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Climate Change Research

Quantifying the Implications of the Paris Agreement for the Czech Republic

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***NB**: All views contained with this report are attributable solely to the authors and do not necessarily reflect those of researchers within the wider Tyndall Centre.*

1. What is the remaining carbon budget of the Czech Republic (in tonnes of CO_2) until 2030 and until 2050 so that the increase in the average global temperature is maintained up to 1.5°C or 2°C, respectively?

In the 2015 Paris Agreement the nations of the world committed to "[holding] the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels". The Agreement requires all countries to bring global greenhouse gas emissions to a peak as soon as possible, with developed countries taking the lead, recognizing that peaking will take longer for developing country Parties[1]. The global carbon budget is the maximum quantity of carbon dioxide that can be emitted for a given likelihood of breaching a particular temperature threshold.

The difference in impacts between 1.5°C and 2°C has been established by IPCC scientific review and documented in the Special Report on Global Warming of 1.5°C (IPCC 2018), known as "SR1.5"[2]. Nevertheless, the language of the Paris Agreement is of a *single* objective that produces an outcome well below 2°C *and* pursues efforts towards 1.5°C. Moreover, smaller carbon budgets associated with lower temperature targets (e.g. 1.5°C) face proportionally greater uncertainties than larger budgets associated with higher temperature targets. For these reasons, a single budget is provided here, which encapsulates the objectives of the Paris Agreement, while avoiding the greater uncertainties of smaller budgets associated with higher chances of 1.5°C.

Using the IPCC's scale of likelihoods[3], the Paris Agreement may be conservatively transposed into somewhere between a 'likely' chance of staying below 2°C and 'unlikely' for pursuing 1.5°C. Anderson et al 2020 adopted a global carbon budget[4] of 900 billion tons of CO_2 ($GtCO_2$) to reflect these temperature objectives and probabilities. This budget was selected from a range given in SR1.5[5], whereby 900 $GtCO_2$ relates to a likely peak warming of 1.7°C above a 1850–1900 baseline, with an equal expectation (fifty–fifty) of temperature change being higher and lower. The likelihood of remaining below 1.5°C is less than 33% for

[1] This is the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC).
[2] There are compelling reasons to pursue 1.5°C in terms of reduced risk of harm to vulnerable populations, food security, water supply, and loss of unique and valuable ecosystems. Vulnerable communities, particularly in Least Developed Countries, will be severely impacted at 1.5 °C, with impacts getting considerably worse at 2°C and beyond. For example, up to 50% fewer people globally may experience water scarcity by restricting global warming to 1.5°C than at 2°C (IPCC 2018). In terms of food security, the IPCC note that there is considerable variability between regions for these impacts, meaning that impacts will be significantly worse in more vulnerable communities. Furthermore, as temperature rises beyond 1.5°C, the direct and indirect effects will be increasingly felt by all communities, such as through reductions in pollinating insects and crop failures, inundation of freshwater supplies, and changes in rainfall patterns. In already vulnerable communities, such stresses will compound existing tensions such as population movements, civil unrest, and resource allocation.
[3] In its guidance to authors, the IPCC (2010) provides a taxonomy of likelihoods that can be used to translate qualitative language into quantitative probabilities. Following a sequential logic from the language of the Paris Agreement through the IPCC's scale of likelihoods, the Agreement may be conservatively expressed as between a 'likely' (66–100% probability) chance of reaching 2°C and 'unlikely' (0–33%) for 1.5°C.
[4] From January 2018 onwards.
[5] SR 1.5, Table 2.2, (IPCC 2018).

this budget, whereas the likelihood of staying below 2°C is over 66%. Thus, Anderson et al argue, 900 $GtCO_2$ reflects the intention to 'hold the increase in the global average temperature to well below 2°C' while pursuing efforts to 1.5°C.

Appropriate allowances are then made for climate feedbacks, global deforestation, cement production and two years of emissions (2018/19), which together reduce the post-2020 Paris-compliant global budget for energy consumption to 656 $GtCO_2$. This is then shared between "developed country parties" and "developing country parties", as distinguished in the Paris Agreement, to reflect their differing respective mitigation responsibilities and capabilities[6].

Anderson et al used a pragmatic and iterative approach to resource sharing between the groups of developed and developing countries. Indicative CO_2 pathways for the group of developing countries were generated first. In recognition of the Paris Agreement's principles of equity, the most ambitious feasible peak date (2025) and mitigation rates (ramping up to 10% per year) were assumed for developing countries. The remainder of the global carbon budget was then apportioned to the group of developed countries.

Anderson et al proposed a Paris-compliant emissions budget for the group of developed countries (including the Czech Republic) of 136 $GtCO_2$, which may be emitted by all forms of energy consumption, from transport to electricity, after and including 2020.

There are various regimes for apportioning a finite carbon budget, some according to population, others by historical emissions, yet others guided by economic indicators such as GDP. Each method has advantages and disadvantages. The regime we judged most appropriately reflects national circumstances within the developed countries is 'grandfathering', whereby each nation receives a share of the future carbon budget in line with its recent proportion of emissions. Grandfathering essentially captures many elements of the other regimes – from structural lock-in of existing infrastructure through to the economic wherewithal to make rapid changes (Anderson and Stoddard, 2020).

For this analysis, we used grandfathering to downscale the global carbon budget remaining for developed countries from the start of 2021[7] down to the EU-27 group of countries[8].

[6] Anderson et al offer two slightly different categorizations of developed and developing countries. The first categorization follows the UNFCCC Annex 1 / non-Annex 1 distinction. In the paper Anderson et al refer to these groups as DD1 and DG1 for developed and developing countries, respectively. The second categorization assesses countries according to their Human Development Index rating, reallocating wealthy oil-producing nations with high HDI scores to the developed country set. These groups are referred to in the paper as DD2 and DG2 for developed and developing countries, respectively. The analysis for this report follows the latter categorization.

[7] Emissions in 2020 are assumed to be 11% less than 2019, based on the central estimate of reductions in European countries due to the COVID-19 pandemic confinement measures given by the Global Carbon Project.

[8] EU-27 CO_2 emissions (including international aviation and shipping) in 2018 accounted for just over 20% of CO_2 emissions from the group of developed countries (the group of countries referred to in Anderson et al 2020 as 'DD2', identified in the supplemental information appendix C to that paper).

This yielded a budget for the EU-27 of around 30 $GtCO_2$. Finally, grandfathering was used again to allocate a proportionate 3.5% share of the EU-27 budget to the Czech Republic[9].

The carbon budget for the Czech Republic from the start of 2021 to the end of the century and beyond is thus estimated to be around **800 $MtCO_2$**. This is referred to as the post-2020 budget. To put this into context, it is equivalent to fewer than eight years of current emissions from the Czech Republic.

An illustrative budget for the Czech Republic for the period from November 2017 onwards was also requested by the client, reflecting the date of the Czech Republic's accession to the Paris Agreement. Temperature-derived global budgets in SR1.5 (IPCC, 2018) are for January 2018 onwards, which is in any case the first full year of the Czech Republic's participation in the Paris Agreement. As such, for this report a Czech emissions budget has been retrospectively calculated from an EU-27 emissions budget for the same period (34 $GtCO_2$), estimated at around **1,100 $MtCO_2$**. This is referred to as the post-2017 budget.

Global budget (from Jan 2018)	**900 $GtCO_2$**		
	< 1.5°C *< 33%*	*1.7°C* *50%*	*< 2°C* *> 67%*
Developed Countries (from Jan 2020)	**136 $GtCO_2$**		
EU-27 (from Jan 2021)	**30 $GtCO_2$**		
Czech Republic (from Jan 2021)	**800 $MtCO_2$**		
EU-27 (from Jan 2018)	**34 $GTCO_2$**		
Czech Republic (from Jan 2018)	**1,100 $MtCO_2$**		

Table 1. Global, regional and national Czech budgets for CO_2 from energy consumption associated with an even chance of 1.7°C, and a good chance of staying well below 2°C.

2. Propose a simple ideal CO_2 reduction pathway for the Czech Republic from 2017 (i.e. the year the Czech Republic became a party to the Paris Agreement) to 2030 and 2050, which would lead to maintaining the "carbon budget" of the Czech Republic for rising temperatures to 1.5 °C and 2°C.

Figure 1 below shows the post-2017 CO_2 pathway for the Czech Republic extrapolated from the post-2017 Paris-derived budget. This is a counterfactual pathway (that is to say, it did not occur) and as such the illustrative pathway follows a simple equal annual percentage reduction of 8.3% from 2018 and every year onwards (Table 2).

[9] Czech Republic's mean emissions 2014-2018 were just over 105 $MtCO_2$, or 3.44% of the EU-27 emissions in 2018.

To reiterate, the **post-2017 pathway is for illustrative purposes only,** to show the annual reductions necessary to respect the Paris-derived carbon budget that remained to Czech Republic at the start of 2018. However, documented historical emissions in 2018 and 2019, and estimated emissions in 2020, have exceeded the post-2017 pathway, consuming a significant portion of the budget (the post-2017 budget of 1,100 $MtCO_2$ is not shown on Figure 1 but corresponds to the area under the post-2017 pathway curve).

For clarity, and to reflect documented, real-world emissions up to the end of 2020, Figure 1 also shows a post-2020 pathway of annual emissions reductions that are aligned with the Paris-derived post-2020 budget for the Czech Republic.

Again, it must be stressed that the Czech Republic cannot simply bring down its annual emissions to 're-join' the post-2017 pathway in 2021 and still conform to a 2°C budget, because emissions have exceeded the post-2017 pathway for the last three years. Rather, to respect a Paris-derived budget from January 2021 onward, annual percentage reductions need to be significantly greater than if sufficient mitigation had begun in 2018. **For the purposes of actual mitigation policy going forward from 2021, the post-2017 pathway is now void.**

As shown in Figure 1, the post-2020 pathway is noticeably steeper than the post-2017 pathway. This reflects that *de facto* emissions already released since 2017 cannot now be influenced, so have been subtracted from the post-2017 budget.

On the Paris-derived post-2020 pathway, annual emissions are reduced by 11.4% year on year from 2021, through 2030 (by when emissions are 75% lower than 2018) and remain constant at 11.4% per year through to 2050 (by when emissions are 98% lower of 2018) and beyond.

Note that given the constraints of the Paris-compliant post-2020 budget, if annual reduction rates are below 11.4% in the immediate term (2020–25), *much* steeper rates of reduction will be required in the short to medium term (2025–2030) to stay within budget.

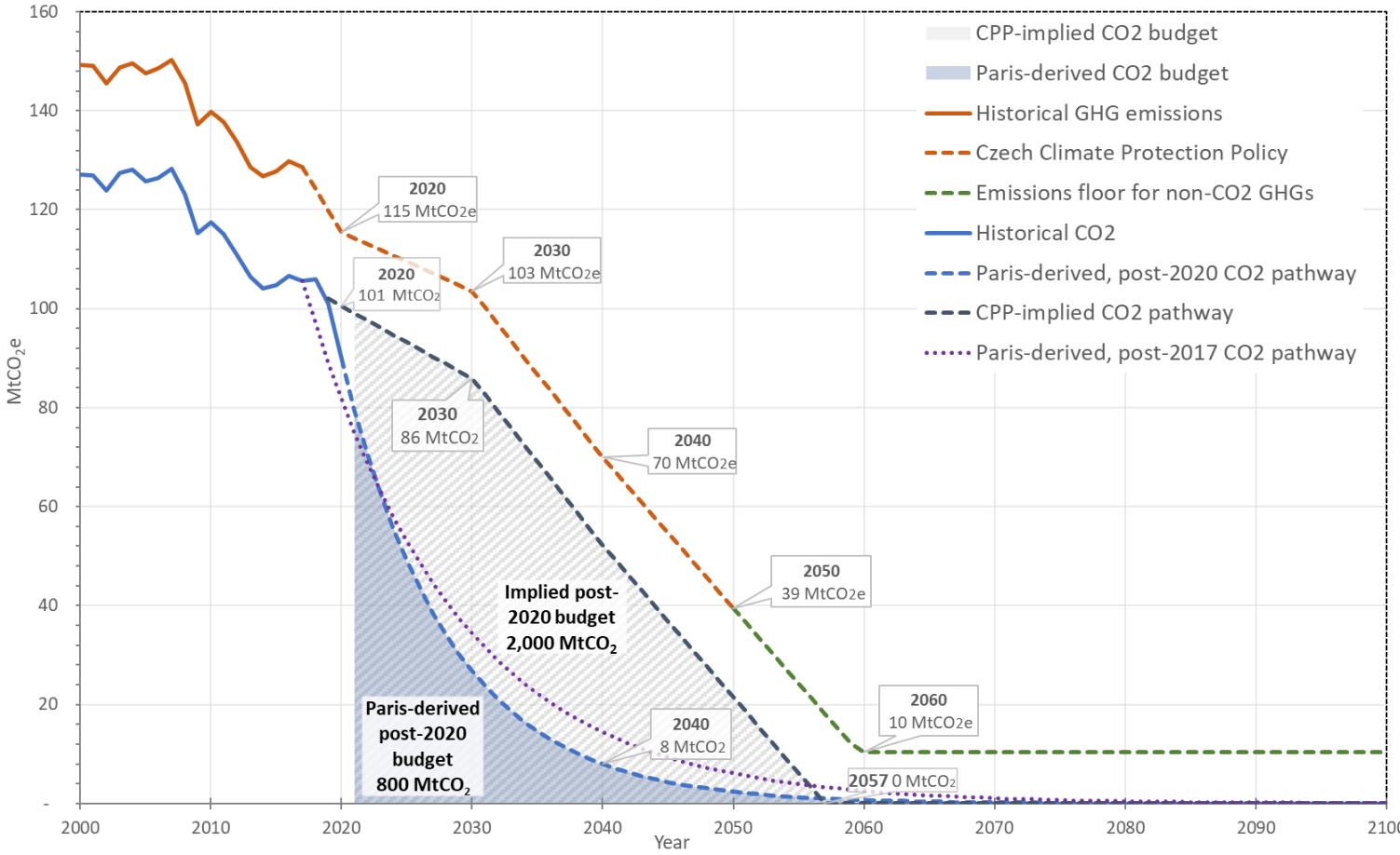

Figure 1. Emissions pathways and budgets for the Czech Republic. Note: both GHGs and CO_2 values exclude land use, land use change and forestry. CO_2 values are for energy use only (Sources: Global Carbon Project and UNFCCC).

Year	Annual CO_2 reduction rate	
	Post-2017 pathway	Post-2020 pathway
2018	8.3%	-
2019	8.3%	-
2020	8.3%	*11%*
2021	8.3%	11.4%
2022	8.3%	11.4%
2023	8.3%	11.4%
2024	8.3%	11.4%
2025	8.3%	11.4%
2030	8.3%	11.4%
2040	8.3%	11.4%
2050	8.3%	11.4%
2099	8.3%	11.4%

Table 2. Annual CO_2 emissions reductions for the Czech Republic for the Paris-derived CO_2 pathways in Figure 1.

3. What CO_2 emissions decrease (absolute and per cent) in the Czech Republic in 2030 (compared to 1990 and compared to the current state) would be necessary in order to achieve the level of emissions leading to the preservation of an increase in the average global temperature up by 1.5°C and 2°C?

Emissions pathways relate to global temperature increases only insofar as they conform to relevant temperature-derived budgets. End-point reduction targets (e.g. x% by 2030) lack a scientific basis and are a poor proxy for cumulative emissions. However, the post-2020 pathway outlined in Figure 1 and Table 2 above conforms to a budget explicitly derived from the Paris Agreement's objective to limit warming to well below 2°C and to pursue efforts to limit warming to 1.5°C.

Imposing such a tight cap on cumulative emissions leaves very little room for manoeuvre with annual reductions. As such, there are limited plausible pathways to delivering the Paris-derived budget. If reductions are lower in the early years (even by a few per cent), the budget is entirely consumed before the higher rates of reduction kick in.

The Paris-derived post-2020 pathway described in Figure 1 and Table 2 produces the following emissions reductions for the Czech Republic**. Note that these reductions are only aligned with the Paris Agreement temperature objective if the overall budget is respected by following the stated pathway.**

Values are not given in Table 3 for emissions reductions in future years on the post-2017 pathway, because the post-2017 pathway is now forfeit (void) and cannot be followed to deliver a 2°C-derived budget. As such it would be deeply misleading to suggest that emissions in future years on a forfeit post-2017 pathway have any meaning.

Year	Reduction compared to 2018		Reduction compared to 1990	
	$MtCO_2$	Per cent	$MtCO_2$	Per cent
2025	57	54%	115	70%
2030	79	75%	137	84%
2035	91	86%	150	91%
2040	98	92%	156	95%
2050	104	98%	162	99%

Table 3. Reductions in CO_2 emissions from energy consumption for Czech Republic compared to estimated 2018 emissions (106 $MtCO_2$) and 1990 emissions (164 $MtCO_2$) on the Paris-derived post-2020 pathway in Figure 1.

4a. Indicate the decrease in CO_2 emissions in the Czech Republic year-on-year since the accession of the Czech Republic to the Paris Agreement (2017) in absolute terms (Mt/year) and in per cent.

Year	Historical $MtCO_2$ (actual)	$MtCO_2$ reduction (actual)	Per cent reduction (actual)	Per cent reduction indicated by post-2017 pathway	$MtCO_2$ indicated by post-2017 pathway
2017	105.6	1.0	0.9%		
2018	105.9	-0.3	-0.3%	8.3%	97.1
2019	101.0	4.9	4.7%	8.3%	89.1
2020	*89.9*	*11.1*	*11.0%*	8.3%	81.7

Table 4. Actual annual reduction in CO_2 emissions (year on year) for Czech Republic since 2017, and emissions indicated by the Paris-derived post-2017 pathway. Emissions data are taken from the Global Carbon Project for 2017, 2018 and 2019. Emissions for 2020 are assumed to be down 11% on 2019, based on the central estimate of emissions sensitivity to the COVID-19 pandemic confinements in Europe given by Global Carbon Project (retrieved 11 December 2020).

4b. What year-on-year reduction would be needed for the Czech Republic to copy the CO_2 emissions trajectory to maintain a global temperature rise up to 1.5°C and 2°C?

Had the Czech Republic started to follow a pathway in January 2018 that conformed to a Paris-compliant, temperature-derived carbon budget, it would have needed to make annual year-on-year reductions of 8.3% (Table 2 and Table 4). However, in January 2021, the historical outturn in actual emissions 2018–2020 has been in excess of the post-2017 pathway. **Therefore, the post-2017 pathway is no longer compatible with a Paris-compliant carbon budget.**

To conform to a Paris-derived carbon budget from January 2021 onwards, the Czech Republic needs annual emissions cuts of 11.4% year-on-year (Table 2).

5. Compare the actual development of greenhouse gas emissions in the Czech Republic with the ideal curve of emission reductions (question 2), which would lead to maintaining a rise in global temperature to 1.5°C, resp. 2°C.

Emissions pathways that conform to temperature-derived budgets are essentially heuristic in nature. That is to say, pathways help us to understand the mitigation effort required to deliver on Paris Agreement commitments. Starting in January 2018, the Czech Republic *would have* needed annual emissions cuts of 8.3% year-on-year (dotted purple line in Figure 1) to conform to its Paris-derived post-2017 budget. In fact, actual Czech emissions (solid blue line in Figure 1) showed a small annual *increase* in 2018, breaking with a Paris-

compliant pathway in the first full year of the country's accession to the Paris Agreement.

2019 emissions showed a 4.9% reduction against 2018, but since the Paris-derived post-2017 pathway was already in jeopardy at that point, a much bigger reduction (well over 10%) would have been required in 2018 for any ongoing chance of complying with the underlying budget.

It is plain from the recent trajectory of CO_2 emissions in the Czech Republic that – the assumed suppression during the 2020 COVID-19 confinement notwithstanding – emissions are not reducing at anything like the rate required to deliver a Paris-compliant budget.

While the 11% decrease assumed for 2020 (cf. 2019) is salutary, it could easily be offset by a rebound in emissions in 2021 if stimulus measures are applied to boost economic activity. The expected 2020 downturn in emissions is emphatically not part of a recent downward trend in line with a Paris-derived budget and pathway. Excluding 2020, CO_2 emissions from energy in the Czech Republic have remained relatively stable since 2013.

From January 2021, rather than the piecemeal reductions and fluctuations in CO_2 emissions since 2013 (COVID-19 notwithstanding), the Czech Republic would have to begin immediate and rapid emissions reductions of 11.4% if it is to stay within its remaining, post-2020 Paris-compliant budget (light-blue dashed line on Figure 1). Note that overshooting this rate in the early 2020s by even half-a-per-centage point per year results in a much larger portion of the budget being depleted than if underachievement occurs in later years. Early underachievement potentially puts the budget beyond reach.

It bears repeating that the Paris-compliant post-2020 budget for the Czech Republic amounts to scarcely eight years' worth of current emissions (similar to other industrialised, developed countries such as the UK and Sweden).

6a. Compare the carbon budget (question 1) and the emission reduction pathway (question 2) with the CO_2 emission reduction targets for years 2020, 2030, 2040 and 2050 according to the Czech Climate Protection Strategy.

The emission reduction targets in the Czech Climate Protection Policy (CPP) are expressed as cuts in total greenhouse gases (GHGs) in 2020 and 2030 compared to 2005 levels, and as aspirational annual emission levels for total GHGs in 2040 and 2050 (Table 5).

Year	Target in Czech Climate Protection Policy	Translates to
2020	Cut GHGs by 32 $MtCO_2e$ cf 2005	115 $MtCO_2e$
2030	Cut GHGs by 44 $MtCO_2e$ cf 2005	103 $MtCO_2e$
2040	Indicative level of 70 $MtCO_2e$ GHGs	70 $MtCO_2e$
2050	Indicative level of 39 $MtCO_2e$ GHGs	39 $MtCO_2e$

Table 5. Emission reduction targets of the Climate Protection Policy of the Czech Republic and the annual emissions that the targets translate to.

However, global carbon budgets associated with temperature rise relate to CO_2 only. Carbon dioxide is the greenhouse gas of principal concern because it is emitted in far greater quantities than other GHGs and is atmospherically stable for hundreds to thousands of years. This means that CO_2 accumulates in the atmosphere and locks in the warming effect much more than short-lived gases, such as methane, which quickly degrades to CO_2 and water vapour. Nitrous oxide and the synthetic F-gases are long-lived in the atmosphere but are emitted in far smaller quantities than CO_2 and methane.

This makes it problematic to compare carbon budgets with NDCs and mitigation targets that are expressed in total GHGs, such as those in the Czech CPP. This difficulty is compounded by the frequent incorporation in national GHG inventories and mitigation targets of land use, land use change and forestry (LULUCF), which have a high degree of uncertainty.

National mitigation targets for total GHGs cannot be related back to temperature increases, because total GHGs includes gases with very different warming effects, from short-lived gases such as methane, through medium-lived gases such as N_2O, to long-lived gases such as CO_2 and F-gases.

However, in the absence of specific CO_2 reduction targets for the Czech Republic, in order to compare the Czech CPP GHG targets with the Paris-compliant CO_2 budget, it is necessary to first render the the policy targets as an 'implied GHG pathway'. This was done by following equal annual reductions in emissions of GHGs between the target years (2020, 2030, 2040 and 2050). This 'implied GHG pathway' is shown as the dashed orange line in Figure 1 above.

The implied GHG pathway is then used as the basis to estimate an equivalent pathway for Czech CO_2 emissions. Starting from the estimated level of CO_2 emissions in 2020, the implied CO_2 pathway mirrors the GHG trajectory to the point of zero emissions where it crosses the x-axis of the chart in 2057. While such a CO_2 pathway is not part of the Czech CPP, in the absence of any other policy measures or documentation it serves as a reasonable if very approximate guide to the amount of CO_2 likely to be emitted in pursuing the Czech CPP.

Note that unlike the implied CO_2 pathway, the implied GHG pathway does not reach zero, but plateaus at around 10 $MtCO_2e$ per year, to account for 'recalcitrant' or unmitigable emissions from agriculture (mostly methane).

Table 6 compares the cumulative CO_2 emissions implied by the Czech CPP targets with the Paris-derived carbon budget described in question 1.

	Czech Climate Protection Policy	**Paris-derived, post-2020 pathway**
Cumulative emissions budget	2000 $MtCO_2$	800 $MtCO_2$
Emissions in 2030	86 $MtCO_2$	29 $MtCO_2$
Emissions in 2040	52 $MtCO_2$	1 $MtCO_2$
Emissions in 2050	22 $MtCO_2$	~0 $MtCO_2$

Table 6. Budgets (for 21st century and beyond) and annual emissions for the CO_2 pathway implied by the Czech Climate Protection Policy and a budget derived from the Paris Agreement for the period post-2020.

6b. If CO_2 emissions were reduced globally only at the pace of Czech Climate Protection Strategy, what global temperature change in °C would that lead to?

Cumulative CO_2 emissions generated by the pathway implied in the Czech CPP are approximately 2.5 times greater than the Paris-compliant post-2020 budget for the Czech Republic. If every nation failed to deliver their respective Paris-compliant carbon budget by a factor similar to that of the Czech Republic's CPP, it would result in global cumulative emissions two and a half times greater than the IPCC's SR1.5 900 $GtCO_2$ budget (i.e. for a good chance of limiting warming to well below 2°C and pursuing efforts to towards 1.5°C).

That is to say, the Czech CPP is consistent with global emissions of 2300 $GtCO_2$, which would relate to holding the temperature rise to "well below 2.7 °C" and "pursuing … 2.1°C"[10].

[10] Based on Figure 2.3 in IPCC SR 1.5, 2018

References

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ERRATA (01.02.2021)

Table 4 stated that Czech CO_2 emissions in 2018 were 105.9 $MtCO_2$, a figure also alluded to in section 5. This was based on Global Carbon Project data embedded within the NDC.org website. However, after this report was drafted the GCP published new data, which updated values in all years, not just adding an extra year. At time of writing, the NDC.org value had not yet been updated to reflect the new 2018 value on GCP's Global Carbon Atlas.

The new values are highlighted in the revised table below. The difference is minor and does not affect the findings of this report.

Year	Historical $MtCO_2$ (actual)	$MtCO_2$ reduction (actual)	Per cent reduction (actual)	Per cent reduction indicated by post-2017 pathway	$MtCO_2$ indicated by post-2017 pathway
2017	105.6	1.0	0.9%		
2018	104.4	1.2	1.1%	8.3%	97.1
2019	101.0	4.9	4.7%	8.3%	89.1
2020	*89.9*	*11.1*	*11.0%*	8.3%	81.7

Table 4 – revised. Actual annual reduction in CO_2 emissions (year on year) for Czech Republic since 2017, and emissions indicated by the Paris-derived post-2017 pathway. Emissions data are taken from the Global Carbon Project for 2017, 2018 and 2019. Emissions for 2020 are assumed to be down 11% on 2019, based on the central estimate of emissions sensitivity to the COVID-19 pandemic confinements in Europe given by Global Carbon Project (retrieved 11 December 2020).

The final sentence of the first paragraph of Section 5 should now read:

> In fact, actual Czech emissions (solid blue line in Figure 1) showed *only a 1.1% reduction* in 2018, breaking with a Paris-compliant pathway in the first full year of the country's accession to the Paris Agreement.

Figure 1 has not been amended, but it should be noted that the 2018 historical emissions value (solid blue line) should be ever so slightly lower.