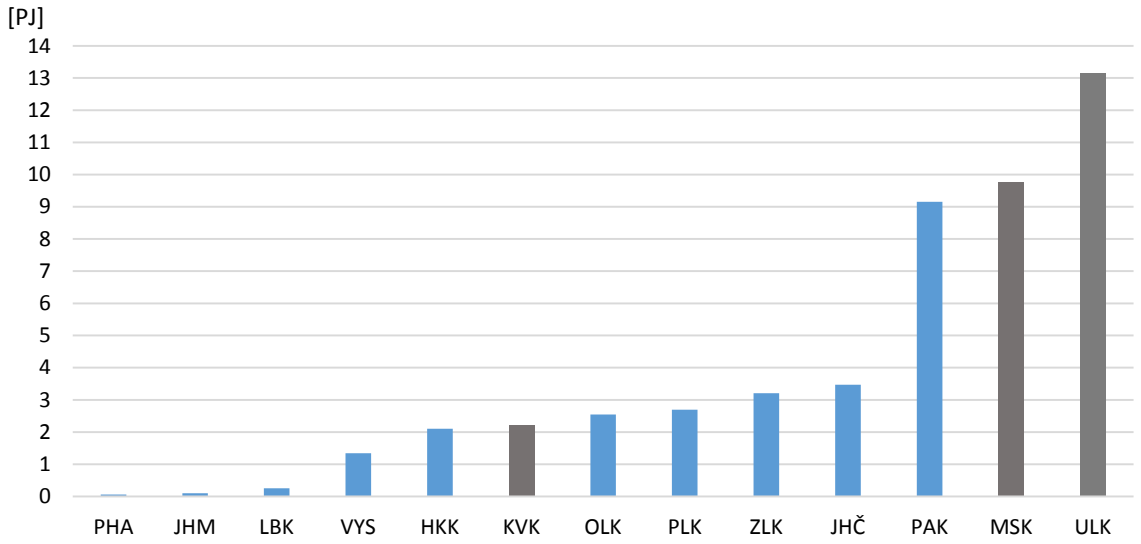
These investments have not yet been written off (repaid). A full reflection of the necessary investments would increase the incentive to disconnect some customers from district heating systems (where this would be possible from a technical and practical point of view, such as the permitting procedure for new smaller sources). In many cases, there would be a disintegration of district heating systems into smaller entities, and in some cases, the tool would consist in the construction of a local gas boiler (this would be possible, for

[218] www.eru.cz
[219] Strategies for stabilization and development of thermal energy supply systems. MIT 2021, working version
[220] Valentová, M., Knápek, J., Krejcar, R., Vašíček, J., Vecka, J. Forthcoming. Klimaticko-energetické investice v teplárenství [Climate and energy investment in district heating sector]. ČVUT v Praze. https://ekonom.feld.cvut.cz/cs/katedra/lide/valenmi7/cic2030/index
[221] I.e., to bring heat production into compliance with the emission limit requirements defined in relation to Directive 2010/75 / EU and to implement the Best Available Techniques Reference Documents` (BREFs) requirements for large combustion plants.

example, due to hygienic limits). The disintegration of district heating systems would complicate the installation of other technologies such as heat storage, use of cogeneration units for system services, effective integration of central sources based on RES, etc. For this reason, funds to cover part of the modernisation investment are recommended.

Although large coal-fired power plants usually have a heat supply (which is a significant problem of the Ústí region in the heat supply sector), coal-fired heating plants are spread across the country. The highest absolute share in the supply of heat from brown coal from plants is the Central Bohemian Region (13.2 PJ), followed by the Ústí Region (9.8 PJ) and the Pardubice Region (3.4 PJ). Prague, South Moravian, Liberec and Vysočina have a minimal share of coal in the supply of heat. In the case of hard coal, the dominant share is in Moravian-Silesian (8.7 PJ) and Olomouc (1.1 PJ). The share of hard coal in other regions is either zero or negligible (see Graph 44).

Graph 44 Volume of coal in heat supply (PJ): by region[222]



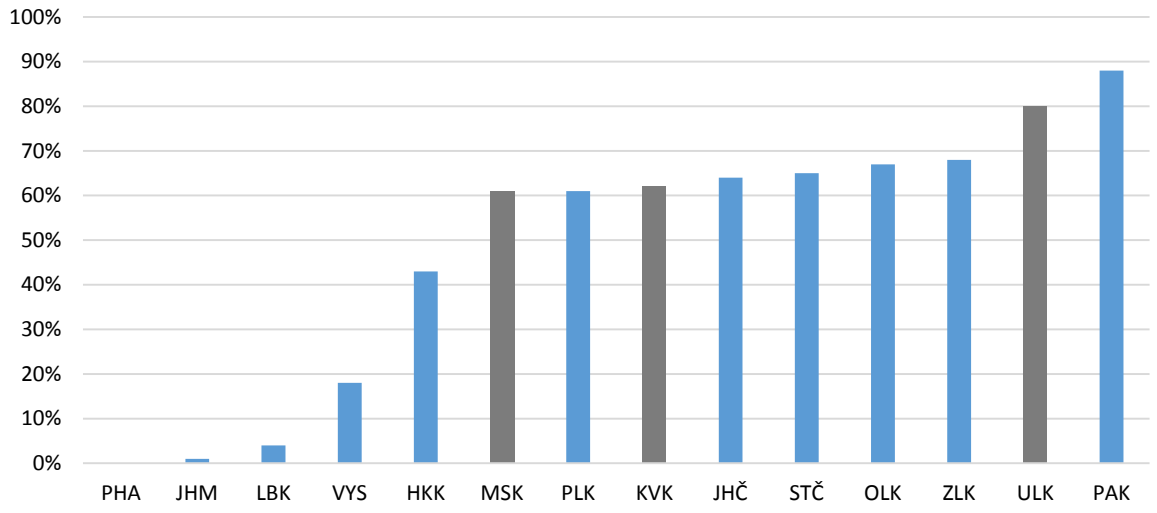
Note: Regions: PHA:Prague, JHM:Jihočeský, LBK: Liberecký, VYS: Vysočina, HKK: Královéhradecký, PLK: Plzeňský, OLK: Olomoucký, ZLK: Zlínský, JHČ: Jihočeský, PAK: Pardubický, KVK: Karlovy Vary, MSK: Moravian-Silesian, STČ: Středočeský, ULK: Ústí

Detailed information on the importance of coal for heat supply to final customers (in terms of production located in the region)[223] is provided in Graph 45, which shows the share of heat supply from coal in the total heat supply in the region.

[222] www.eru.cz

[223] In some cases, heat production takes place in a different region than the consumption of this heat. A typical example is the production of heat for deliveries to Prague at the Mělník I Power Plant, located geographically in the Central Bohemian Region.

Graph 45 Share of heat supply from coal in the total heat supply from plants in the given region[224]



Note: Regions: PHA:Prague, JHM:Jihočeský, LBK: Liberecký, VYS: Vysočina, HKK: Královéhradecký, PLK: Plzeňský, OLK: Olomoucký, ZLK: Zlínský, JHČ: Jihočeský, PAK: Pardubický, KVK: Karlovy Vary, MSK: Moravian-Silesian, STČ: Středočeský, ULK: Ústí

It is clear from Graph 45 that Ústí, Karlovy Vary and Moravian-Silesian have above-average shares of coal in the heat supply. However, this is also a problem in other regions. The transition from coal and the modernisation of heating plants, and the associated economic impacts, affect most of the Czech Republic.

Managing the transformation of the heating industry, which ensures the coverage of heating needs and hot water for about 40% of households (2015),[225] is a key aspect to ensure reliable heat supply. Due to the amount of necessary investments for the transformation of the heating industry and the complexity of the process (project preparation, capacity of suppliers, lengthy permitting process), there are significant risks associated with this process.

With the decline and abandonment of coal use for heat production, a decline in jobs can be expected, mainly due to the prevailing transformation of switching to natural gas, pressure to increase the economic efficiency of business processes (i.e., to maintain competitive heat prices). Although these impacts will be spread across the Czech Republic, the share of the three coal regions will be significant.

The overall impact on employment resulting from the shift away from coal will be significantly lower in the district heating sector than in the shift away from coal. As already mentioned, the phase-out of coal for heating plants does not result in the cessation of activities on the site, but the original coal source is either reconstructed to another fuel or replaced by a new heat source. That is, one technology is replaced by another technology. Usually, coal is replaced with natural gas, which often leads to a reduction in jobs directly at source. However, most jobs will be retained. Conversely, when a coal-fired power plant is decommissioned, with the exception of a few possible cases where the infrastructure is used to build another type of power plant such as a gas or steam-gas plant, there is a slowdown in activities and job losses. The point is that the heating systems are being transformed, not disrupted. The advantage of large heating systems is that they provide more flexibility than small local sources (e.g., in terms of production or consumption of heat, integration of heat storage, etc.).

[224] www.eru.cz
[225] According to the ENERGO2015 sample survey, according to this survey, natural gas and solid fuels also accounted for about 35% and solid fuels for 16% (of which coal 10˘a biomass and RES 6%). http://www.tscr.cz/?ta=124&pg=0750

At the same time, heating plants are currently an important source of electricity. In 2019, they accounted for 10.9 TWh (gross) in the total production of 87 TWh (gross).

Another aspect of the closure of coal-fired power plants is the solution of securing heat supply - e.g., in the case of the Dětmarovice coal-fired power plant, with an installed capacity of 600 MW (expected to cease operations at the turn of 2022/2023), ČEZ expects to build four cogeneration units with a total output of 45 MW, which would further ensure heat supply to Orlová and Bohumín.

6.2 The importance of coal for individual heating

According to the ENERGO2015 statistical survey[226], about 10% of households still use domestic (brown) coal for heating and Domestic Hot Water (DHW) preparation. Despite the massive support to replace obsolete coal boilers – e.g., in the form of boiler subsidies,[227] many households still use equipment that does not meet the requirements of legislation - Air Protection Act (Section 17 (1) (g) of Act No. 201/2012 Coll.), i.e., they do not meet the third class according to ČSN EN 303-5. It will not be possible to operate these devices from 1 September 2022[228].

In many cases, the owners of the buildings attempt to switch to natural gas. The problem, however, is that there is insufficient gas infrastructure in many regions. For example, in the districts of Pelhřimov, Benešov, Příbram, Tábor and Rakovník, more than 77% of municipalities have no connection to natural gas.

Another problem may be that the households using coal are often households with low income, low access to information and orientation on the issue. Specific tools to support the change will be required. In the three coal regions, the concentration of low-income populations is higher than other regions.[229]

The gradual shift away from coal in the electricity and heating sectors will be accompanied by a significant decline in coal mining. This can significantly jeopardize the supply of sorted lignite to households. Sorted coal is produced in the Ledvice (SD) and Komořany (Sev.en) sorting plants and accounts for approximately 5.6% (2.1 million tonnes in 2019) of the total brown coal production.

In the next decade, it will be necessary to address both the issue of households with unsatisfactory combustion plants below third class and to change the fuel base of households that have relatively recently (often with support such as boiler subsidies)[230] purchased new coal boilers. As already mentioned, this is a problem with important social and economic aspects. Coal-burning households are often low-income households with little incentive and/or means to change their heating source. The Ministry of the Environment is facilitating the replacement of the coal heating systems by announcing boiler subsidies. However, this problem has not yet been comprehensively solved.

[226] According to ENERGO 2015, approximately 50,000 households use hard coal (exclusively imported from Poland) and approximately 220,000 households use brown coal as their main fuel. About 160,000 more households use brown coal as a by-fuel. Together with briquettes and a small proportion of coke, solid fossil fuels are used as the main fuel by approximately 300,000 households - see MIT Energy Statistics - Coal in the Czech Republic.

[227] Since the third call for boiler subsidies in 2019, it is not possible to obtain a subsidy for a new coal-fired boiler, resp. to a boiler enabling the combustion of coal in combination with biomass.

[228] The exact number of old solid fuel boilers in Czech households is not known, but experts estimate that the replacement of the boiler will affect about 300,000 households (cc 6-7%). http://www.enviweb.cz/115547

[229] See, for example, Income and living conditions of households in 2018. CZSO. https://www.czso.cz/csu/czso/prijmy-a-zivotni-podminky-domacnosti-kf03f95ff5

[230] 1st call in 2015.

7 CONCLUSIONS AND RECOMMENDATIONS

Based on the above analysis, we provide the following conclusions and recommendations.

- **The key strategic documents have not yet fully reflected the transition to climate neutrality.**

The NECP was prepared at a time when the climate neutrality target at the EU level was not yet established. The Climate Protection Policy aims for an 80% CO_2 reduction by 2050. The Current State Energy Policy was adopted nearly six years ago. The documents were developed in different time periods and have not been clearly connected, also with respect to climate neutrality. Recently, the EU 2030 targets have been revised.

It is expected that with revisions of the strategic national documents (The State Energy Policy is undergoing a revision at the time of writing of this report, the NECP will be revised in 2023), climate neutrality will become the main point of reference in these updates.

Recommendation

The NECP remains the main strategic document of reference for the low-carbon transition and hence the TJTP. However, we recommend that the TJTP reflects on the potential discrepancy between the scenarios and targets in NECPs and the recent development in climate neutrality targets and coal-phase out transition in Czechia.

- **The associated investment needs are yet to be fully assessed and tracked.**

The investment needs (reflecting pathways to decarbonisation) have not been fully quantified in the main strategic documents. Existing analysis of the climate neutrality transition have been conducted by various consultancies. They vary in scope and methods, and therefore, the comparability of the estimates is low.

The availability of funding to support the transition and the specific conditions of public support programmes are being negotiated at the time of writing this report. Importantly, systematic tracking of sustainable investment should be established to track both public and private investment since private investment is to be at the core of the climate neutrality transition. Data on investment from public sources and information on public subsidies are generally available. However, the structure and details of the data are not always aligned to sustainable investment tracking. For the private sector, the data on sustainable investment are even scarcer. Additionally, we are aware that non-tangible investment (e.g., research and development, information campaigns, and policy development) play a key role in driving the energy transition and climate-change mitigation.

Recommendation

The public authorities (ideally, with the Czech Statistical Office) should establish yearly evaluation surveys on climate and energy investment in the private sector[231]. The EU Taxonomy will be instrumental in tagging sustainable investment. The same applies to the tagging of related non-tangible investment (e.g., in the case of R&D, the Technology Agency of the Czech Republic maintains a database on research, development, and innovation conducted with the support from the government budget[232], which can serve as a basis for further data collection and evaluation). Proper implementation of the analytical, evaluation, and decision-making processes will be key for its successful use at the national level.

With respect to non-tangible investment, one appropriate tool could recommend targeted information campaigns aimed at raising awareness not only on the need for energy savings, but especially focused on examples of good practice. Last, but not least, it is also possible to recommend raising awareness among the public of the operation of Energy Consultation and Information Centres (EKIS) and strengthening their role (as it is envisaged in the CZ Recovery and Resilience Plan -RRP).

[231] The climate tracking in France can be taken as a good practice example, see .e.g., https://www.i4ce.org/download/landscape-of-climate-finance-in-france-2019-edition/

[232] https://starfos.tacr.cz/en

- **The transition milestones remain to be defined.**

The Coal Commission has recommended a coal phase-out by 2038. However, the Government has delayed its final decision. It is therefore possible that the final date may even shift to 2033. This is also highly recommended by civil society and environmental groups. However, the underlying analysis tend to omit infrastructure costs, which will be an important part of the climate-neutrality transition. The goals, methods and assumptions of the analysis have not so far allowed for a meaningful comparison among the various studies.

Recommendation

New milestones reflecting the transition to climate-neutrality economy will have to be developed. They are likely to be included in the update of the NECP (2024) and the update of the State Energy Policy. For the time being, the TJTP can reflect on the transition steps in a qualitative manner and include the recommended coal phase-out by the Coal Commission, as well as rely on the national and regional background analytical documents.

- **Modelling shows varying impacts of transition on the three coal regions.**

There are existing differences in the socio-economic indicators of the three transition regions. For instance, there is a significant gap in R&D institutions, technological readiness, and education and healthcare between Moravian-Silesian, the Northwest, and the rest of the Czech Republic. The modelling of the regional impacts of climate neutrality to 2030 is even more striking when comparing the two regions. While Moravian-Silesian is expected to converge with other regions by 2030, the modelling shows that the JTM is likely to be instrumental in mitigating economic effects of the transition, i.e., to raise the Northwest from below the Czech average in employment and GVA. These trends are especially visible in the energy sector. However, the modelling does not show further granularity in the regions regarding socio-economic development, social infrastructure, demographic changes, and other characteristics. These will be further detailed in D4.

Recommendation

The TA team will develop a granular regional impact assessment in D4, including socio-economic factors such as demographic changes, social infrastructure, and enterprise structure. These factors will be instrumental in developing the operations needed to overcome these gaps. As there are clear differences between the starting positions among the regions and often even within the regions themselves, the TJTP and RTPs need to carefully reflect and tailor the priority themes and operations accordingly. It would be helpful for the further discussion. In D4, more concrete measures for action should be elaborated to enhance the preparation of quality ESIF projects in the Northwest and improve the economic fabric of the regions

- **Awareness and engagement, particularly among small stakeholders (SMEs, Municipalities, NGOs), needs to be strengthened.**

Large companies are generally well informed about the Just Transition and have been actively involved in the discussion platforms. The in-depth interviews and workshops with the stakeholders from the regions so far revealed a general lack of information on the process and plans of Just Transition Mechanism, especially among the smaller municipalities, SMEs and NGOs unless they have a proactive approach in looking for information or are personally represented at the regional government platforms. However, they also welcomed the information and participatory activities carried out by the national and regional partners.

Recommendation

The capacity to coordinate the transformation process should be substantially strengthened, especially in the Northwest Region. Stakeholder engagement, activation and participatory approach will be crucial for the success of Just Transition. However, at this stage, the "top-down" strategic vision with respective to transformation processes and projects is equally needed[233].

[233] We develop on the stakeholder engagement and concrete recommendations in detail in Deliverable 2: Report on governance mechanism and stakeholder engagement.

- **The administrative intensity of the upcoming programmes should be carefully observed.**

The administrative burden of the previous programmes has been perceived as one of the prohibitive factors for deploying these programmes, especially for SMEs. Therefore, future SME engagement in these programmes may be largely influenced by the levels of administrative intensity of the programmes.

Recommendation

Continuity and stability of the programmes and clarity of the conditions will be crucial, as these are perceived as one of the major obstacles increasing the administrative intensity of public support programmes both for the recipients and the administrators[234]. Smaller projects should be made as simple and flexible as possible.

- **Businesses lack qualified and/or requalified employees.**

The impact of climate neutrality and coal phase-out obviously depends on the type of business activities, with businesses in the energy sector being most affected. However, all companies so far have expressed the need for qualified and/or requalified employees to implement new strategies and diversify and upscale the business. The connected **challenges** mentioned by the respondents include the potential lack of needed skills of people made redundant by the transformation process, and the challenge to attract young people to stay in the region[235].

Recommendation

The TJTP and RTPs should put an adequate focus on the upskilling, reskilling, and requalification into their priority themes and operations. Related, the TJTP and RTPs are encouraged to envisage activities in construction and improving the local infrastructure, including social infrastructures.

- **The coal phase out will particularly affect the district heating sector and individual heating in other regions.**

In the district heating sector, which has a significantly higher share of heat delivery for households than is the EU average, the coal phase-out will obviously affect the structure of heat production of all district heating plants across the Czech Republic. The transformation of heating branches creates a risk for the continuation of cogeneration and heating plants. Coal still plays a significant part in most of the regions' district heating systems. However, we do not expect large employment impacts in this sense with the heating systems, which are being transformed, rather than disrupted (i.e., they change the fuel basis, but are not being discontinued and closed down). The effect in the price of heat could be attenuated by the expected investment support for these reconstructions from Modernisation Fund. However, the companies have largely invested in reconstruction of the existing facilities in the last years and the depreciation of these investment can be an issue. Similarly, a still significant part of households depends on coal for heating, despite the massive subsidies in boiler schemes. These schemes supported coal or coal/biomass boilers at the beginning. The remaining coal boilers are often connected with general energy poverty of the households. Regionally, the transformation regions are more affected by this aspect.

Recommendation

To maintain the district heating sector and allow for its transformation, the Modernisation Fund will be instrumental, together with other complementary sources (RRF and operational support). While natural gas will likely be the short-term solution, district heating companies should seek to diversify their fuel base as much as possible, diversify the business (e.g., seek to provide energy services), and use modern technologies (e.g., PV, battery systems) in order to stay competitive and on the pathway to climate neutrality. Avoiding the lock-in of fossil fuel (natural gas) is the main challenge. In the short term and given the speed of the transformation, natural gas is the main component of the transition. However, the future of District Heating (DH) will be a mix of highly efficient cogeneration and direct electrification using RES (solar

[234] More on administrative intensity in Section 5.1.6., e.g., https://www.sciencedirect.com/science/article/pii/S0301421520305875 on further insights.
[235] In-depth analysis and recommendations will also be part of D4.

collectors, heat pumps). District heating is expected to play a significant role in sector coupling. Where feasible the new RES systems should be explored and piloted as soon as possible.

The low carbon switch in individual heating will need to be clearly prioritised and supported, such as the continuation of the boiler scheme under the OP Environment. In this respect, energy poverty could be particularly targeted in the programme. The programme should also aim at low carbon solutions as much as possible, avoiding potential lock-in effects in fossil fuels in (vulnerable) households.

However, the solution to this problem is complex and will require the inclusion of a significant part of the overall concept of social policy towards households. In the case of real estate owned by municipalities, it is possible to list a specific grant title. The situation is more complicated in the case of private owners. Here, support will need to be focused not only on the actual replacement of the equipment, but also on the operation itself. It will often be necessary to review the actual condition of the building and thus offer a comprehensive solution. The role of special consultants could be used effectively. In cooperation with municipalities (who know local conditions best), the consultants (energy service providers) could actively search for households and offer them help, in cooperation with the municipality and in connection with a specific grant title.

The most complicated situation will be in the case of buildings owned by private entities, which sublet them to households. Here, it will be necessary to consistently enforce compliance with legislation to prevent the combustion of unsuitable fuels (waste, etc.) while simultaneously offering a specific support title to municipalities to solve the problem. This can take many forms, such as the purchase of an object, consulting support, etc.

- **The regional development strategies reflect the coal phase-out commitment and the technical elements of the energy transition.**

Less attention is paid to the diversification of the regional economies. Limited attention in the regional strategies is paid to the social dimension of the just transition – impacts on the job market (especially in older age cohorts, on employees with lower qualification), the necessary change in the job market, need and demand for new qualification profiles. All these elements are crucial parts to be reflected upon in the upcoming JTPs.

Recommendation

The TA team recommends for the RIS strategies to reflect topics such as climate change or coal phase-out as cross-cutting themes that will be connected with extensive investments across sectors (with potential in forms of diversified eco-innovations) and disruptive changes of the regional job market. Additionally, the TA recommends identifying key challenges and opportunities in the areas outlines above (mainly the employment structure and social infrastructure). The transformation plans should then be interlinked with regional development strategies and be backed by sound underlying analyses of the current situation, including the place-based approach.

8 ANNEXES

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ANNEX 1 – The E3ME Model

The theoretical background

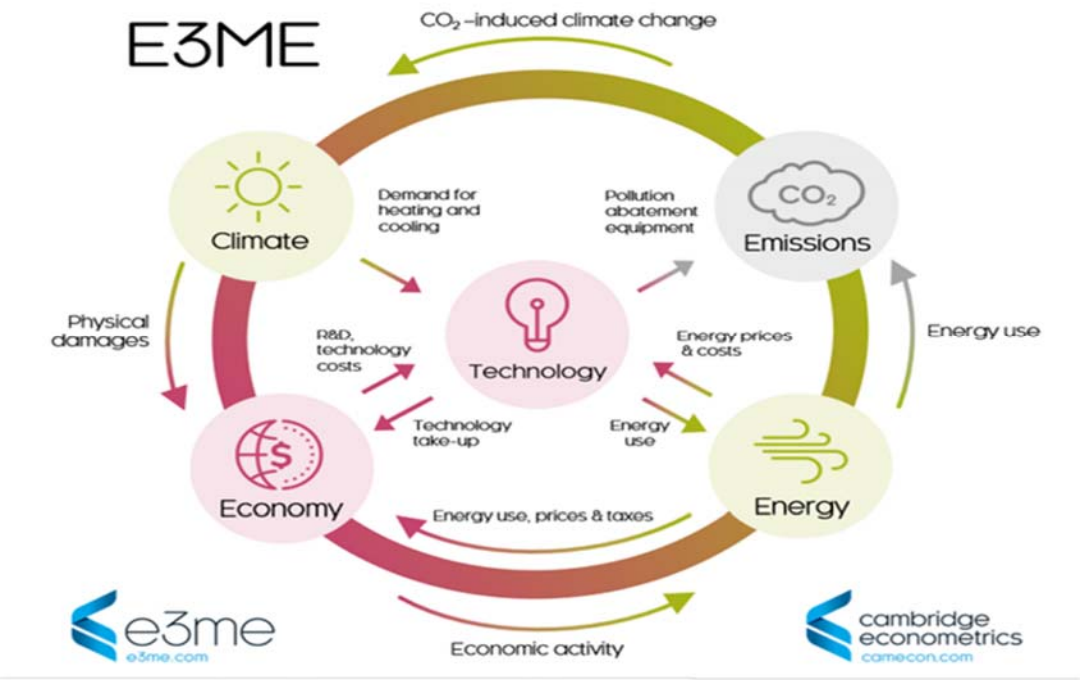
Economic activity undertaken by persons, households, firms and other groups in society has effects on other groups after a time lag. These effects, both beneficial and damaging, accumulate in economic and physical stocks. The effects are transmitted through the environment, through the economy and the price and money system (via the markets for labour and commodities), and through the global transport and information networks.

The markets transmit effects in three main ways: through the level of activity creating demand for inputs of materials, fuels and labour; through wages and prices affecting incomes; and through incomes leading to further demands for goods and services. The economic and energy systems have the following characteristics:

- economies and diseconomies of scale in both production and consumption
- markets with different degrees of competition
- the prevalence of institutional behaviour whose aim may be maximisation, but may also be the satisfaction of more restricted objectives
- rapid and uneven changes in technology and consumer preferences

An energy-environment-economy (E3) model capable of representing these features must therefore be flexible, capable of embodying a variety of behaviours and of simulating a dynamic system.

Structure of the E3ME model



The E3ME model is well suited to analysing the linkages between the economic and energy systems, with links to environmental emissions. Figure below shows how the three main components (modules) of the model - energy, environment and economy - fit together. Each component is shown in its own box. Each data set has been constructed by statistical offices to conform with accounting conventions. Exogenous factors coming from outside the modelling framework are shown on the outside edge of the chart as inputs into each component.

Key dimensions of E3ME

The main dimensions of E3ME are:

- 61 countries – all major and G20 economies, the EU27+UK and candidate countries plus other countries' economies grouped
- 43/69 industry sectors, based on standard international classifications
- 28 categories of household expenditure
- 22 different users of 12 different fuel types

The econometric specification of E3ME gives the model a strong empirical grounding. E3ME uses a system of error correction, allowing short-term dynamic (or transition) outcomes, moving towards a long-term trend. The dynamic specification is important when considering short and medium-term analysis (e.g., up to 2025) and rebound effects, which are included as standard in the model's results[236].

Basic modelling approach

Our modelling approach is based on simulation properties and bases forecasts on a combination of past behaviour and assumptions about key future trends (e.g., population). It allows for a broad range of policies to be tested[237]. This modelling approach is qualitatively different from the standard optimisation tools that are used in other analyses and draws on theories from post-Keynesian and evolutionary economics. Instead of trying to find least-cost pathways, the model simulates the responses to stimuli (including changes in drivers such as economic, demographic, or technological development, or both regulation and market-based policies) and is parameterised on real-world time-series data.

Compared to the other macroeconomic models in operation currently across the world, E3ME has advantages in the following four important areas:

- Geographical coverage: E3ME provides global coverage, with explicit coverage of the world's major economies (all G20 countries). OPEC member countries are either identified explicitly or grouped together so that aggregate impacts can be evaluated.
- Sectoral disaggregation: The detailed nature of the model allows the representation of detailed forecasts with differentiation by sector and by country. Similarly, the impact of any policy measure can be represented in a detailed way, for example showing the winners and losers from a particular policy.
- Econometric pedigree: The econometric and empirical grounding of the model makes it better able to represent performance in the short to medium terms, as well as providing long-term assessment. It also means that the model is not reliant on the rigid assumptions common to other modelling approaches.

236 See: Barker, Terry, Sebastian De-Ramon, and Hector Pollitt. 'Revenue Recycling and Labour Markets: Effects on Costs of Policies for Sustainability'. Modelling Sustainable Development: Transitions to a Sustainable Future, 2009, 104–26.

237 See discussion in: Mercure, Jean-Francois, Hector Pollitt, Andrea. M. Bassi, Jorge. E Viñuales, and Neil R. Edwards. 'Modelling Complex Systems of Heterogeneous Agents to Better Design Sustainability Transitions Policy'. Global Environmental Change 37 (1 March 2016): 102–15. https://doi.org/10.1016/j.gloenvcha.2016.02.003.

- E3 linkages: E3ME is a hybrid model. A non-linear interaction (two-way feedback) between the economy, energy demand/supply, material consumption and environmental emissions is an undoubted advantage over models that may either ignore the interaction completely or only assume a one-way causation.

Comparing E3ME to Computable General Equilibrium (CGE) models

E3ME is often compared to Computable General Equilibrium (CGE) models. The CGE model has become the standard tool for long-term macroeconomic and energy-environment-economy (E3) analysis. CGE models are used all over the world; notable examples include GTAP[238] or GEM-E3-FIT[239]. Many of these models are based on the GTAP database that is maintained by Purdue University in the US.

In many ways, the modelling approaches in CGE models and E3ME are similar; they are used to answer similar questions and use similar inputs and outputs. However, underlying this there are important theoretical differences between the modelling approaches, and it is important to be aware of this when interpreting model results.

The CGE model favours fixing behaviour in line with economic theory. In a typical CGE framework, optimal behaviour is assumed, output is determined by supply-side constraints and prices adjust fully so that all the available capacity is used. CGE models typically assume constant returns to scale; perfect competition in all markets; maximisation of social welfare measured by total discounted private consumption; no involuntary unemployment; and exogenous technical progress following a constant time trend.

In contrast, econometric models like E3ME interrogate historical data sets to try to determine behavioural factors on an empirical basis and do not assume optimal behaviour. In E3ME, the determination of output comes from a post-Keynesian framework, and it is possible to have spare capacity. The E3ME model is demand-driven, with the assumption that supply adjusts to meet demand (subject to any constraints), but at a level that is likely to be below maximum capacity. Unlike CGE models, E3ME does not assume that prices always adjust to market clearing levels.

The treatment of the financial sector in E3ME is also very different to that in CGE models. E3ME does not assume that there is a fixed stock of money but instead allows for the potential of endogenous money, i.e., banks increasing lending for investment, which in turn stimulates demand. This is broadly consistent with how the financial system works in reality (see McLeay et al, 2014[240] for a description, and Pollitt and Mercure, 2018[241], for a wider discussion).

The differences described above have important practical implications for scenario analysis. The assumptions of optimisation in CGE models mean that all resources are fully utilised, and it is not possible to increase output and employment by adding regulation. E3ME, on the other hand, allows for the possibility of unused capital and labour resources that may be utilised under the right policy conditions, making it possible (although certainly not guaranteed) that additional regulation could lead to increases in investment, output and employment. The range of policy options also increases once assumptions about optimal behaviour (e.g., profit and utility maximising, perfect competition or fully rational behaviour) are dropped.

Many of the assumptions that underpin CGE (and DSGE) models have been increasingly questioned as to whether they provide an adequate representation of complex real-world behaviour. Examples include perfect competition, perfect knowledge and foresight, and optimal rational behaviour and expectations. Some CGE models have been adapted to relax certain assumptions, but the underlying philosophy has not changed.

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[238] Hertel, Thomas Warren. Global Trade Analysis: Modeling and Applications. Cambridge University Press, 1997.
[239] Capros, P., Denise Van Regemorter, Leonidas Paroussos, P. Karkatsoulis, C. Fragkiadakis, S. Tsani, I. Charalampidis, and Tamas Revesz. 'GEM-E3 Model Documentation'. JRC Working Papers. JRC Working Papers. Joint Research Centre (Seville site), July 2013. https://ideas.repec.org/p/ipt/iptwpa/jrc83177.html.
[240] McLeay, M, Radia, A and Thomas, R (2014) 'Money creation in the modern economy', Bank of England quarterly bulletin, 2014Q1.
[241] Pollitt, Hector, and Jean-Francois Mercure. 'The Role of Money and the Financial Sector in Energy-Economy Models Used for Assessing Climate and Energy Policy'. Climate Policy 18, no. 2 (7 February 2018): 184–97. https://doi.org/10.1080/14693062.2016.1277685.

Comparing E3ME to econometric forecasting models

E3ME is sometimes also compared to short-term econometric forecasting models. These models are usually used for short-term forecasting exercises, often with a quarterly or even monthly resolution, and are used to describe short and medium-term economic consequences of policies with a limited treatment of longer-term effects. This restricts their ability to analyse long-term policies and they often lack a detailed sectoral disaggregation.

E3ME, on the other hand, combines the features of an annual short- and medium-term sectoral model estimated by formal econometric methods, providing analysis of the movement of the long-term outcomes for key E3 indicators in response to policy changes. Economic theory, for example theories of endogenous growth, informs the specification of the long-term equations and hence properties of the model; dynamic equations which embody these long-term properties are estimated by econometric methods to allow the model to provide forecasts. The method utilises developments in time-series econometrics, with the specification of dynamic relationships in terms of error correction models (ECM) which allow dynamic convergence to a long-term outcome.

Energy-emissions modelling in E3ME

The energy module in E3ME is constructed, estimated and solved for each energy user, each energy carrier (termed fuels for convenience below) and each region. Aggregate energy demand is determined by a set of econometric equations, with the main explanatory variables being:

- economic activity in each of the energy users
- average energy prices for each energy user in real terms
- technological variables, represented by investment and R&D expenditure and spill overs in key industries producing energy-using equipment and vehicles

The econometric parameters in the equations are derived from time series covering the period 1970-2015. The econometric techniques used to specify the functional form of the equations are the concepts of cointegration and error-correction methodology.

In brief, the process involves two stages. The first stage is a levels relationship, whereby an attempt is made to identify the existence of a cointegrating relationship between the chosen variables, selected on the basis of economic theory and *a priori* reasoning, e.g., for employment demand the list of variables contains real output, real wage costs, hours-worked, energy prices and the two measures of technological progress.

If a cointegrating relationship exists then the second stage regression is known as the error-correction representation, and involves a dynamic, first-difference, regression of all the variables from the first stage, along with lags of the dependent variable, lagged differences of the exogenous variables, and the error-correction term (the lagged residual from the first stage regression). Due to limitations of data size, however, only one lag of each variable is included in the second stage.

Stationarity tests on the residual from the levels equation are performed to check whether a cointegrating set is obtained. Due to the size of the model, the equations are estimated individually rather than through a cointegrating VAR. For both regressions, the estimation technique used is instrumental variables, principally because of the simultaneous nature of many of the relationships, e.g., wage, employment and price determination.

Energy price elasticities

In contrast to the rest of the model, the long-run energy price elasticities used in E3ME are not based on time-series econometric estimation; instead, they are taken from a combination of cross-section estimation and reviewed literature. As part of the contract, we will review and if necessary, update the energy price elasticities, based on the most recent data (with a focus on transport sectors).

The reason for using a different approach for these specific elasticities is that the time-series analysis yields responses to fluctuations in energy prices (i.e., temporary effects) whereas the projections we are interested in here relate more to long-term trends that influence expectations (e.g. on vehicle technologies). For most sectors, the current values used range from -0.2 to -0.3, meaning that a 1% increase in price leads to a 0.2-0.3% reduction in consumption. Short-run elasticities are based on the time-series data and are usually close to zero.

Disaggregating energy demand

Fuel use equations are estimated for four energy carriers (coal, oil, gas and electricity) with four sets of equations estimated for the fuel users in each region. These equations are intended to allow substitution between the four energy carriers by users on the basis of relative prices, although overall fuel use and the technological variables are also allowed to affect the choice.

Under the current treatment, the remaining fuels are determined either as fixed ratios to aggregate energy use or are assumed to be used in a similar way to other, closely related fuels (e.g., other coal and hard coal, crude oil and heavy fuel oil, other gas and natural gas).

Determination of global energy prices

The final set of fuel demands must then be scaled to ensure that they add up to the aggregate energy demand (for each fuel user and each region).

One important feature of E3ME, which distinguishes it from most other macroeconomic models, is that it includes a dynamic representation of energy cost-supply curves. This means that if policies are put in place that reduce global fuel demand, it is the highest-cost sources of fuel that are cut first, within a distribution of uncertainty. The result is that climate policies are more likely to result in reduced energy extraction in the US (shale), Canada (tar sands) and Latin America (deep-sea reserves), more than might be expected from applying a simpler coefficient-based approach. This, however, does not mean that OPEC countries do not see a loss of production in scenarios where energy demand falls, just that it is not as high (in real terms) as some other models would predict.

The energy cost-supply curves can also be used to predict future energy prices. For further information about the cost-supply curves, see Mercure and Salas (2012)[242].

Economic modelling

The economic structure of E3ME is based on the system of national accounts, with further linkages to energy demand and environmental emissions. The labour market is also covered in detail, including both voluntary and involuntary unemployment. In total, there are 33 sets of econometrically estimated equations, also including the components of GDP (consumption, investment, international trade), prices, energy demand and materials demand. Each equation set is disaggregated by country and by sector.

E3ME's historical database covers the period 1970-2018 and the model projects forward annually to 2050. The main data sources for European countries are Eurostat and the IEA, supplemented by the OECD's STAN database and other sources where appropriate. For regions outside Europe, additional sources for data include the UN, OECD, World Bank, IMF, ILO and national statistics. Gaps in the data are estimated using customised software algorithms.

Economic interdependence

Output and employment in E3ME economic model are determined by levels of demand, unless there are constraints on available supply. This results in four loops or circuits of economic interdependence, which are described below.

[242] Mercure, J-F and P Salas (2012), 'An assessment of global energy resource economic potentials', *Energy*, vol 46(1), pp 322-336.

The full set of loops comprises:

- Interdependency between sectors: If one sector increases output it will buy more inputs from its suppliers who will in turn purchase from their own suppliers. This is like a Type I multiplier.
- The income loop: If a sector increases output it may also increase employment, leading to higher incomes and additional consumer spending. This in turn feeds back into the economy, as given by a Type II multiplier.
- The investment loop: When firms increase output (and expect higher levels of future output) they may also increase production capacity by investing. This creates demand for the production of the sectors that produce investment goods (e.g., construction, engineering) and their supply chains.
- The trade loop: Some of the increase in demand described above will be met by imported goods and services. This leads to higher demand and production levels in other countries. Hence there is also a loop between countries.

Output and determination of supply

Total product output, in gross terms, is determined by summing intermediate demand and the components of final demand described above. This gives a measure of total demand for domestic production.

Subject to certain constraints, domestic supply is assumed to increase to match demand. The most obvious constraint is the labour market (see below). However, the model's 'normal output' equations provide an implicit measure of capacity, for example leading to higher prices and rates of import substitution when production levels exceed available capacity.

The labour market and incomes

Treatment of the labour market is one area that distinguishes E3ME from other macroeconomic models. E3ME includes econometric equation sets for employment (as a headcount), average working hours, wage rates and participation rates. The first three of these are disaggregated by economic sector while participation rates are disaggregated by gender and five-year age band.

The labour force is determined by multiplying labour market participation rates by population. Unemployment (including both voluntary and involuntary unemployment) is determined by taking the difference between the labour force and employment.

Due to limitations in available time-series data, E3ME adopts a representative household for each region. Household income is determined as:

$$Income = Wages - Taxes + Benefits + Other\ income$$

Household income, once converted to real terms, is an important component in the model's consumption equations, with a one-to-one relationship assumed in the long run.

Price formation

For each real variable, there is an associated price, which influences quantities consumed. Aside from wages, there are three econometric price equations in the model: domestic production prices; import prices; and export prices. These are influenced by unit costs (derived by summing wage costs, material costs and taxes), competing prices and technology. Each one is estimated at the sectoral level.

Emissions modelling

E3ME's emissions module calculates air pollution generated from end-use of different fuels and from primary use of fuels in the energy industries themselves, particularly electricity generation. The model includes 12 different types of emissions, including CO2. However, the treatment of emissions other than CO2 is less detailed and results are not usually disaggregated by sector. In addition, it should be noted that many of the

impacts of the other emissions (e.g., PM10) are localised and cannot be captured by a model that operates at national level.

CO2 emissions

Emissions data for CO2 from energy consumption are available for each of the energy users in the model. Coefficients (tonnes of carbon emitted per toe) are implicitly derived using historical data (and sometimes also baseline projections). This forms the relationship between energy consumption and emissions. Process CO2 emissions, for example from the chemicals and cement sectors, are also included explicitly in the modelling, but are linked to production from those sectors rather than energy consumption. In this modelling exercise, our focus is on CO2 emissions from energy consumption and industrial processes.

Feedbacks to the economy

The modelling does not include any feedbacks from emissions or estimates of climate change to the economy (i.e., climate-related damages are not considered). The reason is that the effects are too uncertain, given the current academic literature on potential effects. Although this is the standard treatment in economic modelling exercises, it does mean that some potentially beneficial effects of reducing greenhouse gas emissions are missed.

Further information

Further information about E3ME is available in the model manual (Cambridge Econometrics, 2014), which is published on the model website www.e3me.com.

ANNEX 2 – Regional modelling

Top-Down Modelling

Shift-share model

First, define growth rates at three separate levels:

- Total growth rate at the national level
- Sectoral growth rate at the national level
- Sectoral growth rate at the regional level

The standard (static) shift-share model can be used to separate total change into the three components.

The difference between the static and the dynamic shift-share models is that the former includes only two years in the analysis, while the latter calculates for every time period. The annual results are then aggregated over the entire period to get the final shift-share effects.

ARIMA forecasting of the competitive component

Auto-Regressive Integrated Moving Average (ARIMA) models are based on the notion that data can be thought of as the realisation of a stochastic process. The goal is to find a simple model that captures the essential characteristics of the stochastic process (i.e., to achieve pattern replication rather than pattern explanation). Hence, the only systematic information used in modelling a time series is:

- The past behaviour of that series
- Deterministic components (e.g., constant, dummy variables, time trend)

These models are estimated through Maximum Likelihood Estimators (MLE) and are characterised by three main parameters:

- p: the order of the autoregressive (AR) part of the model
- d: the degree of first differencing required to achieve stationarity
- q: the order of the moving average (MA) part of the model

ARIMA models can be augmented with further explanatory variables (provided forecasts are available for these additional / eXtra variables), forming **ARIMAX models**. The statistical underpinning of ARIMAX models is similar to ARIMA models, with the additional restriction that the added explanatory variables must be stationary as well.

Having obtained time series with the competitive effect for GVA and employment through dynamic shift-share and regional population projections, a separate ARIMAX(p, d, q) model was specified for each sector, of each region within each country.

The parameters for the ARIMAX model for each region-sector combination were determined using already existing Python libraries. More specifically:

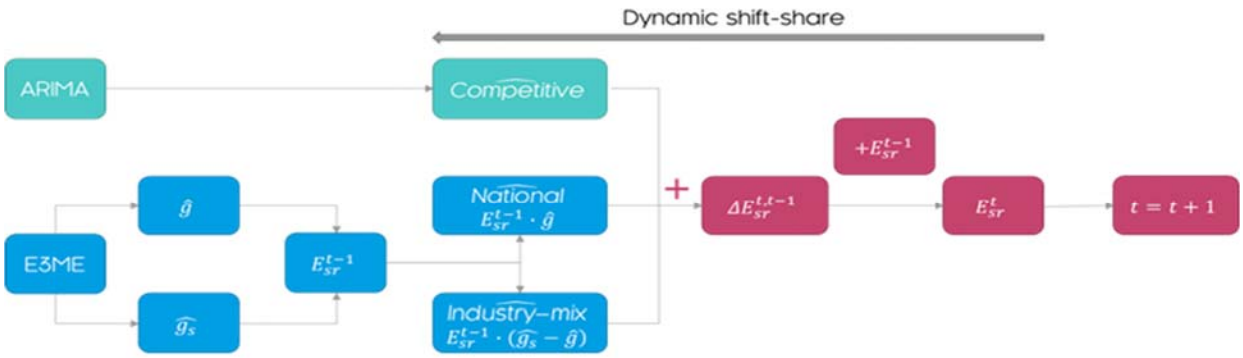
- The Augmented Dickey-Fuller test was used to determine the degree of differencing required to achieve stationarity of the variables used in the model. This was implemented through the relevant method of the *statsmodels* library.
- The order of the AR and MA components was determined using the automatic selection functionality of the *pmdarima* library. The *auto_arima* method of *pmdarima* performs a grid search over potential model parameters and selects the model that minimises the information criterion set by the user. The Bayesian Information Criterion (BIC) was used for the purposes of this project.

Given the relatively short time horizon of the input data, the maximum order was set to two for both the AR and MA components, while the p-value threshold for achieving stationarity was set to 10%. This relatively lax approach was preferred to preserve information that would have been lost due to additional orders of differencing to achieve stationarity (which would have decreased forecast accuracy) and due to the expectation that the variables would have been stationary over a longer period of time. For the same reason,

the competitive effect and the population variables were allowed to have different orders of integration (d), as ensuring a common d is likely to have required additional differencing of the variables to achieve stationarity, resulting in further loss of information.

Reverse dynamic shift-share

This step is where ARIMA(X) forecasts are integrated with E3ME results. The following recursive process is applied for each time period of the forecast horizon:



This process can be seen as a "reverse dynamic shift-share", as forecasts of the three shift-share components are combined to give expected change in the variable year-by-year and eventually the final predictions of the variable levels.

Data input and processing

All historical regional data can be obtained from Eurostat datasets.

Sectoral classification

The sectoral classification of employment and GVA data includes the following aggregated NACE Rev.2 sectors of Eurostat (hereinafter: 10 NACE sectors):

Sector code	Sector name
A	Agriculture, forestry, and fishing
BDE	Mining and quarrying; electricity, gas, steam and air conditioning supply; water supply and sewage
C	Manufacturing
F	Construction
G-I	Wholesale and retail trade, transport, accommodation, and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M-N	Professional, scientific, and technical activities; administrative and support service activities
O-U	Public administration and defence; compulsory social security; education; human health and social work activities; arts, entertainment and recreation, repair of household goods and other services
TOTAL	Regional/Country total

Employment (NUTS-3)

Historical employment data by NUTS-3 regions, for the 10 NACE sectors, obtained from Eurostat's *nama_10r_3empers* dataset for the period 1995-2017.

GVA (NUTS-3)

Gross value added (GVA) at basic prices by NUTS-3 regions, for the 10 NACE sectors, obtained by from Eurostat's *nama_10r_3gva* dataset for the period 1995-2017. The implicit price deflator from the *nama_10_a64* dataset should be used to align price levels (by converting the data to constant 2010 euros), assuming that all regions within the same country have the same price level (as regional deflators were not available).

Population (NUTS-3)

Population data obtained from Eurostat's *demo_r_pjanaggr3* dataset. If needed, missing values for all NUTS-3 regions can be filled using shares from the *nama_10r_3popgdp* dataset.

Population projections (NUTS-3, 2020-2025-2030)

Population projections for NUTS-3 regions are based on the JRC's Urban Data Platform Plus dataset, by NUTS3 regions for the years 2020, 2025 and 2030, available at:
https://urban.jrc.ec.europa.eu/#/en/download

Bottom-Up energy modelling

This section explains the logic applied to determine how country (*ctry*) capacity per technology (*tech*) is split between NUTS-2 regions (*reg*) over time (*t*).

Step 1 - Determining 2017 capacity and capacity age

1. Using the JRC Open Power Plants Database (**JRC-PPDB-OPEN**), national capacity in 2017 is split up to the CZ NUTS2 regions by technology type. This does not always match total national capacity figures provided by Eurostat or E3ME-FTT:Power data – therefore, the JRC-PPDB-OPEN database will need to be scaled up to 2017 E3ME-FTT capacity results.
2. The JRC-PPDB-OPEN database also provides the **commissioning date**, however the coverage of this is limited, only **69%** of power plants in the JRC-PPDB-OPEN dataset have commissioning dates. The rest will be estimated, using the average of the commissioning data available:
    a. Within a given region, if the same technology is available compute the average and use that as a proxy for missing commissioning date of same technology
    b. If the same technology is not available within the same region then use the average of the same technology within the country
    c. If that is not available, use the average of the same technology of the EU
3. Missing capacity, commission year, and location data will be manually filled using:
    a. The JRC Geothermal Power Plant Database
    b. The Global Power Plant Database
    c. The Wind Power database
    d. The JRC Hydro-Power database
    e. Other ad-hoc online sources.
4. The 2017 NUTS-2 capacity data from JRC-OPEN-PPDB database will be scaled to match total 2017 national capacity data from E3ME-FTT:Power.
5. Using the commissioning year data, we will estimate the age of each power plant. This will be used to determine where the national level decommissions (from E3ME) should be removed from the regional level (step 3 below). In short, the oldest power plant will be scrapped first.
6. At this point we have a database with data for all *reg* and all *tech* in 2017 as exemplified below.

2017 capacity and age by technology (tech) and NUTS3 region (reg)

NUTS-2 Region	Technology	2017 Capacity (GW)	Age (years)
CZ041	Solar	2.5	4
CZ041	Solar	1.5	7
CZ041	Gas	5	10
CZ041	Gas	2.1	19
CZ041	…	…	…
CZ042	Solar	2.5	4
CZ042	…	…	…
…	…	…	…

Step 2 - Using E3ME national results to determine annual decommissions and new commissions

E3ME-FTT:Power provides annual country-technology capacity results (MEWK) and annual country-technology new capacity commissions (MEWI).

This will allow us to understand how much new capacity will be installed (MEWI) and how much capacity will be decommissioned (DECOM) in each year-country-technology.

Step 3 - Allocating national decommissions to each NUTS-2 region

1. Once we identify the amount of capacity decommissioned in each year-technology-country, we can prepare the below table for each country-technology combination.

Decommissioning profile example for the CZ-Solar capacity case – country level

NUTS-2 Region	Tech	2017 Capacity (GW)	2017 Age (years)	2018	2019	2020	2021	…
CZ01	**Solar**	**2.5**	**3**					…
CZ01	**Solar**	**1.5**	**7**					…
CZ02	**Solar**	**2.5**	**4**					…
…								
Total = DE DECOM	-	-	-	**-0.5**	**-1**	**-0.25**	**-3**	**…**

The **2017 Capacity** and **2017 age** columns are prepared from the original database files. The 2017 age is calculated by taking the commissioning year from 2017.

2. The **"Total = DE DECOM**" row was estimated in Step 2 using the E3ME-FTT:Power results. In this example the results show the amount of Czech solar capacity that E3ME-FTT:Power decommissioned in each result year.
3. The cells shaded in light blue must be filled in to determine which capacity from which region is decommissioned in each year. This decision is based on the age of each region's capacity as determined in Step 1. In 2018, decommissioning will occur based on capacity age in 2017. In 2019, it will be determined on the age in 2018 and so on. As a logical rule, the oldest capacity will be decommissioned first, irrespective of its NUTS-2 location.

Decommissioning profile example for the Czech-Solar capacity case – regional level

NUTS-2 Region	Tech	2017 Capacity (GW)	2017 Age (years)	2018	2019	2020	2021	…
CZ01	**Solar**	**2.5**	**3**				-0.75	…
CZ01	**Solar**	**1.5**	**7**	-0.5	-1			…
CZ02	**Solar**	**2.5**	**4**			-0.25	-2.25	…

…								
Total = DE DECOM	-	-	-	**-0.5**	**-1**	**-0.25**	**-3**	**…**

4. In the case where capacity in different regions have the same age, we will estimate the weighted average age of all capacity (across all technologies) in each region. And the power plant in the region with the highest weighted average age will be decommissioned. This assumes that decision makers will remove (and therefore potentially replace) technology in regions with older infrastructure first.

Step 4 - Allocating national commissions to each NUTS-2 region

Commissioning profile example for the Czech-Solar capacity case – country level

NUTS-2 Region	Tech	2017 Capacity (GW)	2017 Age (years)	2018	2019	2020	2021	…
CZ01	**Solar**	**2.5**	**3**					…
CZ01	**Solar**	**1.5**	**7**					…
CZ02	**Solar**	**2.5**	**4**					…
…								
Total = MEWI	-	-	-	**+1**	**+0.5**	**+1**	**+0.25**	**…**

The **"Total = MEWI**" row is calculated in Step 2 using the E3ME-FTT:Power results. This shows the amount of Czech solar capacity that E3ME-FTT:Power commissioned and/or replaced in each result year. The empty cells must be filled in to determine which capacity from which region is commissioned in each year.

The allocation of new (and replaced) capacity will differ by technology. E3ME-FTT:Power results will provide an estimate of the capacity installed by technology each year at the national level (MEWI). The model then allocates this additional capacity by NUTS2 region.

New solar and onshore wind capacity

1. The decision to allocate new solar (PV and CSP) and onshore wind capacity will be based on **technical potential** results and **capacity factors** prepared by the JRC in the ENSPRESO database.
1. The ENSPRESO technical potential results will act as an upper capacity limit. No capacity can be installed in a region over and above its estimated technical capacity figure. The ENSPRESO capacity factors allow us to determine which regions will have the highest Solar and Onshore wind efficiency.
2. Each country's NUTS-2 regions will be ranked based on their capacity factors.
3. In each year, regions will be allocated replacement capacity (calculated in Step 2). All excess capacity "additional capacity" will be allocated on the basis of each NUTS-2 region's capacity factor and remaining technical potential.

New coal, oil, gas, nuclear and biomass capacity

In practice, this capacity can be built anywhere and does not depend on the availability of wind or solar radiation. Therefore, the decision rule to allocate new capacity will differ.

1. Allocate the capacity in proportion to the share of the technology's capacity in each NUTS2 region in the current year (i.e., the previous year's capacity including decommissions).

New hydro and geothermal capacity

Unless new data is found, new capacity of hydro and geothermal capacity will only be allocated to regions, which have already installed this capacity in the past. The approach follows the same logic as the allocation of coal, oil, gas etc.

Step 5 – Estimating employment and economic output

Once the decommissions and commissions are allocated to NUTS2 regions by definition the model has attained the net effect of capacity in each region for each technology type. Then, the next step is to calculate generation and economic output. The methodology for each is detailed in the original Task 6.2 methodology report. Once this has been done, the final economic output from the power sector is scaled to output from E3ME and combined with the results from the shift-share model.

Miscellaneous assumptions

- Fuel Cells from FTT:Power assumed to map to 'Other' from the databases. This is scaled accordingly.
- IGCC and CCGT technologies were grouped into 'Gas' technology.

ENSPRESO capacity factors and technical potential

Solar PV and CSP

The ENSPRESO results provides solar PV and CSP capacity factors, technical capacity (GWe) and Power Production (TWh) for several NUTS 2 regions. These results assume a land efficiency of 170 MW/km^2 and a 3% utilisation of the available natural areas.

Onshore wind

The ENSPRESO results provide onshore capacity factors and technical capacity for most NUTS 2 regions. This data varies by scenario, sub-scenario, and wind conditions. The data assumed in this project follows the:

- **EU-Wide low restrictions scenario**: A hypothetical scenario in which the exclusion of surfaces for wind converges in all countries to a low level.
- **Turbine type**: large 400m setback distance
- **Wind condition**: Share of land with certain CF range >25%
- **Capacity factory**: Real average CF over whole region

The wind condition affects the area of suitable land that has a certain capacity. So, when the value "Share of land with certain CF range: >25%" is 1 it means that all available land has a capacity factor higher than 25%. When the value "Share of land with certain CF range: >25%" is 0 it means that, with the type of turbine assumed, there is no available land with a capacity factor higher than 25%.

Data preparation – final results

Estimating generation

Electricity generation is estimated via the multiplication of the capacity factor and the number of hours in a year. The capacity factor for Solar PV, CSP and Onshore is available at a NUTS-2 level and is used in this calculation. The capacity factor is not available for other technologies at the NUTS-2 level, so the national capacity factor (MEWL) is used to calculate generation.

Estimating LCOE

There are several different LCOEs available in the FTT:Power module. Each one varies by which policy inputs are included or not, and some are intended solely for investors purposes not for the market. For this project we want to use the LCOE which represents the market electricity price. The electricity market is competitive; it passes on price decreases (subsidies) but absorbs price increases (carbon taxes). Therefore, we use the LCOE which includes subsidies but excludes carbon tax (MECC).

To estimate LCOE the capacity factor from the NUTS-2 level is used for Solar PV, CSP, and Onshore. Since the capacity factor does not vary by NUTS2 region for the other technologies, we just use the LCOE created by the original E3ME model to reducing computing power and quicken the module.

The results from the E3ME are originally outputted for 24 power generating technologies. In order to get the results for the 13 technologies – as in the regional module E3ME-FTT-ER – we take simple averages across each of the technologies LCOEs (e.g., Gas LCOE is an average of CCGT, CCGT CCS, IGCC and IGCC CSS's LCOE).

Employment factors

The employment factors have been updated according to the latest literature. The Table below shows the coefficient of jobs per installed MW capacity for each technology.

Technology	Jobs/MW
Oil	0.15
Coal	0.3
Gas	0.14
Large Hydro	0.59
Nuclear	0.59
Solar PV	0.15
CSP	1
Onshore	0.4
Offshore	0.2
Geothermal	0.4
Biomass	0.87
Ocean	0.3
Other	0.14

JRC Open Power Plants Database

JRC (2020); JRC Open Power Plants Database (JRC-PPDB-OPEN); Available at: https://zenodo.org/record/3574566#.XyMFkCgzaUk

ENSPRESO capacity factors and technical potential

European Commission, Joint Research Centre (2019): ENSPRESO - an open data, EU-28 wide, transparent and coherent database of wind, solar and biomass energy potentials. European Commission, Joint Research Centre (JRC). Solar and Wind Datasets. Available at: https://data.jrc.ec.europa.eu/collection/id-00138

ANNEX 3: Questionnaire for D2 & D3 interviews

Introduction to the Interview

- Introduction to the project based on the approved 1-pager summary;
- Request informed consent and provide an option to record the interview - written by email or verbal during the interview;
- Assure the interviewee of the confidentiality of the results, in addition mention that all insights will only be used for the purposes of the report and will be anonymized.

Outline for the structured interviews with stakeholders

1. Companies under EU ETS

Data to be collected in advance by the interviewer:

- Annual turnover, number of employees;
- Main strategic documents;
- Value chain;
- Price of the EU ETS.

Awareness about the Just Transition Mechanisms ("warm-up" question)

1.1. How are you involved in/prepared for the transformation/decarbonisation process?
1.2. Do you feel that you have enough information on the processes of the Just Transition and related instruments/funding options (e.g., the Just Transition Fund, etc.)?
1.3. In which areas do you feel that you would benefit from more insights with respect to Just Transition and your company?
1.4. What is your view on the JT programme coordination and flow of information with respect to your activities?

Economic context

1.5. Value chain: What is the value chain in your company? Who are your 3/5 major suppliers and who are your 3/5 major customers in terms of country/region ("kraj") and in terms of NACE?
1.6. Do you expect any major changes in the structure of your suppliers and customers with respect to the decarbonisation transition?
1.7. When selecting your suppliers, do you evaluate the suppliers towards the sustainability criteria (EU Taxonomy on sustainable finance and corporate disclosure on climate-related information)? Or do you customers require such assessment?

Impact of the current regulatory framework

- What regulatory intervention impacts you the most in the current framework?
- How do you perceive changes in the price of EU ETS? How does this affect your company?
- What do you expect will be the development of electricity price (also with respect to EU ETS), and how do you react to this expectation in your strategies?
- Other factors – open questions

Impact of climate neutrality

Changes in the business of the company

1.8. What changes do you expect to the functioning of your company/sector with regard to decarbonisation (e.g., organisational changes, change in production, changes in company orientation, turnover and profit)?
1.9. Have you considered moving your business or part of your business to third countries due to the climate neutrality transition?
1.10. Do you plan to use digitalisation to support your adaptation to the low-carbon economy?

Jobs and employment

1.11. Do you expect any changes in the employment structure in your company with respect to decarbonisation (e.g., significant changes in numbers or structure of employees)?
1.12. If expecting a decrease in the number of employees, have you considered the social and economic impacts of those changes on your employees?
1.13. In relation to these changes, have you prepared, or do you plan to prepare some social programmes? Do you plan to use external programmes to fund the reskilling?
1.14. Would you need additional education/training/skills in order to be prepared for future challenges? If yes, in which areas?
1.15. In your transformation plan, do you expect to find/have sufficient number of skilled employees in the region?

Other impacts

1.16. Do you expect any additional impacts of decarbonisation on your company?

Strategy of the company

1.17. What has been driving your strategic decisions?
1.18. What strategies and measures of diversification (and decarbonisation) do you plan to implement in the future?
1.19. General governance of the decisions about strategy: When developing strategies for your company, who is responsible for the development, adoption, and implementation of strategies in your company (how vertical is the decision-making process)?
1.20. Have you prepared any strategic documents in your company with respect to the transition to a low-carbon economy? How else are you preparing for the end of coal and transition to a low-carbon economy?
1.21. What role does digitalisation play in your strategic vision? Do you expect to use AI/ML in reacting to the diversification processes?

Investment and financial instruments

Investment

1.22. Type of investment

Type of investment	Have you implemented projects that would contribute to any of the aspects below in the last 3 years? ***If yes, please elaborate*** *(details, total volume, results, challenges, related documents?)*	Do you plan to invest in projects that would contribute to any of the aspects below? ***If yes, please elaborate*** *(details, total volume, results, challenges, related documents?)*

Diversification of your business		
Upskilling and/or reskilling of your employees		
Digitalisation and digital connectivity		
Research and innovation activities and fostering the transfer of advanced technologies		
Regeneration and decontamination of sites, land restoration and repurposing projects		
Other relevant		

1.23. Have you evaluated/assessed the investment from a sustainability point of view, i.e., to what extent it complies with the sustainable investment criteria[243]. How will you incorporate this requirement in your future investment plans?

Financial instruments

1.24. Have you used any financial instruments (grants, soft loans, etc.) to finance the investment above? What types of instruments and under what programmes?
1.25. Do you plan to use such financial instruments to finance the upcoming transformational activities?
1.26. If you have used investment grants, how have you co-financed the investment (own sources, loans, etc.)? Barriers to using the instruments.
1.27. Have the existing programmes and instruments been motivational for your company? If not, what have you seen as major obstacles and challenges?

Technical assistance

1.28. Do you need technical assistance to develop the above projects?
1.29. What kind of technical assistance is most needed (feasibility study, etc.), and in what field?
1.30. Who should provide this technical assistance?

Other

1.31. What documents related to the above questions would you share with us?

[243] Regulation 2020/852 from 18 July 2020 on the establishment of a framework to facilitate sustainable investment

Non-EU ETS companies

The same as the questionnaire for the EU ETS, but without the EU ETS questions.

2. NGOs

2.1. How do you see your role in the just transition?

Awareness

2.2. Do you feel you have sufficient level of information on the Just Transition and decarbonisation pathway?
2.3. Do you see the level of public consultation as sufficient? If not, what are your recommendations to improve it?

Climate neutrality transition

2.4. What do you see as major **risks** of the Just Transition in your region/in your area of expertise? What are these risks specifically for small and medium actors (SMEs, municipalities, etc.)?
2.5. What do you see as major **challenges** to the Just Transition in your region/in your area of expertise?
2.6. Where do you see the main **opportunities** of Just Transition in your region/in your area of expertise?

Governance of the design process and future implementation of just transition mechanisms

2.7. What is your view on the coordination between central and regional level in terms of the Just Transition Mechanisms (JTM)?
2.8. What is your view on the coordination among responsible ministries in the JTM?
2.9. What is your view on the coordination among funding programmes in the JTM?

3. Government bodies and regional representatives

Awareness

3.1. Do you feel you have sufficient level of information on the just transition and decarbonisation pathway?
3.2. Do you see the level of public consultation as sufficient? If not, what are your recommendations to improve it?

Governance of the design process and future implementation of just transition mechanisms

3.3. What is your view on the coordination between central and regional level in terms of the Just Transition Mechanisms (JTM)?
3.4. What is your view on the coordination among responsible ministries in the JTM?
3.5. What is your view on the coordination among funding programmes in the JTM?
3.6. How do you think the above activities could be improved to better reflect your needs?
3.7. Do you see any problematic parts in the setting of JTF with respect to Modernisation fund?
3.8. Have you followed the European Semester and how do you incorporate its conclusion in your work?

Specific questions to each Ministry:

3.9. MoE: regarding the governance structure of the JTF, the Modernisation Fund and the MIT programme
3.10. MFin: regarding co-funding

Climate neutrality transition

3.11. What do you see as major **risks** of the just transition in your region/in your area of expertise?
3.12. What do you see as major **challenges** to the just transition in your region/in your area of expertise?
3.13. Where do you see the main **opportunities** of just transition in your region/in your area of expertise?

4. Municipalities

Economic context

4.1. What impacts to the municipal economics (budget, investment, other?) do you expect to occur due to the covid-19 pandemic (and the currently debated fiscal reform)?

Awareness

4.2. Do you feel you have sufficient level of information on the just transition and decarbonisation pathway?
4.3. Do you see the level of public consultation as sufficient? If not, what are your recommendations to improve it?

Climate neutrality transition

4.4. What do you see as major **risks** of the just transition in your region?
4.5. What do you see as major **challenges** to the just transition in your region?
4.6. Where do you see the main **opportunities** of just transition in your region?
4.7. Are there alternatives for employment/entrepreneurship in your municipality/region? (If yes, elaborate more in detail)
4.8. What would be your major needs to facilitate the decarbonisation for your municipality?

Investment and financial instruments

Investment

4.9. Type of investment

Type of investment	Have you implemented projects that would contribute to any of the aspects below in the last 3 years? ***If yes, please elaborate*** *(details, total volume, results, challenges, related documents?)*	Do you plan to invest in projects that would contribute to any of the aspects below? ***If yes, please elaborate*** *(details, total volume, results, challenges, related documents?)*
Diversification of the businesses in your area?		
Upskilling and/or reskilling of your employees/employees in your municipality?		

Digitalisation and digital connectivity		
Research and innovation activities and fostering the transfer of advanced technologies		
Regeneration and decontamination of sites, land restoration and repurposing projects		
Other relevant (e.g., information?)		

Financial instruments

4.10. Have you used any financial instruments (grants, soft loans, etc.) to finance the investment above? What types of instruments and under what programmes?
4.11. Do you plan to use such financial instruments to finance the upcoming transformational activities?
4.12. If you have used investment grants, how have you co-financed the investment (own sources, loans, etc.)? Barriers to using the instruments?
4.13. Have the existing programmes and instruments been motivational for your company? If not, what have you seen as major obstacles and challenges?

Technical assistance

4.14. Do you need technical assistance to develop the above projects?
4.15. What kind of technical assistance is most needed (feasibility study, etc.), and in what field?
4.16. Who should provide this technical assistance?

NOTE: **Priorities of the Annex D: INVESTMENT GUIDANCE ON JUST TRANSITION FUND 2021-2027 FOR CZECH REPUBLIC (European Semester Report for the Czech Republic, 2020)**

Investments in the deployment of technology and infrastructures for affordable clean energy, in greenhouse gas emission reduction, energy efficiency and renewable energy;

- Investments in the creation of new firms, including through business incubators and consulting services;
- productive investments in SMEs, including start-ups, leading to economic diversification and reconversion;
- Upskilling and reskilling of workers;
- Investments in regeneration and decontamination of sites, land restoration and repurposing projects.

Related actions of the Just Transition Fund could target in particular:

- Investments in research and innovation activities and fostering the transfer of advanced technologies;
- Investments in digitalisation and digital connectivity;

- Technical assistance.

Investment needs have further been identified for alleviating the environmental and socio-economic costs of the transition. Related actions of the Just Transition Fund could target in particular:

- Investments in enhancing the circular economy, including through waste prevention, reduction, resource efficiency, reuse, repair and recycling;
- Job-search assistance to jobseekers;
- Active inclusion of jobseekers.

ANNEX 4: List of Stakeholders Interviews

Date of interview/event	Type of meeting	Organization	Type of Organization	Region
2020-10-29	Interview	Deputy Secretary of the Energy Commission	Policy	Ústí Region
2020-11-25	Interview	Lovochemie	EU ETS	Ústí Region
2020-11-30	Interview	Elektrárna Ledvice	EU ETS	Ústí Region
2020-11-30	Interview	Economic and Social Council of the Ústí Region	Policy	Ústí Region
2020-12-06	Interview	SEF	Policy	National
2020-12-02	Interview	MoIT,Dpt. of Strategy and Intl. Cooperation	Policy	National
2020-12-03	Interview	MoE, Dpt. of Energy and Climate Protection	Policy	National
2020-12-04	Interview	CzechInvest	Policy	National
2020-12-11	Interview	ITI - Ústí region	Regional authority	Ústí Region
2020-12-14	Interview	European Commission, Representation in Prague	Policy	EU Commission
2020-12-14	Interview	Anna KK	NGO	KV Region
2020-12-14	Interview	DDM UL	NGO	Ústí Region
2020-12-16	Interview	Orlen UniCRE	EU ETS	Ústí Region
2020-12-21	Interview	Autocont	non-EU ETS	MS Region
2021-01-02	Interview	Varroc Lighting System	non-EU ETS	MS Region
2021-01-02	Interview	RESTART	Policy	National
2021-01-08	Interview	Lovochemie	EU ETS	Ústí Region
2021-01-11	Interview	Lubrication systems CZ	non-EU ETS	KV Region
2021-01-12	Interview	Horní Slavkov	Municipality	KV Region
2021-01-12	Interview	WITTE	non-EU ETS	KV Region
2021-01-12	Interview	Glazura	EU ETS	Ústí Region
2021-01-13	Interview	Chodov	Municipality	KV Region
2021-01-13	Interview	Euro Support Manufacturing Czechia	non-EU ETS	Ústí Region
2021-01-14	Interview	Lias Vintířov	EU ETS	KV Region
2021-01-14	Interview	Paskov	Municipality	MS Region
2021-01-15	Interview	Třinecké železárny	EU ETS	MS Region
2021-01-18	Interview	Tisová/ Sokolovská uhelná	EU ETS	KV Region
2021-01-18	Interview	Horní Suchá	Municipality	MS Region
2021-01-19	Interview	FERRIT s.r.o.	non-EU ETS	MS Region
2021-01-21	Interview	Ledvice Power station	EU ETS	Ústí Region

Date of interview/event	Type of meeting	Organization	Type of Organization	Region
2021-01-26	Interview	TINT	non-EU ETS	MS Region
2021-02-04	Interview	Sokolov	Municipality	KV Region
2021-02-05	Interview	CMZRB	Financial	National
2021-02-05	Interview	Deputy Secretary of the Energy Commission	Regional authority	Ústí Region
2021-02-08	Interview	Center for Transport and Energy	NGO	National
2021-02-08	Interview	MoE	Policy	National
2021-02-09	Interview	Regional Authority of MS Region	Regional authority	MS Region
2021-02-10	Interview	EGU	Other	MS Region
2021-02-15	Interview	Regional Authority of KV Region	Regional authority	KV Region
2021-02-15	Interview	Dean UJEP FSE	NGO	Ústí Region
2021-02-16	Interview	SFZP	Policy	National
2021-02-16	Interview	Regional Authority of Ústí Region	Regional authority	Ústí Region
2021-02-22	Interview	Deputy Secretary of the Energy Commission	Policy	Ústí Region
2021-02-23	Interview	EIB	Financial	National
2021-03-01	Interview	CRDM (Youth organization)	Youth	National
2021-03-30	Interview	KV Region	Regional authority	KV Region
2021-03-30	Interview	Ústí Region representatives	Regional authority	Ústí Region
2021-04-09	Interview	MoE, Dpt for Just Transition	Policy	National
2021-04-16	Interview	EIB	Financial	National
2021-05-14	Interview	Czech Association of Insurance Companies	Financial	
2021-04-29	workshop	Česká veganská společnost	NGO	national
2021-04-29	workshop	Václava Marková	NGO	national
2021-04-29	workshop	Re-set	NGO	national
2021-04-29	workshop	Asociace TRIGON, o.p.s.	NGO	national
2021-04-29	workshop	Agency for Social Inclusion	Policy	national
2021-04-29	workshop	Kuprospěchu, z.s. & Spolek přátel žatecké synagogy, z.s.	NGO	Ústí Region
2021-04-29	workshop	CRDM (Youth organization)	Youth	Ústí Region
2021-04-29	workshop	Dobrovolnické centrum, z.s.	NGO	Ústí Region

Date of interview/event	Type of meeting	Organization	Type of Organization	Region
2021-04-29	workshop	Ústecké šrouby, z. s.	NGO	Ústí Region
2021-04-29	workshop	Association for International Affairs	NGO	National
2021-04-29	workshop	KRDMK, z. s.	NGO	KV region
2021-04-29	workshop	ICUK	Regional authority	Ústí Region
2021-04-29	workshop	Generace KK, z.s.	Youth	KV Region
2021-04-29	workshop	Západočeská univerzita v Plzni	Youth	National
2021-05-06	Interview	PWC - JTP Slovakia	Policy	National
2021-05-12	workshop	Josefov	Municipality	KV Region
2021-05-12	workshop	Kraj zivych vod	Municipality	KV Region
2021-05-12	workshop	Habartov	Municipality	KV Region
2021-05-12	workshop	NS MAS	Municipality	MS Region
2021-05-12	workshop	Třemešná	Municipality	MS Region
2021-05-12	workshop	MoRD	Policy	national
2021-05-12	workshop	Geography dpt, UJEP	Municipality	Ústí Region
2021-05-12	workshop	Blatno	Municipality	Ústí Region
2021-05-12	workshop	Osek	Municipality	Ústí Region
2021-05-12	workshop	DSO Chomutovsko	Municipality	Ústí Region
2021-05-12	workshop	Černovice	Municipality	Ústí Region
2021-05-12	workshop	Spořice	Municipality	Ústí Region
2021-05-13	workshop	Sancho Panza, s.r.o.	SMEs	KV Region
2021-05-13	workshop	MS-IC	SMEs	MS Region
2021-05-13	workshop	Lamella	SMEs	MS Region
2021-05-13	workshop	Karel Polák	SMEs	n/a
2021-05-13	workshop	MoRD	Policy	national
2021-05-13	workshop	Grantex	SMEs	national
2021-05-13	workshop	Biopreparaty, spol. s.r.o.	SMEs	national

9 REFERENCE LIST

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