TyndallManchester
Climate Change Research

A Review of Manchester's Carbon Budgets for Direct / Energy-only CO_2 Emissions

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

Introduction

In June 2018 the Tyndall Centre for Climate Change Research at the University of Manchester was commissioned by Manchester Climate Change Agency to advise on science-based carbon reduction targets for Manchester. This led to the development of the Agency's 'Playing our Full Part' proposal (http://www.manchesterclimate.com/targets-2018) and the formal adoption of science-based carbon reduction targets for Manchester's direct[1] /energy-only CO_2 emissions by Manchester City Council, in November 2018.

In November 2019 the Tyndall Centre was commissioned by the Agency to review the city's climate change targets and recommend revised targets, as required. The review covers four areas of activity:

- Direct / energy-only CO_2 emissions
- Indirect / consumption-based CO_2 emissions
- CO_2 emissions from flights from Manchester Airport
- Target-setting and reporting methodology for organisations and sectors

The full brief is available from http://www.manchesterclimate.com/targets-2020.

This report covers the review of direct /energy-only aspect of the brief in Part 1. Part 2 of this report considers a proposal for a 2030 zero carbon target.

[1] This definition of 'direct' refers to fuel use (Scope 1) and electricity use (Scope 2) within the local authority geographic area.

Part 1: A Review of Manchester's Carbon Budget for Direct / Energy-only CO_2 Emissions

In November 2018 Manchester City Council adopted a local carbon budget as part of their response to tackling climate change. The adopted carbon budget relates to the total remaining amount of carbon dioxide (CO_2) from energy use within the local authority area that Manchester should limit its emissions to in order to meet its goal of making a 'fair contribution' to the United Nations Paris Agreement on Climate Change [1]. This carbon budget was set on the basis of a report by Kuriakose et al [2] which used the latest science and the principle of equity within the Paris Agreement to determine a remaining budget for Manchester for the 2018 to 2100 period. The report [2], as well as providing a quantification of the remaining carbon budget for Manchester, also includes five yearly interim carbon budget periods and proposes an emissions reduction pathway with an average annual reduction rate.

The report [2] is based on an approach to setting local carbon budgets developed as part of the Department of Business Energy and Industrial Strategy (BEIS) funded SCATTER project in 2017/18. This underlying approach also recommended that the carbon budget is 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." [3, p.3]. This review is taking place early due to the release of a new synthesis report by the Intergovernmental Panel on Climate Change in October 2018 – the Special Report on Global Warming of 1.5 °C (SR1.5) [4] – which includes a significant update to the underlying science on the remaining global carbon budget. In the time since the SCATTER project there have also been refinements made to the approach Tyndall Manchester researchers use to calculate local carbon budgets.

This review looks at the implications of recent developments in the scientific understanding of climate change and approach to local carbon budget setting for Manchester's climate change targets. It provides an overview of what has changed in the underlying scientific understanding and presents the difference in remaining carbon budget implied by these developments. Recommendations are made about whether the currently adopted carbon budget for Manchester should be amended.

Updates to the IPCC Remaining Global Carbon Budget

The most substantial change between the SCATTER carbon budget and the updated local carbon budget approach is in the remaining global carbon budget that is used in the analysis. The SCATTER carbon budget was based on the IPCC Fifth Assessment Report (AR5) [5] – the synthesis of which was published in 2014. Since the completion of the SCATTER project analysis, the IPCC released SR1.5 [4]. SR1.5 provides an improved understanding of the impacts of global warming of 1.5°C and 2 °C on natural and human systems. This report re-emphasis the critical importance of staying well below 2°C average global temperature rise above the pre-industrial level and the urgent, wide ranging reductions in CO_2 emissions needed to do so [4]. It also provides an updated assessment of the remaining carbon budget aligned with meeting these temperature targets.

The most fundamental change from AR5 to SR1.5 is the characterisation of the relationship between historic emissions of CO_2 and global temperature change relative to the pre-industrial period (known as the transient climate response to cumulative emissions - TCRE). How historic emissions of CO_2 and temperature change are measured and defined are key to determining a

remaining global carbon budget [6]. SR1.5 differs from the AR5 in its use of observational data and the characterisation of global temperature changes per unit of total carbon dioxide in the atmosphere. A remaining global carbon budget is also in part determined by assumptions on non-CO_2 gases [6], and how these are defined in SR1.5 is another distinction from the previous synthesis report. SR1.5 therefore represents the latest understanding of TCRE and current IPCC thinking on non-CO_2 gases. This means a revision in the headline remaining global carbon budgets reported by the IPCC. For a temperature target equivalent to a 67% chance of staying below 2°C global warming the equivalent remaining carbon budget for 2018 to 2100 in SR1.5 is ~60% larger than stated in the AR5. IPCC SR1.5 also provides global remaining carbon budgets for limiting warming to 1.5ºC. These budgets however are highly varied due to uncertainties in available budget due to future levels of non-CO_2 emissions and earth system feedbacks. They also typically require carbon removal technologies – as yet unproven at large scale – as well was urgent cuts to emissions in order to be met; particularly as annual global CO_2 emissions continued to increase in 2018 and 2019 [7].

In our updated approach for local carbon budget setting we have used the latest headline remaining carbon budgets from the IPCC in Table 2.2 of SR1.5. To meet the emissions criteria of 'well below 2°C and pursuing efforts to 1.5°C' we opted for the 900 $GtCO_2$ remaining carbon budget. We also applied the recommended deduction for earth system feedbacks (100 $GtCO_2$) that may increase warming further, meaning an available global carbon budget of 800 $GtCO_2$ for 2018 to 2100. As our updated methodology has been developed to be applied to the 2020 to 2100 period, an adjustment is made for global energy, industry and land use change CO_2 emissions in 2018 and 2019 (84 $GtCO_2$) for a remaining global carbon budget from 2020 onwards of 716 $GtCO_2$.

Modifications to the Local Carbon Budget Setting Methodology

As well as including updates from the latest IPCC synthesis report, the updated carbon budget setting approach differs from the SCATTER version in further refinements to the Tyndall Manchester methodology used to allocate local carbon budgets.

1. Defining the UK share of the remaining global carbon budget.

In the SCATTER local carbon budget setting approach, the definition of developed and developing countries is based on the longstanding UNFCCC classification to determine the split of the remaining global carbon budget between nations under the equity principles of the Paris Agreement[2]. In further refining the methodology of carbon budget allocation there is a re-classification of countries that are still in the UNFCCC developing world classification, but have very high Human Development Index values – such as some Gulf States – in the updated approach. Moving these countries into the developed world grouping has the effect of increasing the remaining carbon budget for the UK based on SR1.5 to change from 3 $GtCO_2$ to 3.7 $GtCO_2$. We have also changed to a single allocation - on grandfathering[3] basis – for downscaling to the UK level with the developed nations remaining budget. The revised approach therefore no longer includes population as an allocation option for estimating the UK's remaining carbon budget. The assumptions on the share of the UK budget for aviation and shipping (outlined in [3]) are unchanged between the two versions of the budget setting approach.

[2] i.e. that developing countries have longer to peak their CO_2 emissions due to their stage of economic development so that development goals are met and historic emissions from developed world countries are taken into account.

[3] A proportional share based on averages of recent emissions.

2. Core recommended carbon budget pathway.

In the updated approach to local carbon budget setting we provide a maximum recommended carbon budget based on a common allocation principle to all areas of the UK. This replaces the range of allocations presented in the SCATTER based Manchester report in [2]. We have used three allocation principles for sub-allocation local carbon budgets within the UK:

- Population; Whereby the local emissions budget (2020-2100) is apportioned from the UK budget based on its average proportion of population for the period 2011-2016.
- Gross Value Added[4] (GVA): Whereby an economic metric such as GVA is used to apportion local carbon budgets from the UK budget based on its average proportion of GVA for the period 2011-2016.
- Grandfathering: Whereby allocation is on the basis of recent emissions trend data (i.e. mean from 2011-2016), compared to those of the UK averaged over the same period. This proportion of local area emissions relative to UK emissions is then applied to the UK post-2020 emissions budget to give a local carbon budget for 2020 to 2100.

For the Manchester carbon budget based on the SCATTER report a mean value of the budgets based on different allocation methods was used to set the adopted carbon budget. In the updated carbon budget setting approach we use grandfathering as the recommended allocation principle for determining the maximum carbon budget for all local carbon budgets. This enables the combined maximum local carbon budgets for all areas of the UK to be consistent and align with the Paris Agreement. We selected the grandfathering allocation approach for setting the maximum recommended budget. This allocation avoids observed distortions in local carbon budget setting due to instances where per capita energy demand or the economic 'value' relative to energy use deviates significantly from the average (e.g. a large energy intensive industry is currently located there), as happens with population and GVA allocations. Therefore we argue it is the most appropriate and widely applicable regime within the UK and therefore suitable for setting a maximum recommended budget across all administrative areas.

3. Global cement emissions.

In the Updated Local Carbon Budget Setting approach a revised figure for projected global cement process emission CO_2 of 60 $GtCO_2$ based on more recent International Energy Agency [8] data is used instead of the previous 100 $GtCO_2$ projection. This however has a negligible impact on the remaining carbon budget in relation to the other modifications to the budget.

Variation in Carbon Budgets for Manchester

In addition to the updated underlying remaining global carbon budget used and the carbon budget methodology it is important to note that the original SCATTER local carbon budget approach period begins in 2018 using available baseline data up to 2015. 2018 is a start year in line with the UK Climate Change Acts 5-yearly budget periods which this work also adopts. The updated local carbon budget approach period also has 5-yearly budget periods starting in 2018, however the reduction rate starts in 2020 as 2018 and 2019 are historic emissions in this budget projection. Therefore the comparison budgets are for the same time period, however the 'remaining carbon budget' calculated in the updated approach is 2020 to 2100 whereas for original Manchester remaining budget was calculated starting in 2018.

Figure 1 is a comparison between the adopted carbon budget based on the SCATTER local carbon budget approach and the maximum recommended carbon budget from the updated local

[4] Balanced approach at current basic prices

carbon budget approach. Both are for the 2018 to 2100 period, although for original budget 2018 and 2019 are in the reduction pathway projection, whereas for the updated pathway historic emissions are used for these years. The maximum recommended carbon budget for Manchester based in the updated approach is 19% larger than the adopted carbon budget based on the original SCATTER approach. While the SCATTER based budget is 15 MtCO2, for the same comparable period (2018 to 2100), the new maximum recommended budget is 18 $MtCO_2$ (the remaining 2020 to 2100 budget based on the updated approach is 14 $MtCO_2$),

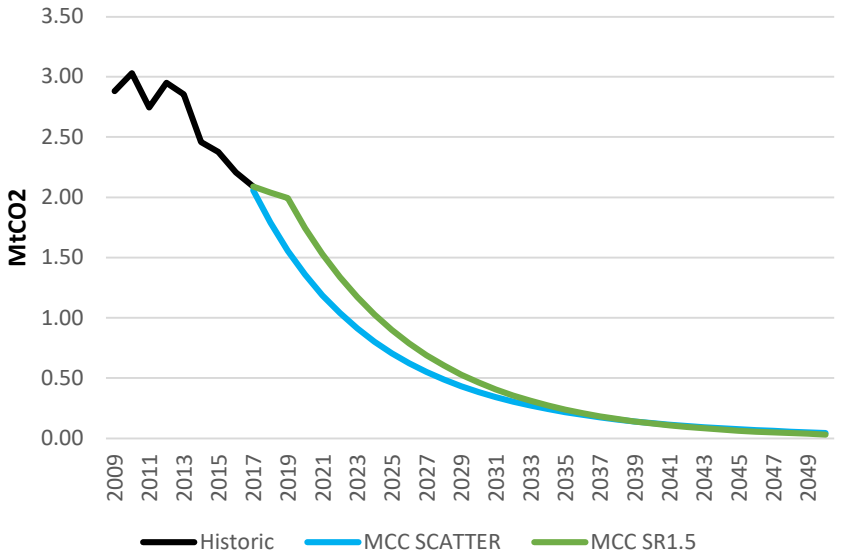

Figure 1: Projected carbon emissions pathways based on SCATTER and updated carbon budget approaches

Between the two budget approaches there is a significant difference in emissions in the 2018 to 2022 interim budget period, however the disparity in 5-yearly budgets diminishes over time as in both budget emission pathways annual emissions need to be low by 2030 (Figure 2 and Table 1).

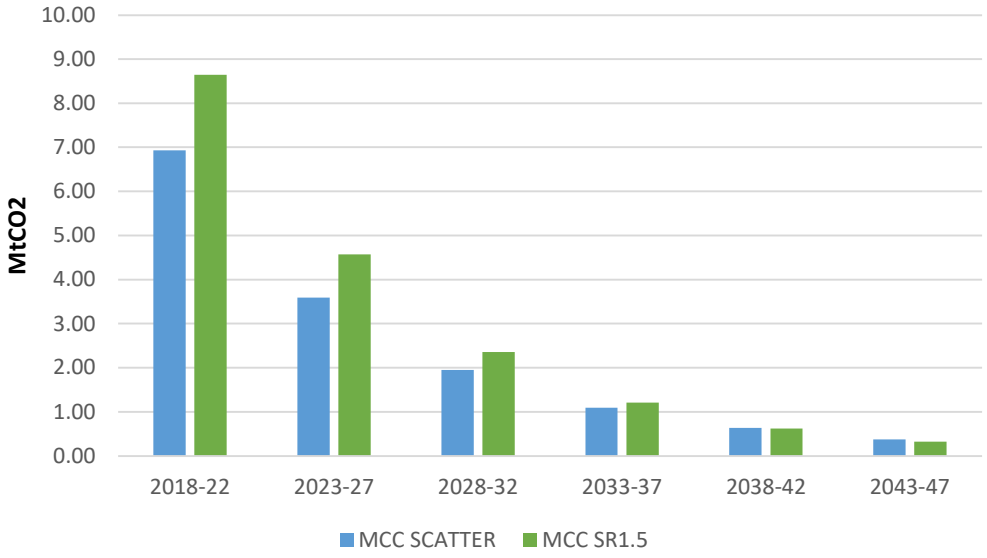

Figure 2: Five yearly carbon budgets based on the SCATTER and updated carbon budget approaches

Table 1: Five yearly carbon budget periods

Energy-only CO_2 Budget by Time Period ($MtCO_2$)	MCC SCATTER	MCC SR1.5
2018-22	6.93	8.64
2023-27	3.59	4.57
2028-32	1.95	2.35
2033-37	1.10	1.21
2038-42	0.64	0.62
2043-47	0.38	0.32
2048-2100	0.59	0.34
Total	15.17	18.07

Table 2 shows how in terms of absolute change in emissions per year compared to the Paris Agreement baseline year (2015). The change in emissions for 2020 in the original budget (MCC SCATTER) includes the projected reduction rate from 2018, whereas for the updated budget (MCC SR1.5) the 2020 change refers to historic emissions. The larger carbon budget for MCC SR1.5 means that the change in emissions by 2025 (assuming the even 12% per year reduction rate) is notably different from the MCC SCATTER budget, however by 2035 a similar change in annual emissions is required in both budget projected pathways,

Table 2: Change in emissions relative to the 2015 Paris baseline year

Reduction in Annual Emissions Compared to 2015	MCC SCATTER	MCC SR1.5
2020	43%	27%
2025	70%	62%
2030	84%	81%
2035	91%	90%
2040	95%	95%
2045	97%	97%
2050	98%	99%

Monitoring Performance on Emissions Reductions Relative to the Carbon Budget:

The emissions reduction curve (Fig. 1), relative emissions change (Table 2) and the point at which the area reaches zero carbon depends on emissions reduction performance (the cuts in emissions achieved). If emission reduction rates consistently fall short of the average rate required to stay within the overall budget (currently 13% per year for Manchester from 2018) then the budget will either be exceeded or far greater cuts in emissions are required in future years. Figure 3 shows the implications of not achieving required emissions cuts in initial budget years. Here it is assumed that only the average historic emissions reductions for 2010 to 2017 (7% per year) is achieved until 2022 (dotted line) and 2025 (dash line) respectively, but total emissions stay within the 15 $MtCO_2$ budget. Figure 3 therefore highlights the ongoing risk of using up the remaining budget too quickly and thereby leaving very steep reduction rates (18% and 31% respectively for the 2022 and 2025 delayed action projections) for the future.

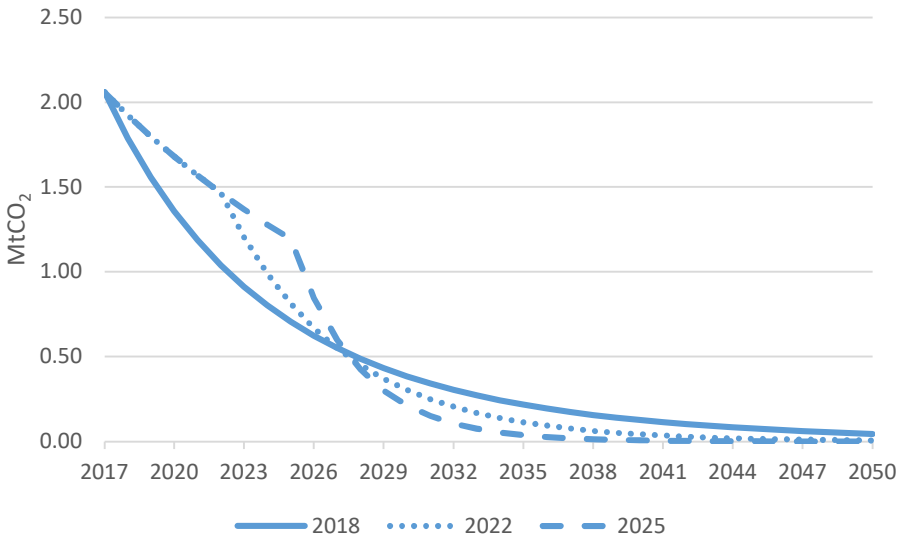

Figure 3: Comparison of carbon reduction pathways for the MCC SCATTER budget, varying delay in urgent emissions reductions

The figure illustrates the need for urgent action to reduce emissions to stay within the carbon budget and to re-evaluate the required carbon reduction need based on how emissions have changed in past years.

Recommendations

We recommend that Manchester City Council:

1. Retain the existing carbon budget (15MtCO_2) set through the SCATTER pilot project. As it is a smaller budget than the maximum recommended carbon budget calculated by the updated approach to local carbon budget setting it fulfills the aim of Manchester making a fair contribution to meeting the objectives of the Paris Agreement and shows further enhanced ambition and leadership.

2. Monitor progress in year-on-year carbon emissions reductions to ensure Manchester stays with the carbon budget

3. Further review of the carbon budgets is advised in five years or in the event of a significant change in scientific understanding or successful deployment of large scale carbon removal technologies. The next IPCC Synthesis report is due in 2022. Whatever further developments in the underlying characteristics of the remaining global carbon budget, the overall signal – for urgent and widespread decarbonisation of the energy system is expected to remain consistent.

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Part 2: Implications of Alternative End Point Target Years

As part of this review we have been asked to consider the implications of a proposed 2030 target year for reaching zero CO_2 emissions from energy. Without a carbon budget associated with this end point target a direct comparison with current targets and pathways is not possible without making further assumptions. We have therefore considered two broad implications of adopting an end date based target for 2030;

A. An alternative distribution of the Manchester carbon budget so that emissions reach zero – or a near zero definition of zero[5] – by 2030

B. A different carbon budget is developed resulting from a selected pathway to 2030 from a reference start year

A. Alternative Distribution of the Current Carbon Budget:

The same carbon budget may be distributed differently over time resulting in an earlier or later date of zero carbon emissions. Figure 4 shows different carbon reduction projections that all meet the current 15 $MtCO_2$ carbon budget for Manchester. The difference between the projections in the Figure is the year in which interventions are enacted in addition to the assumed average 7% per annum emissions reductions trend .

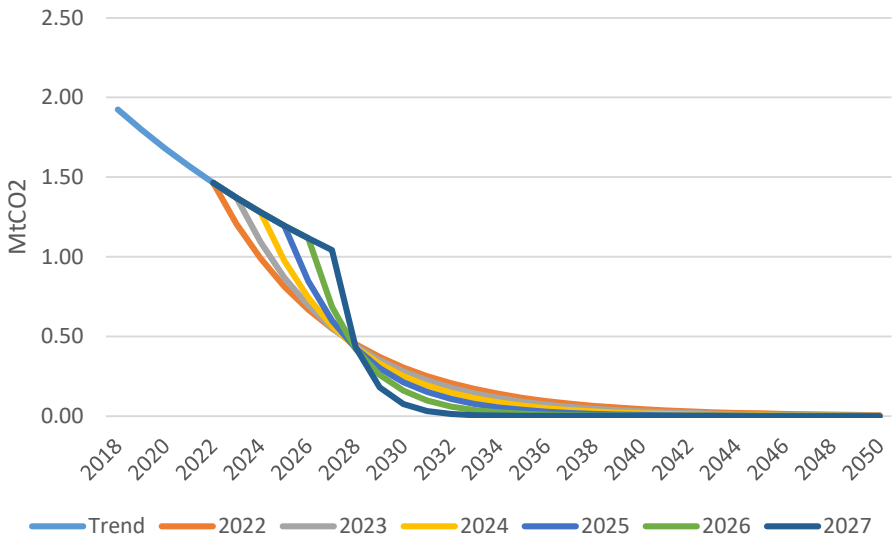

Figure 4: Illustration of different emissions pathways in line with the 15 MtCO2 budget

Maintaining an average mitigation rate of 13% per year from 2018 was proposed in the original Manchester SCATTER carbon budget report [2]. It is acknowledged that a more uneven and 'step-like' (greater in some years, less in others) rate of reduction is more likely in reality, however the average rate provides a reference point to compare progress at different stages. Figure 4 shows

[5] i.e. if a definition of 'zero' carbon as considered in both versions of the Tyndall carbon budget approach – the point at which only residual emissions (<5% of the carbon budget) remain.

the implications of not tracking the average reduction rate over time and then the required effort to stay within the 15 $MtCO_2$ carbon budget. By delaying actions that are in keeping with the average 13% per year rate (i.e. remaining at the 7% per year reduction rate) until 2022 an average reduction rate of 18% per year is then required to stay within the budget, and the year Manchester reaches its definition of zero carbon is 2033. Delaying significant action until 2024 will subsequently require an average reduction rate of 25% per year and reaching the zero carbon point in 2030 to stay within the budget. Transferring greater emissions reductions to a later period by averaging a lower reduction rate in the near term - while possible – does increase the risk of exceeding the carbon budget if greater reductions at a future point are not possible.

B. Changing the Remaining Carbon Budget.

The updated version of the carbon budget approach, based on IPCC SR1.5 sets a maximum carbon budget (2018 to 2100) of 18$MtCO_2$ to meet the objectives of the Paris Agreement. By following the recommendation to stay with the current 15 $MtCO_2$ budget Manchester (as set out in this report), would be committed to a smaller carbon budget. It is not within the scope of this report to calculate carbon budgets based on alternative climate change goals. However all targets that keep within the recommended maximum carbon budget for Manchester based on the IPCC SR1.5 updated budget are consistent with the goal of a fair contribution to Paris Agreement. Preferably such targets should also meet or better the annual reduction rate of 13% and not exceed the interim 5 year budgets for the 15 $MtCO_2$ adopted budget to ensure progress and a more equitable distribution of the available budget through time.

Whether a 2030 target represents an equivalent, more or less ambitious goal than has been adopted to date depends on the pathway associated with it. From the perspective of meeting a climate change temperature target (e,g. the Paris Agreement), the target year for reaching zero carbon is of less significance than the cumulative CO_2 emissions from the pathway (i.e. total emissions over time).

While a 2030 zero carbon date may certainly be considered consistent with meeting the objectives of the Paris Agreement, this must also include a carbon budget consideration to ensure that actions to keep within the budget are taken in the very near term so as not to use up the total available budget at the expense of future (i.e. 2025 onwards) residents of Manchester.

Recommendations

Further details on the meaning of a 2030 zero carbon year - such as the reference start year, associated carbon budget, emissions reduction rate and definition of zero - are needed to make a comparison between an alternative target year and the current Manchester commitment. However it is recommended that any alternative climate change target or commitment that is considered results in an emissions pathway (reduction rate over time) that equates to less CO_2 being emitted over time than in the maximum CO_2 emissions carbon budget currently set (15 $MtCO_2$). We recommend that any proposed alternative pathway related to an alternative target should also exceed the minimum 13% reduction rate currently advised for Manchester.

The 15 $MtCO_2$ carbon budget presented to Manchester is our recommendation of the maximum amount of CO_2 related to energy within Manchester that can be emitted in line with the Paris Agreement. A smaller carbon budget is also compatible with this approach provided it does not defer the start of significant carbon reductions and it requires an emissions pathway that exceeds a 13% per annum reduction rate average from 2018.