# Setting Climate Committments for Sheffield

## Quantifying the implications of the United Nations Paris Agreement for Sheffield

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

**Key Messages**

This report presents climate change targets for Sheffield[i] that are derived from the commitments enshrined in the Paris Agreement [1], informed by the latest science on climate change [2] and defined in terms of science based carbon setting [3]. The report provides Sheffield with budgets for carbon dioxide ($CO_2$) emissions and from the energy system for 2020 to 2100.

The carbon budgets in this report are based on translating the "well below 2°C and pursuing 1.5°C" global temperature target and equity principles in the United Nations Paris Agreement to a national UK carbon budget [1][ii]. The UK budget is then split between sub-national areas using different allocation regimes [4]. Aviation and shipping emissions remain within the national UK carbon budget and are not scaled down to sub-national budgets. Land Use, Land Use Change and Forestry (LULUCF) and non-$CO_2$ emissions are considered separately to the energy $CO_2$ budget in this report.

Based on our analysis, for Sheffield to make its 'fair' contribution towards the Paris Climate Change Agreement, the following recommendations should be adopted:

1. Stay within a maximum cumulative carbon dioxide emissions budget of 15.2 million tonnes ($MtCO_2$) for the period of 2020 to 2100. At 2017 $CO_2$ emission levels[iii], Sheffield would use this entire budget within 7 years from 2020.
2. Initiate an immediate programme of $CO_2$ mitigation to deliver cuts in emissions averaging a minimum of -12.3% per year to deliver a Paris aligned carbon budget. These annual reductions in emissions require national and local action, and could be part of a wider collaboration with other local authorities.
3. Reach zero or near zero carbon no later than 2043. This report provides an indicative $CO_2$ reduction pathway that stays within the recommended maximum carbon budget of 15.2 $MtCO_2$. At 2043 5% of the budget remains. This represents very low levels of residual $CO_2$ emissions by this time, or the Authority may opt to forgo these residual emissions and cut emissions to zero at this point. Earlier years for reaching zero $CO_2$ emissions are also within the recommended budget, provided that interim budgets with lower cumulative $CO_2$ emissions are also adopted.

### 1. Introduction

This report presents advisory climate change targets for Sheffield to make its fair contribution to meeting the objectives of the United Nations Paris Agreement on Climate Change. The latest scientific consensus on climate change in the Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5°C [2] is used as the starting point for setting sub-national carbon budgets [3, 4] that quantify the maximum carbon dioxide ($CO_2$) associated with energy use in Sheffield that can be emitted to meet this commitment. This report translates this commitment into;

1. a long-term carbon budget for Sheffield;
2. a sequence of recommended five-year carbon budgets;
3. a date of 'near zero'/zero carbon for the area.

The United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement commits the global community to take action to "hold the increase in global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C" [1]. Cumulative emissions of $CO_2$ from human activity are the principle driver of long-term global warming[iv]. It is the relationship between $CO_2$ and global temperatures which means that staying within a given temperature threshold requires that only a certain total quantity of $CO_2$ is released to the atmosphere. This is the global carbon budget.

In addition to setting global average temperature targets, the UNFCCC process also includes foundational principles of common but differentiated responsibility [1]. This informs the fair (equitable) distribution of global emissions between nations at different stages of economic development. Industrialised nations are expected to show leadership towards a low carbon future, while it is acknowledged that a greater total share of future emissions will be associated with other countries as they develop (though their emissions per capita will remain low). Any sub-division of the global carbon budget must therefore account for the development needs of what the Paris Agreement refers to as "developing country Parties" in setting a fair/equitable national or sub-national carbon budget.

The carbon budgets presented here apply to $CO_2$ emissions from the energy system only. Although all greenhouse gas (GHG) emissions, such as methane and other forcing agents, such as aircraft contrails, affect the rate of climate change, long term warming is mainly driven by $CO_2$ emissions [5]. Furthermore the physical or chemical properties of each GHG vary, with different life-times causing warming in different ways, and with subsequent, and often large, uncertainties in their accounting [6]. As such the global carbon budgets in the Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5°C (SR1.5) [2], relate to $CO_2$-only emissions. In this report we have discussed non-$CO_2$ emissions and $CO_2$ emissions associated with land use, land use change and forestry separately.

Ultimately staying within a global temperature threshold (e.g. "well below 2°C") requires limiting cumulative $CO_2$ emissions over the coming decades. Carbon budgets can be an effective way to understand the amount of $CO_2$ emissions that can be released into the atmosphere in order to do this. End point targets such as 'net zero' by 2050, with very clear assumptions, can be useful indicators of ambition, but it is ultimately the cumulative $CO_2$ released on the way to that target that is of primary significance to achieving climate change goals. Whereas end point focused

targets can be met with varying levels of $CO_2$ emissions (and therefore varying global temperature with consequent climate impacts) depending on their reduction pathways, carbon budgets specify the limits to $CO_2$ emissions within the period of the commitment. This is a reason why the UK Climate Change Act has legislated 5-year carbon budget periods, as well as a long term target, to keep $CO_2$ emissions consistent with the framing goal of the climate change commitment. It is also the reason why we recommend a carbon budget based approach.

### 1.2 Wider UK Policy Context

The UK Climate Change Act now legislates for a commitment to net zero greenhouse gas emissions by 2050[v], with five yearly carbon budgets to set actions and review progress [7]. The carbon budgets for this target were not available at the time of our analysis for direct comparison, however the recommended budget in this report will most likely be more stringent. This is primarily due to two key differences between our approach and the current recommendations of the UK Government's advisory body the Committee on Climate Change (CCC) that inform the revised UK net zero target:

1. The equity principles of the Paris Agreement and wider UNFCCC process are explicitly and quantitatively applied. Our approach allocates a smaller share of the global carbon budget to the ‘developed country Parties’, such as the UK, relative to ‘developing country Parties’. Moreover the approach is also distinct in including global ‘overheads’ for land use, land use change and forests (LULUCF) and cement process emissions related to development.
2. Carbon dioxide removals via negative emissions technologies (NETs) and carbon offsets[vi] are not included. The UK Climate Change Act's ‘net zero’ framing means that the commitment is met when greenhouse gas emissions (debits) and removals (credits) from the UK’s carbon ‘account’ balance at zero. Hence the 2050 target can be met using carbon dioxide removal technologies, including land use sequestrations, and potentially carbon offsetting. The CCC include a significant role for NETs such as bioenergy carbon capture and storage and direct air capture in their analysis supporting the net zero target. Doing so theoretically increases the size of a carbon budget, but increases the risk of failing to deliver on the Paris global temperature target. The UK Government has also rejected the CCC's advice to explicitly exclude international carbon offsetting as an approach to meeting the net zero target. Allowing for future carbon dioxide removal technologies and international carbon offsetting ostensibly increase the size of the UK's carbon budget. However carbon removal technologies are at a very early stage of development and whether they can be successfully deployed at sufficient scale is highly uncertain. While they are an important technology to develop, it is a major risk to prematurely adopt a carbon budget that allows for additional $CO_2$ on the basis that future generations will be in a position to deploy planetary-scale NETs. Similarly, as the CCC note in their advice, the efficacy of carbon offsetting as a contribution to meeting global climate change commitments is not robust enough to incorporate into recommended carbon budgets.

We regard our UK carbon budget to be at the upper end of the range that is aligned with the Paris Agreement's objectives. Early results from the latest Earth system models suggest that the climate may be more sensitive to greenhouse gases than previously thought implying a smaller global carbon budget is required [8]. In addition, assuming that developing countries will, on aggregate, implement rapid emissions reduction measures in line with a 2025 peak year is far from certain. Therefore, we recommend that these budgets are taken as reflective of the minimum commitment required to deliver on the Paris Agreement.

## 2. Method

The Setting City Area Targets and Trajectories for Emissions Reduction (SCATTER) project [4] funded by the Department for Business Energy and Industrial Strategy (BEIS) developed a methodology for Local Authorities to set carbon emissions targets that are consistent with United Nations Paris Climate Agreement. This report uses the SCATTER methodology with revised global carbon budgets, based on the latest IPCC Special Report on 1.5°C and updated $CO_2$ emissions datasets, to downscale global carbon budgets to Sheffield. This methodology has been successfully piloted with Greater Manchester Combined Authority and is being made available nationally to support all local authorities and groupings of local authorities.

**Step 1:** A global carbon budget of 900 $GtCO_2$ is taken from the Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5ºC [2]. This global carbon budget represents the latest IPCC estimate of the quantity of $CO_2$ that can be emitted and still be consistent with keeping global temperatures well below 2ºC with an outside chance of stabilising at 1.5 ºC. This budget assumes no reliance on carbon removal technologies.

**Step 2:** A 'global overhead' deduction is made for process emissions arising from cement production (60 $GtCO_2$) [9][vii]. Cement is assumed to be a necessity for development [5]. We also assume that there is no net deforestation at a global level (2020 to 2100) so none of the global carbon budget is allocated to this sector. This will require a significant global effort to rapidly reduce deforestation and significantly improve forestry management as well as increase rates of reforestation and potentially afforestation.

**Step 3:** A share of the global carbon budget is allocated to "developing country parties" assuming a trajectory for those countries from current emissions to a peak in 2025 then increasing mitigation towards zero emissions by around 2050. The remaining budget is allocated to "developed country parties" which includes the UK [10]. This approach of considering developing countries first, is guided by the stipulation of equity within the Paris Agreement (and its earlier forebears, from Kyoto onwards)[10].

**Step 4:** The UK is apportioned a share of the 'developed country Parties' budget after Step 3 to provide a UK national carbon budget. The apportionment is made according to "grandfathering"[viii] of emissions for the most recent period up to the Paris Agreement (2011 to 2016).

**Step 5:** Aviation and shipping emissions are deducted. Assumptions and estimates are made about the level of future emissions from aviation, shipping and military transport for the UK. These emissions are then deducted from the national budgets as a 'national overhead" to derive final UK energy only carbon budgets. Emissions from aviation including military aircraft are assumed to be static out to 2030, followed by a linear reduction to complete decarbonisation by 2075. The total $CO_2$ emissions of this path are >25% lower than Department for Transport central forecast followed by reduction to zero by 2075. Shipping emissions are based on Walsh et al [11] 'big world' scenario out to 2050 followed by full decarbonisation from this sector by 2075. These aviation and shipping emissions (1,518 $MtCO_2$) are then deducted as a 'national overhead' from the UK budget to derive the final carbon budgets for the UK, from which local authority budgets are subsequently derived [4]. The budgets provided are therefore aligned with "well below 2°C and pursuing 1.5°C" provided that aviation and shipping emissions do not exceed the pathway assumed in our analysis [4]. Failure to hold aviation and shipping emissions within the outlined allocation will reduce the carbon budget for UK regions, including for Sheffield.

**Step 6:** Sheffield is apportioned a part of the remaining UK carbon budget. Our recommended budget is based on sub-national allocation through 'grandfathering'. A grandfathering approach allocates carbon budgets on the basis of recent emissions data. The most recent annual $CO_2$ emissions for Sheffield up to the Paris Agreement [12] (2011-2016) is averaged and compared to averaged data for the whole UK [13] over the same period. The carbon budget (2020-2100) for Sheffield is then apportioned based on Sheffield's average proportion of UK $CO_2$ emissions for the 2011-2016 period. $CO_2$ emissions in the carbon budget include emissions from fossil combustion within the region and a share of the emissions from national electricity generation (relative to the Sheffield area's end-use electricity demand).

**Step 7: Carbon emission pathways.** The carbon budgets for Sheffield are related to a set of illustrative emission pathways. These pathways show projected annual $CO_2$ emissions from energy use in Sheffield and how these emissions reduce over time to stay within the budget. The energy-only $CO_2$ emissions for 5-yearly interim carbon budget periods are calculated in line with the framework set out in the UK Climate Change Act. It is the cumulative carbon budget and the 5 year interim budgets that are of primary importance as opposed to a long term target date. The combination of a Paris-compliant carbon budget and the projected emissions pathways can however be used to derive an indicative near zero carbon target year for Sheffield. The near zero carbon year of 2043 is defined here as the point at which, on the consistent reduction rate curve, less than 5% of Sheffield's recommended budget remains. Annual $CO_2$ emissions at this point fall below 0.09 $MtCO_2$ ($CO_2$ levels >96% lower than in 2015 – a Paris Agreement reference year).

## 3. Results

### 3.1 Energy Only Budgets for Sheffield

Following the Method the recommended energy only $CO_2$ carbon budget for the Sheffield area for the period of 2020 to 2100 is 15.2 $MtCO_2$. To translate this into near to long term commitments a $CO_2$ reduction pathway within the 15.2 $MtCO_2$ is proposed here. A consistent emissions reduction rate of -12.3% out to the end of the

century is applied. In 2043 95% of the recommended carbon budget is emitted and low level CO2 emissions continue at a diminishing level to 2100.

2010202020302040205020602070208020902100 0.00.51.01.52.02.53.0Mt CO2Key:HistoricalRecommended2010201520202025203020352040204520500.00.51.01.52.02.53.0Mt CO2Key:HistoricalRecommended

***Figure 1a (left):*** *Energy related $CO_2$ only emissions pathways (2010-2100) for Sheffield premised on the recommended carbon budget.* ***Figure 1b (right):*** *Energy $CO_2$ only emissions pathways (2010-2050) for Sheffield premised on the recommended carbon budget.* ***y-axis shows emissions in $MtCO_2$***

Table 1 presents the Sheffield energy $CO_2$ only budget in the format of the 5-year carbon budget periods in the UK Climate Change Act. To align the 2020 to 2100 carbon budget with the budget periods in the Climate Change Act we have included estimated $CO_2$ emissions for Sheffield for 2018 and 2019, based on BEIS provisional national emissions data for 2018 [14] and assuming the same year on year reduction rate applied to 2019. The combined carbon budget for 2018 to 2100 is therefore 19.6 $MtCO_2$.

***Table 1:*** *Periodic Carbon Budgets for 2018 for Sheffield.*

| **Carbon Budget Period** | **Recommended Carbon Budget (**Mt $CO_2$**)** |
|---|---|
| **2018 - 2022** | 9.3 |
| **2023 - 2027** | 4.9 |
| **2028 - 2032** | 2.6 |
| **2033 - 2037** | 1.3 |
| **2038 - 2042** | 0.7 |
| **2043 - 2047** | 0.4 |
| **2048 - 2100** | 0.4 |

The recommended budget is the maximum cumulative $CO_2$ amount we consider consistent with Sheffield's fair contribution to the Paris Agreement. A smaller carbon budget, with accelerated reduction rates and an earlier zero carbon year, is compatible with this approach. It is however important that for an alternative zero carbon year the proposed 5 year budget periods are the same or lower that those specified in Figure 2. Furthermore meeting the budget must not rely on carbon offsets.

0123456789Mt CO22018 - 20222023 - 20272028 - 20322033 - 20372038 - 20422043 - 20472048 - 2100

***Figure 2:*** *Cumulative $CO_2$ emissions for budget period (based on Table 1) from 2018 to 2100 for Sheffield*

### 3.2 Recommended Allocation Regime for Carbon Budget

The recommended carbon budget is based on a grandfathering allocation regime for sub-dividing the UK sub-national energy only carbon budget. There are three distinct allocation regimes that can be applied to determine sub-national budgets. We have opted to recommend one common approach for allocating carbon budgets that can be applied to all Local Authority areas. This enables straightforward compatibility

between carbon budgets set at different administrative scales. For example this makes it easier for individual Local Authorities to calculate their own carbon budgets that are compatible with a budget set at Combined Authority scale. It also means that under the recommended carbon budgets, all Authorities are contributing to a common total UK carbon budget. If for example all Authorities selected the allocation regime that offered them largest carbon budget the combined UK budget would not comply with the objectives of the Paris Agreement. The common approach to allocation we recommend therefore further assures that the carbon budget adopted is Paris Agreement compatible.

We have chosen a grandfathering as our common allocation approach because, based on our analysis, it is the most appropriate and widely applicable regime within the UK.

Population and Gross Value Added[ix] (GVA) are alternative allocation regimes. Population shares the carbon budget equally across the UK on a per capita basis. In this allocation regime the UK population [15] is compared to that of Sheffield [16] from 2011 to 2016. The carbon budget (2020-2100) for Sheffield is then apportioned based on its average proportion of the UK population for the period 2011-2016. For regions where per capita energy demand deviates significantly from the average (e.g. a large energy intensive industry is currently located there) the budget allocated may not be equitable for all regions, therefore it is not recommended as the preferred allocation. GVA is used as an economic metric to apportion carbon budgets. For example, the UK total GVA [17] is compared to that of Sheffield [17] from 2011 to 2016. The carbon budget (2020-2100) for Sheffield is then apportioned based on Sheffield's average proportion of UK GVA for the period 2011-2016. GVA can be useful as a proxy for allocation on economic value, however without an adjustment for the type of economic activity undertaken, areas with high economic 'value' relative to energy use can get a relatively large budget, while the inverse is true for areas with energy intensive industries, and/or lower relative economic productivity. We would therefore not recommend GVA as an appropriate allocation regime for all regions.

Table 2 presents the result outcomes for alterative allocation regimes – population and gross value added (GVA).

***Table 2:*** *Energy only $CO_2$ budgets and annual mitigation rates for Sheffield (2020-2100) by allocation regime*

| Allocation regime (% of UK Budget allocated to Sheffield | UK Budget[x] ($MtCO_2$) | Sheffield Budget ($MtCO_2$) | Average Annual Mitigation Rate (%) |
|---|---|---|---|
| **Grandfathering to Sheffield from UK (0.7%)** | 2,239 | 15.2 | -12.3% |
| **Population split to Sheffield from UK (0.9%)** | 2,239 | 19.6 | -9.9% |
| **GVA split to Sheffield from UK (0.7%)** | 2,239 | 15.6 | -12.1% |

Pathway projections for the change in annual energy-only $CO_2$ emissions pathways for Sheffield based on the carbon budgets in Table 2 are illustrated in Figure 3a & 3b.

2010202020302040205020602070208020902100 0.00.51.01.52.02.53.0Mt CO2Key:HistoricalGrandfatheringPopulationGVA2010201520202025203020352040 204520500.00.51.01.52.02.53.0Mt CO2Key:HistoricalGrandfatheringPopulationGVA
***Figure 3a (left):*** *Energy related $CO_2$ only emissions pathways (**2010-2100**) for Sheffield premised on carbon budgets shown in Table 2.* ***Figure 3b (right):*** *Energy related $CO_2$ only emissions pathways (**2010-2050**) for Sheffield premised on carbon budgets shown in Table 2.* ***y-axis shows emissions in $MtCO_2$***

### 3.3 Land Use, Land Use Change and Forestry emissions for Sheffield

Land Use, Land Use Change and Forestry (LULUCF) consist of both emissions and removals of $CO_2$ from land and forests. We recommend that $CO_2$ emissions and sequestration from LULUCF are monitored separately from the energy-only carbon budgets provided in this report. Sheffield should increase sequestration of $CO_2$ through LULUCF in the future, aligned with Committee on Climate Change's high level ambition of tree planting, forestry yield improvements and forestry management [18]. Where LULUCF is considered, we recommend it compensate for the effects of non-$CO_2$ greenhouse gas emissions (within the geographical area) that cannot be reduced to zero, such as non-$CO_2$ emissions from agriculture.

### 3.4 Non-$CO_2$ Emissions

The IPCC SR1.5 report identifies the importance of non-$CO_2$ climate forcers (for instance methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), sulphur dioxide ($SO_2$) and black carbon) in influencing the rate of climate change. However, a cumulative emission budget approach is not appropriate for all non-$CO_2$ greenhouse gases, as the physical and chemical properties of each leads to differing atmospheric lifetimes and warming effects [19]. There are also substantial relative uncertainties in the scale, timing and location of their effects.

We do not provide further analysis or a non-$CO_2$ emissions reduction pathway in this report. However the global carbon budget in the IPCC Special Report on 1.5ºC, that our analysis is based on, assumes a significant reduction in rate of methane and other non-$CO_2$ emissions over time. Therefore to be consistent with carbon budgets Sheffield should continue to take action to reduce these emissions.

The Department of Business Energy and Industrial Strategy’s Local Authority emissions statistics do not at this time provide non-$CO_2$ emissions data at the regional level. Given the absence of robust non-$CO_2$ emissions data, any non-$CO_2$ emissions inventory by other organisations at scope 1 and 2 for Sheffield may form the basis of monitoring and planning for these emissions. We recommend considering the adoption of a LULUCF pathway that includes $CO_2$ sequestration sufficient to help compensate for non-$CO_2$ emissions within Sheffield's administrative area.

## 4. Conclusions

The results in this report show that for Sheffield to make its fair contribution to delivering the Paris Agreement's commitment to staying “well below 2°C and pursuing 1.5°C” global temperature rise, then an immediate and rapid programme of decarbonisation is needed. At 2017 $CO_2$ emission levels[xi], Sheffield will exceed the recommended budget available within 7 years from 2020. **To stay within the recommended carbon budget Sheffield will, from 2020 onwards, need to achieve average mitigation rates of $CO_2$ from energy of around -12.3% per year**. This will require that Sheffield rapidly transitions away from unabated fossil fuel use. For context the relative change in $CO_2$ emissions from energy compared to a 2015 Paris Agreement reference year are shown in Table 3.

***Table 3:*** *Percentage reduction of annual emissions for the recommended $CO_2$-only pathway out to 2050 in relation to 2015*

| Year | Reduction in Annual Emissions (based on recommended pathway) |
|---|---|
| **2020** | 26.4% |
| **2025** | 61.9% |
| **2030** | 80.3% |
| **2035** | 89.8% |
| **2040** | 94.7% |
| **2045** | 97.3% |
| **2050** | 98.6% |

The carbon budgets recommended should be reviewed on a five yearly basis to reflect the most up-to-date science, any changes in global agreements on climate mitigation and progress on the successful deployment at scale of negative emissions technologies.

These budgets do not downscale aviation and shipping emissions from the UK national level. However if these emissions continue to increase as currently envisaged by Government, aviation and shipping will take an increasing share of the UK carbon budget, reducing the available budgets for combined and local authorities. **We recommend therefore that Sheffield seriously consider strategies for significantly limiting emissions growth from aviation and shipping.** This could include interactions with the UK Government or other local authority and local enterprise partnership discussions on aviation that reflect the need of the carbon budget to limit aviation and shipping emissions growth.

$CO_2$ emissions in the carbon budget related to electricity use from the National Grid in Sheffield are largely dependent upon national government policy and changes to power generation across the country. **It is recommended however that Sheffield promote the deployment of low carbon electricity generation within the region and where possible influence national policy on this issue**.

**We also recommend that the LULUCF sector should be managed to ensure $CO_2$ sequestration where possible. The management of LULUCF could also include action to increase wider social and environmental benefits.**.

**Endnotes**

Defined in terms of the administrative boundary of the Sheffield area.
We base our global carbon budget on the latest IPCC Special Report on 1.5ºC (IPCC SR1.5) findings on how carbon emissions relate to global temperatures. The budget value we have selected provides a 'likely' chance of staying below 2°C and offers an outside chance at holding temperatures to 1.5°C. As IPCC SR1.5, notes there are no emissions pathways for limiting warming to 1.5°C that do not rely upon significant carbon dioxide removal technology deployment [2]
Based on BEIS LA statistics 2017 $CO_2$ emissions Sheffield (excluding aviation, shipping, process CO2 emissions from cement production and those from LULUCF).
This is due to the near-linear relationship between cumulative CO2 emissions and temperature is the result of various feedback processes and logarithmic relationship between atmospheric CO2 concentrations and radiative forcing, as well as the changes in the airborne fraction of CO2 emissions [19].
The 2019 amended UK Climate Change Act commits the UK to at least a 100% reduction in greenhouse gas emissions by 2050 from 1990 levels on the basis that the UK's 'carbon account' is 'net zero' by this point. This is not the same as zero greenhouse gas emissions by 2050. In this framing residual greenhouse gas emissions are net zero on the provision that they are balanced by greenhouse gas removals in the UK's carbon account.
Carbon offsetting refers to the purchase of a tradeable unit, representing emissions rights or emissions reductions, to balance the climate impact of an organisation, activity or individual.
Based on IEA's ambitious 2 degree scenario on process $CO_2$ for the period 2020-2050, subsequently extrapolating to zero by 2075
Grandfathering is based on the average proportion of $CO_2$ emissions from each Party in recent years.
Balanced approach at current basic prices
After deducting an emissions budget for aviation, shipping and military transport of 1,518 $MtCO_2$
Based on Sheffield's 2016 CO2 emissions (excluding aviation, shipping, process $CO_2$ emissions from cement production and those from LULUCF).

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