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Article

Green transition in CESEE : sectoral emissions and EU recovery plans

Green transition in CESEE: sectoral emissions and EU recovery plans

Andreas Breitenfellner, Mathias Lahnsteiner, Thomas Reininger[1]

The EU's financial response to the pandemic was designed to also promote climate action. This descriptive study investigates to what extent the recovery and resilience plans (RRPs) of EU member states in Central, Eastern and Southeastern Europe (CESEE) address some of the most pressing issues regarding their greenhouse gas (GHG) emission levels compared with other EU countries (EU-16). We assess that the ex ante allocation of spending within climate-related RRP spending in CESEE EU countries appears to be broadly appropriate. First, their plans' focus on renewable energy and networks is particularly important given that their per capita GHG emissions in energy industries were, on average, more than 50% higher than in the EU-16 in 2019, despite lower per capita GDP levels. These high emissions result, to a large extent, from a small group of economically significant countries that substantially use coal for power generation and district heating/cooling (as well as directly in the household sector). Given generous financial support, more ambitious coal-exit strategies could have been expected. Second, the focus of CESEE EU countries' RRPs on energy efficiency is welcome, given high energy intensity in manufacturing and poorly insulated buildings, which are an additional cause of high energy industries' emission levels. In some countries, this area would clearly deserve being made a higher spending priority. Third, the RRPs' focus on sustainable mobility is justified by the dynamic rise of transport sector emissions in CESEE EU (particularly in international aviation), even though per capita GHG emissions in transport are still lower in most CESEE countries than in the EU-16. While our findings support the general judgment that the RRPs' spending structures indeed correspond to major country-specific climate-related weaknesses, we do not assess whether the plans are sufficient to put countries on track to their net-zero goals or whether individual measures are appropriate. Needless to say, the current energy crisis related to the Russian invasion in Ukraine and Russia's earlier restrictions on gas exports already in 2021 adds to the urgent need to steer energy production and consumption away from fossil sources and to advance energy saving.

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Europe has a particular responsibility in the global quest for an effective and efficient response to climate change.[2] The EU's challenge to deliver appropriate mitigation, adaptation and transition policies is urgent. It is a challenge that has presented itself for a long time and will continue to do so for a long time to come.

The European Green Deal envisaged by the European Commission in 2019 and the emergence of the COVID-19 pandemic in 2020 led to significant adjustments in the European Union's multiannual financial framework (MFF) 2021–2027

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[2] *Europe has a large share in total historical GHG emissions and a still substantial share in total current GHG emissions. Moreover, it has a significant role as an international standard setter, role model and technology exporter.*

(European Commission, 2019; European Union, 2020a). Moreover, in response to the pandemic, the European Union agreed on establishing a European Union Recovery Instrument (EURI) complementary to the regular EU budget provided by the MFF.[3] The cornerstone of the EURI is the Recovery and Resilience Facility (RRF), which provides funding for EU member states according to national recovery and resilience plans (RRPs) if jointly agreed upon at the EU level. The established common guidelines for these RRPs stipulate a minimum share of 37% for a "green pillar" in the RRP expenditures of each member state (European Union, 2020b, 2021; Reininger, 2021).

After Russia already used its energy export policy for strongly driving up EU gas prices in 2021 and then escalated its war against Ukraine, the implementation of the RRPs' green pillars is both more challenging and even more urgent in most EU member states. Against this background, the REPowerEU Plan aims to reduce the EU's energy dependency and greenhouse gas (GHG) emissions faster, even if temporary deviations from its ambitious climate goals are tolerated (European Commission, 2022a). National policies, however, are in part undermining these goals, as several member states have been shielding consumers and companies from rising energy prices by (partially) suspending market mechanisms and thus reducing incentives for emission cuts (Sgaravatti at al., 2022).

Against this policy background, this study provides a stocktaking of issues related to GHG emissions in EU member states, particularly in Central Eastern and Southeastern Europe (CESEE) in the year 2019, prior to the COVID-19 pandemic. It builds on a previous study which focused on the developments regarding the green transition in the period between 1990 and 2018. In our earlier study, we had confirmed broad compliance with climate policy commitments in both subaggregates of 11 EU member states in CESEE (CESEE EU) and 16 other EU member states (EU-16) while highlighting the challenges ahead (Breitenfellner et al., 2021).

This study focuses on the status quo in the year 2019 and only occasionally refers to developments in the decade following the global financial crisis in 2008. Moreover, it provides comprehensive country-specific information as well as deeper sectoral insights. Following a descriptive and comparative approach regarding the European Union, it uses the EU-27 aggregate and the 16 other EU member states, both individually and as EU-16 aggregate, as benchmarks for CESEE EU member states and their aggregate. Methodologically, like in the previous study, we apply the Kaya decomposition to gain a deeper understanding of the relative intensities involved in these countries and sectors (Kaya and Yokoburi, 1997; Umweltbundesamt, 2021). According to the Kaya identity, total anthropogenic GHG emissions of an economy are the product of four multiplying factors: GHG emission intensity of the energy mix, energy intensity of GDP, GDP per capita, and population. In our paper, the term "carbon intensity" refers to the product of emission intensity and energy intensity and, hence, relates GHG emissions to GDP. After presenting an overview on the size of the national RRPs and on the structure and quantitative design of their respective green pillars, the study explores whether the ex ante allocation of spending under these RRPs is appropriate to address general or country-specific weak spots that emerged in the preceding stocktaking exercise. In no way, however, do we claim to comprehensively assess whether these

[3] *The EURI is also called NextGenerationEU recovery plan (NGEU).*

plans are adequate or whether individual measures envisaged therein are sufficient or timely.

The study is structured as follows: Section 1 provides an analysis of various aspects of GHG emissions in EU member states, with subsection 1.1 focusing on GHG emissions per capita and their structure by sectors, and subsection 1.2 dealing with the economy-wide and sectoral decomposition of these emissions into intensities. Section 2 gives an overview of the RRPs and their green transition pillars, especially in CESEE EU member states. In section 3, we wrap up and draw some conclusions.

1 Analysis of GHG emissions in EU member states

This chapter provides a stocktaking of the level and structure of GHG emissions in EU member states, particularly in CESEE, as well as of the relative intensities involved in these economies and their sectors.

1.1 GHG emissions per capita and structure by sectors

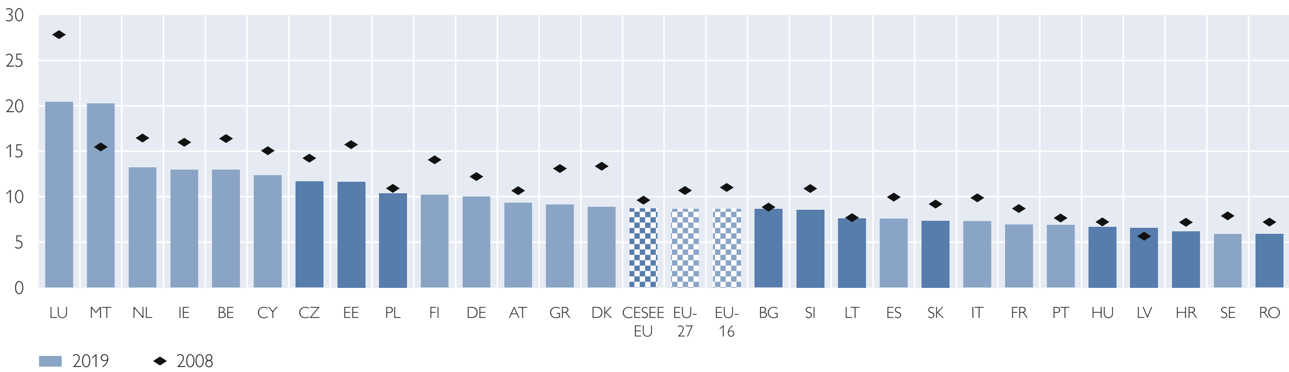
1.1.1 GHG emissions per capita in 2019

At first glance, CESEE EU member states do not seem to contribute more to climate change than other EU member states, relative to the size of their population. The subaggregates of the CESEE EU member states (in the following: CESEE EU) and the other EU member states (in the following: the EU-16) had almost the same level of *GHG emissions per capita* in 2019, and hence were almost equal to the EU-27 average of 8.7 tons CO_2 equivalent of GHG emissions (see chart 1).[4] These aggregate figures mask pronounced heterogeneity within both country groups. The highest GHG emissions per capita in the EU-27 are recorded by the Benelux countries, Cyprus, Malta and Ireland, with readings that are about 50% higher than the EU-27 average. These are followed by Czechia, Estonia and Poland, a group of countries that comprises two heavyweights within the CESEE EU subaggregate, with per capita emissions 20% to 35% above average. At the other end of the

Chart 1

Greenhouse gas emissions per capita

Tons of CO_2 equivalent per person



Source: Authors' calculations, Eurostat, UNFCCC.

[4] *These GHG emissions include allotted emissions released from international bunkers related to international navigation and aviation. They exclude the impact of land use, land use change and forestry (LULUCF).*

spectrum, with the lowest GHG emissions per capita, are Sweden and Romania with per capita emissions about 30% below average. These are followed by Croatia, Latvia, Hungary, Portugal and France with slightly higher per capita emissions that are still at least 20% below average.

However, this comparison does not condition on different GDP per capita levels, and we will turn to this issue further below.

1.1.2 Uneven decline in GHG emissions between 2008 and 2009

A brief look at the development of *GHG per capita levels from 2008 to 2019* shows that the EU-27 average declined by almost 20% in this period, resulting from decreases in all EU member states except Malta and Latvia (see chart 1). However, these decreases differed markedly in size. The CESEE EU subaggregate posted a decline of only 10%, as most of the included member states had a below-average decline of their per capita emissions, particularly Bulgaria, Poland and Hungary. Estonia is the only CESEE country among those EU member states that have recorded very large decreases of per capita emissions, namely by more than 25% and up to 33%. On a positive note, two CESEE countries, Slovakia and even more so Romania, registered substantial reductions of per capita GHG emissions, i.e. close to the EU-27 average, despite starting at already far below-average per capita emissions in 2008.

In general, the dynamics observed from 2008 to 2019 do not fundamentally change when considering demographics and looking at *GHG total*. Not only per capita but also in terms of total GHG emissions, the decline was far more pronounced in the EU-27 than in CESEE EU, as population figures changed only modestly, rising by 2% in the EU-27 but declining by 3% in CESEE EU.[5] However, the relative position of a few CESEE EU member states shifts considerably when looking at total emissions. In Romania, where the decline in per capita emissions roughly equaled the EU-27 average, the accompanying substantial population decline resulted in a decline of total emissions that was larger than the EU-27 average. In Croatia, substantial population decline coupled with a decline in per capita emissions that was smaller than the EU-27 average resulted in a decline of total emissions that roughly equaled the EU-27 average.

1.1.3 The sectoral structure of GHG emissions

International data on GHG emissions differ slightly depending on the source and the underlying concept. Regarding the *sectoral structure of GHG emissions*, according to data provided by the *United Nations Framework Convention on Climate Change (UNFCCC)*[6], emissions of transport have the largest share in total GHG emissions in the EU-27 aggregate at close to 30%. These are followed by emissions from energy industries, comprising (1) generation of electricity and heating/cooling and (2) refineries for oil and petroleum products and coke ovens, with a combined share of 23%, emissions from manufacturing with 20% (breaking down into roughly equal parts stemming from energy use and from industrial processes and

[5] *Among EU-16 countries, only Greece and Portugal recorded declines in population figures, which in both countries roughly equaled the average decline in CESEE EU.*

[6] *This subsection includes allotted GHG emissions released from international bunkers related to international navigation and aviation. We use emissions data without the impact of land use, land use change and forestry (LULUCF).*

product use) and emissions from agriculture with 12% (the bulk of which coming from agricultural processes, mainly emitting non-CO_2 GHG, rather than energy use). Finally, there are the emissions from the residential sector (8%), resulting from the burning of fossil energy like coal, oil and gas within households for heating, as well as the emissions from other items (8%), which comprise (1) emissions from the burning of fossil energy within commercial/institutional buildings for heating, (2) emissions from wastewater treatment and solid waste disposal sites and (3) emissions from fossil energy mining and exploration (as "fugitive emissions from fuel").

Moderately different sector structure results from *Eurostat's Air Emissions Accounts (AEA)* data. The AEA data follow the residence principle, with emissions assigned to the country where the economic operator causing the emission (the operator of the ship/aircraft in the case of international navigation and aviation) is resident and are classified by economic activity (NACE) (Eurostat, 2022). The UNFCCC data, reported to international conventions, follow the territory principle, with emissions assigned to the country where the emission takes place (or, in the case of international navigation and aviation, where the associated fuel is bunkered), and are classified by the type of technical process (UNFCC, 2006).[7] On aggregate, for the EU-27, the difference between the AEA total GHG emissions and the UNFCCC total GHG emissions[8] was about 0.5% in 2019. However, in some small and open countries (especially those considerably involved in international navigation and/or aviation) the difference may be substantial.[9]

For the sectoral structure, part of AEA emissions may be clustered into the category of "services," both commercial and public services, which, in turn, comprise some emissions covered by the categories "transport sector" and "other items" in the UNFCCC reporting. On the EU-27 aggregate level, the share of services accounted for slightly more than 10% of total emissions in 2019, lowering, in turn, the transport sector's share according to AEA data to the still large size of nearly 25%.

This subsection continues to focus primarily on the sector structure derived from the *UNFCCC data*, while subsection 1.2 uses AEA data when investigating sectoral decomposition and intensities, as the classification of these emissions data is comparable to that of economic structure.

1.1.4 Differences in the sectoral structure of GHG emissions

Accordingly, the *sectoral structure of GHG emissions clearly differs between the CESEE EU and EU-16 subaggregates,* with the EU-16 sector structure dominating the EU-27 structure given its coverage of more than three-quarters of the EU. In 2019, the sector structure of the CESEE EU subaggregate was set apart from that of the EU-16 and EU-27, particularly in three categories: first, the considerably larger share

[7] *Note that the volume of emissions caused by nonresidents in the territory of any country is not just an unavoidable result of nonresidents' decision-making but may well be influenced by policy, like, for instance, tax policy that aims at lifting government revenues via fuel taxes instead of aiming at containing GHG emissions.*

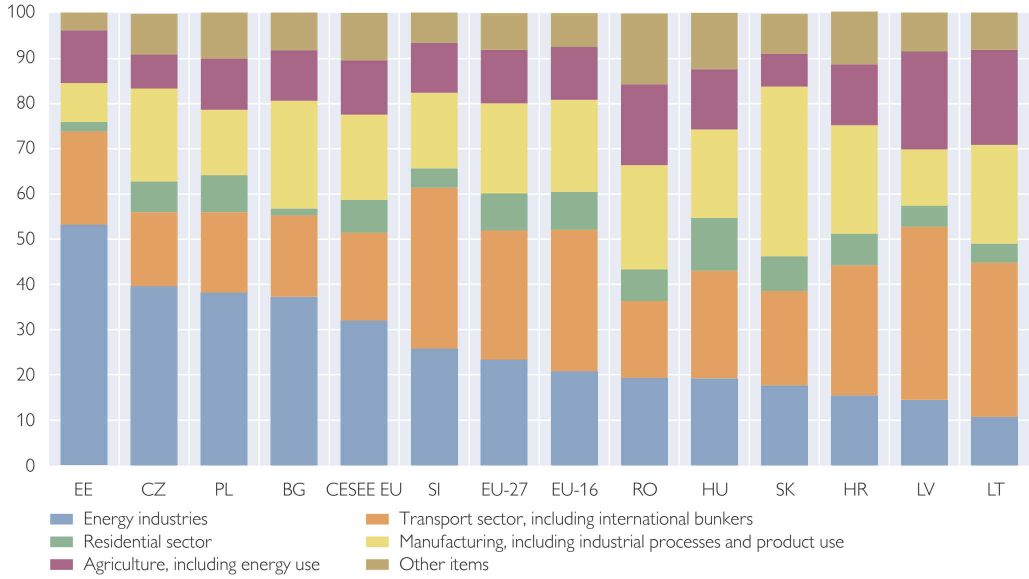
[8] *Including allotted emissions released from international bunkers related to international navigation and aviation. We use emissions data without the impact of land use, land use change and forestry (LULUCF).*

[9] *In Lithuania, Denmark and Ireland, the AEA data for total GHG emissions are 15% or more higher than the UNFCCC totals, while in Belgium, Cyprus, Luxembourg, Malta and the Netherlands the AEA data are 10% or more below those totals.*

Chart 2

Sectoral structure of greenhouse gas emissions (2019)

% of total greenhouse gas emissions without LULUCF (including international bunkers)



Source: UNFCCC.

Note: Countries ordered by size of energy industries' share of emissions in % of total GHG emissions. LULUCF = land use, land use change and forestry.

of emissions from energy industries (about 32%); second, the considerably smaller share of emissions from the transport sector (about 19%); and third, the larger share of emissions summarized under "other items" (about 11%), on account of emissions from waste and from fugitive emissions from fuel (see chart 2). Note that, when using AEA data, similarly sized deviations result for energy industries and the transport sector. Moreover, both the UNFCCC and AEA data clearly indicate that in CESEE EU more than half of the difference vis-à-vis the EU-27 figures for the transport sector is attributable to the comparatively lower level of emissions from international navigation and aviation.[10]

The highlighted differences in the sector shares are also reflected in the differences in 2019 *sector-specific per capita GHG emissions between CESEE EU on the one hand and the EU-16 and EU-27 on the other hand*, given the almost equal level of total per capita emissions.

To put these differences into perspective, note that the (still) lower shares and per capita emissions of the transport sector in CESEE EU do not leave room for complacency. First, these emissions have been growing very dynamically in the relevant CESEE EU subaggregate in both the international and the domestic segment while declining in the EU-16 in both segments in recent years. And second, particularly the per capita emissions from international aviation in CESEE EU are very likely to rise further from their current, comparatively lower level.

[10] *Besides, the AEA data show that in 2019 slightly less than half of the transport sector emissions stemmed from households both in CESEE EU and in the EU-16, while in 2008 the household share was just above 40% of total transport emissions in CESEE EU but already about 50% in the EU-16.*

More obviously, the higher shares of energy industries, fugitive emissions and waste emissions and the higher per capita emissions in these sectors in CESEE EU call for specifically targeted climate policy action.

At the same time, even shares and per capita emission levels in manufacturing, the residential sector and agriculture, which are comparable to the EU average, are no excuse for inaction in these countries.

At this point, let us emphasize the distinction between emissions from fuel combustion by the residential sector, which is an activity category in the UNFCCC statistics, and all emissions caused by the energy supply for residential buildings demanded by households. As pointed out above, emissions by the residential sector comprise only emissions directly generated within residential buildings, e.g. by burning fossil fuels. In addition, there are emissions indirectly caused by energy supply for residential buildings, namely emissions generated by the energy industry when producing electricity and heating/cooling for delivery to households. The latter emissions are part of total emissions by energy industries. For emissions from fuel combustion by the commercial/institutional sector, the case is similar. Avoiding this confusion is so important, as for both residential and commercial buildings there is large scope for energy saving via thermal insulation and a change of heating systems both in CESEE EU and in the EU-16. These energy-saving measures do not only help reduce per capita emission levels in the residential sector but also the per capita emission levels in energy industries, which are generally far higher than those in the residential sector and – as mentioned above – comparatively even higher in CESEE EU than in the EU-16.[11]

In which sectors do individual CESEE countries differ markedly from the overall regional structure? If we compare chart 2 and table 1, we find that differences in the sector structure of emissions reflect differences not only in the countries' economic

Table 1

Sectoral greenhouse gas emissions per capita (2019)

	CZ	EE	PL	CESEE EU	EU-27	EU-16	BG	SI	LT	SK	HU	LV	HR	RO
	Tons of CO_2 equivalent per person													
Total greenhouse gas emissions	11.7	11.6	10.4	8.7	8.7	8.7	8.6	8.5	7.6	7.3	6.7	6.6	6.2	5.9
Energy industries	4.6	6.2	4.0	2.8	2.0	2.0	3.2	2.2	0.8	1.3	1.3	1.0	1.0	1.1
Manufacturing (including industrial processes and product use)	2.4	1.0	1.5	1.6	1.7	1.7	2.1	1.4	1.7	2.8	1.3	0.8	1.5	1.4
Transport sector (including international bunkers)	1.9	2.4	1.9	1.7	2.5	2.5	1.6	3.0	2.6	1.5	1.6	2.5	1.8	1.0
Residential sector	0.8	0.2	0.9	0.6	0.7	0.7	0.1	0.4	0.3	0.6	0.8	0.3	0.4	0.4
Agriculture (including energy use)	0.9	1.4	1.2	1.0	1.0	1.0	1.0	0.9	1.6	0.5	0.9	1.4	0.8	1.1
Other items	1.0	0.5	1.1	0.9	0.7	0.7	0.7	0.6	0.6	0.6	0.8	0.6	0.7	0.9

Source: Authors' calculations, Eurostat, UNFCCC.

[11] *Also note that equal (or, in fact, slightly lower) per capita emission levels in CESEE EU manufacturing where FDI from the EU-16 have a strong or even dominant role, cast doubts over a specific form of carbon leakage hypothesis according to which the EU-16's outward FDI in CESEE EU member states consisted largely in transferring above-average polluting industries to CESEE. However, these data do not allow rejecting this hypothesis either, as the counterfactual is unknown.*

structure but also in (past) energy and climate policy. The share of energy industries as well as related per capita emissions are markedly lower in Croatia, Slovakia, Hungary and Romania, and particularly high in Estonia, Czechia, Poland and Bulgaria. In manufacturing, Slovakia and Czechia do not only have above-average shares but also above-average per capita emission levels. In the transport sector, Slovenia, Lithuania and Latvia stand out with above-average figures, and in the residential sector, Poland, Hungary and Czechia. In agriculture, Romania and Croatia have above-average figures in terms of shares, Poland in terms of per capita emissions and the Baltic countries in terms of both shares and per capita emissions. In the category "other items," Romania has a particularly high share and Poland clearly above-average per capita emissions; in both cases, this is attributable to the subitem of fugitive emissions from fuel. In addition, within "other items," per capita emissions from waste are particularly high in Czechia, Croatia, Bulgaria and Hungary. Finally, note that there is sizable heterogeneity in sectoral per capita emissions also among the EU-16 countries.

1.2 Intensities in the overall economy and in different sectors

1.2.1 Carbon intensity: GHG emissions per unit of GDP and GVA

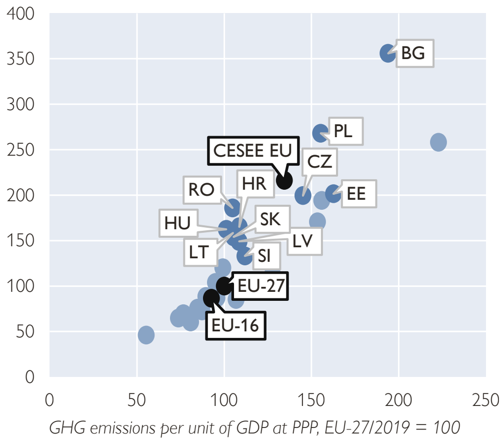
In this subsection, GHG emissions of the total economy and of sector clusters of economic activities are related to an economy's total GDP and the corresponding gross value added (GVA) of these sector clusters, respectively. The GHG emissions allotted to each sector cluster stem from Eurostat's AEA data (see subsection 1.1.3). Conditioning on related GDP or GVA levels implicitly means that, for an appropriate assessment, not only costs (in terms of GHG emissions) but also benefits (in terms of products and services for well-being) must be considered.

Obviously, for cross-country comparison, the question arises whether GDP and GVA are measured in euro at purchasing power parity (PPP) or at market exchange rates. Focusing on the volume of GHG emissions associated with comparative income levels would suggest applying PPP. In contrast, focusing on the volume of GHG emissions associated with international competition in tradable goods and economic activities related to their production would suggest using the market exchange rate. Hence, for GDP we consider PPP more appropriate, while for the GVA of internationally exposed sectors we prefer using the market exchange rate. However, for the sake of transparency and comparability between the total economy and individual sectors, we will look at both measures regarding GDP, focusing primarily on the PPP-related measure while highlighting if the exchange rate-related measure yields considerably different results. The sub-

Chart 3

Carbon intensity of the whole economy

GHG emissions per unit of GDP at market exchange rates, EU-27/2019 = 100



Source: Authors' calculations, Eurostat, UNFCCC.

stantially higher *GDP-based carbon intensity* levels in CESEE EU (according to both measures) reveal the need of their further lowering in order to allow per capita income convergence within ecologically sustainable limits. Based on GDP at PPP, average carbon intensity for CESEE EU was one-third above the EU-27 average, while the EU-16 carbon intensity was 7% below this average in 2019 (see table 2, first column). Based on GDP at market exchange rates, CESEE EU carbon intensity was more than 110% higher than in the EU-27 while EU-16 carbon intensity was 13% lower (see table 2, second column). Thus, in chart 3, the dot for CESEE EU lies clearly above the 45° line. According to both measures, carbon intensity was above the EU-27 average in each CESEE EU country, with Bulgaria, Estonia, Poland and Czechia belonging to the most carbon-intense economies in the EU-27. Among the EU-16 member states, only Malta, Greece and Cyprus were close to such high levels of carbon intensities. On a PPP basis, Belgium and the Netherlands had carbon intensities below those in the four CESEE EU member states mentioned above (and thus also below the CESEE EU average) but higher than those in the remaining seven CESEE EU member states[12], which in turn had carbon intensities up to 12% above the EU-27 level on a PPP basis (but exceeded that level by at least 30% on an exchange rate basis).

Looking at the dynamics (on PPP basis), carbon intensity declined in each EU member state from 2008 to 2019 and on average by 26% in the EU-27. On the positive side, the decline was stronger on average in the CESEE EU member states, amounting to 32%, with above-average declines in Poland and Estonia, two of the four countries with still above-average levels in 2019. However, among the CESEE countries, Bulgaria together with Latvia and Croatia showed less progress than the EU-27.

1.2.2 Possible explanations for country differences in carbon intensity

Analytically, one way to explore these differences is the decomposition of carbon intensity (GHG emissions per unit of GDP) into *emission intensity*, that is GHG emissions per unit of energy used, and *energy intensity*, that is energy used per unit of GDP[13].

Emission intensities of total economies in CESEE EU were on average 29% higher than in the EU-27 in 2019 (see table 2, third column). This mirrors the above finding that CESEE EU carbon intensity (based on GDP at PPP) was 34% higher than in the EU-27. Moreover, those four CESEE EU countries with carbon intensity above the CESEE EU average (Bulgaria, Estonia, Poland, Czechia) were those (together with Romania) that had above-average emission intensities. The same applies to Greece as one of the three EU-16 countries with above-average carbon intensity. Congruently, five of the seven CESEE EU countries with the lowest carbon intensities (Hungary, Lithuania, Slovakia, Croatia, Slovenia), which exceeded the EU-27 level by only 12% or less, had emission intensities close to the

[12] *While the exceptionally high level of per capita GHG emissions and carbon intensity in Malta may be attributed exclusively to the far above-average emissions associated with international navigation and aviation, the later may explain only part of the above-average per capita GHG emissions and carbon intensities in Cyprus, Belgium and the Netherlands. In the Netherlands, per capita emissions in energy industries and in agriculture are extraordinarily high, while in Belgium emissions from manufacturing are particularly high.*

[13] *To be precise, total final energy consumption is used for calculating energy intensity.*

Table 2

Decomposition of total emissions

	Carbon intensity (with GDP at PPP)	Carbon intensity (with GDP at market exchange rates)	Emission intensity	Energy intensity (with GDP at PPP)	Energy intensity (with GDP at market exchange rates)
Malta	223	258	89	251	291
Bulgaria	**194**	**356**	**165**	**118**	**216**
Estonia	**163**	**202**	**136**	**120**	**148**
Greece	156	194	137	114	142
Poland	**155**	**268**	**146**	**107**	**184**
Cyprus	153	171	121	127	141
Czechia	**145**	**200**	**134**	**108**	**149**
CESEE EU	**134**	**216**	**129**	**104**	**167**
Belgium	128	113	90	142	125
Netherlands	117	102	97	120	105
Slovenia	**112**	**133**	**97**	**115**	**137**
Croatia	**109**	**165**	**98**	**110**	**168**
Latvia	**108**	**149**	**77**	**141**	**193**
Finland	107	85	59	181	145
Slovakia	**105**	**154**	**99**	**107**	**156**
Lithuania	**105**	**158**	**101**	**104**	**157**
Romania	**105**	**186**	**132**	**79**	**141**
Hungary	**101**	**162**	**96**	**105**	**169**
EU-27	**100**	**100**	**100**	**100**	**100**
Portugal	99	120	101	99	119
Germany	96	87	102	94	85
Spain	95	104	100	95	104
EU-16	**93**	**87**	**94**	**98**	**92**
Italy	90	88	99	90	89
Luxembourg	87	73	70	125	104
Austria	85	75	78	108	96
Denmark	81	60	89	91	68
France	77	69	84	91	82
Ireland	74	65	129	57	50
Sweden	55	46	49	114	95

Source: Authors' calculations, Eurostat, UNFCCC.

Note: Indexed values, EU-27/2019 = 100.

EU-27 average. (Latvia was the only CESEE country with an emission intensity far below the EU-27 average.)

Thus, the emission intensity ranking of most CESEE countries among all EU-27 countries matched their ranking with respect to carbon intensity and, in addition, the heterogeneity in carbon intensity resulted mainly from the heterogeneity in emission intensity. This means that in the CESEE EU countries energy intensity, i.e. the second factor determining carbon intensity, was relatively close to the EU-27 average. At the same time, in each CESEE EU country (except for Romania), energy intensity was above the EU-27 level (see table 2, fourth column). Romania and Latvia were the outliers among CESEE countries, with their emission and carbon intensity rankings not matching each other and their energy intensity deviating strongly from the EU-27 average, as Latvia had particularly high and Romania particularly low energy intensity in 2019.

Besides, if measuring carbon intensity and hence energy intensity is based on GDP at market exchange rates, then the energy intensity of CESEE EU countries is driven up and is shown to be even more important than emission intensity for determining the above-average carbon intensity levels of CESEE EU countries and the heterogeneity in carbon intensity within the EU-27 (see table 2, fifth column).

This decomposition shows that both saving energy and expanding low-emission energy sources, particularly renewable energy, are even more urgent challenges for the CESEE EU than the EU-16 countries. The scope for reducing carbon intensity toward the lower EU-16 levels is particularly large with respect to emission intensity.

1.2.3 Why was emission intensity so much higher in CESEE EU than in EU-16 countries?

From a sectoral perspective, energy industries for generation of electricity and heating/cooling are a prime candidate to look at, not least because of their large share in total GHG emissions. Indeed, emission intensities of *energy industries for generation of electricity and heating/cooling* were on average almost 70% higher in CESEE EU than in the EU-27 in 2019, while 17% lower in the EU-16 (see table 3, first column). At the far end of the spectrum, Poland exceeded the EU-27 level by about 150%, roughly matched only by Greece and Cyprus with deviations by 120% and then followed by Estonia, the only other EU country above the CESEE EU average. Slovenia and Hungary were close to the EU-27 average, while only Latvia, Lithuania and Slovakia were below that level; Lithuania and Slovakia were also below the EU-16 average. Energy industries' emission intensity is determined first by the share of fossil energy in total energy used in this sector, proxied by the combined share of coal, oil and natural gas (see table 3, second column), and second by the importance of coal within fossil energy sources (compare table 3, third column, showing the share of coal in total energy used, with the second column).[14] In 2019, more than one-third (35%) of total coal used in energy industries for generation of electricity and heating/cooling of the EU-27 aggregate were employed in Germany, further 28% in Poland, 10%

Table 3

Energy industries

	Emission intensity	Share of coal, oil and gas	Share of coal
		%	%
Poland	**253**	**85**	**77**
Cyprus	221	94	0
Greece	220	81	33
Estonia	**187**	**5**	**0**
CESEE EU	**169**	**59**	**47**
Germany	162	51	34
Malta	158	93	0
Bulgaria	**145**	**48**	**40**
Czechia	**143**	**53**	**46**
Netherlands	139	71	16
Ireland	135	61	3
Romania	**128**	**55**	**32**
Croatia	**120**	**48**	**17**
Italy	110	61	8
Slovenia	**108**	**37**	**32**
Hungary	**101**	**36**	**11**
EU-27	**100**	**39**	**19**
Portugal	95	58	15
Latvia	**87**	**48**	**0**
EU-16	**83**	**34**	**12**
Luxembourg	79	23	0
Denmark	67	26	13
Finland	66	16	8
Spain	65	40	7
Belgium	61	21	0
Lithuania	**60**	**17**	**0**
Slovakia	**55**	**24**	**10**
Austria	53	28	4
Sweden	14	1	0
France	14	7	1

Source: Authors' calculations, Eurostat.

Note: Indexed values in the first column, EU-27/2019 = 100, percentage shares in total energy used in the second and third columns.

[14] *Note that Estonia is a special case where the high emission intensity results from the high share of two special sources of fossil energy, namely shale oil and oil sands as well as manufactured gases, both not included in oil and natural gas in the table below.*

Table 4

Residential sector

	Energy used to generate E&H directly within HH	Thereof:			Emission intensity
		Share of coal and peat	Share of oil	Share of gas	
	% of total energy for E&H used in HH	*%*			
Ireland	76	16	54	27	158
Malta	29	0	53	0	145
Belgium	80	1	37	52	133
Luxembourg	83	0	30	64	126
Netherlands	76	0	1	92	118
Poland	**71**	**34**	**4**	**25**	**114**
Portugal	61	0	23	16	111
Greece	62	0	45	15	108
Bulgaria	**43**	**11**	**2**	**9**	**106**
Germany	74	1	28	52	106
Spain	57	1	29	42	104
Cyprus	58	0	53	0	103
EU-16	**67**	**1**	**21**	**51**	**102**
Italy	79	0	8	66	100
EU-27	**67**	**5**	**17**	**48**	**100**
France	62	0	18	46	95
Hungary	**74**	**2**	**2**	**66**	**94**
CESEE EU	**69**	**16**	**4**	**35**	**92**
Czechia	**67**	**14**	**1**	**38**	**92**
Slovakia	**67**	**2**	**0**	**63**	**85**
Austria	65	0	21	33	81
Romania	**77**	**1**	**5**	**43**	**64**
Lithuania	**52**	**6**	**8**	**21**	**63**
Slovenia	**65**	**0**	**18**	**15**	**57**
Denmark	43	0	11	33	57
Croatia	**71**	**0**	**6**	**29**	**53**
Latvia	**57**	**1**	**8**	**16**	**52**
Estonia	**47**	**0**	**2**	**13**	**38**
Finland	37	0	14	1	34
Sweden	14	0	19	2	30

Source: Authors' calculations, Eurostat.

Note: E&H = electricity and heating, HH = households; percentage shares in columns 1 to 4; indexed values in column 5, EU-27/2019 = 100. Columns 2 to 4: shares in 100 = energy used to generate E&H directly within HH in the respective countries.

in Czechia, 4% each in Bulgaria, Romania and Italy, and 3% each in the Netherlands, Spain and Greece.

A considerable part of electricity and heating/cooling provided by energy industries is delivered to households' residential buildings. In turn, these deliveries constituted a substantial part of total energy used in households for electricity and heating, namely about 33% in the EU-16 and 31% in CESEE EU. The other part is made up by energy that is used to generate electricity and mainly heating directly within households. The relative size of these two parts varies substantially within both country groups as can be seen from table 4, first column.

The generation of electricity and heating directly within households causes those GHG emissions that are attributed to the *residential sector's activity*. Relating these GHG emissions to the energy used for producing electricity and heating directly within households yields the corresponding emission intensity. Unlike in energy industries, households' residential sector had emission intensity levels that in CESEE EU were moderately lower (by 8%) than the EU-27 average, while slightly higher by 2% in the EU-16 in 2019 (see table 4, fifth column). However, these average figures also mask considerable heterogeneity within both country groups. At the high-intensity end of the spectrum, there are EU-16 countries (Ireland and Benelux) where the emission intensities were higher than the EU-27 average by 18% (Netherlands) to 58% (Ireland), driven by the overall high share of fossil energy (that is, the combined share of coal, peat, oil and natural gas), partly coupled with a substantial share of oil (and coal and peat in Ireland). This is followed by the country with the highest emission intensity in CESEE EU, which is Poland, exceeding the EU-27 average by almost 15%. Here, the high share of coal played a decisive role in the relative level of emission intensity. While Poland had a visibly lower overall share of fossil energy than the Netherlands, the large weight of coal within that share caused Poland's emission intensity to be almost as high as that of the Netherlands (see table 4, second, third and fourth column).[15] In 2019, more than three-quarters (76%) of total coal used by the residential sector (households) in the EU-27 aggregate were used in Poland, further 10% in Czechia, 5% in Ireland and 2% in Bulgaria. Note again that these emission intensities do not provide any information about the extent to which above-average volumes of energy may be employed in residential heating and, more generally, about the varying scope for energy saving (e.g. via thermal insulation) across countries in this sector.

1.2.4 Carbon intensity of industry and its decomposition

In how far does CESEE EU's relative position with respect to carbon, emission and energy intensity differ between *the internationally strongly exposed part of the economy* and the total economy? Here, the focus is on *industry*, defined as comprising the economic activities of mining (NACE B), manufacturing (NACE C[16]) and construction (NACE F). As pointed out above, for industry as an internationally exposed sector, measuring carbon intensity and energy intensity on the basis of GVA at market exchange rates is considered more appropriate. Accordingly, the *carbon intensity of industry* was on average almost 85% higher in the CESEE EU member states than in the EU-27, and 13% lower in the EU-16 (see table 5, first column). Thus, in CESEE EU countries, the order of magnitude by which industry's carbon intensity exceeded the EU-27 average was comparable to that of carbon intensity of GDP measured at market exchange rates. In Bulgaria but also Slovakia, Poland, Romania and Croatia, carbon intensities in industry were above the CESEE EU average, and again their levels were matched only by Cyprus and Greece among the EU-16. Industry's carbon intensities in Lithuania, Czechia and Hungary were ranked next, below the CESEE EU average but still 30% to 50% above the EU-27

[15] *Note that for a few economically smaller countries the resulting data are quite a bit surprising: For Malta and Cyprus and even more so for Portugal and Bulgaria, the share of fossil energy was strikingly low, implying a high share of renewables and biofuels. The fact that emission intensity was nevertheless above the EU-27 average might partly be explained by the share of coal in Bulgaria and the share of oil and petroleum in Malta and Cyprus, which made up the entire fossil energy share while there was no use of natural gas. Both explanations do not work for Portugal, however. At least, these data would suggest sub-optimal technology in using fossil energy in households resident in these countries.*

[16] *Excluding C19 (manufacture of coke and refined petroleum products) categorized under energy industries and C33 (repair and installation of machinery and equipment) categorized under services.*

Table 5

Decomposition of industry emissions

	Carbon intensity	Emission intensity	Energy intensity
Bulgaria	**319**	**133**	**240**
Greece	294	197	149
Slovakia	**237**	**120**	**197**
Cyprus	228	256	89
Poland	**206**	**140**	**147**
Romania	**201**	**148**	**135**
Croatia	**197**	**140**	**141**
CESEE EU	**184**	**127**	**145**
Luxembourg	148	97	154
Lithuania	**145**	**144**	**101**
Belgium	143	93	153
Portugal	142	107	133
Czechia	**140**	**109**	**129**
Hungary	**131**	**86**	**153**
Spain	120	116	103
Ireland	118	123	96
Slovenia	**117**	**113**	**103**
Latvia	**112**	**69**	**161**
Netherlands	112	90	124
Austria	101	92	110
EU-27	**100**	**100**	**100**
Estonia	**96**	**104**	**92**
France	93	105	89
Other EU	**87**	**94**	**93**
Italy	85	111	76
Finland	77	34	228
Germany	66	87	76
Sweden	64	47	138
Malta	49	102	48
Denmark	46	105	44

Source: Authors' calculations, Eurostat.

Note: Indexed values, EU-27/2019 = 100.

level, and close to their levels were those of the EU-16 subgroup with the second-highest levels (Luxembourg, Belgium, Portugal).

Emission intensities of industry in CESEE EU were on average 27% higher than in the EU-27 in 2019 (see table 5, second column). Thus, in CESEE EU countries, the extent to which industry's emission intensity surpassed the EU-27 average was roughly equally pronounced as in the case of the total economy's (GDP's) emission intensity. At the same time, both emission intensities surpassed the EU-27 average to a considerably lesser extent than the respective carbon intensities of industry and GDP exceeded the EU-27 average.

The combination of the carbon intensity of industry in CESEE EU that exceeded the EU-27 average to a very large extent and emission intensity that surpassed the EU-27 average to a considerably lesser albeit still substantial extent implies that the *energy intensity of industry* in CESEE EU was much higher than the EU-27 average, namely by 45% (see table 5, third column). Thus, like for carbon intensity, in CESEE EU countries, the order of magnitude by which industry's energy intensity exceeded the EU-27 average was comparable to that observed for energy intensity of GDP measured at market exchange rates, which was 67% higher than in the EU-27. Hence, CESEE EU's relative position with respect to industry's intensities was roughly comparable to its relative position with respect to GDP's intensities measured at exchange rates. In contrast, for GDP measured at PPP, CESEE EU's energy intensity and thus its carbon intensity exceeded EU-27 levels to a considerably smaller extent, leaving its emission intensity as the considerably more important factor for explaining its higher carbon intensity.

Note that four of the five CESEE EU countries whose industrial sectors recorded carbon intensity levels above the CESEE EU average (Bulgaria, Poland, Romania, Croatia but not Slovakia) were those (together with Lithuania) that showed above-average emission intensities. The same applies to Greece and Cyprus among the EU-16 countries. Slovakia registered particularly high energy intensity, and the same is true for Bulgaria, in addition to its emission intensity being only moderately above the CESEE EU average.

In almost all EU countries, more than half of industry's GHG emissions stem from *three manufacturing branches:* metal industry, chemical and petrochemical industry and non-metallic minerals. On average, their combined share amounted to 65% of GHG emissions in industry in the EU-27, 58% in CESEE EU and 67% in the EU-16 in 2019 (reaching even close to 80% in Lithuania, Luxembourg, Cyprus, Austria and Belgium, hence in several of the EU countries with the highest per capita emissions in industry). In contrast, these three branches together accounted for not more than 13.8% of total industry's GVA (at market exchange rates) in the EU-27, 11% in CESEE EU and 14.3% in the EU-16, with the highest share among the EU-16 countries seen in Belgium (32%) and, among CESEE EU countries, in Slovenia (21%). However, the output of these manufacturing branches constitutes important intermediate consumption goods for other branches of industry, like e.g. machinery, with substantial gross value added.

If we briefly turn to *agriculture, forestry and fishing as the other internationally exposed sector of the economy*[17], we see that the average carbon intensity in CESEE EU (based on GVA at market exchange rates) surpassed the EU-27 level by 40% – thus less strongly than in industry. Moreover, unlike what we saw for industry, there are more EU-16 countries (Ireland, Luxembourg, Belgium, Denmark) than CESEE countries (Poland, Bulgaria, Lithuania) in the group of countries whose carbon intensities are above the CESEE EU average, with intensity levels in Ireland and Luxembourg exceeding the Polish level. Overall in the EU-27, carbon intensity in agriculture is seven times higher than in industry. Note that agricultural GHG emissions do not primarily stem from final energy used but from agricultural processes, which would render decomposition into emission intensity and energy intensity less meaningful.

For the sake of completeness, note that *services* comprise a large number of economic activities as classified by NACE (C33, E, G, H52–53, I to S, and U) and their GVA constitutes a predominant share of the total economy's GVA (and GDP), but their overall carbon intensity based on PPP (given the largely nontradable character of services) amounts to only about one-sixth of total economy's carbon intensity in absolute terms in the EU-27. Thus, differences relative to the EU-27 average in services, have an only minor effect on the overall ranking of most economies' carbon intensity. Carbon intensity was about two-thirds higher on average in the CESEE EU member states than in the EU-27, while 10% lower in the EU-16.

2 The green transition pillar within recovery and resilience plans

The EU's Recovery and Resilience Facility (RRF), which was created with the intention to strengthen and steer EU member states' economic recovery after the adverse economic effects of the COVID-19 pandemic, provided an opportunity to advance the green transition agenda in CESEE EU member states. Having identified several areas where the need for action is particularly evident, this section looks at the green transition pillar forming part of each country's national recovery and resilience plan (RRP)[18].

[17] *Note that, also in this paragraph, we use emissions data without the impact of land use, land use change and forestry (LULUCF).*

[18] *Data used in this chapter were obtained from the European Commission (2022g, 2022h), including in particular the European Commission's Recovery and Resilience Scoreboard (2022f). Hungary's RRP data were not available at the time of writing. Information on measures included in the RRPs were taken from European Commission factsheets and European Commission assessments (2021a–p and 2022b–e).*

2.1 Overall size and structure of national recovery and resilience plans

As pointed out in the introduction, this section offers a bird's-eye view on the RRPs' size and structure, instrumental to the aim of this study to complement the country-specific and sectoral stocktaking of GHG emissions and related intensities with a broad comparison of the structure of emissions and the allocation of green spending under the RRPs. For more detailed as well as more comprehensive assessments of RRPs, please refer to the official assessments by the European Commission and the critical assessments of draft RRPs provided by the Green Recovery Tracker (see Green Recovery Tracker, 2021a–i), a project launched by the Wuppertal Institute and E3G. Reviewing the work done in this framework, Heilmann and Lehne (2021) concluded that most early drafts fell short of the 37% climate spending target. Subsequent drafts did improve in their view but were still not seen as transformational. Further criticism touched upon the lack of decisive reforms (such as tackling national regulatory hurdles that are holding back renewable energy development) and weak points with respect to the drafting processes (which in part involved the compilation of pre-existing projects rather than strategic thinking and suffered from a lack of public involvement). In addition, the Climate Action Network (CAN) Europe and CEE Bankwatch Network (2022) published a report that provides detailed critical assessments of individual climate-related measures envisaged in the RRPs of seven CESEE EU member states. Moreover, the report also identifies investments and reforms that were not included but should have been included in the view of the authors.

Turning to the overview on RRPs, it is worth noting that CESEE EU member states are among those EU countries that are entitled to receive comparatively large amounts of RRF grants when compared to their GDP. Maximum allocation of multiannual RRP grants (for payout in the years 2021 to 2026) as a percentage of annual GDP in the year 2021 amounts to between 8% and 10% in Bulgaria and Croatia and stands between about 3% (Estonia, Slovenia, Czechia) and 6% (Slovakia) in the remaining CESEE EU countries. In the CESEE EU aggregate, this ratio amounts to 4.5%. Among the EU-16 member states, Greece (9.5%) matches the level of Croatia and Bulgaria, followed by Portugal (7.5%); Spain (6%), Cyprus and Italy (each 4%) come next, lying in the range of the other CESEE EU countries. In contrast, Luxembourg, Ireland and Denmark receive the lowest amounts of multiannual RRP grants, reaching not more than 0.5% of GDP 2021. On top of grants, EU member states are entitled to apply for loans amounting to 6.8% of GNI at terms and conditions that are favorable for the majority of member states, including all CESEE EU member states. Remarkably, among CESEE countries, only Romania requested the full amount of available loans, as did Italy and Greece. While the RRPs of Poland and Slovenia involved requests for portions of the available loans, other CESEE countries opted for relying on grants only. Hence, the full potential of the RRF is not going to be used. In several CESEE countries, this might signal authorities' awareness of some limits of absorption capacity and/or their aim to contain the rise in public indebtedness already pushed up by the pandemic-related crisis.

The RRF regulation (European Union, 2021) obliged each member state to dedicate at least 37% of total RRP expenditures (i.e. grants) contained in its RRP to measures contributing to climate objectives (and at least 20% to digital objectives)[19]. Within CESEE countries, Bulgaria surpassed this benchmark with the widest margin (59%). Most CESEE countries (Slovakia, Poland, Slovenia, Czechia, Estonia, Romania and Croatia) show a climate spending share between 40% and 45%. Thus, this share tends to be somewhat higher in CESEE EU countries than in those EU-16 countries that are also set to receive similarly high amounts of RRF grants relative to GDP. In Greece, Italy, Portugal, Spain and Cyprus the share of expenditures devoted to climate objectives ranges from 37% to 41%. For all EU member states taken together (referred to as the "EU-27" but effectively EU-26, as Hungary's RRP data were not available at the time of writing), estimated climate expenditures amount to about 40% of their total RRF grants.

2.2 The structure of expenditure toward climate objectives under the RRPs

The *breakdown of expenditure toward climate objectives into policy areas* in chart 4 shows that, in most CESEE countries, the three most important areas are renewable energy and networks, energy efficiency and sustainable mobility. While in the EU-27 aggregate the combined share of these three areas makes up about two-thirds of expenditures toward climate objectives, in the CESEE EU countries the combined share ranges from about 50% in Slovenia to 95% in Bulgaria.

The relative importance of the three individual areas also varies widely across CESEE countries.

Bulgaria stands out with a particularly high share of expenditure for *renewable energy and networks;* Lithuania, Poland, Estonia, Croatia and Czechia also are above the EU average in this respect. Bulgaria inter alia defined the aim of tripling the power generation from renewables, and, at the same time, committed to set out a framework for the coal phaseout (phaseout as soon as possible and at the latest by 2038). In this context, Bulgaria's RRP also includes binding targets for the reduction of the CO_2 emissions associated with electricity generation by 40% below 2019 levels to be achieved by 2025[20] as well as a regulatory cap on carbon dioxide emissions from coal and lignite power plants applicable as of January 1, 2026. Various types of investments in renewables and grid and storage capacity are part of most CESEE countries' RRPs. The Polish RRP envisages funding for off-shore wind energy plants and terminal infrastructure, as well as regulatory changes facilitating the construction of onshore wind energy plants. In parallel, the Polish RRP is based on the National Energy and Climate Plan 2021–2030 and a strategy entitled Energy Policy of Poland until 2040 (Polish Ministry of Climate and Environment, 2021), which provides for a reduction of the share of coal in electricity generation to 56% by 2030 (from 73.6% in 2019) and 11% to 28% in 2040 as well as the abandonment of direct use of coal in households in cities by 2030 and in rural areas by 2040. This strategy is currently under review, following the Russian invasion of Ukraine. On top of this, in late 2020, the Polish government and trade unions agreed a plan to phase out coal mines by 2049. Czechia had a coal phaseout

[19] *The RRPs had to specify and justify to what extent each measure contributes fully (100%), partly (40%) or has no impact (0%) on climate and/or digital objectives. The contributions to climate and digital objectives have been calculated using Annexes VI and VII of the RRF Regulation, respectively. Combining the coefficients with the cost estimates of each measure makes it possible to calculate to which degree the plans contribute to climate and digital targets.*

[20] *However, in early 2023, Bulgaria's parliament agreed that the interim government should start talks with the European Commission and backtrack from this commitment.*

target of 2038 at the time of drafting the RRP. However, in early 2022, the Czech government announced plans to prepare for the phaseout of coal already by 2033. In Romania, the RRP includes reforms to phase out coal-based power production by 2032.

In some CESEE countries, the *use of biomass as a renewable energy source* for heating and electricity generation is a critical issue due to sustainability concerns (see Heilmann et al., 2020). In the context of the EU recovery and resilience plans, an important criterion is the "Do no significant harm" (DNSH) principle[21]. It is worth mentioning that in the framework of Czechia's RRP investment in biomass (with the aim of reducing coal combustion for heat production and electricity generation) is subject to specific conditions and the sustainability criteria for renewable energy sources set out in the EU's Renewable Energy Directive (RED II)[22]. Only biomass waste and residues that can be extracted in a sustainable manner shall be used. Moreover, milestones under the RRP include an assessment for the decarbonization of district heating as well as of the trajectories of sustainable use of bioenergy and supply of biomass to be prepared by the Czech authorities (see Council of the European Union, 2021). Within other CESEE countries' RRPs, biomass projects are also linked to certain criteria and conditions and must comply with the RED II. In Romania, reform measures contained in the RRP aim at combating illegal logging and setting out sustainability criteria for forest biomass for energy use.

The share of spending for *energy efficiency* is particularly high in Slovakia, and it is also above EU average in Latvia, Czechia, Bulgaria and Romania. Expenditures in this area reflect, to a considerable extent, renovation initiatives with regard to public and private buildings. (For a more general discussion on EU policies aimed at reducing emissions related to buildings, see Rochet et al., 2021.) Yet, some countries' RRPs also contain measures to promote energy efficiency in industry (e.g. Croatia, Romania, Slovenia, Slovakia and Poland), hence supporting industry decarbonization.

In Romania, Latvia and Lithuania, the share of planned expenditures for *sustainable mobility* is above the EU average share. Key measures include: investments in railway and urban transport infrastructure in Romania; an overhaul of the Riga metropolitan area transport in Latvia; phasing out the most polluting road transport vehicles (private, public and commercial); and increasing the share of renewable energy sources in the transport sector in Lithuania. Hanzl-Weiss (2022) points to the fact that CESEE's automotive industry lags behind in car electrification, possibly also due to dependency arising from foreign ownership. In a joint EIB-OeNB-wiiw study (Delanote et al., 2022), the authors criticize the apparent lack of attention given to this issue in the RRPs of most countries. One might, however, argue that the gap in public transport is even more critical.

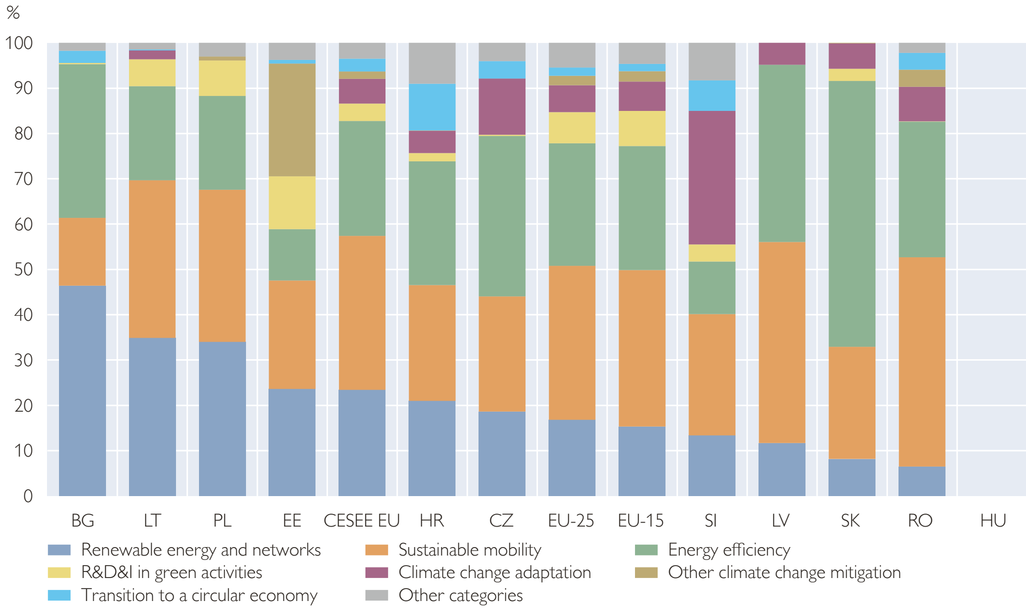
Going beyond these main three policy areas, chart 4 shows that some CESEE countries (Estonia, Poland, Lithuania, Slovenia, Slovakia and Croatia) have earmarked RRF funds for *research, development and innovation (R&D&I) in green activities*, with Estonia and Poland lying above the EU average.

[21] *'Do no significant harm' technical guidance (2021/C58/01).*

[22] *In particular, see Article 29 of Directive 2018/2001 on the promotion of the use of energy from renewable sources (Renewable Energy Directive, RED II).*

Chart 4

Breakdown of expenditure toward climate objectives into policy areas



Source: European Commission.

Note: Each recovery and resilience plan must dedicate at least 37% of the plan's total allocation to climate objectives. To this end, the plans have to specify and justify to what extent each measure contributes fully (100%), partly (40%) or has no impact (0%) on climate objectives, using Annex VI of the RRF Regulation. Combining the coefficients with the cost estimates of each measure makes it possible to assess to what degree the plan contributes to climate objectives and whether it meets the 37% target. No data available for Hungary and the Netherlands (hence EU-15 instead of EU-16). Countries ordered by size of the share of renewable energy and networks in % of total expenditures.

It is also worth highlighting that Estonia shows a relatively high share of expenditure in the area of *other climate change mitigation*. This reflects measures aimed at speeding up the green transition in the business sector, inter alia through a green fund set up to finance innovative green technologies that contribute to solving environmental problems.

Expenditure for *climate change adaptation* plays a large role in Slovenia and is also above the EU average in Czechia and Romania, with measures addressing flood risks being part of the RRPs in these three countries.

Croatia's RRP features a relatively high share of expenditures devoted for the *transition to a circular economy* (e.g. investments to upgrade water and wastewater systems). Compared to the EU average, this policy area also plays a larger role in Slovenia (e.g. upgrading energy-efficient wastewater and drinking-water systems), Czechia (e.g. constructing recycling infrastructure and generating water savings in the industrial sector), Romania (e.g. investments in municipal waste management systems) and Bulgaria (e.g. support for companies in modernizing their technology and in their transition to green and circular business practices).

3 Conclusions

Taking stock of GHG emissions in the European Union in 2019 shows that *emissions per capita were equal on average in CESEE EU and in the EU-16* (i.e. non-CESEE EU), with sizable heterogeneity in both country groups. The *CESEE EU aggregate showed considerably larger shares of total GHG emissions from energy industries* (reflecting inter alia the demanded volume of energy supply) and *from waste* and *from fugitive emissions from fuel*, implying correspondingly higher per capita emissions in these sectors. While a comparison of per capita emissions is useful as a first point of orientation, one also must consider that per capita income levels are still lower in the CESEE EU country aggregate than in the EU-16 country aggregate. Hence, the *carbon intensity (measuring GHG emissions per unit of GDP) was substantially higher in CESEE EU than in the EU-16*. This reveals the urgent need for further lowering emissions in order to enable further per capita income convergence within ecologically sustainable limits.

The comparatively *higher GDP-based carbon intensity* in all CESEE EU countries *resulted mainly from higher emission intensity* (measuring GHG emissions per unit of energy used), *but also from above-average energy intensity* (measuring energy used per unit of GDP). This outcome indicates that both saving energy and expanding low-emission sources of energy, particularly renewable energy, are even more urgent challenges for the CESEE EU countries than for the EU-16. The *higher GDP-based emission intensity* in CESEE EU resulted mainly from energy industries for generation of electricity and heating/cooling. Moreover, higher GDP-based emission intensity is being driven up by the emission intensity of industry and, particularly in Poland, by the intensity of emissions directly generated within residential buildings due to the widespread use of coal. The comparatively *higher carbon intensity of industry* in CESEE EU resulted mainly from higher energy intensity.

How do the results of our stocktaking exercise relate to the CESEE EU countries' spending preferences within climate-related RRP expenditures? Overall, the ex ante allocation of spending within climate-related expenditures in the framework of CESEE EU RRPs described in section 2 appears to be broadly appropriate, in as far as the *three largest spending categories* relate to areas where weaknesses emerged in CESEE. We caution that in no way should this be regarded as a sufficiently detailed assessment of whether the RRPs are adequate in general or whether individual measures envisaged in these plans are sufficient in terms of content or timeliness. The focus on *renewable energy and networks* is particularly important in view of the fact that, in CESEE EU, per capita GHG emissions in energy industries (generation of electricity and heating/cooling as well as refineries for oil products and coke ovens) were on average more than 50% higher than in the EU-16 despite the lower per capita GDP level. At the same time, we appreciate that the RRPs do not endorse the expansion of any type of renewable energy production but must comply with the "do no significant harm" principle and sustainability criteria. Therefore, regarding the use of biomass, only biomass waste and residues that can be extracted in a sustainable manner shall be used and reforms and milestones that advance such types of biomass shall be implemented in the context of the RRPs. The focus on *energy efficiency*, that is the inverse of energy intensity, at first glance does not appear to be much more important in CESEE EU than in the EU-16 if energy intensity based on GDP at PPP is taken as the yardstick, while in fact it certainly is an urgent challenge for the EU-16 and hence for CESEE EU, too. Moreover, if we look at energy intensity based on GDP at exchange rates or at energy intensity in industry, the need for catching-up in CESEE EU is still quite substantial indeed. More specifically, energy-saving measures, particularly in residential and commercial or institutional buildings, would be instrumental in lowering per capita emissions generated directly within these buildings and lowering per capita emissions in energy industries, which are far higher in CESEE EU than in the EU-16. The focus on *sustainable mobility* at first sight appears to be even less important in CESEE EU than in the EU-16 when looking at per capita GHG emissions in transport. However, as argued above, both the far more dynamic rise of these emissions in CESEE EU and the expectation of gradual structural alignment of CESEE's participation in international aviation call for sustainability-oriented action in the transport sector early on.

Looking into country-specific spending preferences generally confirms the broad picture for the three largest climate-related spending categories in RRPs, even though some questions arise. In the area of *renewable energy and networks*, the above-average shares of expenditure in Bulgaria, Poland, Estonia and Czechia address these countries' far above-average per capita GHG emissions in energy industry. In this area, coal phaseout is an important issue in the small group of countries that still use coal to a non-negligible extent in energy industries for generation of electricity and heating/cooling and directly in the residential sector (households). It appears that this issue is generally addressed in the RRPs or in related plans and strategies, but to different extents and with quite different time frames concerning the coal phaseout. While the RRPs of Bulgaria and Romania refer explicitly to their plans to phase out the use of coal, Czechia and Poland published phaseout targets only in related documents. Romania appears to pursue the most ambitious target, while Poland seems to have positioned itself at the other end of the spectrum with reduction targets for coal-based power production to be achieved by 2030 and 2040 but no clear target year for the ultimate phaseout. It would be highly welcome if Poland set an ambitious target date for the ultimate phaseout of coal-based power production and adopted a more ambitious approach with respect to the phaseout of coal use by households in rural areas (combined with a strong effort to promote heat pumps).

In the area of *energy efficiency*, the above-average shares of expenditure in Latvia and Bulgaria address their considerably above-average energy intensity based on GDP at PPP, and in Slovakia and Czechia, spending reflects intensities that exceed the average as well, albeit by a smaller margin. In the case of Estonia, which also shows high GDP-based energy intensity, only a rather modest share of total RRP spending explicitly addresses energy efficiency (especially in dwellings); but the particularly large and somewhat opaque item of "green transition in business" may inter alia advance economy-wide energy efficiency. For Latvia and Bulgaria, it would be important that their energy efficiency plans also comprise significant measures for industry, given the high intensity levels in their industrial sectors. However, the Bulgarian RRP measures for industry contain an only moderate share that contributes to climate objectives and the Latvian RRP hardly mentions climate issues related to industry. In contrast, it is particularly welcome that Slovakia's energy efficiency plans also cover the industrial sector, given the particularly high energy intensity of that sector. In this context note that also the RRPs of Croatia, Romania and Poland address their above-average energy intensities in industry. In view of the above-mentioned fact that energy-saving measures also help lower per capita emissions in energy industries, a larger general effort to promote energy-saving measures would be very welcome in Poland, given its far above-average per capita emissions in energy industries.

In the area of *sustainable mobility*, the above-average shares of expenditure in Lithuania, Latvia and Romania address the fact that the per capita GHG emissions in transport were considerably above the EU-27 average in Lithuania and Latvia and that the growth rates of these emissions were particularly high in these two countries and in Romania. In Slovenia, characterized by high per capita GHG emissions in transport, and in Poland, where transport emissions grew particularly rapidly, expenditures for sustainable mobility also play an important role, accounting for the largest share in both countries' total RRP spending, though they do not exceed the corresponding spending share for the EU-27.

Apart from these three major climate-related spending categories, note that the category of *transition to a circular economy*, which particularly includes waste management and wastewater treatment, accounts for an above-average share of spending within the RRPs' climate-related expenditures in Croatia, Czechia and Bulgaria (among others), hence in those countries where (together with Hungary) per capita GHG emissions from waste are above the CESEE EU average and between 50% and 110% higher than in the EU-16.

To sum up, the national recovery and resilience plans of CESEE EU member states form part of a sizable EU-coordinated policy intervention effort. Overall, the ex ante allocation of spending within climate-related expenditures under these plans appears to be broadly appropriate in general, in as far as the three largest spending categories relate to areas where CESEE countries exhibit particular weaknesses. Future research may use the updated dataset on climate-related intensities for deriving an output-/performance-based ex post assessment of the actual achievements of this policy effort. But there is ample room for further research even today. One strand could be to add further elements to the emission-related analysis. For instance, a country- and sector-specific dynamic perspective could enrich the analysis and add to policy insights. Also, a look at the country-specific efficiency in electricity and heat supply (e.g. relating energy input to energy output) would be interesting. Another strand would be to scrutinize in depth the wide range of measures envisaged under the RRPs to derive detailed policy assessments and recommendations on top of the already existing literature.

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