Calculation of an emissions budget for Switzerland based on Bretschger's (2012) methodology

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Dr. Yann Robiou du Pont,
Dr. Zebedee Nicholls

This scientific report is based on the most recent and best available science. The authors are uninfluenced as to form or content by the exigencies of litigation.

Dr. Yann Robiou du Pont is a researcher at Utrecht University. His current research is funded by a Marie Curie fellowship from the European Commissions, focuses on quantifying what are fair and ambitious contributions from national and subnational actors to align with the Paris Agreement mitigation goals. He holds a PhD from the University of Melbourne focused on quantifying equitable mitigation scenarios for all countries to meet the Paris Agreement goals. His results, published in *Nature Climate Change* and *Nature Communications*, visible on the Paris-Equity-Check.org interactive website that assesses the ambition of countries emissions pledges. His studies are used in IPCC and UNEP reports, court cases, by diplomats at UN climate negotiations and by national and subnational governments to set their emissions targets (net-zero target and 2030 NDC of the UK, the Government of Victoria).

His background is in physics, with a Magistère in fundamental physics and a Master in climate physics. Prior to his current research focus, he conducted research in physical oceanography (University of Harvard and Paris Sorbonne), hydrology (University of California, Berkeley), sea-ice modelling (McGill University) and cosmology (University of Oxford).

Full profile available at: https://www.uu.nl/staff/YRobiouduPont

Dr. Zebedee Nicholls is an expert from the University of Melbourne and the International Institute for Applied Systems Analysis (IIASA) in reduced complexity climate modelling. He is also the Modelling and Data Director at Climate Resource. His research focuses on the development, evaluation and application of reduced complexity models with a particular focus on the Model for the Assessment of Greenhouse gas Induced Climate Change (MAGICC).

Alongside A/Prof Malte Meinshausen, he leads the Reduced Complexity Model Intercomparison Project (RCMIP). In the IPCC's Sixth Assessment Report, he led the writing of Cross-Chapter Box 7.1 on reduced complexity models used for scenario classification in AR6, was a Contributing Author to WG1 Chapters 1, 4, 5, 6, 7 and Technical Summary and WG3 Chapter 3 and Annex C. He completed his PhD at the Climate & Energy College within the University of Melbourne's School of Geography, Earth and Atmospheric Sciences in 2021, and his undergraduate Masters course in Physics at St. John's College, University of Oxford, where his Master's thesis was supervised by Prof Myles Allen. He is currently working on the next phase of RCMIP, taking MAGICC open source and developing more regionally detailed emulators.

Full profile available at: https://findanexpert.unimelb.edu.au/profile/792896-zebedee-nicholls

1. Introduction

This report is drafted at the request of the Verein KlimaSeniorinnen and of the four individual applicants for the purpose of the proceedings in the case Verein KlimaSeniorinnen and Others v. Switzerland (Application no. 53600/20).

The request made to us on 1 April 2023 was as follows:

> *In the context of the proceedings of the Verein KlimaSeniorinnen and others before the European Court of Human Rights, the Verein KlimaSeniorinnen and the four individual applicants were provided by the Swiss State with a submission that had a Policy Brief of Lucas Bretschger dated March 2012 titled: Climate Policy and Equity Principles: Fair Burden Sharing in a Dynamic World as an annex. The Policy Brief presents a methodology to divide the remaining carbon budget for holding global warming below (the now outdated target of) 2 °C between countries based on "relevant equity principles" described in the paper. On the basis of this methodology, the Policy Brief presents budgets for several countries, but not for Switzerland.*
> *For these reasons, the Verein KlimaSeniorinnen and the four single applicants are seeking an expert analysis of the carbon budget for Switzerland for holding the global temperature increase to 1.5 °C, based on the methodology set out in the Policy Brief of Lucas Bretschger. More specifically, they ask the undersigned to provide the following results based on this methodology:*
>
> 1. *What is the remaining budget for Switzerland as of 2022 (or an earlier year, depending on the availability of emission data).*
> 2. *What is the year in which this budget would be depleted based on the implied emission trajectory set by the emission reduction targets proposed by the Swiss government (i.e. minus 34% by 2030 and net-zero by 2050).*
> 3. *What is the year that net-zero emissions would need to be achieved if Switzerland were to remain within this carbon budget, assuming a linear reduction as of 2022 (or an earlier year depending on the availability of emission data).*

We note that the version of Policy Brief (March 2012) provided to us in the context of this request does not seem to be published online. An updated version dated June 2012 is published on the website of the Swiss Federal Institute of Technology (ETH) in Zurich (link). A further updated version of the Policy Brief was published in October 2013 in the journal Environment and Development Economics Vol. 18, No. 5, pp. 517–536 (link). Both documents were provided to us. We found the methodology between the three versions of the study to be identical. The main differences between the three studies are that the more recent versions of the studies provide results for more countries. None of the versions of the study, however, present results for Switzerland and no results for Switzerland based on this study could be retrieved elsewhere.

For this reason, within the context of this report, the original modelling as described in the study has been replicated and updated with the Paris Agreement temperature target of 1.5 °C and historical emission data.

Model descriptions are shown as in the October 2013 article in the journal Environment and Development Economics. Where reference is made to "Policy Brief", this refers to all three versions of the study by professor Bretschger.

2. Description of methodology used in the Policy Brief

In this report, we calculate each country's share of the global budget following the methods described in equation (5) of the Policy Brief. The Policy Brief[1] calculates each country's share as:

$$Q_j = \frac{m_j.F_j}{\sum_{j=1}^{M} m_j.F_j}.Z,$$

where Q_j is the emissions budget allocated to a country j, m_j is the country's share of the global population, and Z is the total budget. F_j is calculated using equation (3) of the Policy Brief:

$$F_j = \left(\frac{E_j}{L_j}\right)^{0.25},$$

where E_j is the country's total emissions and L_j is the country's population. A country's fraction of the global budget increases with its per capita emissions, which is favourable to countries with high per capita emissions.
The Policy Brief proceeds to apply this formula, using data available at the time of publication, to derive the shares for different countries. These shares are then applied to global greenhouse gas (GHG) emissions budgets taken from Meinshausen et al. 2009[2]. As mentioned above, the Policy Brief does not present any results for Switzerland.

To consider the importance of historical responsibility, the Policy Brief uses four different models: from 'no responsibility' to full inclusion of historical emissions for the period starting in 1990 and ending in the latest available reported national emissions data, which was 2008 at the time the Policy Brief was written. When fully accounting for historical emissions, the Policy Brief calculates emissions budgets as of 1990 (using 1990 indicators), and then subtracts from this budget countries' historical emissions since 1990 to derive the remaining budget. For the scenario of assuming 'no responsibility', the Policy Brief calculates the emissions budget directly at the year of interest (that was 2008, the time of the latest available data in the Policy Brief).

3. Brief critique of the methodology

As described in the ANNEX, based on the methodology in the Policy Brief, Switzerland's budget as of 2016 (the year after the Paris Agreement was signed) is 0.1201% of the global budget. We note that the budget share resulting from this methodology is larger than Switzerland's share of the global population in 2016 which was around 0.1117%.

[1] Lucas Bretschger, Climate Policy and Equity Principles: Fair Burden Sharing in a Dynamic World Center for Economic Research at ETH Zurich, Policy Brief 12/16, March 2012.
[2] Meinshausen, M., Meinshausen, N., Hare, W. *et al.* Greenhouse-gas emission targets for limiting global warming to 2 °C. *Nature* **458**, 1158–1162 (2009). https://doi.org/10.1038/nature08017

The Policy Brief approach is, in general, favourable to developed nations compared to the literature on equitable budget-sharing approaches. Rather than the standard equity approach of giving less to countries who have emitted in the past, the Policy Brief approach gives higher shares to countries that currently have higher per capita emissions. The capability of countries does not affect the fair share. Approaches based purely on equity principles, including responsibility and capability, would give Switzerland significantly smaller shares than those presented here.

The Policy Brief explains that it adds aspects of costs and technological feasibility to increase the political acceptance of its results. In the academic literature on effort-sharing, considerations on the fairness of the responsibility for emission reductions (who pays) are separated from where these reductions take place.[3] Given the focus of the Policy Brief on the inclusion of costs, technological feasibility and political acceptance, the methodology is not appropriate to inform emission targets as a fair-share of a collective goal, which can be met with international support, as is the case with the target communicated by Switzerland in its NDC.

4. Applied assumptions for updated modelling

To calculate a 1.5 °C emissions budget for Switzerland based on the methodology of the Policy Brief, we directly use the equation (5) from the Policy Brief as described in the previous section.

We updated the underlying data and parameterisation to reflect the latest available inventories and findings on carbon budgets. In this section, we set out the most important choices and assumptions used in this report. In the ANNEX to this report, we provide a detailed step by step description of all the modelling steps taken.

The Policy Brief used the global GHG budget as the starting point for its calculations. Here, we use the global carbon (CO_2) budget for 1.5 °C from the most recent IPCC report as a starting point. After determining Switzerland's CO_2 budget based on the methodology in the Policy Brief, we convert the budget into a GHG budget.

The updated emissions budget for Switzerland is calculated as of 2016, instead of 2008 as in the original Policy Brief. The date of 2016 is chosen to reflect the information available as of 2015 (the year in which the Paris Agreement was signed) regarding the remaining emissions budget, including information which could be used to set an emissions target for 2030. The budget allocated remaining as of 2022 (the year after the most recent available historic emissions data) is the 2016 budget minus Switzerland’s emissions between 2016 and 2022.

[3] Section 6.3.6.6, p. 456-461 of: Clarke L., K. Jiang, K. Akimoto, M. Babiker, G. Blanford, K. Fisher-Vanden, J.-C. Hourcade, V. Krey, E. Kriegler, A. Löschel, D. McCollum, S. Paltsev, S. Rose, P. R. Shukla, M. Tavoni, B. C. C. van der Zwaan, and D.P. van Vuuren, 2014: Assessing Transformation Pathways. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Regarding the parameterisation, we only model the case that does not account for historical emissions, which is consistent with the 'no historical responsibility' quantification in the Policy Brief. This choice has been made due to the time constraints for preparing this report. A full analysis reflecting all the parameterisations of the Policy Brief would account for historic emissions prior to 2016. Compared to accounting for historical emissions since 1990, not accounting for historic emissions prior to 2016 yields greater emissions budgets for countries with higher historical per capita emissions than average, such as Switzerland. This can, for instance, be seen in the results in the Policy Brief for countries such as Germany or the USA that have smaller budgets when accounting for more historical emissions. The results presented here are thus favourable to Switzerland based on this methodology, and can therefore be seen as a generous parameterisation of the approach presented in the Policy Brief for Switzerland.

5. Results

Applying the Policy Brief's formula with updated data, we find an emissions budget for Switzerland of 381 $MtCO_2$-eq from 1st Jan 2022 onwards [**answer to question 1**]. The year of depletion of this budget as requested in question 2 and 3 is dependent on the future emission trajectory of Switzerland.

Here we present three possible emissions scenarios for Switzerland starting at current emissions levels (43.4 $MtCO_2$-eq / yr in 2021).

Firstly, we model a linear phase-out of emissions so that emissions reduce in a straight line and reach zero when the remaining budget based on the Policy Brief runs out (**Figure A**). Switzerland would need to reach net-zero by 2040 to stay within its budget of 381 $MtCO_2$-eq [**answer to question 3**].

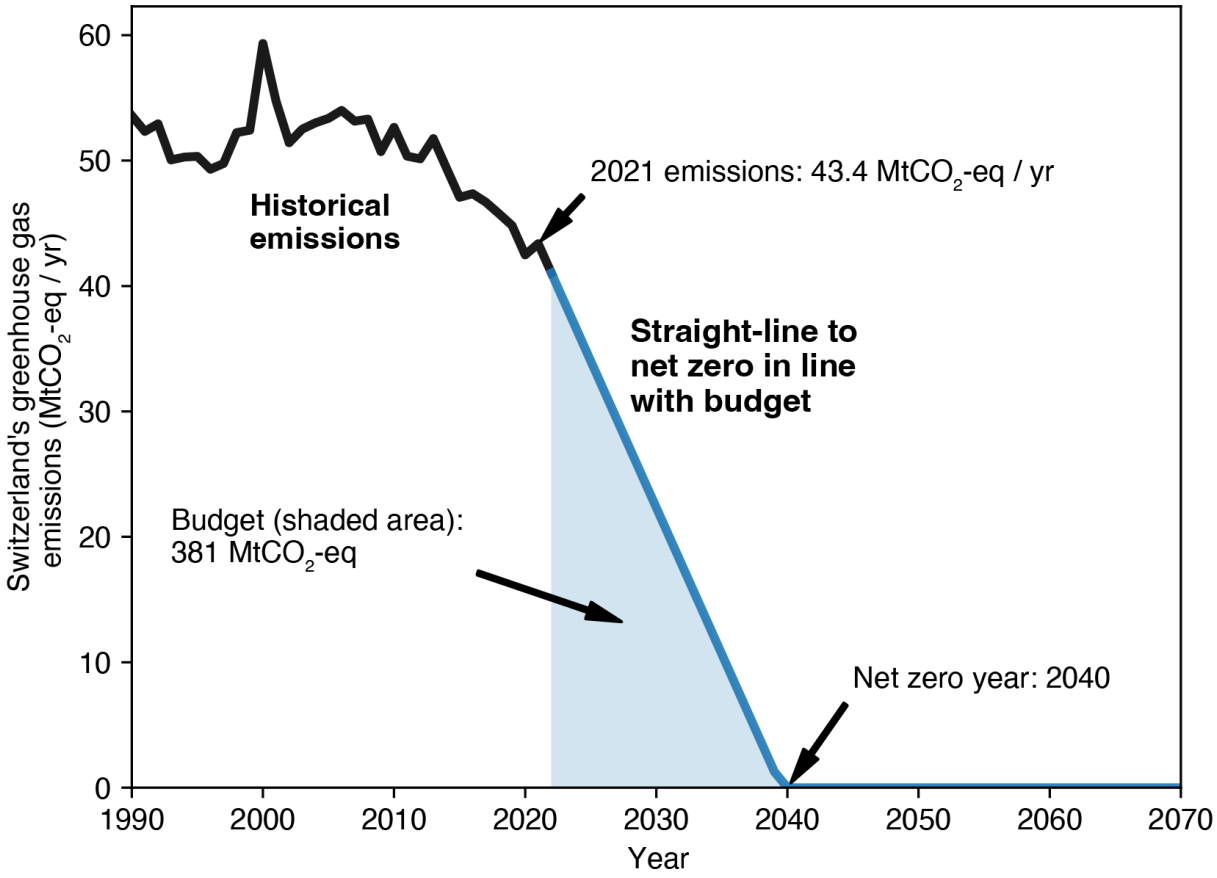

Figure A | Straight-line pathway to net-zero in line with Switzerland's calculated budget. To stay within its budget, Switzerland would need to reach net-zero emissions by 2040.

Secondly, we model how the remaining part of the calculated budget is used from the start of 2022. As described in the previous chapter, the methodology of the Policy Brief is not appropriate to inform emission targets as a fair-share of a collective goal, which can be met with international support.

For this reason, we compare the emissions budget to Switzerland's emissions targets of:

- 34% emissions reduction in 2030 compared to 1990 levels (domestic emissions reduction)
- 75% emissions reduction in 2040 compared to 1990 levels (pursued through domestic emissions reduction with possible international offsets if necessary)
- 100% emissions reduction in 2050 compared to 1990 levels, i.e. the net-zero emissions target (pursued through domestic emissions reduction with possible international offsets if necessary)

Figure B shows the emissions scenario towards net-zero emissions in 2050 following straight-line emissions trajectories between these reduction targets. Following this trajectory, the remaining budget for Switzerland of 381 $MtCO_2$-eq will be all used up by the end of 2030 **[answer to question 2]**. Following this pathway would lead to Switzerland's budget being exceeded by 263 $MtCO_2$-eq.

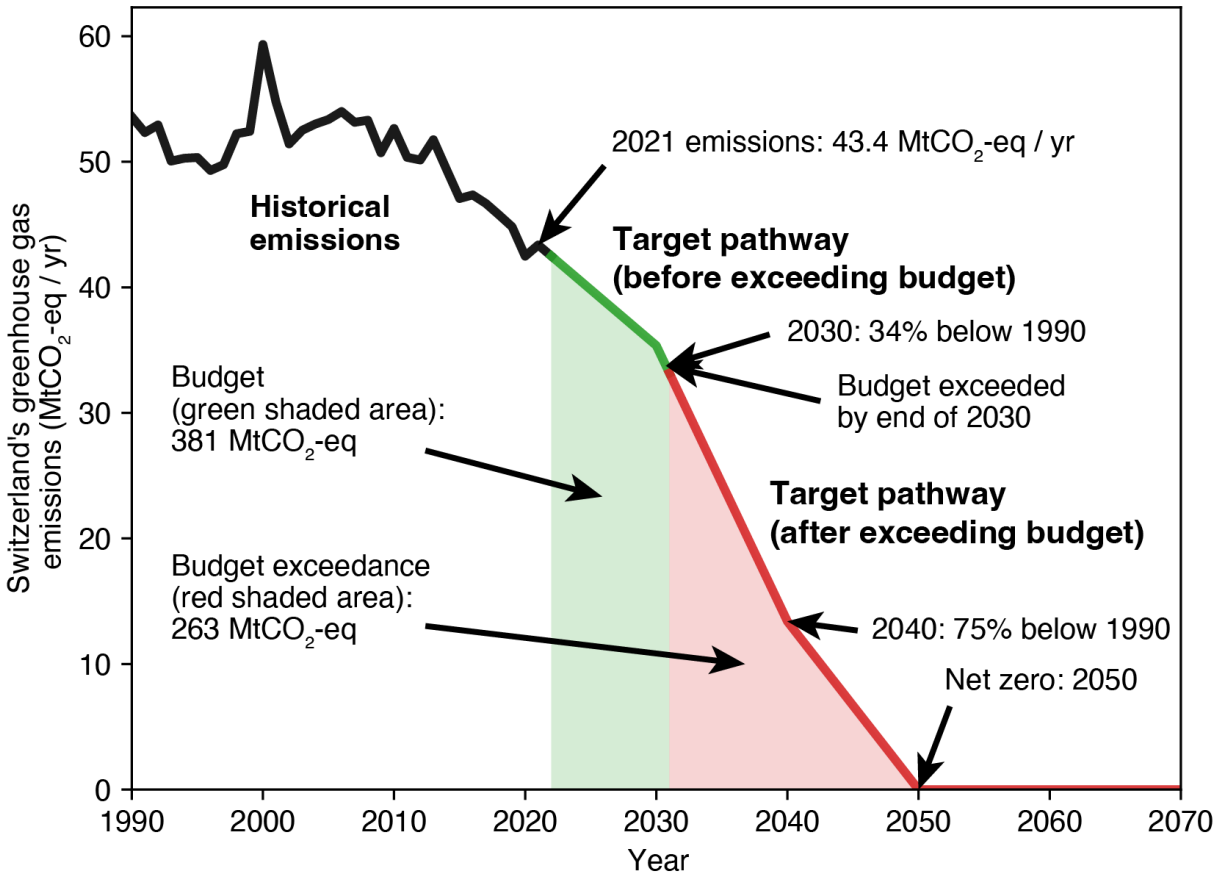

Figure B | Comparison of Switzerland's emissions budget to a linear emissions pathway towards its domestic targets. Following its reduction targets of 34% below 1990 levels by 2030, 75% below 1990 by 2040 and net-zero by 2050, would result in Switzerland exceeding its budget of 381 MtCO2-eq by the end of 2030.

Thirdly, for illustrative purposes only, we also model how the remaining part of the calculated budget is used from the start of 2022 pursuing the existing emissions targets of:

- 50% emissions reduction in 2030 compared to 1990 levels (pursued through global emissions reduction including international offsets)
- 75% emissions reduction in 2040 compared to 1990 levels (pursued through domestic emissions reduction with possible international offset if necessary)
- 100% emissions reduction in 2030 compared to 1990 levels, also name net-zero emissions target (pursued through domestic emissions reduction with possible international offset if necessary)

Figure C shows the emissions scenario towards net-zero emissions in 2050 following straight-line emissions trajectories between these reduction targets. This comparison with the overall 50% emissions reduction by 2030 below 1990 illustrates that even if the emissions budget calculated here is used to inform a fair-share overall target of 50% reduction by 2030 (despite the inconsistency of the methods to determine a fair-share budget), the budget would be depleted by the end of 2033.

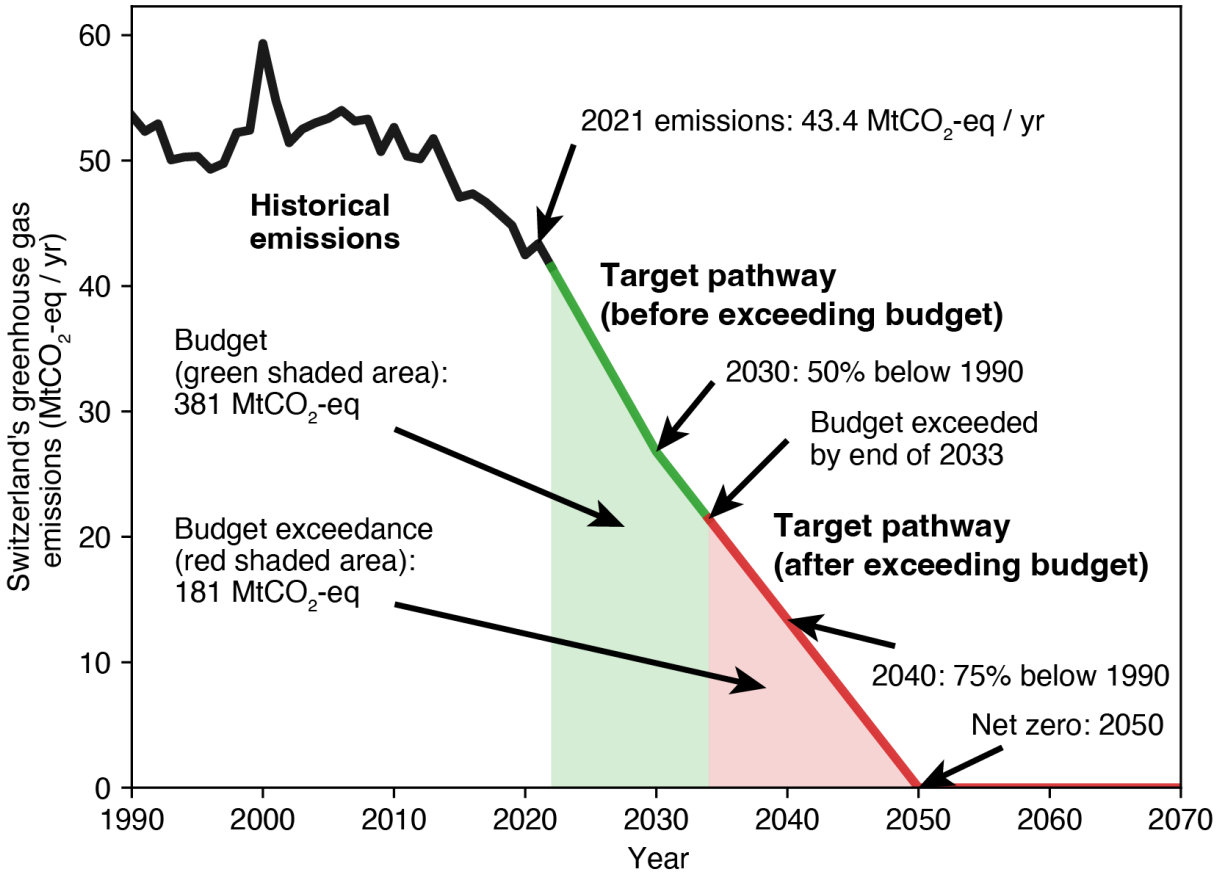

Figure C | Comparison of Switzerland's emissions budget to a linear emissions pathway towards its targets, including international offsets. Following its pledges of emissions reductions of 50% below 1990 levels by 2030, 75% below 1990 by 2040 and net-zero by 2050, Switzerland will exceed its budget of 381 MtCO2-eq before the end of 2033. Following this pathway would lead to Switzerland's budget being exceeded by 181MtCO2-eq.

The cumulative emissions that Switzerland could emit on the basis of its emissions targets can be expressed as a fraction of the remaining global budget. The remaining global CO_2 budget to be shared between countries as of 2022 is 217 $GtCO_2$. Switzerland's total cumulative CO_2 emissions based on a linear pathway between the emission targets of 50% below 1990 levels by 2030, 75% below 1990 by 2040 and net-zero by 2050 would be 450 $MtCO_2$ (note that this is a CO_2 only budget, as compared to the GHG budgets used in the figures above). This represents 0.2073% of the still available global CO_2 budget as of 2022. As noted in the above, Switzerland's share of the global population in 2016 was around 0.1117% and its population share as of 2022 is around 0.1099%.

For illustrative purposes, **Figure D** shows the effect of delaying emissions reductions on future mitigation rates. To meet its emissions budget, the longer Switzerland waits to start cutting emissions, the faster it must cut emissions. Had Switzerland started reducing its domestic emissions linearly in 1990, its emissions would only need to reach net-zero after 2060 to stay within the budget calculated above. The lack of mitigation compared to a linear reduction since 2016 implies that the date to reach net-zero emissions under a linear use of the calculated emissions budget has moved a few years earlier in time, from 2044 to 2040.

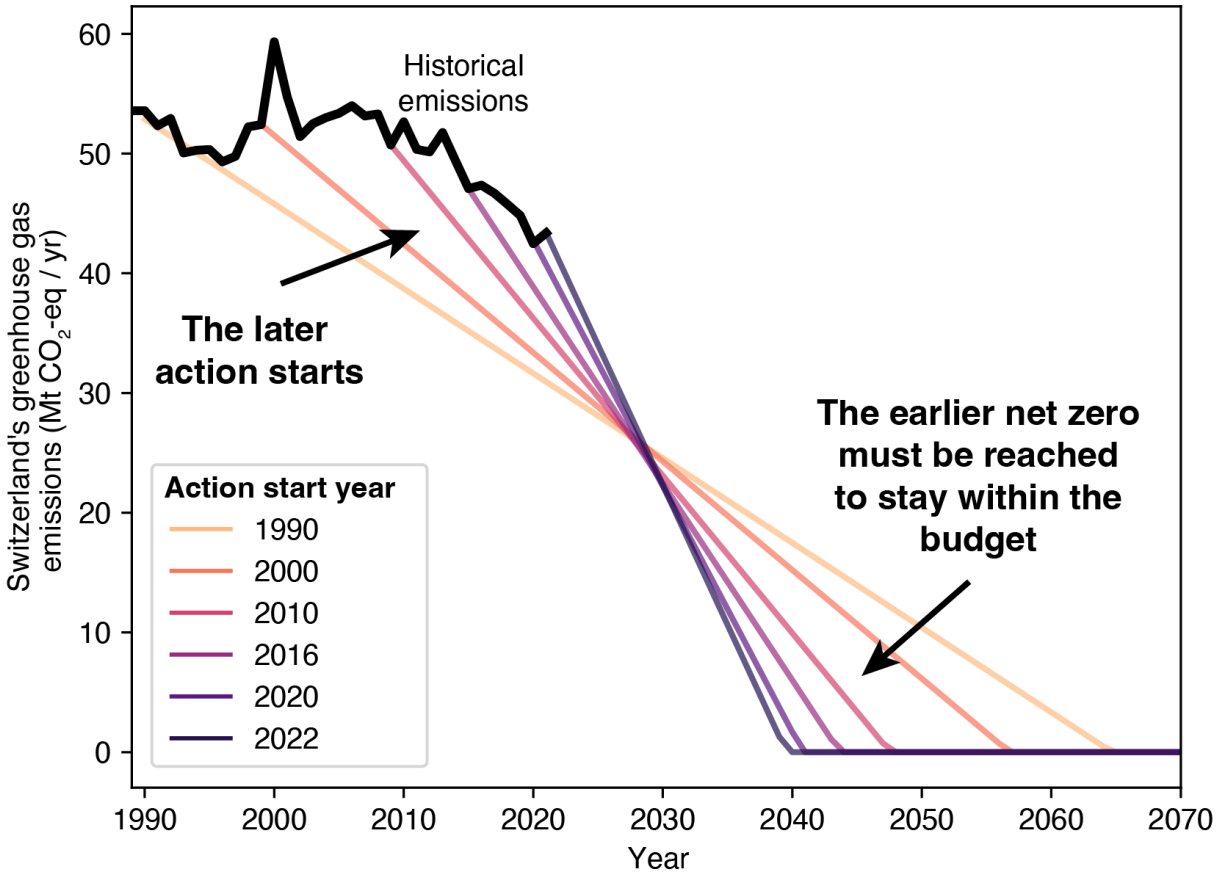

Figure D | Illustrative scheme showing the linear emissions reductions scenarios starting at different dates and consistent with a given budget. Note that, as this figure is for illustrative purposes, it uses a fixed budget and does not recalculate the emissions budget based on the population shares that applied at each of the various starting dates.

6. Conclusions

The effort-sharing formula presented in the Policy Brief was designed to limit fairness considerations to fit political acceptance. As such, the approach in the Policy Brief reflects neither the dimensions of equity described by the IPCC[4] nor the principle of "common but differentiated responsibilities and respective capabilities, in the light of different national circumstances" and equity of the Paris Agreement. Thus, the methodology of the Policy Brief is not appropriate to determine Switzerland's' "fair share" of the global burden to achieve the Paris Agreement warming threshold. This is particularly the case as parts of a "fair share" can be met by complementing domestic emission reductions with international support.

Applying the Policy Brief's methodology, we find an emissions budget for Switzerland of 381 $MtCO_2$-eq from 1st Jan 2022 onwards [**answer to question 1**].

[4] Section 4.6.2 of Chapter 4: Fleurbaey M., S. Kartha, S. Bolwig, Y. L. Chee, Y. Chen, E. Corbera, F. Lecocq, W. Lutz, M. S. Muylaert, R. B. Norgaard, C. Okereke, and A. D. Sagar, 2014: Sustainable Development and Equity. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Even when ignoring historic responsibility prior to 2016, this emission budget is depleted by the end of 2030 or 2033 at the latest, should Switzerland's emissions follow a straight line to its current emission targets **[answer to question 2]**. Based on the methodology of the Policy Brief, Switzerland's emissions targets for 2030, 2040 and 2050 represent insufficient emissions reductions to stay within its 1.5 °C budget.

Staying within the calculated budget requires net-zero emissions to be achieved by 2040, assuming that emissions follow a straight-line trajectory from 2022 onwards **[answer to question 3]**. Delaying emissions reduction implies an earlier date for reaching net-zero emissions in order to stay within the calculated 1.5 °C budget.

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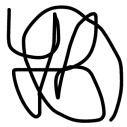

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ANNEX

Detailed description of modelling choices and updated data sources

The implementation of the formulas from the Policy Brief is based on updated emissions data as follows.

Instead of the reported population, national emissions data and global emissions budget available at the time of publication of the Policy Brief, we use 2016 carbon emissions and population data for all calculations of countries' fair shares. The population data is from the World Population Prospect from the United Nations[5], specifically this data file (last accessed April 4, 2023). We use historical carbon emissions data from the peer reviewed composite aggregation of emissions data PRIMAP-hist v2.4.2 and specifically its dataset prioritising country reported data (named HISTCR)[6]. The data used reflects the latest available data for national emissions reporting and remaining carbon budgets as per the IPCC. For Switzerland's emissions, we use the latest update to Switzerland's national emissions inventory provided by the Bundesamt für Umwelt[7]. For Switzerland's targets and trajectories, this report uses the Global Warming Potential of the fifth IPCC Assessment Report, consistent with the convention used for the emissions targets of the Swiss government.

Applying the Policy Brief's formula with updated data we find that Switzerland's budget Q from the start of 2016 is 0.1201% of the global budget (Z in equation (5) of the Policy Brief). We note that the budget share resulting from this methodology is larger than Switzerland's share of the global population in 2016 which was 0.1117%.

To calculate the global budget Z, and get the budget for Switzerland, a few steps are necessary.

We begin from the carbon budgets reported in the latest IPCC Working Group I Summary for Policy Makers[8]. Specifically, we start from the budget for a 67% chance of staying below 1.5 °C (defined as *likely* in the IPCC reports) of 400 $GtCO_2$ from the 1st Jan 2020.

We then convert this to a budget from the 1st Jan 2016 by adding global CO_2 emissions between 2016 and 2020 i.e. 160 $GtCO_2$. This gives a global carbon budget of 560 $GtCO_2$ from 1st Jan 2016.

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[5] United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022, Online Edition. The specific file used can be retrived here (last accessed April 4th 2023) https://population.un.org/wpp/Download/Files/1_Indicators%20(Standard)/EXCEL_FILES/1_General/WPP2022_GEN_F01_DEMOGRAPHIC_INDICATORS_COMPACT_REV1.xlsx

[6] Gütschow, J.; Pflüger, M. (2023): The PRIMAP-hist national historical emissions time series v2.4.2 (1750-2021). zenodo. doi:10.5281/zenodo.7727475

[7] Data retrieved in April 2023 from Schweizer Treibhausgas-Ausstoss 2021 leicht gestiegen https://www.bafu.admin.ch/bafu/de/home/dokumentation/medienmitteilungen/anzeige-nsb-unter-medienmitteilungen.msg-id-94169.html

[8] Table SPM.2 page 29 of IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3−32, doi:10.1017/9781009157896.001

Next, we must account for a difference in accounting conventions between countries' nationally reported emissions and the conventions which underpin IPCC carbon budgets. This difference relates to how CO_2 uptake by the land is accounted for in country reported emissions compared to when it is used as the basis for a carbon budget. In short, the carbon budget is based on anthropogenic fluxes only, while countries include some natural uptake in their emissions accounting. To account for this difference, we reduce the budget by 15 %, in line with Grassi et al.[9]. This reduces the global carbon budget to 476 $GtCO_2$.

The global carbon budget to be shared across countries should also exclude the emissions scope that does not fall within countries' borders and national emissions reporting, namely emissions from international aviation and shipping. The average of the very low (SSP1-1.9) and low (SSP1-2.6) emissions scenarios[10] from the latest Coupled Model Intercomparison Project[11], which were also widely used in the Physical Science (WG1) Contribution to the latest IPCC report (see, for example, Table SPM.1 of WG1's Summary for Policy Makers[12]), indicates that international aviation and shipping will contribute to 46 $GtCO_2$. Given the strong mitigation assumed in these scenarios, this estimate may be lower than the space expected to be taken by international aviation and shipping and may be considered conservative. Removing these 46 $GtCO_2$ brings the global carbon budget to be shared across countries to 430 $GtCO_2$ from the start of 2016. When using accounting conventions consistent with country reporting, global emissions between 2016 and 2022 were 213 $GtCO_2$. Given these emissions, the global carbon budget to be shared across countries from 2022 onwards is 217 $GtCO_2$.

The 2016 budget is now a) appropriate for division among countries and b) consistent with national emissions reporting conventions. Multiplying the budget from 2016 of 430 $GtCO_2$ by Switzerland's share of 0.1201% gives a carbon budget for Switzerland from 1st Jan 2016 of 516 $MtCO_2$.

Next, we can convert to a Swiss budget from 1st Jan 2022 onwards (2021 is the last year for which historical emissions data is reported) by removing Swiss observed CO_2 emissions

[9] Grassi, G., Stehfest, E., Rogelj, J. *et al.* Critical adjustment of land mitigation pathways for assessing countries' climate progress. *Nat. Clim. Chang.* **11**, 425–434 (2021). https://doi.org/10.1038/s41558-021-01033-6

[10] Riahi, K., Van Vuuren, D.P., Kriegler, E., Edmonds, J., O'neill, B.C., Fujimori, S., Bauer, N., Calvin, K., Dellink, R., Fricko, O. and Lutz, W., 2017. The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. Global environmental change, 42, pp.153-168.
Van Vuuren, D.P., Stehfest, E., Gernaat, D.E., Doelman, J.C., Van den Berg, M., Harmsen, M., de Boer, H.S., Bouwman, L.F., Daioglou, V., Edelenbosch, O.Y. and Girod, B., 2017. Energy, land-use and greenhouse gas emissions trajectories under a green growth paradigm. Global Environmental Change, 42, pp.237-250.
O'Neill, B.C., Kriegler, E., Ebi, K.L., Kemp-Benedict, E., Riahi, K., Rothman, D.S., Van Ruijven, B.J., Van Vuuren, D.P., Birkmann, J., Kok, K. and Levy, M., 2017. The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. Global environmental change, 42, pp.169-180.

[11] Tebaldi, C., Debeire, K., Eyring, V., Fischer, E., Fyfe, J., Friedlingstein, P., Knutti, R., Lowe, J., O'Neill, B., Sanderson, B. and Van Vuuren, D., 2021. Climate model projections from the scenario model intercomparison project (ScenarioMIP) of CMIP6. Earth System Dynamics, 12(1), pp.253-293.
O'Neill, B.C., Tebaldi, C., Van Vuuren, D.P., Eyring, V., Friedlingstein, P., Hurtt, G., Knutti, R., Kriegler, E., Lamarque, J.F., Lowe, J. and Meehl, G.A., 2016. The scenario model intercomparison project (ScenarioMIP) for CMIP6. Geoscientific Model Development, 9(9), pp.3461-3482.

[12] IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K.Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3−32, doi:10.1017/9781009157896.001.

between 2016 and 2021. These emissions amount to 211 $MtCO_2$, leaving Switzerland with a carbon budget of 305 $MtCO_2$ from 1st Jan 2022 onwards.

Finally, we convert from the CO_2-only budget to a GHG budget. This is different from the methodology in the Policy Brief, which determined GHG budgets for individual countries based on a global GHG budget. For physical reasons, the former methodology is more scientifically sound, and it is also in line with the IPCC that provides CO_2 rather than GHG budgets. Global warming is proportional to cumulative CO_2 emissions, but not GHG emissions that can have a shorter lifetime in the atmosphere. For that reason, CO_2 budgets can be associated with given warming thresholds, unlike GHG budgets that could yield various warming responses depending on the timing of emissions over the century. This is the reason why the IPCC only provides CO_2 budgets associated with given temperature thresholds (including the 1.5 °C threshold with a 67% likelihood used here) and not GHG budgets. To convert the CO_2 budget calculated for Switzerland to a GHG budget we assume that CO_2 makes up 80% of the GHG budget, consistent with the assumptions used in the Third Party Intervention by Prof. Dr. Sonia I. Seneviratne and Prof. Dr. Andreas Fischlin in the proceedings in the case Verein KlimaSeniorinnen and others v Switzerland (Application no. 53600/20). This gives an emissions budget for Switzerland of 381 $MtCO_2$-eq from 1st Jan 2022 onwards.

The assumption used in the Third Party Intervention was also used to determine the cumulative CO_2 emissions implied by the pledged GHG emission targets of 50% below 1990 levels by 2030, 75% below 1990 by 2040 and net-zero by 2050.