Climate Analytics equity methodology

Marcia Rocha, Alain Coimbra, Paola Yanguas-Parra, Uğur Ural

Description of the Equity Analysis Tool

The PRIMAP group at the Potsdam Institute for Climate Impact Research (PIK) developed the Potsdam Real-time Integrated Model for the probabilistic Assessment of emission Paths (PRIMAP model) (Potsdam Institute of Climate Impact Research, n.d.). The Emissions Module (Nabel et al., 2011) has been developed as part of this model and allows for the flexible combination of data sources into composite datasets, and the calculation of national, regional and global emission pathways following various emission allocation schemes. At the core of the Emissions Module is a custom-built emissions database, the so-called PRIMAPDB. Climate Analytics and the PRIMAP group developed an Equity Analysis Tool for the assessment of equity principles and indicators, embedded in the Emissions Module. Currently implemented in the tool we have the following published equity methodology proposals:

- Greenhouse Development Rights (Kartha, Baer, Athanasiou, & Kemp-Benedict, 2009)
- South North Proposal (Ott et al., 2004) with own methodology for downscaling emissions from groups to country level based on GDP and population projections (details available upon request)
- Per capita convergence (Agarwal & Narain, 1991; Meyer, 2000)
- South-African Proposal (Winkler, Letete, & Marquard, 2013)
- Chinese proposal (BASIC Experts, 2011)

Building on a range of methodologies and equity criteria for sharing the burden of reducing emissions put forward by the scientific community and Parties to the UNFCCC, the PRIMAP equity tool also offers a modality that allows users to emulate equity regimes based on various equity criteria - and for each criterion a range of possible empirical metrics to quantify them is available. The equity criteria selected and the different empirical metrics available to evaluate them in the Equity Tool are:

Historical Responsibility: this remains the main argument often used by many developing countries that the greenhouse gas problem is primarily caused by emissions from industrialised countries. The metrics used as a proxy for historical responsibility in this exercise are based on per capita cumulative emissions i.e. the quotient of cumulative emissions for each country and its cumulative population within the pre-set time frame:

- Cumulative greenhouse gases emissions per capita, excluding deforestation emissions: starting and end years for accounting cumulative emissions are flexible
- Cumulative greenhouse gases emissions per capita, including deforestation emissions: starting and end years for accounting cumulative emissions are flexible

Capacity to mitigate: the overall capacity to mitigate in a country is often related to a country's wealth or degree of development, as these relate to the country's ability to pay for and implement measures to reduce greenhouse gases emissions. Metrics available to evaluate this criterion are:

- GDP Purchasing Power Parity (PPP) per capita
- Human Development Index (HDI) at a certain year

Potential to mitigate is a measure of the actual room for improvement existing in a country. Among proposals that consider potential as criteria are the Triptych methodology[1] and the South North Proposal. The following intensities can be used to estimate a country's potential to mitigate:

- Emissions intensity: Energy related greenhouse gas emissions per unit of GDP
- Emissions per capita: Total national greenhouse gas emissions per capita, including deforestation emissions.
- Carbon intensity: greenhouse gas emissions per unit of energy production

Weights can be attributed to each one of the criteria selected. This means that allocation regimes based on only one of the criteria, e.g. responsibility, or based on more than one criterion, and assuming either equal or different weighting among the different criteria can be studied. For each criterion, one or a set of empirical measures to evaluate them can be selected, also with different weights. Such an approach allows for full flexibility of assumptions in regard to criteria and metrics.

Another important feature of the tool is that is that it allows for the calculation of **ranges of responsibilities** for countries, based on the different indicators. To calculate ranges, (1) **random weights** are attributed to each indicator and measure, (2) resulting emissions pathways calculated and finally (3) calculations are repeated multiple times to define a range of possible pathways. Such an approach allows capturing the full range of emissions allowances of a country and to determine how different criteria and metrics influence its outcome.

[1] The Triptych methodology contains elements of cost–effectiveness in that those with high specific emissions (i.e. high potential for reductions) have to reduce more. It was used as a basis to share the emissions reductions of the first commitment period for the Kyoto Protocol within the EU.

Index Calculation

The selected quantitative measures are weighted, normalised and added, to obtain an interim index. The split of the mitigation burden is calculated proportionally to a final index, which is obtained by normalising and weighting the interim index by the population share of each country. To avoid using projections, we calculated the index based on the last common historical year shared between all selected metrics, which was 2014. The index is calculated for as many countries as possible, which is the number of common countries available for all selected metrics. Because the index is the result of the normalisation of variables, we investigated the presence of extreme countries in each one of the metrics and excluded those countries (potentially a different set of countries at each iteration of the model) to avoid the over or under-estimation of countries' share of responsibility.

Box 1: Data collection

Data availability and quality represents a major challenge for this exercise. Even though the Equity Analysis Tool is embedded in the PRIMAP database (Nabel et al., 2011), which offers a wide range of choices of data sources, a few restrictions prevent a free choice. First, as we are interested in the relative contribution of countries to a certain qualitative metric, top-down data provides a more adequate frame for comparison, as it usually implies that a set of requirements have been met to ensure quality and comparability of data (as opposed to data provided on a national level, following e.g. own – nonstandard – inventory methodologies). Second, for each metric resulting from two single metrics e.g. emissions per GDP, we consistently used data from the same data source. For the current exercise, we have used the following data sources: UNFCCC Common Reporting Framework (CRF) GHG data, World Development Indicators 2013, Carbon Dioxide Information Analysis Center (CDIAC), International Energy Agency (IEA) data for energy, United Nations 2012 for population and Human Development Index (HDI).

The data used here is from state-of-the-art sources and are regularly updated in the PRIMAP database. We have consistently used the same datasets across all scenario runs, ensuring that the differences between emissions allowances across scenarios arise from criteria/metric choices alone and not through data divergences. For business-as-usual projections, we used RCP8.5 scenario downscaled to country level using SSP scenarios. From the few SSP scenario families, we have used the PIK implementations of the SSP2 narrative (for detail, refer to detailed methodology), which provides a global median of estimates. The RCP regional emissions are downscaled to country level using the SSP GDP pathways for individual countries, the IPAT equation and the assumption of (partial) convergence of regional emission intensities. The methodology is based on van Vuuren et al. (2007).

Global mitigation burden

Equity methodologies often fit global emissions to levels that are in line with temperature targets. Based on the selected low-carbon scenario, an emissions mitigation burden is calculated as the difference between global business-as-usual emissions (RCP8.5) and an emissions trajectory that avoids the worst effects of global warming.

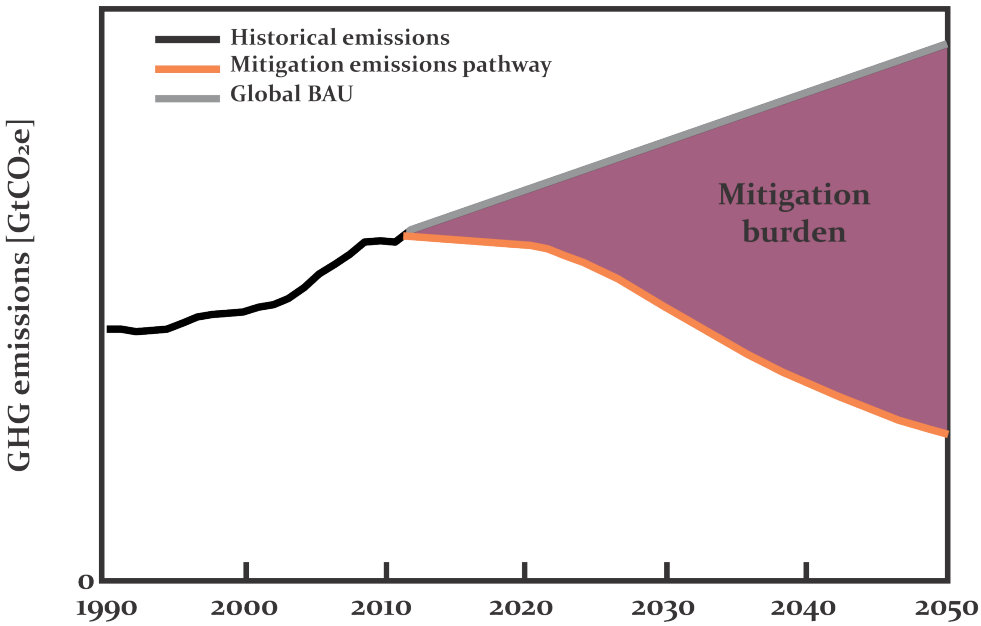

Figure 1: Mitigation burden

Calculation of emissions allowances

The index calculated using the methodology described above is then used to split the mitigation burden across countries, in such way that the country's index share of the sum of all indices will be proportional to its share of the mitigation burden. Countries with high indices will be attributed a high share of the mitigation burden and vice-versa. The share of the global mitigation burden of a country is subsequently subtracted from this country's business-as-usual emissions to obtain its final emissions allocations[2].

The assessment of fairness of all commitments was done against emissions allowances excl. land-use, land-use change and forestry (LULUCF) emissions. This is due to two main reasons. First, emissions projections in the LULUCF sector are generally highly doubtful and would add a considerable amount of uncertainty to the overall assessment. Second, while the LULUCF sector requires important emissions reductions (and increasing sinks), a pathway towards 1.5°C requires decarbonisation of the world energy system. The use of sinks to achieve targets may mask e.g. an increase in emissions from the energy and industrial emissions which would be inconsistent with a low carbon, transformational pathway towards 1.5°C goal. Real, substantial reductions in emissions from all sectors need to be made by all countries to set the world on a pathway towards a decarbonised economy. The

[2] Such an approach allows for attribution of negative emissions allocations.

emissions allowance ranges presented in this report constitute the 20th to 80th percentile of the overall range, which is consistent with IPCC AR5 methodology (Höhne, den Elzen, & Escalante, 2014).

Selection of scenarios

Based on the range of equity proposals, criteria and quantification metrics described above, **we defined roughly 40 equity regimes to allocate mitigation efforts across countries** in the world, with the goal of capturing the widest possible range of and outcomes in terms of emissions reductions for the studied regions. These regimes are based on the following proposals, criteria and metrics:

- Different methodologies: GDR, per capita convergence, South North Proposal, South African proposal, Chinese proposal, proposal based solely on historical responsibility, proposal based on historical responsibility and capability, proposal based on potential, historical responsibility, and capability.
- Different starting years for historical period (1950, 1970, 1990)
- Different weighting schemes for the criteria (e.g. 50/50 responsibility and capability vs 75/25
- Different metrics for the criteria (e.g. capability measures in terms of HDI or GDPPPP and their different impacts)

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About Climate Analytics

Climate Analytics is a non-profit climate science and policy, which focuses on assessing climate change impacts, adaptation and mitigation. This includes the study of emissions pathways and energy transformation pathways globally, regionally and nationally to avoid dangerous levels of climate change in accordance with Paris Agreement goals, as well strategies and implementation policies consistent with these goals. Examples include the 2016 Low Carbon Monitor for the Climate Vulnerable Forum, which looks at global and regional environmental, social and economic benefits and opportunities of a transformation pursuing the 1.5°C limit of the Paris Agreement; and the 2016 coal report looking at the implications oft he Paris Agreement for coal use in the power sector globally and regionally (EU, OECD, USA). This was followed by a detailed analysis of a strategy for phasing out coal in the European Union and its Member States, providing a science-based shut-down schedule of coal power plants at the individual unit level, in line with the Paris Agreement long-term temperature goal.

It also is part of the Climate Action Tracker, an independent scientific assessment of progress towards the globally agreed aim of holding warming well below 2°C, and pursuing efforts to limit warming to 1.5°C. The Climate Action Tracker also tracks important decarbonisation pathways and provides recommendations for key strategies, such as the ten most important short-term steps for decarbonisation.

Contact

Paola Yanguas-Parra
Climate Policy Analyst
E-mail: paola.parra@climateanalytics.org