Technical notes.

The Climate Transparency Report – which includes the twenty G20 Member profiles and a Highlights report - assesses the G20 Members' past, present and indications of future performance towards a low-carbon and climate-resilient economy by evaluating mitigation, adaptation and climate-related finance.

Country-specific references are included in the bibliographies which can be found on pages 19 and 20 of each profile. Where Partners have provided alternatives to Enerdata data, these are recorded in the profiles and therefore also in the bibliographies.

As references and sources are recorded in the country profiles, this technical note provides, only where necessary, background information or further explanation on calculation methods.

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NDC target, 1.5°C compatible emissions pathway, and ambition gap

This graph draws on data and analysis from the Climate Action Tracker, and 1.5°C National Pathways Explorer tools and historical emissions data from PRIMAP.

Please see the methodology sections for more information

- *1.5°C National Pathways Explorer: http://1p5ndc-pathways.climateanalytics.org/methodology/*
    - *Climate Action Tracker: https://climateactiontracker.org/methodology/cat-rating-methodology/*
    - *Gütschow, J. et al. (2021). The PRIMAP-hist National Historical Emissions Time Series (1850-2018), V.2.2. Zenodo open access repository. https://doi.org/10.5281/zenodo.4479172*

GHG emissions (including land use) per capita

PRIMAP-hist combines several published datasets to create a comprehensive set of GHG emissions pathways for every country and all Kyoto gases covering the years 1850 to 2016. The data resolves the main International Panel on Climate Change (IPCC) 2006 categories (Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Land-Use Change and Forestry, and Waste). Data presented in The Climate Transparency Report 2022 is for 2018.

- *Gütschow, J. et al. (2021). The PRIMAP-hist National Historical Emissions Time Series (1850-2018), V.2.2. Zenodo open access repository. https://doi.org/10.5281/zenodo.4479172*
- *The World Bank. (2022). Population, total. https://data.worldbank.org/indicator/SP.POP.TOTL*

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Socio-economic context

Human Development Index

The Human Development Index (HDI) is a composite index published by the United Nations Development Programme (UNDP). It is a summary measure of average achievement in key dimensions of human development with 1.0 being the highest possible score. A country scores higher when the lifespan is higher, the education level is higher, and GDP per capita is higher. Data presented in the Climate Transparency Report 2022 is for 2020.

- *United Nations Development Programme (UNDP). (2020). Human Development Index Ranking, Human Development Reports. http://hdr.undp.org/en/content/latest-human-development-index-ranking*

Population and urbanisation projections

Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. Population estimates are usually based on national population censuses. Population projections, starting from a base year, are projected forward using assumptions of mortality, fertility, and migration by age and sex through 2050, based on the UN Population Division's World Population Prospects database medium variant.

The proportion of urban (and rural) population is estimated from the most recently available census or official population estimate of each country. If this estimate is only available for some period in the past, the proportion urban is extrapolated to the base year. In the 2018 Revision of the World Urbanization Prospects the base year is 2018.

- *United Nations. (2018). World Urbanisation Prospects. UN Department of Economic and Social Affairs, Population Division.* https://population.un.org/wup
- *The World Bank. (2022). Population, total.* https://data.worldbank.org/indicator/SP.POP.TOTL

GDP per capita

Gross Domestic Product (GDP) is the value of all final goods and services produced within a country in a given year. GDP per capita is calculated by dividing the GDP of a country with midyear population figures. The Climate Transparency Report 2022 uses GDP figures at purchasing power parity (PPP) from 2015. The PPP constant 2015 international USD figures were employed in order to bring the GDP per capita numbers into alignment with the 1.5°C degree projections and modelling which still use 2015 values in their calculations.

- *The World Bank. (2021). GDP per capita (constant 2015 US$). https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD*

Death rate attributable to air pollution

Ambient air pollution attributable death rate per 1,000 population per year, age standardised in 2019.

- *Institute for Health Metrics and Evaluation (IHME). (2020). Global Burden of Disease Study 2020.* http://ghdx.healthdata.org/gbd-results-tool

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ADAPTATION

Impacts of a changing climate

Changes in average temperatures experienced – G20 data extracted from dataset for Indicator 1.1.1: Exposure to Warming

Methods (as provided by The Lancet Countdown data team)

The input data for this indicator have been improved and extended for the 2022 (Lancet) report.

The indicator uses monthly temperature from European Centre for Medium-Range Weather Forecasts (ECMWF) ERA5 climate reanalysis dataset. From this, a baseline global mean temperature grid was first calculated as the average of summer temperatures (June, July, August for the northern hemisphere, December, January, February for the southern hemisphere) from 1986–2005, the same period used by the Intergovernmental Panel on Climate Change (IPCC AR5)[1]. Then global summer temperature changes relative to the 1986–2005 average were calculated for every grid point for every year and weighted by true pixel area to obtain a year-by-year global average. The 'population-weighted' average was calculated by weighting each grid cell by the fraction of the total world population contained within that grid cell. This method allows the difference between global effects of climate change and the effects experienced by the human population to be highlighted.

Population data from 2000 to present are from NASA GPWv4 dataset at 0.25° x 0.25° spatial resolution, the same as ECMWF ERA5. Population data from 1980 to 2000 are from the ISIMIP Histsoc dataset at 0.5° x 0.5° spatial resolution. In the main text both the Histsoc-derived findings (1980-2000) and the GPWv4-derived findings (2000–2021) are presented.

Data

1. *Climate data from the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA5 reanalysis.*[2]
2. *Population data from the NASA Socioeconomic Data and Applications Center (SEDAC) Gridded Population of the World (GPWv4) and The Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) Histsoc dataset.*[3,4]

Changes in the ability to work due to exposure to excessive heat- G20 data extracted from dataset for indicator 1.1.4

Methods

The methodology for this indicator has been updated and improved from previous (Lancet) reports, by better accounting for the impact of solar radiation on people's capacity to work.

It is based on 68,940 grid cell data (0.5 x 0.5 degrees with boundaries exactly on the degree and half degree co-ordinates) for climate and population. The focus is on trends since the end of the 20th century and on a method that can calculate labour capacity loss at country level. The model data chosen for the calculations was the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA5 reanalysis hourly data on single year levels, and the analysis method is described in detail in the paper by Kjellstrom et al., 2018.[14]

Analysis starts from hourly ambient (t2m) and dew point temperatures (d2m), as well as short wave (solar) radiation downward (ssrd). These inputs are used to derive the hourly heat stress index Wet Bulb Globe Temperature (WBGT) and, from that, the work loss factor (WLF) at three different metabolic rates in both the shade and the sun is calculated. The inclusion of the solar component represents a novelty for the 2022 report.

The full Liljegren formula for calculating WBGT in the sun was used for one year (2010) for all grid cells. This involved also downloading ERA5 surface pressure, surface thermal radiation downwards, total sky direct solar radiation at surface. With this data a good approximation for WBGT *uplift* in the sun was determined from WBGT in the shade. Tested in warm to hot Koppen climate regions, this uplift was 0.0035 * ssrd, which matched the Liljegren WBGT calculation to ±0.2 C. As the Liljegren WBGT calculation[15] also requires air speed, an air movement of 1 m/s was used, the approximate speed at which arms and legs move during work.

For indoor work, exposure was assumed to be atmospheric heat in the shade without effective air conditioning. The impact of heat on labour capacity depends on clothing (assuming light clothing for all) and metabolic rate based on physical work activity. The methodology considers 3 metabolic rates: 200W (light work, sitting or moving around slowly), 300W (medium intensity work) and 400W (heavy labour).
The function relating WLF (the fraction of work hours lost) to an hourly WBGT level is given by the cumulative normal distribution (ERF) function:

$$Loss\ fraction = \frac{1}{2}\left(1 + \mathrm{ERF}\left(\frac{\mathrm{WBGThourly} - \mathrm{WBGTaver}}{\mathrm{WBGT}_{\mathrm{SD}} * \sqrt{2}}\right)\right)$$

where WBGTaver and $\mathrm{WBGT}_{\mathrm{SD}}$ are the parameters *Table 1. Input values for labour loss fraction calculation.***Table 1**) in the function for a given activity level.
The data were then aggregated to provide estimates of annual WLF between the hours of 6 am - 6 pm local solar time for each grid-cell.

Metabolic rate	WBGTaver	$\mathrm{WBGT}_{\mathrm{SD}}$
200 Watts	35.5	3.9
300 Watts	33.5	3.9
400 Watts	32.5	4.2

Table 1. Input values for labour loss fraction calculation.

For each grid cell, the working age population (15+ years old; as in the ILOSTAT data) for each time period is used as input data as well as the percentages of people in this age range working in 4 sectors: agriculture, construction, manufacturing and "other" sectors, which include the service sector (based on ILOSTAT data). Populations in grid cells that overlap country borders have been apportioned to the countries involved based on population distribution within the cell (variable CountryPop% in the formulas below).
For the work hours lost (WHL), ILO sector proportions are assigned to metabolic rates and sun or indoors/shade calculations applied as shown in **Table 2**:

Metabolic rate:	200W (shade), light work	300W (shade), moderate work	400W (sun), heavy labour
Employment sector:	Other (mainly services)	Manufacturing	Agriculture + Construction

Table 2. Employment sector to metabolic rate assignment

The total annual work hours lost (WHL) for each metabolic rate and country (as well as a global aggregate) are calculated by, first, for each grid cell multiplying each employment sector population by the relevant work loss factor and then, second, summing the resulting sector work hours lost over all grid-cells in each country:

Annual WHL200W (per country) =

Σ(for each country grid-cell): Pop15plus * CountryPop% * Other% * WLF200W

Annual WHL300W (per country) =

Σ(for each country grid-cell): Pop15plus * CountryPop% * Manuf% * WLF300W

Annual WHL400W (per country) =

Σ(for each country grid-cell): Pop15plus * CountryPop% * (Agr% + Constr%) * WLF400W

Then: Total Annual WHL (country) = Annual WHL200W + Annual WHL300W + Annual WHL400W

The annual work hours lost per person (WHLpp) are arrived at by dividing the total annual country WHLs by the total number of employed people in each country for each year. The annual total number of employed people for each country is calculated like:

Annually Employed People (per country) =

(Agr% + Manuf% + Constr% + Other%) * Σ(for each country grid-cell): Pop15plus * CountryPop%

Data

1. Climate data from the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA5 reanalysis.[2]
2. Population data from the NASA Socioeconomic Data and Applications Center (SEDAC) Gridded Population of the World (GPWv4).[3]
3. Sector employment data from ILOSTAT.[16]

Caveats

The distribution of agricultural, construction, manufacturing and other sector workers is only reported at country level, hence this proportion is distributed evenly to all grid cells within each country, and thus does not capture the geographical differences in the proportion of people working in the different sectors.

Loss of Earnings from Heat-Related Labour Capacity Reduction - G20 data extracted from dataset for indicator 4.1.3

Methods

Indicator 1.1.4 provides data on heat-related labour capacity loss, in terms of lost work hours, at country scale across four sectors (services, manufacturing, construction and agriculture) for the years 1990-2020 inclusive. In order to calculate potential loss of earnings from this labour capacity loss, it was necessary to compile a dataset of average earnings per hour for each of these countries, sectors and years.

Earnings and income statistics were compiled from the ILOSTAT databases held by the ILO, within the category ‘Statistics on Wages’.[323] ILOSTAT includes a number of indicators which are of potential relevance to deriving the average annual hourly wages for the required countries and years. There are variations in the coverage of these indicators, with none having an entirely comprehensive coverage of the countries, sectors and years required for this indicator. Multiple ILOSTAT indicators were therefore used to fill as many gaps as possible. The three main indicator sets used were:

- Mean nominal monthly earnings of employees by sex and economic activity: annual
- Mean nominal monthly earnings of employees by sex and occupation: annual
- Mean nominal hourly earnings of employees by sex and occupation: annual

Within each of these indicator sets, the employment activities most accurately reflecting the four required sectors were selected. In some cases, more than one such activity was available, due to different reporting conventions (for example, the set of activities under ISCO-08 being an update from ISCO-88). Full descriptions of ILO indicators and classifications are available on the ILOSTAT website.[324]
Each indicator and activity was available in US dollar and local currency units. US dollar units were preferred, however in each indicator and activity case, the number of returns in local currency units was slightly higher, so these were selected as well in case more data points could be covered by doing so.
The following tables set out for each of the four employment sectors, the ILOSTAT indicators and activity definitions that were selected in order to supply as much of used the required data as possible. In each table the indicator, activity and currency combinations are arranged in the order of preference with which they were used.

	Indicator	Activity	Currency
1	Mean nominal monthly earnings of employees by sex and economic activity: annual	Aggregate: Trade, transportation, accommodation and food, and business and administrative services	US Dollars
2		Aggregate: Trade, transportation, accommodation and food, and business and administrative services	Local currency
3	Mean nominal monthly earnings of employees by sex and occupation: Annual	ISCO-08: 5. Service and sales workers	US Dollars
4		ISCO-08: 5. Service and sales workers	Local currency
5		ISCO-88: 5. Service workers and shop and market sales workers	US Dollars
6		ISCO-88: 5. Service workers and shop and market sales workers	Local currency
7	Mean nominal hourly earnings of employees by sex and occupation: Annual	ISCO-08: 5. Service and sales workers	US Dollars
8		ISCO-08: 5. Service and sales workers	Local currency
9		ISCO-88: 5. Service workers and shop and market sales workers	US Dollars
10		ISCO-88: 5. Service workers and shop and market sales workers	Local currency
11	Mean nominal monthly earnings of employees by sex and economic activity: annual	ISIC Rev.4: N. Administrative and support service activities	US Dollars
12		ISIC Rev.4: N. Administrative and support service activities	Local currency
13		ISIC Rev. 3.1: K. Real estate, renting and business activities	US Dollars
14		ISIC Rev. 3.1: K. Real estate, renting and business activities	Local currency
15		ISIC Rev.2: 8. Financing, insurance, real estate and business services	US Dollars
16		ISIC Rev.2: 8. Financing, insurance, real estate and business services	Local currency

Table 3: Indicators, activity classes and currencies selected to gather data from the ILOSTAT databases on earnings in the services sector, in order of preference

	Indicator	Activity	Currency
1	Mean nominal monthly earnings of employees by sex and economic activity: Annual	Aggregate: Manufacturing	US Dollars
2		Aggregate: Manufacturing	Local currency
3		ISIC Rev.4: C. Manufacturing	US Dollars
4		ISIC Rev.4: C. Manufacturing	Local currency
5		ISIC Rev. 3.1: D. Manufacturing	US Dollars
6		ISIC Rev. 3.1: D. Manufacturing	Local currency
7		ISIC Rev.2: 3. Manufacturing	US Dollars
8		ISIC Rev.2: 3. Manufacturing	Local currency
9	Mean nominal monthly earnings of employees by sex and occupation: Annual	ISCO-08: 8. Plant and machine operators, and assemblers	US Dollars
10		ISCO-08: 8. Plant and machine operators, and assemblers	Local currency
11		ISCO-88: 8. Plant and machine operators and assemblers	US Dollars
12		ISCO-88: 8. Plant and machine operators and assemblers	Local currency
13	Mean nominal hourly earnings of employees by sex and occupation: Annual	ISCO-08: 8. Plant and machine operators, and assemblers	US Dollars
14		ISCO-08: 8. Plant and machine operators, and assemblers	Local currency
15		ISCO-88: 8. Plant and machine operators and assemblers	US Dollars
16		ISCO-88: 8. Plant and machine operators and assemblers	Local currency

Table 4: Indicators, activity classes and currencies selected to gather data from the ILOSTAT databases on earnings in the manufacturing sector, in order of preference

	Indicator	Activity	Currency
1	Mean nominal monthly earnings of employees by sex and economic activity: Annual	Aggregate: Agriculture	US Dollars
2		Aggregate: Agriculture	Local currency
3		ISIC Rev.4: A. Agriculture; forestry and fishing	US Dollars
4		ISIC Rev.4: A. Agriculture; forestry and fishing	Local currency
5		ISIC Rev.3.1: A. Agriculture, hunting and forestry	US Dollars
6		ISIC Rev.3.1: A. Agriculture, hunting and forestry	Local currency
7		ISIC Rev.2: 1. Agriculture, hunting, forestry and fishing	US Dollars
8		ISIC Rev.2: 1. Agriculture, hunting, forestry and fishing	Local currency
9	Mean nominal monthly earnings of employees by sex and occupation: Annual	ISCO-08: 6. Skilled agricultural, forestry and fishery workers	US Dollars
10		ISCO-08: 6. Skilled agricultural, forestry and fishery workers	Local currency
11		ISCO-88: 6. Skilled agricultural and fishery workers	US Dollars
12		ISCO-88: 6. Skilled agricultural and fishery workers	Local currency
13	Mean nominal hourly earnings of	ISCO-08: 6. Skilled agricultural, forestry and fishery workers	US Dollars
14		ISCO-08: 6. Skilled agricultural, forestry and fishery workers	Local currency

15	employees by sex and occupation: Annual	ISCO-88: 6. Skilled agricultural and fishery workers	US Dollars
16		ISCO-88: 6. Skilled agricultural and fishery workers	Local currency

Table 5: Indicators, activity classes and currencies selected to gather data from the ILOSTAT databases on earnings in the agricultural sector, in order of preference

	Indicator	Activity	Currency
1	Mean nominal monthly earnings of employees by sex and economic activity: annual	Aggregate: Construction	US Dollars
2		Aggregate: Construction	Local currency
3		ISIC Rev.4: F. Construction	US Dollars
4		ISIC Rev.4: F. Construction	Local currency
5		ISIC Rev. 3.1: F. Construction	US Dollars
6		ISIC Rev. 3.1: F. Construction	Local currency
7		ISIC Rev.2: 5. Construction	US Dollars
8		ISIC Rev.2: 5. Construction	Local currency
9	Mean nominal monthly earnings of employees by sex and occupation: Annual	ISCO-08: 9. Elementary occupations	US Dollars
10		ISCO-08: 9. Elementary occupations	Local currency
11		ISCO-88: 9. Elementary occupations	US Dollars
12		ISCO-88: 9. Elementary occupations	Local currency
13	Mean nominal hourly earnings of employees by sex and occupation: Annual	ISCO-08: 9. Elementary occupations	US Dollars
14		ISCO-08: 9. Elementary occupations	Local currency
15		ISCO-88: 9. Elementary occupations	US Dollars
16		ISCO-88: 9. Elementary occupations	Local currency

Table 6: Indicators, activity classes and currencies selected to gather data from the ILOSTAT databases on earnings in the manufacturing sector, in order of preference

A spreadsheet tool was developed to select the relevant data points for all available countries in order of indicator preference – if there was no data point for a given country, year and sector in the first priority indicator, the data point was sought in the next indicator, and so on until a data point was found, or all indicators had been tried.
Monthly earnings data were converted to hourly values using a standard assumption of 40 hours per week and 4.33 weeks per month, i.e., 173.2 hours per month.

Data in nominal local currency units were converted to nominal US dollars at market exchange rates using IMF International Financial Statistics.[325] Nominal US dollar values were converted to real 2021 US dollar values using the US dollar consumer price index from the IMF World Economic Outlook database.[316]

Even after searching 16 variations of ILO indicator, activity and reporting currency for each sector, there were still considerable gaps, with around two thirds of required data points unfilled. In addition, there was a small number of clearly erroneous data points – e.g., with hourly earnings rates orders of magnitude too high, possibly caused by incorrect recording of the currency in which the data were reported, or by episodes of rapid inflation and currency devaluation, with which the recorded market exchange rates were not keeping track.

In order to fill the gaps with no data, as well as to correct data points that were clearly erroneous, a gap filling process was undertaken, using other data points to stand in for the missing or erroneous data. This process was undertaken after all of the data had been corrected to real 2021 US dollar values, so that all of the data were already expressed in constant values. Wherever possible, gaps were filled using data

from a different year but from the same sector and country. Where data was available in years before and after the gaps in the same sector and country, linear interpolation was used to fill the gaps. If no future year was available, data were filled using the nearest past year. Likewise, if no previous year was available, the nearest future year was used. If there were no data points available at all for a certain sector or country, the data were taken from the same sector of a different country that was as comparable as possible to the country with missing data. Identification of a reasonably comparable country was achieved primarily by selecting one as close as possible on the HDI scale, within the same or similar region, of a similar size, and with a reasonable number of datapoints. If there were no countries from a similar world region with a similar HDI ranking, the closest possible country on the HDI scale was selected, regardless of its geographic proximity.
A small number of countries have not been given an HDI value and hence could not be included in the analysis.

This process resulted in estimates of hourly earnings for the four sectors, for the years 1990-2021 inclusive, for 188 countries. These hourly earnings data were multiplied by the corresponding values for work hours lost (WHL) in each country, sector, and year, to provide a quantification of potential earnings lost. The WHLs used assumed that work in the agricultural and construction sectors took place in the sun.

These total lost earnings were expressed as a percentage of the country's GDP in each relevant year. GDP data in nominal US dollars at market exchange rates were downloaded from the IMF World Economic Outlook database,[2] and rendered in constant 2021 US dollars using the GDP deflator index from the same source. Gaps in this GDP data for some countries and years imposed a small further restriction on the coverage of this indicator, and not all of the same countries are available for all years. The maximum country-coverage of the indicator is 183 countries, during the years 2002–2021 inclusive. Results presented as the average value for countries in each of the four HDI groups.

Data

1. Data on working hours lost from indicator 1.1.4
2. Data on earnings by country and sector from ILOSTAT[323]
3. Exchange rate data from IMF International Financial Statistics[325]
4. US Dollar CPI and GDP deflator index from the IMF World Economic Outlook database[316]
5. Country GDP data from the IMF World Economic Outlook database[316]

Caveats

There are several important caveats associated with the analysis:

- The ILOSTAT data do not cover all of the countries, years and sectors required, hence some gap filling was required, as described above. Whilst reasonable care has taken to identify appropriate estimates, these gaps filled data are subject to uncertainties
- Whilst reasonable efforts have been made to correct for clearly erroneous data points, the analysis is dependent on the reliability of the ILOSTAT data, which could be subject to uncertainties in reporting, collection and processing

- The use of different combinations of ILOSTAT indicators and activity classes, rather than one single indicator and one activity class per sector, was necessary to increase data coverage as much as possible. Nonetheless this entails risks of inconsistencies, for example associated with different classifications and reporting methods
- The conversion of monthly data to hourly was carried out on the basis of a standard assumption of 4.33 weeks per month, and 40 hours per week. Real monthly working times will vary from these assumptions to a greater or lesser extent in different countries

All of these issues mean that caution should be exercised when examining results for any particular country. In addition, it must be emphasised that the results produced are the *potential* loss of earnings, rather than actual. The indicator is not based on evidence as to whether time off work was in fact taken. Further, if time was taken off work, the bearer of the costs of the lost labour could have varied between countries and sectors. In some instances, workers may have been able to claim sick pay, in which case the losses would have been borne by the employer through paying for non-productive time. In other instances, no arrangements for sick pay may have been in place, in which case it would have been the worker who would have borne the cost through a direct loss of earnings due to the inability to work.

Finally, the indicator by definition is an estimate of potential loss of earnings from formal paid sectors. In many countries informal and unpaid labour is also significant. Such activities could include domestic work and small-scale agriculture.[316,326,327] The impacts on productivity and health of extreme heat on workers involved in so-called informal sectors, would be in addition to the monetised estimates quantified by this indicator.

- *Romanello M. et al. (2022). The 2022 Report of The Lancet Countdown on Health and Climate Change. https://www.thelancet.com/countdown-health-climate*
- *World Meteorological Organization, 2022.*

Exposure to future impacts at 1.5°C warming and higher

Different levels of global warming are projected to have a wide range of impacts of varying severity across the world. Using the projected impacts at 1.5°C of warming as a reference, we compare impacts that may occur at higher levels of warming. Different indicators are used and are spread out into five categories: climatic, fresh water, hazards, economic and agriculture. Values are either missing when the data is not available, or the indicator is not relevant for a specific country (e.g., snowfall or river discharge in Saudi Arabia).

Reference period

Most of the indicators are based on a reference period of 1986-2006 – this is the case for the whole categories climatic, fresh water, hazards and agriculture. For those impacts, base reference period of 1986-2006 was adopted as it includes the reference period for the IPCC AR5 (1986-2005), i.e., the last years of the historical simulations in CMIP5. The extra year was added to bring the calculation process of the value for the reference period in line with the calculation process of the GMT, which is calculated as a 21-year average of the Global Temperatures. All projections are calculated assuming that socio-economic conditions (population, land-use, management practices, etc.) will remain constant as of 2005. For the last category (economic), Annual expected damage due to tropical cyclones and Annual expected damage from river flood are based on a reference year of 2020, while Labour productivity due to heat stress is based on the previous reference period (1986-2006).

Projections

The Representative Concentration Pathways (RCPs) are greenhouse gas concentration scenarios used to make the projections. They are commonly used in the climate modelling community. Produced within CMIP5, they were officially adopted by the Intergovernmental Panel on Climate Change (IPCC) and provide a basis for the projections and predictions of the Fifth Assessment Report of the IPCC. The RCPs are defined by the approximate level of radiative forcing (in W/m2) by the end of the 21st century, relative to the pre-industrial level. The use of radiative forcing allows the calibration of different warming potentials of various greenhouse gases. The word "representative" signifies that each pathway is an archetype of several scenarios sharing similar radiative forcing and emission characteristics. In this report, the data presented are from the highest future emissions scenario (RCP8.5) of the four distinguishable pathways that were designed. They are driven by various assumptions about population, GDP, energy use and mix, and land-use and thus carry substantial uncertainties. van Vuuren et al. (2011) provide more details on main characteristics of these four RCPs, such as emission trends and end-century warming levels.

Uncertainty

It is important to note that the confidence in the results decreases for high warming levels (and particularly beyond 2.5-3°C of global warming), since these levels have been attained in a smaller number of the RCP experiments due to the differing climate sensitivity of the GCMs that conducted them.

Data

1. **Local precipitation:** Precipitation is defined as the mass of water (both rainfall and snowfall) falling on the Earth's surface, per unit area and time. The data used for this variable have undergone a bias-adjustment procedure to correct for deviations between modelled and observed values over the time period when they overlap.
2. **Local snowfall:** Snowfall is defined as the mass of water falling on the Earth's surface in the form of snow, per unit area and time. The data used for this variable have undergone a bias-adjustment procedure to correct for deviations between modelled and observed values over the time period when they overlap.
3. **Surface run-off:** Surface run-off (also called overland flow) describes the flow of water occurring on the Earth's surface when excess water, e.g., rainwater, can no longer be absorbed by the soil.
4. **River discharge:** Discharge (also called streamflow) is the volume of water flowing through a river or stream channel in a day.
5. **Total soil moisture content:** Total soil moisture content quantifies water stored in soil, per unit area. Here we consider soil moisture contained within the root zone, i.e., until a depth of approximately 1 metre.
6. **Number of people annually exposed to heatwave:** Population annually exposed to heatwaves, in a grid cell of 0.5° resolution, equals the total population of that grid cell every year it is struck by a heatwave, and zero otherwise. It thus reflects the part of this population which experiences a heatwave on average every year. A heatwave is here considered to occur when both a relative indicator based on air temperature and an absolute indicator based on air temperature and relative humidity exceed exceptionally high values.

7. **Number of people annually exposed to crop failures:** Population annually exposed to crop failures is defined as the fraction of the labour force working in agriculture multiplied by the land area exposed to crop failures, and divided by the grid cell area fraction used for agriculture. Land area exposed to crop failures is defined as the fraction of a grid cell, of 0.5° resolution, in which one of the four considered crops (maize, wheat, soybean, and rice) is grown, and where its annual yield falls short of the 2.5th percentile of the pre-industrial reference distribution (i.e., an exceptionally low yield that would occur on average only 2-3 years per century in the absence of climate change). All crop-specific land area fractions exposed are added together.
8. **Number of people annually exposed to wildfires:** Population annually exposed to wildfires describes the annual aggregate of land area, within a grid cell of 0.5° resolution, burnt at least once a year by wildfires, multiplied by the total population of that grid cell.
9. **Annual expected damage from tropical cyclones and river flood:** CLIMADA, an open-source catastrophe risk modelling framework, is used to estimate the damages from extreme events by modelling their likelihood of occurring and the hazard associated with them. The expected damage to physical assets exposed to these events is calculated using vulnerability functions which quantify the relationship between the amount of damage to an asset and the intensity of the hazard. This mapping of hazard to damage is applied to all exposed assets and allows an estimate of the total loss from physical damages to be calculated for each extreme event.
10. **Labour productivity due to heat stress:** Heat stress impact on labour productivity indicates the percentage decrease in labour productivity under hot and humid climate conditions due to the reduced capacity of the human body to perform physical labour. The analysis is building on previous work by Gosling et al. (2018).
11. **Reduction in maize yield:** Maize yields were calculated by assuming that the cultivated areas of both rainfed and irrigated maize will remain constant through the 21st century. Their projected changes hence only reflect the future evolution of climate, and not that of agricultural management practices.
12. **Reduction in soy yield:** Soy yields were calculated by assuming that the cultivated areas of both rainfed and irrigated soy will remain constant through the 21st century. Their projected changes hence only reflect the future evolution of climate, and not that of agricultural management practices.
13. **Reduction in rice yield:** Rice yields were calculated by assuming that the cultivated areas of both rainfed and irrigated rice will remain constant through the 21st century. Their projected changes hence only reflect the future evolution of climate, and not that of agricultural management practices.
14. **Reduction in wheat yield:** Wheat yields were calculated by assuming that the cultivated areas of both rainfed and irrigated wheat will remain constant through the 21st century. Their projected changes hence only reflect the future evolution of climate, and not that of agricultural management practices.

- *Climate Analytics (2021). climate-impact-explorer.climateanalytics.org*

National Adaptation Strategies

The national adaptation strategies were retrieved mainly through national websites.

Nationally Determined Contribution (NDC): Adaptation

Adaptation-related aspects of each country's Nationally Determined Contribution were extracted from the NDCs submitted to the UNFCCC registry.

- *https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx*

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MITIGATION

Woven through the mitigation section there are ratings of decarbonisation efforts and assessments of countries policies.

Ratings of decarbonisation efforts

The Climate Transparency Report provides ratings for different decarbonisation indicators. These ratings assess each country's performance **relative** to the other G20 members. The lowest and highest data points (countries) for each indicator form each end of a range along which the 5 quintiles are delineated to create the ratings of 'very low', 'low', 'medium', 'high' and 'very high'. Outliers were eliminated to allow for a more accurate representation of the relative performance of each country.

This is same methodology employed in the 2022 report. A high rating reflects a relatively good effort to decarbonise an aspect of the economy (i.e., it is a rating from a **climate protection perspective)** but is not necessarily 1.5°C compatible. This rating does not take account of other socio-economic aspects, but rates the indicators on their climate impact. The ratings assess both the current level (2022) and recent developments to take into account the different starting points of different G20 members. The recent developments ratings compare the development of the last five available years - 2016 to 2021 - for indicators. Where 2022 data isn't available, the most recent five-year span of data is used.

Policy assessments

The policies evaluated were agreed by the Partners in early 2019 and based on their relevance for global decarbonisation and data availability across all G20 members. The criteria for rating were also decided by consensus in the Partnership.

Policy Assessment Criteria

	LOW	MEDIUM	HIGH	FRONTRUNNER
Renewable energy in power sector	No policies to increase the share of renewables	Some policies	Policies and longer-term strategy/ target to significantly increase the share of renewables	Short-term policies + long-term strategy for 100% renewables in the power sector by 2050 in place
Coal phase-out in power sector	No targets and policies in place for reducing coal	Some policies	Policies + coal phase-out decided	Policies + coal phase-out date before 2030 (OECD and EU28) or 2040 (rest of the world)
Phase out fossil fuel cars	No policies for reducing emissions from light-duty vehicles	Some policies (e.g. energy/emissions performance standards or bonus/ malus support)	Policies + national target to phase out fossil fuel light-duty vehicles	Policies + ban on new fossil fuel-based light-duty vehicles by 2035 worldwide
Phase out fossil fuel heavy-duty vehicles	No policies	Some policies (e.g. energy/emissions performance standards or support)	Policies + strategy to reduce absolute emissions from freight transport	Policies + innovation + strategy to phase out emissions from freight transport by 2050
Modal shift in (ground) transport	No policies	Some policies (e.g. support programmes to shift to rail or non-motorised transport)	Policies + longer-term strategy	Policies + longer-term strategy consistent with 1.5°C pathway
Near zero energy new buildings	No policies	Some policies (e.g. building codes, standards or fiscal/financial incentives for low-emissions options)	Policies + national strategy for near zero energy new buildings	Policies + national strategy for all new buildings to be near zero energy by 2020 (OECD countries) or 2025 (non-OECD countries)
Energy efficiency in industry	No policies	Mandatory energy efficiency policies cover more than 26-50% of industrial energy use	Mandatory energy efficiency policies cover 51–100% of industrial energy use	Policies + strategy to reduce industrial emissions by 75-90% from 2010 levels by 2050
Retrofitting existing buildings	No policies	Some policies (e.g. building codes, standards or fiscal/financial incentives for low-emissions options)	Policies + retrofitting strategy	Policies + strategy to achieve deep renovation rates of 5% annually (OECD) or 3% (non-OECD) by 2020
Net zero deforestation	No policies or incentives to reduce deforestation in place	Some policies (e.g. incentives to reduce deforestation or support schemes for afforestation/ reforestation in place)	Policies + national target for reaching net zero deforestation	Policies + national target for reaching zero deforestation by 2020s or for increasing forest coverage

If a policy is not relevant for a country (e.g., no coal in Saudi Arabia), we do not give a rating but write "not applicable". If there is a considerable lack of implementation that contradicts a positive policy is noted in the assessment.

Trend calculations

Trends are calculated using the most recent and five earlier data years, calculating a linear trend out of those values and then calculating a trend ($\frac{y2-y1}{y1}$, y1 being the base year) out of the values of the linear trend in the respective years. In comparison to a trend using only the first and last values of a 5-year period, the trend analysis has the advantage that all other data years within the time period are taken into account, making it less susceptible to noise in the data (e.g., an unusually warm winter affecting emissions).

1.5°C Benchmarks

At the beginning of each mitigation subsection are global benchmarks adopted from the IPCC's *Special Report on the impacts of global warming of 1.5°C* as agreed by the Partnership in May 2019 and used in the 2019 Report. Several of these are augmented by more recent analysis, as agreed by the Partnership in March 2021.

- *Rogelj, J. et al. (2018) 'Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development', in Masson-Delmotte, V. et al. (eds) Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above preindustrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter2_Low_Res.pdf*

- *Climate Action Tracker (CAT). (2020). Paris Agreement Compatible Sectoral Benchmarks Study.* https://climateactiontracker.org/documents/753/CAT_2020-07-10_ParisAgreementBenchmarks_FullReport.pdf

Emissions Overview

GHG emissions across sectors ($MtCO_2$ e/year)

- *Gütschow, J. et al. (2021). The PRIMAP-hist National Historical Emissions Time Series (1850-2018), V.2.2. Zenodo open access repository.* https://doi.org/10.5281/zenodo.4479172

Total Methane (CH_4) emissions across sectors

GHG emissions ($MtCO_2e$/year)

- *Gütschow, J. et al. (2021). The PRIMAP-hist National Historical Emissions Time Series (1850-2018), V.2.2. Zenodo open access repository.* https://doi.org/10.5281/zenodo.4479172
- *Climate and Clean Air Coalition. (2021). Global Methane Pledge.* https://www.ccacoalition.org/en/resources/global-methane-pledge

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Energy-related CO_2 emissions by sector

Annual CO_2 emissions from fuel combustion ($MtCO_2$ /year)
CO_2 emissions from energy account for the highest share of total GHG emissions in most countries. They are emissions resulting from fuel combustion (coal, oil and gas) in sectors electricity and heat, transport, buildings, agriculture, industries and other emissions from the energy sector (e.g., the emissions of transforming coal into coke). Emissions are calculated according to the 2006 IPCC Guidelines for National GHG Inventories.

Enerdata provided data: Global Energy and CO_2 data: CO_2 emissions from fuel combustion (sectoral approach); CO_2 emissions in energy sector (Fuel combustion); CO_2 emissions from industries (fuel combustion incl. auto producers); CO_2 emissions from households, services, agriculture (fuel combustion); CO_2 emissions from transport (Fuel combustion, including domestic aviation emissions); CO_2 emissions from industrial process.

Energy Overview

Energy Mix

Total primary energy supply (TPES) is the sum of energy production, energy imports and stock variations minus energy exports and international bunkers. Other reports sometimes consider total final consumption, which is TPES minus losses in energy conversion. From a climate perspective it is, however, more important how much fuel is fed into the system and combusted, and not how much energy is consumed by end users. 'Other' includes solid fuel biomass from residential use, which is shown separately because of its negative social and environmental impacts.

All energy data is from Enerdata (with the exception of Argentina's country profile) and excludes non-energy use values, i.e., fuels that are used as raw materials.

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Solar, Wind, Geothermal, and Biomass Development

This indicator covers solar, wind, geothermal and non-residential biomass. It excludes unsustainable renewable sources such as large hydropower or traditional biomass used in the residential sector (mainly fuel wood used for cooking).

Enerdata provided data: Global Energy and CO_2 data: Total primary consumption; Primary production of solar electricity; Share of wind in primary consumption; Share of geothermal electricity in primary consumption; Share of Biomass in TPES (excl. traditional biomass - mainly solid fuel biomass for residential use).

Carbon Intensity of Energy Supply

Carbon intensity of a country's energy sector describes the CO_2 emissions per unit of total primary energy supply. It gives an indication on the share of fossil fuels in the energy supply, the choice of fuel (e.g., gas is less carbon intensive than coal) and on the efficiency of generation.

A country with a very low level of carbon intensity in 2021, **when compared to other G20 members,** receives a very high **rating** for decarbonisation of the 'current year'. A very high rating for the 5-year trend from 2016 to 2021, indicates good progress on decarbonising the energy supply —when compared to the G20 peers.

Enerdata provided data: Global Energy and CO_2 data: CO_2 per toe consumed (CO_2 from fuel combustion).

Energy supply per capita

Total Primary Energy Supply (TPES) per capita encapsulates the energy supply in relation to a country's population. The level of energy use per capita is closely related to economic development, climatic conditions and the price of energy. There are enormous differences in the level of energy use per capita between low- and middle-income economies, and high-income economies.

Energy intensity of the economy

TPES per unit of GDP describes the energy intensity of a country's economy. This indicator illustrates the efficiency of energy usage by calculating the energy needed to produce one unit of GDP. A decrease in this indicator can mean an increase in efficiency but also reflects structural economic changes.

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Power Sector

1.5°C Benchmark sources

- *Rogelj, J. et al. (2018). "Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development", in Masson-Delmotte, V. et al. (eds) Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C. IPCC. https://www.ipcc.ch/*
- *Climate Action Tracker (CAT). (2020). Paris Agreement Compatible Sectoral Benchmarks Study. https://climateactiontracker.org/documents/753/CAT_2020-07-10_ParisAgreementBenchmarks_FullReport.pdf*

Electricity mix

Enerdata provided data: Global Energy and CO_2 data: Electricity production; Nuclear electricity production; Electricity production from oil; Electricity production from natural gas; Electricity production from coal, lignite; Share of renewables in electricity production (incl. large hydro).

Share of Renewables in Power Sector

Enerdata provided data: Global Energy and CO_2 data: Electricity production from renewable biomass and waste; Offshore wind electricity production; Onshore wind electricity production; Solar electricity production; Geothermal electricity production; Hydroelectric production.

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Power Sector, continued

Emissions intensity of the power sector

Enerdata provided data: Global Energy and CO_2 data: CO_2 emissions of the electricity production.

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Transport Sector

1.5°C Benchmark source

- *Rogelj, J. et al. (2018). "Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development", in Masson-Delmotte, V. et al. (eds) Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C. IPCC. https://www.ipcc.ch/*
- *Climate Action Tracker (CAT). (2020). Paris Agreement Compatible Sectoral Benchmarks Study. https://climateactiontracker.org/documents/753/CAT_2020-07-10_ParisAgreementBenchmarks_FullReport.pdf*

Transport Energy Mix

Enerdata provided data: Global Energy and CO_2 data: Total energy final consumption of transport; Oil products final consumption of transport; Natural gas final consumption of transport; Electricity final consumption of transport; Coal final consumption of transport; Biofuels final consumption of transport.

Transport emissions per capita

Enerdata provided data: Global Energy and CO_2 data: CO_2 emissions from transport (Fuel combustion).

- *World Bank (2022). Population, total.* https://data.worldbank.org/indicator/SP.POP.TOTL

Reductions in transport emissions per capita in 2021, and concomitant changes in the 5-year trends and decarbonisation ratings, reflect widespread economic slowdowns and transport restrictions imposed in response to the COVID-19 pandemic.

Aviation emissions per capita (2018)

- *Enerdata. (2022). Global Energy and CO_2 Data. https://www.enerdata.net*
- *International Energy Agency (IEA). (2021). Aviation. https://www.iea.org/reports/aviation*
- *World Bank (2022). Population, total.* https://data.worldbank.org/indicator/SP.POP.TOTL

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Motorisation rate and modal splits

Data for motorisation rates and modal splits are mainly drawn from Enerdata, or from domestic data. Note that, where stated, owing to other sources and data years available, these data may not be comparable across G20 members. Enerdata data has been harmonised and therefore is comparable across G20 members.

- *Enerdata. (2022). Global Energy and CO_2 Data. https://www.enerdata.net*

Market share (%) of electric vehicles in new car sales

Data for market share (%) of electric vehicle (PHEVs and BEVs) sales in new car sales are drawn from the IEA, or from domestic data. Note that, where stated, owing to other sources and data years available, these data may not be comparable across G20 members. IEA provided data has been harmonised and is comparable across G20 members.

- *International Energy Agency (IEA). (2022). Global Electric Vehicle Outlook 2022. https://www.iea.org/reports/global-ev-outlook-2022*

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Building Sector

1.5°C Benchmark sources

- *Rogelj, J. et al. (2018). "Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development", in Masson-Delmotte, V. et al. (eds) Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C. IPCC. https://www.ipcc.ch/*
- *Climate Action Tracker (CAT). (2020). Paris Agreement Compatible Sectoral Benchmarks Study. https://climateactiontracker.org/documents/753/CAT_2020-07-10_ParisAgreementBenchmarks_FullReport.pdf*

Building emissions per capita

Enerdata provided data: Global Energy and CO_2 data: CO_2 emissions from households (Fuel combustion); Indirect CO_2 emissions from households; and

- *World Bank (2022). Population, total. https://data.worldbank.org/indicator/SP.POP.TOTL*

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Industry Sector

Industry emissions intensity (Data for 2017)

Industry sector emissions are primarily from steel, cement and concrete production, and the chemicals sub-sector (producing everything from plastics to pharmaceuticals and fertilisers). Smaller contributions are from so-called 'light' manufacturing and industry, smelting and
processing of non-ferrous metals (like aluminium, copper and zinc), and pulp and paper production.

Energy emissions in industry are taken from Enerdata.

- *Enerdata provided data: Global Energy and CO_2 data: CO_2 emissions from industries (Fuel combustion incl. auto-producers).*
- *The World Bank. (2021). GDP per capita (constant 2015 US$). https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD*

Carbon intensity of steel production

Steel emissions intensity (kg CO_2 / t product). CO_2 emissions per tonne of steel produced Includes scope 1 (direct energy-related and process emissions) and scope 2 (i.e., related to electricity consumption) emissions.

- *Enerdata provided data: Global Energy and CO_2 data: CO_2 emissions from industries (Fuel combustion incl. auto-producers).*
- *World Steel Association. (2021). Steel Data and Statistics. https://www.worldsteel.org/*

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Land Use

Annual forest expansion, deforestation and net change ______________________________

As measured by forest area change in 1,000 ha/year

- Global Forest Resources Assessment. (2020). *Annual Forest Expansion, Deforestation and Net Change Indicator. Food and Agriculture Organisation*. https://fra-data.fao.org/WO/fra2020/forestAreaChange/
- Source not updated annually, therefore data the same as reproduced in 2021.

Emissions from agriculture ____

Emissions from agriculture, excluding energy-related emissions.

- Food and Agriculture Organization (FAO). *(2022). Emissions Totals: Agriculture.* http://www.fao.org/faostat

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Mitigation: Targets and Ambition

Nationally Determined Contribution (NDC): Mitigation

Mitigation-related aspects of each country's Nationally Determined Contribution were extracted from the NDCs submitted to the UNFCCC registry.

- *https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx*

Climate Action Tracker (CAT) evaluation of NDC and actions

The Climate Action Tracker's new (launched in 2021) **assessment framework** combines both fair share and cost-efficient mitigation perspectives to assess the different components of government targets and actions. For each country, CAT develops:

- ***The overall rating:*** *the combination of all the ratings generates an overall rating for the country. This is used on page 15 of the country profiles.*
- *A rating of the **policies and action**: are governments putting in place real policies and action in line with global least-cost mitigation pathways or fair share principles?*
- *A rating of the "**domestic target**" or the "**internationally supported target**": are government promises for targets in their country ambitious with respect to global least-cost mitigation pathways, acknowledging that most developing countries will need support to achieve this level?*
- *A rating of the "**fair share target**": is a country doing its fair share? We assess whether government promises for action in their country with their own resources and, if relevant, the financing of action abroad represents a fair contribution to global efforts.*
- *A rating of **climate finance** for those countries where relevant; we assess whether governments are providing sufficient support for mitigation actions in other countries.*

Governments should commit to reducing their own emissions and follow through on those commitments by implementing policies that reduce emissions to meet those targets. These actions in a country can be assessed against what is technically and economically feasible, usually a globally cost-efficient perspective.

However, for many countries, what is feasible either falls short of what would be expected of them based on principles of fairness, or is beyond what is possible with domestic resources alone. Fair share principles mean that developed country governments need to support developing countries in achieving the global mitigation goals.

As EU member states, France, Germany and Italy committed to contributing to the EU's NDC. 'Fair-share' pathways and ratings for individual EU member states are not provided due to the intricacies and inter-linkages of the internal burden sharing system. Given its withdrawal from the European Union on 31 January 2020, the UK submitted its own NDC to the UNFCCC in 2020.

CAT uses five rating categories for its overall rating and the different elements:

- *The "1.5°C Paris Agreement compatible" rating indicates that a country's climate policies and commitments are consistent with the Paris Agreement's 1.5°C temperature limit.*
- *The "Almost sufficient" rating indicates that a country's climate policies and commitments are not yet consistent with the Paris Agreement's 1.5°C temperature limit but could be with moderate improvements.*
- *The "Insufficient" rating indicates that a country's climate policies and commitments need substantial improvements to be consistent with the Paris Agreement's 1.5°C temperature limit.*
- *The "Highly insufficient" rating indicates that a country's climate policies and commitments are not consistent with the Paris Agreement's 1.5°C temperature limit. For many countries in this category, policies and commitments lead to rising, rather than falling, emissions.*
- *The "Critically Insufficient" rating indicates that a country's climate policies and commitments reflect minimal to no action and are not at all consistent with the Paris Agreement.*

For a very in-depth explication of the new rating methodology see:

- *https://climateactiontracker.org/methodology/cat-rating-methodology*

Long-Term Strategies

The tables give an overview of the main content of a country's long-term strategy submitted to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat. The report provides only a summary of the targets and does not provide an evaluation.

- *Communication of long-term strategies retrieved from: https://unfccc.int/process/the-paris-agreement/long-term-strategies*

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3. FINANCE

MAKING FINANCE FLOWS CONSISTENT WITH CLIMATE GOALS

Fossil fuel subsidies relative to national budgets

The fossil fuel subsidies data presented in the Climate Transparency Report is taken from the OECD/IEA joint fossil fuel subsidies database, released in 2021 The OECD inventory collates information on the amount of subsidies provided by governments in the form of tax breaks and budgetary support. The OECD data include country information for all G20 countries, except Saudi Arabia. The estimates include support towards production and consumption of fossil fuel subsidies, as well as general services, which for the purposes of this report are combined with producer support into a single 'production' category.

The inventory is used in the Climate Transparency Report because it provides a 'bottom-up' way of quantifying subsidies by collating government information on individual policy measures, and in this way, helps identify specific opportunities for reform. The results in this report are presented in US$ billions and are taken from the latest year for which data is available, which is 2020. The results are also broken down into four end uses: coal, petroleum, natural gas, and fossil fuel-powered electricity. Trends in the time period 2011 to 2020 are also presented for countries. The original data provided by the OECD is in national currencies, and in the Climate Transparency Report have been converted to common currency using current exchange rates from the OECD database. GDP data is also provided by the OECD. Aggregate G20 numbers for 2021 were released in a report by the OECD in August 2022 but country-level data was not yet made available at the time of doing the analysis for this report. Public spending data, where it is used in country profiles, is obtained from national government databases.

The subsidy data for Saudi Arabia is from the IEA database because no OECD data are available. The IEA uses a different methodology for calculating subsidies, called the 'price-gap' approach. This approach compares average end-user prices paid by consumers with reference prices that correspond to the full cost of supply. It covers a sub-set of consumer subsidies, and does not include production subsidies. The differences between OECD and IEA methodology can result in significant variations in the calculated total amount of subsidies. The results are presented in US$ billions and are taken from the latest year for which data is available on the database (2019). Trends are also presented for the time period 2011-2020.

It is worth noting that estimates on fossil fuel subsidies can differ across sources, therefore OECD may not necessarily reflect government perceptions on the level of fossil fuel subsidies (even though the inventory is produced in collaboration with governments). The OECD data is, however, useful in providing a comparable tool for G20 countries, from a methodological perspective. Moreover, independent estimates have often found measures and resulting subsidies that are not included in the OECD database. Electricity subsidies themselves are not necessarily fossil expenditures, as decarbonisation will require significant investments in electricity infrastructure. OECD calculates the support to fossil fuel-powered electricity with pro-rata calculations of the total support to electricity, multiplied by the share of fossil fuels in electricity generation.

It should also be noted that support measures may be added to the OECD inventory, or resulting subsidy estimates revised, in later years as countries improve their reporting. Climate Transparency Reports of any given year should therefore not be compared against reports of previous years – instead, comparisons over time are made within each CT report.

- *OECD. (2020). OECD analysis of budgetary support and tax expenditures. Fossil Fuel Support Database.* http://www.oecd.org/fossil-fuels/data/
- *IEA. (2020). Value of fossil fuel consumption subsidies, 2010-2020.* https://www.iea.org/data-and-statistics/charts/value-of-fossil-fuel-consumption-subsidies-2010-2020
- *Energy Policy Tracker. (2021). Track public money for energy in recovery packages.* www.energypolicytracker.org

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Carbon Pricing and Revenues

The Institute for Climate Economics (I4CE) performed the analysis of carbon pricing and revenue data for G20 countries. The I4CE data collates information on the amount of carbon revenues generated by explicit carbon pricing schemes. This includes explicit carbon taxes and emissions trading schemes, both national and subnational in nature; it does not include implicit schemes, that is the taxation of emissions through policies other than explicit carbon pricing policies (e.g., VAT on petrol). It is used in the Climate Transparency Report because it provides a 'bottom-up' way of quantifying carbon revenues, and in this way, helps to identify the country's ambitions in carbon pricing now and in the future (including data on schemes currently under consideration but not yet implemented). In terms of pricing, the carbon prices used in the report are the *nominal* carbon rates adopted in each country, as opposed to the *effective* carbon rates, which would instead take applied exemptions into account in the final price of carbon. The revenues are presented in US$ billions and are taken from the latest year for which data is available, which is 2021 (March 2021 – March 2022 for the EU ETS). Trends for countries in the time period 2012 to 2021 are also presented.

A comparison has also been drawn for G20 countries in terms of the coverage and pricing of their explicit carbon schemes. For the EU ETS member countries, the comparison includes the EU ETS as well as any national scheme prices. Price ranges in some countries based on sector or use type. For EU countries, the prices shown are in addition to the EU ETS price listed at the bottom of the table, and coverage is the percent of national emissions covered by the EU ETS added to the percent covered by any national carbon tax. Coverage rating criteria are based on that which was used in the BNEF Climate Policy Factbook, and price criteria are based on the thresholds recommended by 2020 by the High-Level Commission on Carbon Prices as well as the authors' own assessment.

- *Institute for Climate Economics. (I4CE). Global Carbon Accounts 2021. Paris, France. https://www.i4ce.org/download/global-carbon-account-in-2021/*

Public finance

Public finance for fossil fuels

The public finance data presented in the Climate Transparency Report is taken from Oil Change International's Public Finance for Energy database (2022), which includes information from several sources including information provided by public finance institutions and from the Infrastructure Journal Global database (IJ Global, 2019). The Public Finance for Energy database collates information on public finance for energy projects by G20 public finance institutions, domestically and internationally, in the form of loans, grants and guarantees. This database is used in the Climate Transparency Report because it provides a 'bottom-up' way of quantifying public finance by collating information on individual projects. The results presented are in US$ billions. As public financing is intermittent in nature, we use annual averages for the time period 2019 to 2020 (the most recent two years for which complete data is available). This is calculated as the total amount of public finance provided for any relevant fossil fuel project whose financing was agreed in 2019 and 2020, divided by two (i.e., across the two years), to obtain annual average annual values.

There are some data caveats that are important to note. Due to limited transparency on the support provided by public finance at the project-level, the database is an underestimate of the total amount of support provided. The data also omits most finance delivered through financial intermediaries (because the volume of finance for specific energy activities ultimately delivered through those intermediaries is often unclear). For the same reason, the datasets omit significant volumes of MDB development policy finance. Given a lack of transparency, other important multilateral institutions in which G20 governments participate are not covered in this report, for example, the Development Bank of Latin America (CAF), Asian Infrastructure Investment Bank, New Development Bank, Islamic Development Bank, the sub-regional MDBs, and other non-MDB multilateral financial institutions. There is a general lack of transparency in the public finance institutions in Argentina, Indonesia, Mexico, Russia and Turkey, which is likely to lead to underestimates in public financing towards fossil fuels.

The Public Finance for Energy dataset includes Multilateral, Bilateral, or Export Credit. National Development Banks, government departments, and publicly-owned banks that provide consumer banking are not included as they have not been consistently updated. Data for public finance for energy in Australia and Turkey may therefore be significant underestimates.

Oil Change International categorises the data as follows:

Fossil Fuel: This includes the oil, gas, and coal sectors. This includes access, exploration and appraisal, development, extraction, preparation, transport, plant construction and operation, distribution, and decommissioning. It also includes energy efficiency projects where the energy source(s) involved are primarily fossil fuels.

Clean: This includes energy that is both low-carbon and has negligible impacts on the environment and human populations if implemented with appropriate safeguards. This includes solar, wind, tidal, geothermal, and small-scale hydro. This classification also includes energy efficiency projects where the energy source(s) involved are not primarily fossil fuels.

Other: This includes projects where (a) the energy source(s) are unclear or unidentified, as with many transmission and distribution projects as well as (b) non-fossil energy sources that typically have significant impacts on the environment and human populations. This includes large hydropower, biofuels, biomass, nuclear power, and incineration. If a project includes multiple energy sources, we split it into multiple transactions whenever possible. Otherwise, it is also classified as 'Other.' More than 70% of the finance in this category is for transmission and distribution projects and other projects where the associated energy sources are unclear. This also includes energy efficiency projects where the mix of fossil fuels involved is unknown.

- *Oil Change International. (2022). Public Finance for Energy Database. https://energyfinance.org/#/data*

Provision of international public support

The official reporting on climate finance contributions are sourced from the latest Party reporting to the UNFCCC, corresponding to year 2017-18 (the latest years for which reporting is consistently available).

Annex I and II Parties are required to provide information on financial resources provided to non-Annex I Parties through their National Communications as well as their Biennial Reports (BR) and Common Tabular Format (CTF) Tables. Developed countries have submitted four Biennial Reports, the last submission being by 30 October 2021 from the United States for 2017-18. As such, the data on the climate finance provided to developing countries to support climate change mitigation and adaptation actions are sourced from this fourth biennial reporting of developed country Parties to the UNFCCC. The Fifth BR is expected to be submitted by December 2022, as decided by COP25 (CFAS, 2022). We present data for only those countries that are listed as Annex II of the UNFCCC and are therefore formally obliged to provide climate finance.

While not obligated, Russia has provided data in its reporting to the UNFCCC as an Annex I country. It is also worth noting that there is climate finance provision that is not captured in common tabular format in biennial update reports and thus is not presented here. China for example, reports the provision of bilateral climate finance but not in a format or over a time period that allows comparison with other countries. South Korea, while a non-Annex II country, is an OECD DAC member and therefore reports bilateral climate finance to the OECD-DAC. A number of other countries have contributed to multilateral climate funds on a voluntary basis. The total financial contributions reported in biennial reports BRs consist of climate-specific contributions through bilateral channels and through multilateral climate change funds, split into four categories: mitigation or adaptation, cross-cutting or other. The multilateral climate change funds included are those listed in paragraph 17(a) of the “UNFCCC biennial reporting guidelines for developed country Parties” in decision 2/CP.17, i.e. The Global Environment Facility, the Least Developed Countries Fund, the Special Climate Change Fund, the Adaptation Fund, the Green Climate Fund and the Trust Fund for Supplementary Activities and, other multilateral climate change funds as referred in paragraph 17(b) of the “UNFCCC biennial reporting guidelines for developed country Parties” in Decision 2/CP.17 (page 34).

Flows are measured at the point of commitment to specific climate projects or programmes. The theme of the climate finance is dictated by the reporting of the country to the UNFCCC. It is classified as mitigation, adaptation, cross-cutting or other. The definitions of these categories vary by country (and institution), however (see UNFCCC 2016, Annex D, Table D1). Germany includes mobilised finance through KfW in its reporting to the UNFCCC. The figure in the country profile is adjusted to make figures more comparable with other G20 countries. Germany’s thematic breakdown is based on the full amount, including this KfW mobilised finance, however, since data availability is not sufficient to disaggregate by theme. Similarly, the EU reports also EIB figures in their reporting, and for comparison only the EU contributions are reported here, again while recognizing the important contribution.

Reporting further includes a ‘core’ or ‘general’ contribution category that includes support provided to multilateral institutions, including regional development banks, that Parties cannot specify as being climate-specific support (e.g., to the core budget of the World Bank or UNDP, UNEP). This allows us to capture some of the climate finance that countries provide through the MDBs. It is noted however, that MDBs can borrow funds1, which means their development finance commitments can exceed the funds provided by their shareholders. Each MDB has a number of developed and developing country shareholders that contribute capital (paid-in capital), as well as committing to provide additional funds in certain circumstances (callable capital)2. Concessional finance provided by MDBs is funded mainly by developed country contributions and retained earnings, while non-concessional finance is funded mainly with money borrowed from capital markets3. While the core/general contributions reported by Annex II Parties in BRs went mostly to MDBs, MDB outflows are significantly greater than the government contributions (or inflows) reported in this data. Thus, while the inclusion of core-general funding in country profiles improves our understanding of MDB contributions it still omits magnitudes of funding from MDBs to support climate action in developing countries.

- *Country Biennial Report submissions to the UNFCCC retrieved from: https://unfccc.int/BRs*

Bilateral climate finance contributions

The numbers published in the country profiles refer to bilateral, concessional, public climate finance delivered annually in the period to developing countries. It includes climate finance reported as committed directly by donors in their biennial reporting to the UNFCCC. Only bilateral data is taken from country reports and not the multilateral nor the core general contributions that countries report to the UNFCCC. This is done to avoid double counting with the multilateral climate change funds. Flows are measured at the point of commitment to specific climate projects or programmes.

Germany includes mobilised finance through KfW in its reporting to the UNFCCC. The figure reported is therefore adjusted to make figures more comparable with other G20 countries. But this contribution is recognized. Germany's thematic breakdown is based on the full amount, including this KfW mobilised finance, however, since data availability is not sufficient to disaggregate by theme. Similarly, the EU reports also EIB figures in their reporting, and for comparison only the EU contributions are reported here, again while recognizing the important contribution. The theme of the bilateral climate finance is dictated by the reporting of the country to the UNFCCC. It is classified as mitigation, adaptation, cross-cutting or other. The definitions of these categories vary by country (and institution), other, however, where used, generally refers to finance supporting REDD+ (see UNFCCC 2016, Annex D, Table D1).

The summary report presents data for only those countries that are listed as Annex II of the UNFCCC and are therefore formally obligated to provide climate finance. While not obligated, Russia has provided data in its reporting to the UNFCCC. It is also worth noting that there is bilateral finance provision that is not captured in common tabular format in biennial update reports and thus is not presented here. China for example, reports the provision of bilateral climate finance but not in a format or over a time period that allows comparison with other countries. South Korea, while a non-Annex II country, is an OECD DAC member and therefore reports bilateral climate finance to the OECD-DAC.

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[1] An MDB can borrow on favourable terms, in part because some of the bank's developed country shareholders have excellent credit ratings, and also because the developing country recipients of MDB finance have a strong track record of repayment. An MDB can then lend funds to its developing country clients on more favourable terms than they would get from other lenders.

[2] Unlike shareholders of a private firm, a bank's shareholders receive no dividends or interest on their capital.

[3] MDBs are allowed to do this, largely as it can rely on callable capital if it needs to repay debt.

- *Country Biennial Report submissions to the UNFCCC retrieved from: https://unfccc.int/BRs*

Multilateral climate funds contributions

The numbers published in the country profiles refer to the G20 annual average contributions via the multilateral climate funds in 2017 and 2018 to developing countries. It is generated by attributing the resources approved by each fund's governing board/committee for projects in 2017 and 2018 to individual donors based on the percentage of each funds resources that their pledges represented at the end of 2018. Data is included for the following climate funds: Adaptation for Smallholder Agriculture Programme; Adaptation Fund; Clean Technology Fund; Forest Carbon Partnership Facility; Forest Investment Program; Global Environment Facility (6th Replenishment, Climate Mitigation Focal Area only); Green Climate Fund; Least Developed Countries Fund; Partnership for Market Readiness; Pilot Program for Climate Resilience; Scaling-up Renewable Energy Program; Special Climate Change Fund and the UNREDD Programme.

The theme of the multilateral climate fund finance is dictated by the nature of the fund and can be split into adaptation, mitigation and to projects that deliver both mitigation and adaptation actions, so called 'cross-cutting'. It should be noted that such a thematic categorization can go against those of the countries that provide finance, e.g., while REDD+ was designed as a mitigation mechanism, many contributors consider adaptation benefits can also be delivered and may consider such projects crosscutting. Unlike other funds, the GCF supports adaptation, mitigation and crosscutting objectives. For the GCF, the approved amounts in 2017 and 2018 are first broken down into the theme as determined in the project design, and each countries contribution established as a proportion of this thematic amount.

The country reports include developing countries that have contributed to the multilateral climate funds. However, the summary report only ranks those countries that are signatories to Annex II of the UNFCCC and therefore formally obligated to provide climate finance under the Convention. Figures for finance delivered through multilateral climate funds are sourced from Climate Funds Update, a joint ODI/Heinrich Böll Foundation database that tracks spending through all major climate funds.

Fair Share

In 2009, so-called 'developed countries' committed to jointly mobilise USD100 billion a year by 2020 to address the needs of 'developing countries'. The Copenhagen Accord does not apportion individual country responsibility for the USD bn 100 a year goal and thereby ensure accountability on climate finance provision. The Fair Share appraisal focuses on progress towards the goal of $100 billion a year. Provision of climate finance typically refers to resources supplied by developed countries' governments – that is, public funds – whether as grants or as loans.

We use three metrics to assess each developed country's fair share of the climate finance goal:

1. gross national income (GNI) in current US dollars for 2020 (World Bank, 2022a) as a proxy for ability to pay
2. cumulative territorial carbon dioxide emissions ($GtCO_2$) between 1990 and 2020 (calculated[4] using Friedlingstein et al., 2022) as a proxy for historic responsibility for climate change

[4] Conversion calculation from carbon to carbon dioxide using the recommended coefficient as per Friedlingstein et al. (2022).

3. population in 2020 (World Bank, 2022), which is the simplest form of assessing 'fair share' as it allocates equal responsibility for climate finance to all people living in developed countries.

While imperfect, these metrics each offer an indicative benchmark to explore individual countries' responsibility for climate finance.

We developed a composite indicator that uses all three of these metrics. We then calculated a proportion of each country's economy, emissions and population as a proportion of developed countries' total, and used these percentages to indicate each country's fair share of the $100 billion a year target. The composite indicator is an average of each country's share of developed countries' collective GNI, cumulative territorial emissions and population – that is, the composite indicator gives each of the three metrics equal weight. We use climate-related finance data (i.e., ODA tagged as having climate as a significant or principal objective) from the OECD Development Assistance Committee (DAC) as a proxy for climate finance flows in 2019 and 2020, as updated data from the UNFCCC is not yet available.

For details on this fair share methodology,

- *Colenbrander, S. et al. (2022). A Fair Share* of Climate Finance? An Appraisal of Past Performance, Future Pledges and Prospective Contributors. https://cdn.odi.org/media/documents/A_fair_share_of_climate_finance.pdf

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Financial policy and regulation

This section utilises data on macro-prudential regulations and policy measures and instruments from the country's respective government, central banks, public financial institutions and financial regulators database. It also refers to an existing dataset, the Green Finance Platform, by the Green Growth Knowledge Partnership, that records finance measures on legislation, sectoral and system level regulations, supervisory frameworks, fiscal support mechanisms, market codes and standards, guidance, guidelines, consultations and other activities like climate-oriented research.

Central banks and financial regulators are important as they can set market rules that shift investments, often driven by short-term yields, to long-term sustainable solutions. They can support the direction of finance towards green projects through, for example, priority lending. They can also encourage the incorporation of climate risks in investment decisions, including through banking stress tests and improving standards of due diligence for banks and financial institutions to consider climate risks.[5]

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Endnotes and policy assessment criteria.

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Bibliography.

[5] D'Orazio and Popoyan (2019) Fostering green investments and tackling climate-related financial risks: Which role for macroprudential policies? *Ecological Economics*, Volume 160, June 2019, Pages 25-37