
Supplementary information

Fossil CO₂ emissions in the post-COVID-19 era

In the format provided by the authors and unedited

Fossil CO₂ emissions in the post-COVID era

Authors: Corinne Le Quéré^{1,2}, Glen P. Peters³, Pierre Friedlingstein^{4,5}, Robbie M. Andrew³, Josep G. Canadell⁶, Steven J. Davis⁷, Robert B. Jackson^{8,9,10}, Matthew W. Jones^{1,2}

¹School of Environmental Sciences, University of East Anglia, Norwich, UK.

²Tyndall Centre for Climate Change Research, University of East Anglia, Norwich, UK.

³CICERO Center for International Climate Research, Oslo, Norway.

⁴College of Engineering, Mathematics and Physical Sciences, University of Exeter, Exeter EX4 4QF, UK

⁵LMD/IPSL, ENS, PSL Université, École Polytechnique, Institut Polytechnique de Paris, Sorbonne Université, CNRS, Paris France

⁶Global Carbon Project, CSIRO Oceans and Atmosphere, Canberra, Australia.

⁷Department of Earth System Science, University of California, Irvine, 3232Croul Hall, Irvine, CA, USA.

⁸Earth System Science Department, Stanford University, Stanford, CA US.

⁹Woods Institute for the Environment, Stanford University, Stanford, CA US.

¹⁰Precourt Institute for Energy, Stanford University, Stanford, CA US.

*e-mail: c.lequere@uea.ac.uk

Supplementary information

1. List of countries in each country group

Annex B (mostly high-income economies). Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, USA.

Group 2 (upper-middle income economies). Albania, Andorra, Anguilla, Antigua and Barbuda, Argentina, Armenia, Aruba, Azerbaijan, Bahamas, Bahrain, Barbados, Belarus, Belize, Bermuda, Bonaire, Saint Eustatius and Saba, Bosnia and Herzegovina, Botswana, Brazil, British Virgin Islands, Brunei Darussalam, Chile, China, Colombia, Cook Islands, Costa Rica, Cuba, Curaçao, Cyprus, Dominica, Dominican Republic, Ecuador, Equatorial Guinea, Faeroe Islands, Fiji, French Polynesia, Gabon, Georgia, Greenland, Grenada, Guatemala, Guyana, Hong Kong, Indonesia, Iraq, Iran, Israel, Jamaica, Jordan, Kazakhstan, Kosovo, Kuwait, Lebanon, Libya, Macao, Macedonia (Republic of), Malaysia, Maldives, Malta, Marshall Islands, Mauritius, Mexico, Montenegro, Montserrat, Namibia, Nauru, New Caledonia, Niue, Oman, Palau, Panama, Paraguay, Peru, Qatar, South Korea, Saint Helena, Saint Lucia, Sint Maarten (Dutch part), Samoa, Saudi Arabia, Serbia, Seychelles, Singapore, South Africa, Saint Kitts and Nevis, Saint Pierre and Miquelon, Saint Vincent and the Grenadines, Suriname, Taiwan, Thailand, Tonga, Trinidad and Tobago, Turkey, Turkmenistan, Turks and Caicos Islands, Tuvalu, United Arab Emirates, Uruguay, Venezuela, Wallis and Futuna Islands.

Group 3 (lower-middle income and low-income economies). Algeria, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Cape Verde, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, North Korea, Democratic Republic of the Congo, Djibouti, Egypt, El Salvador, Eritrea, Ethiopia, Micronesia (Federated States of), Gambia, Ghana, Guinea, Guinea-Bissau, Haiti, Honduras, India, Kenya, Kiribati, Kyrgyzstan, Laos, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mongolia, Morocco, Mozambique, Myanmar, Nepal, Nicaragua, Niger, Nigeria, Occupied Palestinian Territory, Pakistan, Papua New Guinea, Philippines, Bolivia, Cameroon, Moldova, South Sudan, Sudan, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Solomon Islands, Somalia, Sri Lanka, Swaziland, Syria, Tajikistan, Timor-Leste, Togo, Tunisia, Uganda, Ukraine, Tanzania, Uzbekistan, Vanuatu, Viet Nam, Yemen, Zambia, Zimbabwe.

2. Methodological differences compared to previous publications

Compared to previous publications^{1,2} of the decrease in CO₂ emissions caused by confinement measures, parameters were updated for the changes in industry and aviation emissions during confinement levels 2 and 1 after the peak of the first lockdown (level 3), to take into account updated and new data available at the end of 2020. A full list of all parameters is provided in Le Quéré et al. 2020¹. Supplementary Table 1 and the text below describes only the parameters that changed compared to reference (3).

Supplementary Table 1. Updated parameters used in this study. The levels correspond to the stringency of the confinement as described in reference (3).

| Reference Publication date | Le Quéré et al. 2020 ¹ May 2020 | Friedlingstein et al. 2020 ² December 2020 | This study March 2021 |
|-------------------------------|---|--|--------------------------|
| <i>Industry</i> | | | |
| Level 1 | -10% (0% to -20%) | No change | No change |
| Level 2 | -15% (0% to -35%) | No change | No change |
| Level 3 | -35% (-25% to -45%) | No change | No change |
| Level 2 | -15% (0% to -35%) | -35% (-25% to -45%) | -25% (-15% to -45%) |
| Level 1 | -10% (0% to -20%) | -20% (0 to -30%) | -15% (0 to -25%) |
| <i>Aviation</i> | | | |
| Level 1 | -20% (0% to -50%) | No change | No change |
| Level 2 | -75% (-55% to -95%) | No change | No change |
| Level 3 | -75% (-60% to -90%) | No change | No change |
| Level 2 | -75% (-55% to -95%) | -65% (-50% to -90%) | -65% (-50% to -90%) |
| Level 1 | -20% (0% to -50%) | -50% (-40% to -80%) | -50% (-40% to -80%) |

Difference to Le Quéré et al. (2020)¹. The confinement index was updated from mid-April 2020 to 11 January 2021. For India, USA and EU27, CO₂ emissions could be estimated monthly based on energy statistics¹ over most of 2020. We therefore adjusted the parameters for specific sectors to better match the energy data, keeping close to the observed evidence on changes in activities in the different sectors for those countries. No tuning was required for EU27. For the USA, only the parameters for the power sector were changed to a decrease of -5% (0 to -15%) during confinement level 3 and 0 (0 to -5%) during level 2. For India, parameters for power were changed to a decrease of -30% (-16% to -26%) during confinement level 3 and -10 (0 to -18%) during level 2, and parameters for industry were changed to a decrease of -50% (-25% to -65%) during confinement level 3, -5 (0 to -15%) during level 2, and 0 (0 to -5%) during level 1. Furthermore, for Norway, further insights could be obtained from national statistics for electricity and fuel use. Based on these data we set the parameters for power to 0; for industry to -10% (0 to -20%) during level 3 and level 2 (after lockdown), and -5% (0 to -10%) for level 2 and level 1 (after lockdown); and for surface transport to -20% (-10% to -30%) for level 3, -10% (0 to -20%) for level 2, and 0 (0 to -10%) for level 1.

Difference to Friedlingstein et al. (2020)². The confinement index was updated to 11 January 2021. Parameters for industry were updated (see Supplementary Table 1). Parameters for India and USA were as described above. Parameters for Norway were updated to country-specific parameters. An error was corrected in the global totals for the UEA product (based on Le Quéré et al. 2020) which did not include changes in emissions from international transport in the version published in Friedlingstein et al. (2020). This would have deepened the drop in global emissions in emissions by 1% in that estimate, but not changed the overall assessment of the 7% decrease over the full 2020, which is based on multiple estimates.

References

1. Le Quéré, C. et al. Temporary reduction in daily global CO₂ emissions during the COVID-19 forced confinement. *Nature Climate Change* **10**, 647-653 (2020).
2. Friedlingstein, P. et al. Global Carbon Budget 2020. *Earth Syst. Sci. Data* **12**, 3269-3340 (2020).