

Cynulliad Cenedlaethol Cymru <a href="#">Pwyllgor Amgylchedd a Chynaliadwyedd</a>	National Assembly for Wales <a href="#">Environment and Sustainability Committee</a>
Egwyddorion cyffredinol <a href="#">Bil yr Amgylchedd (Cymru)</a>	General principals of the <a href="#">Environment (Wales) Bill</a>
Ymateb gan Comisiwn Cymru ar Newid yn yr Hinsawdd	Response from Climate Change Commission for Wales
EB 20	EB 20



Climate Change Commission for Wales:

June 2015

**Response to National Assembly for Wales Environment & Sustainability Committee inquiry -  
Environment Bill**

The Commission was established in 2007 as an important independent forum for developing and driving forward the Welsh programme of action to tackle the causes and effects of climate change. It brings together leaders and representatives from all sections of Welsh society (business, academia, the voluntary sector, environmental groups, political parties, public sector and local government), and seeks to advise Welsh Government on climate change, mobilise action and build consensus across sectors.

The Commission welcomes the introduction of the Environment (Wales) Bill, and particularly the focus on climate change, the creation of a statutory framework for action on climate change including targets for reducing emissions of greenhouse gasses, and setting carbon budgets.

Our response specifically addresses Part 2 - Climate Change, and the following questions:

*1. Do you agree with the proposals for the 2050 target?*

The Commission has for some time been calling for a **stronger framework** for climate change and emission reduction in Wales, and in [our response](#) to Welsh Government's Climate Change Policy Refresh last year we called for

- a much clearer structure of responsibility, accountability and reporting across Government and the public sector to enable monitoring of progress against climate change objective, and
- the introduction of statutory targets (within forthcoming legislation) for public bodies to monitor and report on emissions and adaptation performance.

The current 2050 target is in line with the existing UK Climate Change Act (2008), so there is a question about whether it should be going beyond this. What is critical is that these targets are based on the **latest scientific evidence** and any developments in international negotiations. The current Welsh targets (40% and 3% per annum) are also based on analysis undertaken for the 2010 Strategy, so again we would recommend that these are brought up-to-date and based on the latest evidence as presented by the IPCC in 2014.

In addition the Environment Bill has to clearly link to, and strengthen, the requirements of the **Well-being of Future Generations (Wales) Act** and the indicators, milestones and measures that are being developed to support the delivery of the seven wellbeing goals.

*2. For your views as to whether the interim targets should be on the face of the Bill?*

With such a complex issue as climate change we understand the difficulty of placing targets on the face of the Bill. Not including a target would allow for a greater degree of flexibility, however

there could be arguments for including something (perhaps the 40% by 2020 target) to reinforce the Welsh Government's commitment.

3. *Do you believe that the introduction of carbon budgets is a more effective approach than the 3% annual emissions reduction target that is currently in place in Wales?*

Yes – it will set the route map for reducing emissions across all Government departments over appropriate time periods, and is also in line with the UK's approach. We agree that the timing for the budget should be aligned to the electoral cycle and also to the requirements under the Well-being for Future Generations (Wales) Act and development of local Wellbeing plans.

We are slightly concerned that the progress reports will only be undertaken every five years – this may not be sufficiently frequent to hold Welsh Government to account. Currently the Welsh Government reports annually on their climate change targets, and this is the main way that the Commission is able to scrutinise progress and provide advice on areas for improvement. Would the carbon budgets replace the current annual targets, and if so how will progress against emission reduction be reported?

The Commission recently funded the **Tyndall Centre** to carry out a study on carbon budgets for Wales – **copy attached**. This provides an in depth analysis of the evidence for targets and budgets, including what would be a 'fair' budget allocation for Wales, so should be considered as part of the evidence base for the Environment Bill.

We would like to see how the carbon budgets will extend to an analysis of the carbon impact of financial budget setting similar to the emission impact assessment of the fiscal budget that is undertaken in Scotland.

4. *What are your views on what emissions should be included in targets? All Welsh emissions or those within devolved competence?*

To allow for consistency with the United Nations Framework on Climate Change (UNFCCC) reporting guidelines, we advise that all Welsh emissions should be included. The Scottish Government has adopted this approach, although when assessing performance against the targets it allows for the sale and purchase of relevant carbon units (tradable emissions allowances), through the European Union Emissions Trading Scheme (EU ETS). In effect, this means that, when assessing performance against targets, the emissions attributed to the traded sector are those allowed within their annual cap, as opposed to the emissions actually made (see <http://www.gov.scot/Publications/2014/06/5527/4>). The issue of devolved competence (which may change over time) is probably best addressed when setting the particular value of each target or budget.

It is also worth noting that all Wales emissions are provided on a yearly basis by the National Atmospheric Emissions Inventory report. The latest figures, published on June 9<sup>th</sup>, shows that although emissions have reduced by 12% compared to base year, they have increased by 10% between 2012 and 2013. This increase is largely driven by emission from the production of heavy industry and a shift from natural gas to coal use in power stations. It would therefore appear that the generation and reporting of all Wales emissions would not require much additional work for the Welsh Government for either the budget period report or the annual update.

As well as considering the devolved / non-devolved issue, it's also worth considering reporting on consumption-based emissions particularly as Wales is a net exporter of energy. This would support action in relation to personal behaviour change and individuals taking greater responsibility for supporting actions that lead to emission reduction.

*5. Do you agree with the Bill's proposals as to what should happen if the Welsh Ministers fail to meet emissions targets or carbon budgets?*

Yes we welcome a **framework for stronger accountability across Welsh Government**, and the emphasis on the need for a **cross-departmental approach** to deliver emission reduction. We would welcome further consideration of accountability outside Welsh Government across the public and private sector bodies – for instance the Scottish Act has a requirement on all public sector bodies to contribute to their climate change targets and this would seem a sensible approach for Wales.

Again we feel that any requirements on the public sector would need to build on and complement the requirements in place through the **Well-being of Future Generations (Wales) Act**.

*6. What should the role of an advisory body on climate change be?*

We feel that there is a need to clarify the role of the various bodies here. The UK Committee on Climate Change, who already advise the UK Government on setting carbon budgets and have significant analytical and scientific capacity, are well placed to advise the Welsh Government on the technical detail e.g. setting initial carbon budgets for Wales.

The Well-being of Future Generations (Wales) Act sets out a clear role for the **new Future Generations Commissioner** in relation to providing advice on climate change (Part 3, Section 19 1a) – the Environment (Wales) Bill should seek to strengthen and clarify this role and not undermine it. A review of the Climate Change Commission for Wales is currently taking place and the findings will inform the future role of the new Commissioner.

## ADAPTATION

We note that Part 2 focuses entirely and in much detail on emission reduction. There is no explicit reference to **Adaptation**. This is in marked contrast with legislative frameworks in other home countries. The Climate Change Act 2008 places a duty on the UK Government and the Northern Ireland Administration to place plans before their respective Parliament and Assembly, outlining how they are addressing the risks identified in the most recent UK Climate Change Risk Assessment (which is undertaken every five years). The Climate Change (Scotland) Act 2009 places a similar requirement on the Scottish Government. There is, however, no corresponding legal requirement placed on the Welsh Government.

The **Well-being of Future Generations (Wales) Act** stipulates that Welsh Ministers must take account of the UK CCRA when producing their Future Trends Report, and that Public Service Boards should do so when preparing their Assessments of Local Well-being. Presumably, actions arising from taking account of the UK CCRA will be embedded within Welsh Ministers' Well-being Objectives, and within Local Well-being Plans, and would encourage action to support the Resilient Wales goal. Similarly the Environment (Wales) Bill, as introduced, places a duty on Welsh Ministers to "prepare, publish and implement national natural resources policy ... including what they consider should be done in relation to climate change".

As things stand, therefore, actions to adapt to climate change will be embedded within a range of mainstream programmes – as is appropriate for effective integration. The question is whether Welsh Government is content that, if challenged, they could extract from these programmes the actions that when collated would constitute an "Adaptation Programme for Wales". In this situation we think it may be appropriate for this Act to consider placing a specific duty on Welsh Ministers to prepare a National Adaptation Programme for Wales which takes account of the most recent UK CCRA. It would be helpful to look at lessons from the UK National Adaptation Programme and the Scottish Adaptation work to develop the most appropriate response for Wales.

The Commission's **Adaptation sub-group** would be happy to provide further information and insights about this. Further the Commission's **Land Use sub-group** wishes to emphasise the role of land management in adaptation – protecting us from the extremes of storms, flood and drought as well as retaining carbon stocks in peat and other organic soil. The ability of land to sequester more carbon will contribute very little to the overall budget and our land management policies should reflect this.

# Estimating 2°C Carbon Budgets for Wales

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May 2015

A research briefing commissioned by the Climate Change Commission for Wales

*This report is non-peer-reviewed and all views contained within are attributable to the authors and do not necessarily reflect those of researchers within the wider Tyndall Centre or University of Manchester*

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## Headline messages on developing carbon-only budgets for Wales:

- The 2014 IPCC report provides clear global carbon budgets for different probabilities of maintaining the global temperature rise below 2°C.
- Global emissions to date and the current emissions trajectory put the “likely” (66%) and “as likely as not” (50%) chance of 2°C beyond practical reach without significant deployment of negative emissions technologies, technologies which are as yet unproven.
- A 33% chance of staying below 2°C demands deep and immediate reductions in emissions from Annex 1 nations with similar reductions from non-Annex 1 nations by 2025 to 2030.
- Depending on the suite of assumptions, but particularly the apportionment method chosen here, Wales has a 2015-2100 carbon budget of between 467 and 711 million tonnes of CO<sub>2</sub> (for a 33% chance of staying below 2°C). This is the equivalent of around 11 to 18 years<sup>1</sup> of Wales’ current annual territorial emissions.
- The chosen carbon budget for Wales depends not only on the science but also on moral, ethical and political choices made when apportioning a global carbon budget to an individual country. It is paramount that these are made explicit, clearly argued and are consistent with Wales’ high-level commitments on climate change.

## Introduction

The *Climate Strategy for Wales* (2010) sets out a key target of cutting greenhouse gas (GHG) emissions by 3% per year in areas of devolved competence. However, it was recognized at the time that “*the 3% target falls far short of the effort required of developed countries if globally we are to avoid a high risk of an increase in average temperatures of more than 2°C.*”<sup>2</sup> It has also been acknowledged that, rather than annual percentage reduction targets, the level of warming that can be expected (measured as an increase in global mean surface temperature) is directly proportional to the cumulative quantity of GHGs emitted to the atmosphere<sup>3,4</sup>. In order to avoid warming greater than 2°C, the cumulative amount of emissions to the atmosphere must be controlled; i.e. a carbon budget should be adhered to.

The *Well-Being for Future Generations Bill*, and a proposed *Environment Bill* set out the intention for the introduction of statutory carbon budgets to tackle climate change in Wales<sup>5</sup>. Given this, Tyndall Manchester has been asked by the Climate Change Commission for Wales to advise on the size of the

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<sup>1</sup> Based on 2012 emissions and roughly factoring in aviation and shipping emissions.

<sup>2</sup> Welsh Assembly Government (2010) *Climate Change Strategy for Wales*, October 2010 p. 5

<sup>3</sup> Meinhausen, M., Meinhausen, N., Hare, W., Raper, S., Frieler, K., Knutti, R., Frame, D., Allen, A., *Nature* 2009, 458, 1158-U1196.

<sup>4</sup> IPCC 2013: Summary for Policymakers. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. .

<sup>5</sup> See e.g. <http://gov.wales/about/cabinet/cabinetstatements/2015/climatechange/?lang=en>

carbon budget that would be consistent with international commitments to maintain the “*increase in global temperature below 2 degrees Celsius*”.

International mitigation policy to deliver the 2°C commitment is informed by the United Nations Framework Convention on Climate Change (UNFCCC) which states that “...*Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities...*”<sup>6</sup>. The term ‘common but differentiated responsibilities’ refers to a consensus that developed countries – named in Annex I of the convention - should take the lead in emission reductions enabling developing (non-Annex I countries) to continue their development. That said, given the pace of emissions growth over the last decades, it is now only possible for global mitigation targets to be met if non-Annex I countries also reduce their emissions<sup>7,8</sup>. The relative mitigation effort between (and within) Annex I and non-Annex I nations is thus the topic of current international negotiations.

For the purposes of this report we have used the latest global carbon budgets for the period 2011-2100 published by the IPCC (2014) as a basis from which to apportion an amount to Wales using a method that acknowledges the principles of common but differentiated responsibility and equity. There is no one ‘correct’ way of apportioning an emissions budget to Wales, it is a matter of political and societal interpretation of these principles. In the absence of a global agreement on apportionment, it is necessary for Wales to consider, and explicitly establish, what its ‘fair’ effort would be. As part of this Wales must choose how to acknowledge its historic responsibility for climate change and its position as a developed nation able and equipped to decarbonise more readily than a developing country.

In addition to providing advice on the size of a carbon budget for Wales this report also includes reduction pathways for methane and nitrous oxide. These pathways have also been developed based on the IPCC (2014) and are found in an appendix to this document.

### **Calculating a CO<sub>2</sub> only carbon budget for Wales**

The most recent Synthesis Report from the IPCC (2014) emphasises<sup>9</sup> three global carbon budgets for the period 2011-2100 with keeping temperature increases to below 2°C with different levels of probability.

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<sup>6</sup> UN 1992 *United Nations Framework Convention on Climate Change* (New York)

<sup>7</sup> IPCC (2014) *Climate Change 2014 Synthesis Report* Editors Pachauri, R. and Meyer, L. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

<sup>8</sup> C. Le Quéré, G. P. Peters, R. J. Andres, R. M. Andrew, T. Boden, P. Ciais, P. Friedlingstein, R. A. Houghton, G. Marland, R. Moriarty, S. Sitch, P. Tans, A. Arneeth, A. Arvanitis, D. C. E. Bakker, L. Bopp, J. G. Canadell, L. P. Chini, S. C. Doney, A. Harper, I. Harris, J. I. House, A. K. Jain, S. D. Jones, E. Kato, R. F. Keeling, K. Klein Goldewijk, A. Körtzinger, C. Koven, N. Lefèvre, A. Omar, T. Ono, G.-H. Park, B. Pfeil, B. Poulter, M. R. Raupach, P. Regnier, C. Rödenbeck, S. Saito, J. Schwinger, J. Segsneider, B. D. Stocker, B. Tilbrook, S. van Heuven, N. Viovy, R. Wanninkhof, A. Wiltshire, C. Yue, S. Zaehle, 2013. *Global Carbon Budget 2013*. *Earth Syst. Sci. Data Discuss.*, doi:10.5194/essdd-6-689-2013, <http://www.earth-syst-sci-data-discuss.net/6/689/2013/essdd-6-689-2013>

<sup>9</sup> The numbers presented in the table below are the IPCC’s simplified values taken from IPCC, 2014 *Climate Change Synthesis Report, Summary for Policy Makers*, 5<sup>th</sup> Assessment Synthesis Report Eds Pachauri, R and Meyer, L. Page 10 and footnote 7.



**Table 1: Cumulative CO<sub>2</sub> emission from 2011-2100 consistent with limiting warming to less than 2°C above an 1861-1880 base period according to the IPCC Synthesis Report (2014).**

Probability of limiting warming to <2°C <sup>10</sup>	<b>66%</b>	<b>50%</b>	<b>33%</b>
<b>Cumulative CO<sub>2</sub> emissions (GtCO<sub>2</sub>)</b>  (range dependent on non-CO <sub>2</sub> drivers from 2011)	1000  (650-1250)	1100  (1000-1300)	1400  (1050 – 1900)

The task undertaken here is to translate these global budgets into budgets for Wales. The approach taken is outlined below:

*Step 1: Consider emissions since 2011*

The budgets in Table 1 cover the period 2011-2100 and these have been updated to take into account emissions in 2011, 2012 and 2013<sup>11</sup> along with an assumption that emissions in 2014 are the same as in 2013<sup>12</sup>. Subtracting these values from the budgets in Table 1 gives a new set of budgets for the period 2015-2100. Global emissions (excluding cement and land use change) amounted to 127GtCO<sub>2</sub> for these years. Cement and land use change emissions during this time are considered in Step 2.

*Step 2: Consider cement and deforestation emissions*

In addition to the CO<sub>2</sub> emissions released from fossil fuel combustion, significant levels of emissions arise from cement manufacture and deforestation. We have considered these emissions as global

<sup>10</sup>IPCC, 2014 Climate Change Synthesis Report, Summary for Policy Makers, 5<sup>th</sup> Assessment Synthesis Report Eds Pachauri, R and Meyer, L. Page 10 and footnote 7 – these values are based on the cumulative emissions budget for all anthropogenic sources since 1870, subtracting 1900Gt the IPCC estimate was emitted globally between 1870-2011. The range provided is dependent on non-CO<sub>2</sub> drivers.

<sup>11</sup> From Global Carbon Atlas, <http://www.globalcarbonatlas.org/?q=en/emissions> C. Le Quéré, G. P. Peters, R. J. Andres, R. M. Andrew, T. Boden, P. Ciais, P. Friedlingstein, R. A. Houghton, G. Marland, R. Moriarty, S. Sitch, P. Tans, A. Arneeth, A. Arvanitis, D. C. E. Bakker, L. Bopp, J. G. Canadell, L. P. Chini, S. C. Doney, A. Harper, I. Harris, J. I. House, A. K. Jain, S. D. Jones, E. Kato, R. F. Keeling, K. Klein Goldewijk, A. Körtzinger, C. Koven, N. Lefèvre, A. Omar, T. Ono, G.-H. Park, B. Pfeil, B. Poulter, M. R. Raupach, P. Regnier, C. Rödenbeck, S. Saito, J. Schwinger, J. Segsneider, B. D. Stocker, B. Tilbrook, S. van Heuven, N. Viovy, R. Wanninkhof, A. Wiltshire, C. Yue, S. Zaehle, 2013. Global Carbon Budget 2013. Earth Syst. Sci. Data Discuss., doi:10.5194/essdd-6-689-2013, <http://www.earth-syst-sci-data-discuss.net/6/689/2013/essdd-6-689-2013>

<sup>12</sup> Final figures for 2014 global emissions were not available at the time of writing.

overheads i.e. that they are responsibility of all nations<sup>13</sup>. Projections of global emissions of these sources have been developed from forthcoming analysis by Anderson et al 2015.

The budget for cement builds on cement-emission data and trends from the Global Carbon Project<sup>14</sup>, private communication with the relevant GCP researcher working at CICERO (Nov 2014), and potential industry mitigation technologies and assumptions outlined in the International Energy Agency’s Cement Road (2009)<sup>15</sup>, their Energy Technology Perspective (2014)<sup>16</sup> and private communication with the relevant IEA cement specialist (Feb. 2015). The global assumptions embedded within this budget require Wales to ensure that carbon capture and storage technology are fitted to all new cement plant built in Wales and a programme is developed for retrofitting existing plant with this technology over the next 20 years.

The figure for deforestation is from an updated analysis of the figures published in Anderson and Bows (2011)<sup>17</sup>, that is revised downwards following recent trends.

For this report it is estimated that deforestation emissions from 2011-2100 are 100GtCO<sub>2</sub> and those for cement manufacture are 150GtCO<sub>2</sub>.

Taking account of these emissions gives revised budgets as follows:

**Table 2: Cumulative CO<sub>2</sub> emission from fossil fuel combustion for 2015-2100 consistent with limiting warming to less than 2°C accounting for deforestation and cement emissions 2011-2100.**

	<b>66%</b>	<b>50%</b>	<b>33%</b>
<b>Cumulative CO<sub>2</sub> emissions (GtCO<sub>2</sub>)</b>	623	723	1023

### *Step 3: Apportioning the budget to non Annex I and Annex I countries*

<sup>13</sup> This borrows the arguments first proposed by Anderson and Bows (2011), where they noted how industrialised nations had already both deforested and constructed infrastructures heavily reliant on cement (from power stations and industries, to rail track and roads, and on to the array of built environments. Access to land and cement are both prerequisites of contemporary development and as such should not be specifically denied poorer non-Annex 1 nations. Consequently, emissions from deforestation and cement (process only) should be a global rather than a national overhead.

<sup>14</sup> See: <http://www.globalcarbonproject.org>.

<sup>15</sup> IEA (2009) Cement Technology Roadmap 2009: Carbon emissions reductions up to 2050. International Energy Agency, Paris, France.

<sup>16</sup> IEA (2014) Energy Technology Perspectives 2014. Harnessing Electricity’s Potential. International Energy Agency, Paris, France.

<sup>17</sup> Anderson, K., Bows, A., (2011) Beyond dangerous climate change: emission pathways for a new world, *Philosophical Transactions of the Royal Society A*, 369, 20-44, DOI:10.1098/rsta.2010.0290.

As stated earlier, in 1992 the UNFCCC introduced a dual track approach to reducing emissions to take account of the idea that while all countries would need to address climate change, the onus was on some countries to act first, taking account of historic development and emissions. Hence, Annex 1 countries should lead by acting first to reduce emissions.

Negotiations regarding the actual apportionment of the remaining budget between countries consider among other factors: historic responsibility (the cumulative emissions of a country since the start of the industrial revolution or the establishment of the UNFCCC); capability (the ability of the country to mitigate its emissions without compromising the welfare of its population); equity (the distribution of emissions rights between both inter and intra generational populations) and inertia (the current share of emissions used to represent the inertia to emissions reduction by a country)<sup>18</sup>.

Building on the above and other factors, alternative methods of apportioning the carbon budget have been developed – all applying different interpretations and mixes of factors to various global datasets. Table 3 applies two frequently used methods to estimate Wales’ 2015-2100 carbon budget (the same method is assumed to apply to all non-Annex I and Annex I countries). The first apportions the global budget between nations according to cumulative population numbers (i.e. the sum of annual population numbers projected between 2015-2100). The second apportions the global budget according to the percentage of 2012 emissions of each country or country grouping.

**Table 3: Cumulative CO<sub>2</sub> emission from fossil fuel combustion for 2015-2100 consistent with limiting warming to less than 2°C accounting for deforestation and cement emissions 2011-2100 apportioned to Wales, all Annex I and Non Annex 1 nations.**

Apportionment Method	Country / Group	Cumulative emissions budget 2015-100 Gt CO <sub>2</sub>		
		66%	50%	33%
Cumulative population 2015-100	Wales	0.22	0.26	0.36
	Non-Annex I	535	620	878
	Annex I	89	103	146
Emissions Share in 2012 (the latest available complete set of data)	Wales	0.76	0.89	1.25
	Non-Annex I	370	430	608
	Annex I	253	294	416

The above two methods of apportionment do not explicitly consider the relative emissions trajectories for non-Annex I countries. Given this, a less idealised but more practical method (initially proposed by

<sup>18</sup> Grasso, M., Roberts, T., (2014) A compromise to break the climate impasse. *Nature Climate Change* 4, 543-549. Raupach et al 2014 Sharing a quota on cumulative carbon emissions. *Nature Climate Change*, 4, 873-879.

Anderson and Bows 2011) estimates the potential emissions from non-Annex I countries, assuming they are very active in pursuing low-carbon development. This value is then subtracted from the global 2°C budget to provide an estimate of the budget remaining for Annex I countries. Taking the recent announcement from China that CO<sub>2</sub> emissions would peak in 2030<sup>19</sup> as a starting point, two scenarios for non-Annex I countries are developed here. These are:

- Scenario 1 – CO<sub>2</sub> emissions continue to grow but at a declining rate, peaking in 2030. After 2030 emissions start to fall with increasing rapidity until they are reducing by 10% every year from 2040-2100.
- Scenario 2 – CO<sub>2</sub> emissions continue to grow but at a declining rate, peaking in 2025. After 2025 emissions start to fall with increasing rapidity until they are reducing by 5% every year from 2035-2100.

The scenarios are ambitious – Scenario 1 requires reductions of 10% per annum from 2040 -2100 and Scenario 2 requires a much earlier peak in emissions than currently envisaged possible. Additional analysis not published here shows that if non-Annex I nations do not peak until 2030, reduction rates less than 10% are likely to use up the entire global budget for all probabilities of avoiding a 2°C increase.

Using these scenarios two cumulative budgets for non-Annex I countries for 2015-2100 were produced.

- Scenario 1 – 787GtCO<sub>2</sub>
- Scenario 2 – 836GtCO<sub>2</sub>

These figures, that acknowledge the current trajectories of non-Annex I nations and their capability to reduce emissions, are significantly higher than most of the apportioned amounts in Table 3. The figures can then be used to give a budget for Annex I countries under each scenario and for different probabilities of keeping below 2°C.

**Table 4: Cumulative CO<sub>2</sub> budgets (GtCO<sub>2</sub>) for fossil fuel combustion from 2015-2100 consistent with limiting warming to less than 2°C for Annex I countries taking into account emission space for non-Annex I countries.**

	Annex 1 budget (GtCO <sub>2</sub> )		
	66%	50%	33%
<b>With Scenario 1</b>	-164	-64	236
<b>With Scenario 2</b>	-213	-113	187

This presents some profound results. The line of negative numbers under the 66% and 50% columns means that given the two non-Annex I scenario budgets, the 66% chance of keeping emissions under 2°C

<sup>19</sup> <https://www.whitehouse.gov/the-press-office/2014/11/11/fact-sheet-us-china-joint-announcement-climate-change-and-clean-energy-c>

is not achievable.<sup>20</sup> That this situation arises even when very challenging emission reductions are placed on non-Annex I nations, makes it clear just how difficult global emission reductions are when taking account of practical transition rates and current trajectories.

*Step 4: Apportioning carbon budgets to Wales*

With the budgets for a 66% and 50% chance of 2°C rendered untenable, the Annex 1 budget for a 33% chance can now be allocated to Wales on the basis of the two apportionment regimes referred to earlier and outlined below.

- Population based – Cumulative projections for the population of Wales from 2014-2100<sup>21</sup> are compared to Medium fertility cumulative projections for the population of Annex I countries as a whole<sup>22</sup>. Wales is then apportioned emissions based on its % of total cumulative Annex I population. The per capita method is commonly used for equitable apportionment.
- Emissions based – The proportion of Welsh emissions in 2012, compared to overall 2012 Annex I country emissions is used to assign a budget to Wales. This method uses the size of existing emissions as a proxy for an Annex I nation’s ability to mitigate.

**Table 5: Cumulative CO<sub>2</sub> budgets for fossil fuel combustion (MtCO<sub>2</sub>) for Wales 2015-2100.**

Apportionment method:	<b>Wales budget (MtCO<sub>2</sub>) 2015-2100</b>	
	<b>33% Probability of warming &lt;2°C</b>	
	<b>Share of Annex-I Population</b>	<b>Share of Annex-I 2012 Emissions</b>
<b>With Scenario 1: non-Annex I peak in 2030 10% per annum reduction from 2040.</b>	590	711
<b>With Scenario 2 Non-Annex I peak in 2025 peak 5% per annum reduction from 2035</b>	467	563

<sup>20</sup> Unless it is assumed that negative emission technologies prove successful and can be rolled out in a timely fashion, at a sufficient scale and that the initially higher emissions do not trigger large scale positive feedbacks.

<sup>21</sup> Office for National Statistics (2013) *National Population Projections – 2012*, Published 6 November 2013.

<sup>22</sup> United Nations, Department of Economic and Social Affairs, Population Division (2013) *World Population Prospects: The 2012 Revision*, DVD Edition.

## Conclusions and discussion

This analysis demonstrates that there is no unreservedly ‘right’ answer to the allocation of a ‘fair’ proportion of the remaining global carbon budget to Wales. The budgets provided in Table 3 apportion global emissions to Wales based on an interpretation of the equity principle and inertia – two methods common in the literature - however they do not acknowledge the current emissions trajectories and capabilities of non-Annex I nations to meet their apportioned budgets. The four alternative budgets for Wales presented in Table 4, are consistent with different assumptions about the rate of decarbonisation achievable by developing countries, the probability of avoiding a 2°C increase and different ways of apportioning the remaining budgets between Annex I countries. Taking this approach highlights the practical challenge of achieving global decarbonisation consistent with a 67 and 50% probability of avoiding a 2°C increase.

While the global budget can be informed by the latest climate science, the distribution of that budget between countries is a political and moral decision. Following this, the size of the budget that Wales chooses to use to inform its climate change strategy also has moral, ethical and political implications. In making an informed, coherent and transparent decision a number of questions need to be considered. These include:

- How important is it to have a reasonable chance of staying below 2°C?
- What does reasonable mean; 50%, 33%, less, more?
- What can, or should, be expected from non-Annex I countries and how might Annex I countries assist them?
- How important are ‘equity’ and ‘fairness’ and what does an equitable or fair approach entail?

The outcome of the analysis presented here, relies heavily upon what could be feasibly expected from non-Annex I countries fully committed to the enormous challenge posed by staying within the IPCC’s 2°C carbon budgets. Ideally, non-Annex I countries would be able to peak their emissions much sooner than 2025, however even with an earlier peaking date the cumulative emissions rely strongly on the annual percentage reductions thereafter, anything less than 5% post 2035 leaves little budget for Annex I nations. Yet such a level of ambition is not apparent in current commitments of even the wealthier Annex I countries, let alone the 10% assumed post 2040 in for non-Annex nations in scenario 1.

Delivering emissions budgets associated with a reasonable probability of maintaining the “*increase in global temperature below 2 degrees Celsius*” demands rates of mitigation beyond anything yet countenanced; this is the case regardless of how the budgets are divided. Virtually all scenarios outlining how these stringent carbon budgets may be met globally rely heavily on the use of ‘negative emissions’: that is technologies that either capture CO<sub>2</sub> directly out of the atmosphere and store it or through the use of biomass combustion attached to carbon capture and storage equipment. The IPCC’s emission pathway consistent with a 66% probability of avoiding 2°C, shows emissions globally at net zero emissions by 2070 with increasing negative emissions in the latter half of the century. By contrast, the analysis within this report expressly excludes the uptake of negative emission technologies as a means

of effectively increasing the available carbon budgets in the first half of the century as this would lock-in reliance upon the large scale deployment of currently unproven technologies.

## Appendix

### Non-CO<sub>2</sub> greenhouse gases

While the IPCC provide cumulative budgets for CO<sub>2</sub>, the latest report does not provide equivalent information for non-CO<sub>2</sub> Kyoto GHGs. Instead they have produced emission reduction pathways for each of the gases for different country groupings published in the RCP database<sup>23</sup>. These pathways have been used to provide % reduction targets for methane and nitrous oxide for each decade to 2060. The figures below are taken from the emission scenarios that underpin the RCP2.6 pathway (a pathway consistent with avoiding 2°C increase) for OECD countries. The different targets for each sector producing methane reflects the different technical ability of the sectors to mitigate their emissions, while the RCP database provide figures for methane, a similar breakdown is not provided for other gases. It can be assumed that similar reductions would be required for Wales to be in line with a 2°C target.

**Table 6: Percentage reductions of emissions for methane and nitrous oxide on a 2010 baseline consistent with a reduction pathway with a 66% probability of avoiding an increase of more than 2°C.**

	% Reduction in Methane from Agriculture	% Reduction in Methane from Power Plants, Energy Conversion, Extraction, and Distribution	% Reduction in methane from Waste (landfill, waste water, non-energy incineration)	% Reduction in methane from Industry (combustion & processing)	% Reduction in methane emissions - Residential and Commercial	% Reduction in total Nitrous Oxide emissions
2020	11	60	62	1	18	20
2030	20	70	71	16	32	21
2040	27	78	71	31	38	24
2050	35	83	83	44	44	32
2060	38	89	89	51	48	38

<sup>23</sup>RCP Database (Version 2.0.4) <http://www.iiasa.ac.at/web-apps/tnt/RcpDb>

generated: 2010-04-15 15:22:57 The methodology used to develop the RCP 2.6 pathway is published in:

van Vuuren, D.P., B. Eickhout, P.L. Lucas, and M.G.J. den Elzen, 2006. Long-term multi-gas scenarios to stabilise radiative forcing - Exploring costs and benefits within an integrated assessment framework. Multigas Mitigation and Climate Policy. The Energy Journal Special Issue and

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Stabilizing greenhouse gas concentrations at low levels: an assessment of reduction strategies and costs. Climatic Change, doi:10.1007/s/10584-006-9172-9.