

An assessment of 'Contraction & Concentrations'-'Contraction & Convergence' & C&C targets & modelling behind various rates of 'sink-efficiency' in the UK Government's 'Climate Act' [2008].

Presentation/animation: - http://www.gci.org.uk/animations/Sources_and_Sinks_UK_Climate_Act.swf

This presentation/animation audits the "2016 4% Low" CO₂-contraction:atmospheric-CO₂-concentrations:convergence budget that is the Government's prescribed basis of the UK Climate-Act. The Government's prescription results from runs of the MAGICC climate-model that the UK Hadley Centre was requested to conduct with an overall view to avoiding a global temperature rise of more than two degrees. Keeping the CO₂ emissions budget ['2016 4% Low'] constant and selecting the 'median' case for the resultant CO₂ concentrations in the atmosphere, Government published the view that this scenario gave only 44% odds for not exceeding an overall temperature rise of 2 degrees by 2100.

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### **Major contradiction from DECC/AVOID in future Ocean CO<sub>2</sub> Acidification projections.**

Subsequently DECC, using analysis from members of the consortium in the AVOID programme, projected calculations of future increases in 'ocean acidification', or pH decreases, onto this fixed emissions:concentrations prescription. In the total ensemble of results from this "2016 4% Low" 'scenario', 2050 emerges as a year of great significance as the Government's prescription displays the following four features: -

1. atmospheric CO<sub>2</sub> concentrations peak in 2050 and then start declining, consequently . . .
2. sinks are absorbing more than the emissions equivalent from 2050 onwards and . . .
3. ocean acidification stops increasing from 2050 onwards and within contraction
4. convergence to globally equal emissions entitlements per capita is completed by 2050.

GCI audited this ensemble and serious contradictions emerge.

What DECC/AVOID have done was to: -

5. prescribe a fixed CO<sub>2</sub> emissions budget [[2016 4% Low]
6. project an array of atmosphere CO<sub>2</sub> concentrations paths [10%-ile;median;90%-ile] that result from this and then separately
7. project arrays of ocean CO<sub>2</sub> acidification paths resulting from these atmosphere concentration path.

What the DECC/AVOID/Hadley modellers didn't do was to look at ocean CO<sub>2</sub>-concentration pathways that resulted from the above and it is these which reveal the contradiction observed and discussed here.

Using the detailed projections of emissions and concentrations for 2016 4% Low given in the Committee of Climate change report 'Building a Low Carbon Economy' [2008], Chapter 1 spreadsheet, Model Emissions and Climate Data, GCI produced a time-series as follows: -

8. quantify the carbon-weights of the CO<sub>2</sub> concentration pathways and then, against the CO<sub>2</sub> budget . . .
9. quantify the carbon-weights of the 'fractions-of-CO<sub>2</sub>-emissions-retained-to-the-sinks' [FERTS] . . .
10. quantify the 'fractions-of-CO<sub>2</sub> emissions-retained-in-the-atmosphere' [FERTA] that result . . .
11. quantify the 'accumulated-fractions-of-emissions-retained-to-the-sinks' [AFERTS] . . .
12. assign 50% of AFERTS to the ocean-sinks [AFERTOS] . . .
13. compare the various rates of AFERTOS with the rates of ocean-acidification.

What emerges from this audit is the DECC/Hadley/AVOID modelling of future CO<sub>2</sub> emissions:ocean-atmosphere-concentrations:ocean-acidification has a major contradiction. They claim: -

14. ocean CO<sub>2</sub> acidification is a function only of increasing atmospheric CO<sub>2</sub> concentration and
15. increasing ocean acidification is not a function of increasing oceanic CO<sub>2</sub> concentration but that
16. increasing oceanic CO<sub>2</sub> concentration is a function of increasing atmospheric CO<sub>2</sub> concentration
17. and further that oceanic CO<sub>2</sub> acidification increases while oceanic CO<sub>2</sub> concentration does not
18. or conversely oceanic CO<sub>2</sub> concentration increases while oceanic CO<sub>2</sub> acidification does not.

In other words the AVOID/DECC results claim what is impossible in the real world: that ocean CO<sub>2</sub> acidification can just stop while ocean CO<sub>2</sub> concentration continues to increase and/or that ocean CO<sub>2</sub> concentration can just stop while ocean CO<sub>2</sub> acidification continues to increase.

This impossibility shows that the key part of this modelling was omitted, namely the effect on the biological aspect of the ocean sink of increased levels of CO<sub>2</sub> acidification. This omission results from 'fixing' and pre-scripting the CO<sub>2</sub> budget and the concentrations paths that are portrayed as 'high/middle/low' and then just telling oceanographers to predict ocean-acidification-levels off the concentration paths only.

It is of central importance in the exercise to realize that this isn't simply a dispute about the quantum of projected rates of ocean CO<sub>2</sub> acidification. This is about an audit of "2016 4% Low" revealing the use by DECC/AVOID of a bureaucratic and demonstrably flawed modelling procedure to achieve projections of CO<sub>2</sub> concentration in the atmosphere and the oceans.

Dr Toby Tyrrell of Southampton Oceanography Department, who was tasked with projecting the rates of ocean acidification under "2016 4% Low" said: -

1. *"the time evolution of atmospheric CO<sub>2</sub> was prescribed. We imposed it on the model and then calculated the resulting impact on pH"* and
2. *"these model runs are not suitable for calculating the ocean CO<sub>2</sub> sink over time, and therefore neither are they suitable for calculating the fraction of emissions that is retained in the atmosphere."*

He's welcome to say that, but that is exactly what the DECC/AVOID model runs did. The spreadsheets accompanying the publication of the UK Climate-Act give year-on-year values for CO<sub>2</sub> emissions and CO<sub>2</sub> concentrations. Southampton's imposing the CO<sub>2</sub> concentrations only to calculate the resulting impact on ocean CO<sub>2</sub> acidification is flawed as it cuts out a - if not the - key bit of the modelling challenge [quantifying the impact on ocean-sink biology] and contradicts the Met Office's own statement on its web-site which says: -

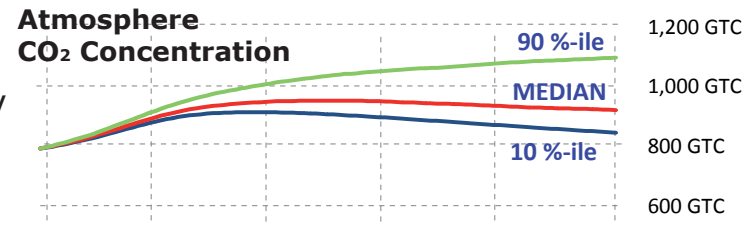
*"As the oceans acidify they are less able to absorb further CO<sub>2</sub> accelerating climate change because more man-made emissions remain in the atmosphere."*

The sensible way to model this, and the more responsible way ahead is recommending fixed concentration pathways [RCPs]. This means: - [a] 'fixing' an atmosphere CO<sub>2</sub> concentration path estimated to equal no more than a two degree rise in temperature [b] varying the size of the CO<sub>2</sub> 'emissions-budget' - 90%-ile/median/10%-ile - around that RCP and [c] seeing that the ocean-acidification-level read off the fixed and constant CO<sub>2</sub> concentration path in the atmosphere, is 'fixed' in synch with the constant CO<sub>2</sub> concentration path in the ocean bars noting the AFERTOS pathway arising doesn't change either.

This procedure avoids the concentration/acidification conflict stated above and focuses on the one thing over which we still [tentatively] have control for UNFCCC-compliance and that is 'emissions' and the size and international sharing of the emissions-budget that achieves UNFCCC-compliance - i.e. contraction and convergence. This is over-riding reason to work to RCPs and the IPCC 5th Assessment calls for RCPs.

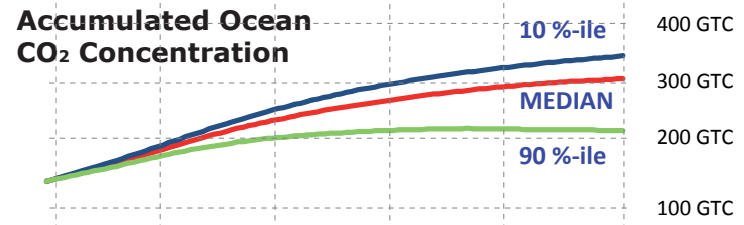
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**(a) Accumulated CO<sub>2</sub> deposition**  
 [or CO<sub>2</sub> concentration] in the global atmosphere [here in Gigatonnes carbon] that Hadley/ Lowe/MAGICC say accompany the "2016 4% Low" CO<sub>2</sub> Emissions Budget, as prescribed in the UK Climate Act [see (d) below] at Median, 10%-ile and 90%-ile values.



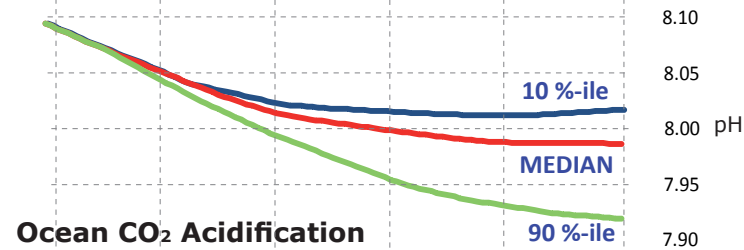
Source: - UK Climate Change Committee [CCC] spreadsheets for CO<sub>2</sub> emissions-budget, '2016 4% LOW', as adopted in the UK Climate Act.

**(b) Accumulated CO<sub>2</sub> deposition**  
 [or CO<sub>2</sub> concentration] in the global oceans [here in Gigatonnes carbon] that accompany the "2016 4% Low" CO<sub>2</sub> Emissions Budget in the UK Climate Act [see (d) below] at Median, 10%-ile & 90%-ile values, [calculated GCI].



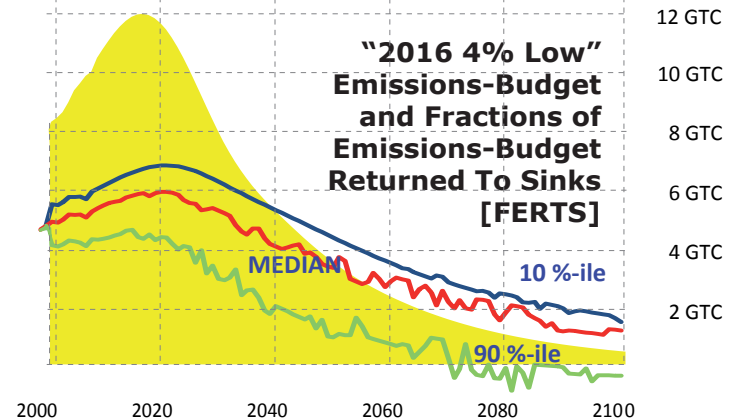
Source: - these AFERTOS levels were calculated by GCI in an audit of '2016 4% Low'.

**(c) Increased CO<sub>2</sub> acidification**  
 in the global oceans [on pH scale] that DECC/AVOID/Lowe/Tyrrell say accompany the "2016 4% Low" CO<sub>2</sub> Emissions Budget in the UK Climate Act [see (d) below] at Median, 10%-ile and 90%-ile values [calculated by AVOID].

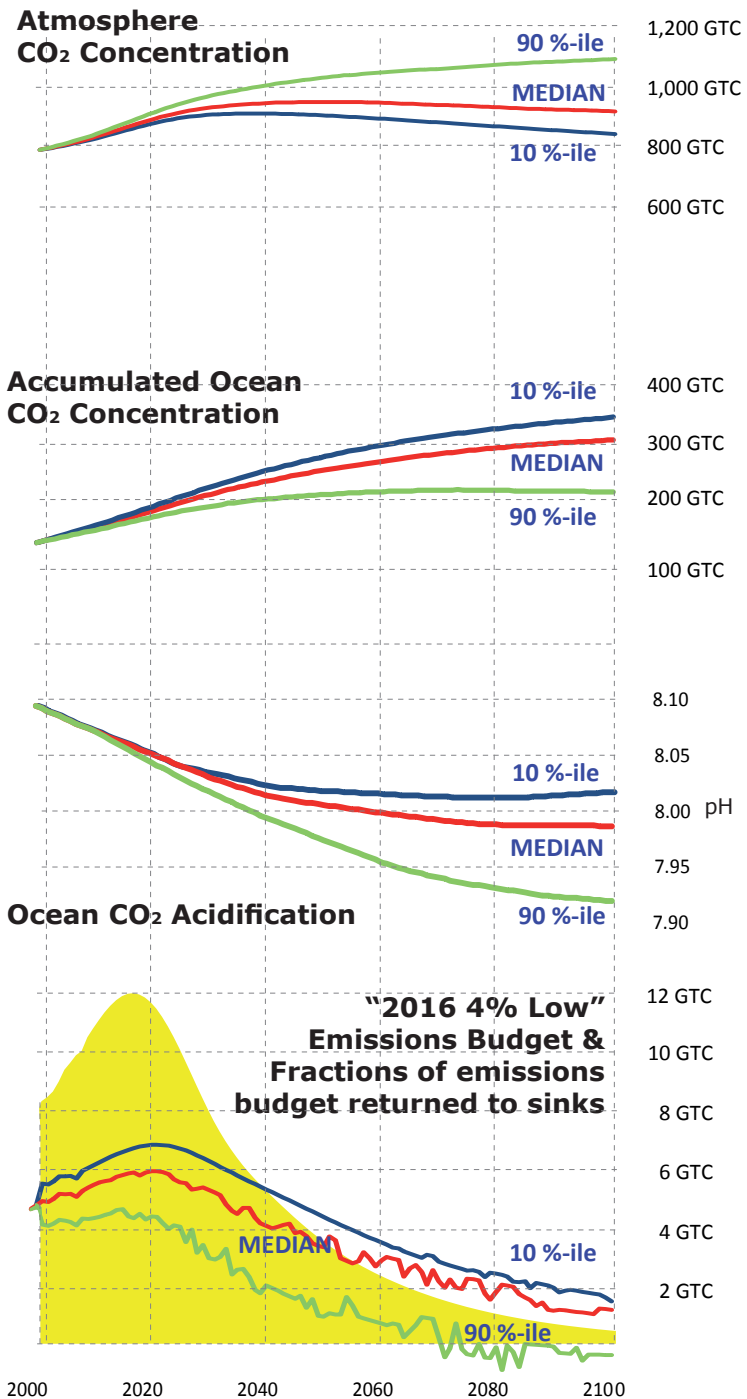


Source: - these levels were calculated and published by the UK Government funded AVOID programme.

**(d) "2016 4% Low" CO<sub>2</sub> Emissions Budget** prescribed in the UK Climate Act, showing Fraction of emissions returned to sinks [calculated by GCI following the DECC/ Hadley/Lowe/MAGICC prescription at Median, 10%-ile and 90%-ile values.



Source: - UK Climate Change Committee [CCC] spreadsheets for CO<sub>2</sub> emissions-budget, '2016 4% LOW', with FERTS levels calculated by GCI in the audit of '2016 4% Low'.



The “2016 4% Low” CO<sub>2</sub> Emissions Budget prescribed in the UK Climate Act gave [they say] these atmosphere concentrations at Median [Red], 10%-ile [Dark Blue] and 90%-ile [Green] values.

The combination of these values with values of the Emissions Budget [in yellow, at (d) below] made it possible to calculate the ‘Fraction of this Emissions Budget’ that [they say] was theoretically returned to the global sinks and the Fraction that was retained in the atmosphere. These values are shown superimposed on the Emissions Budget below at Median, 10%-ile and 90%-ile values.

DECC/Hadley/Lowe state that ~half the ‘Fraction Returned’ will accumulate in the oceans: - shown as ‘CO<sub>2</sub> accumulation curves’ in graphic (b) alongside again at Median, 10%-ile and 90%-ile values.

AVOID/Lowe/Hadley state that CO<sub>2</sub> acidification of the ocean will cease by around 2050 in the median case of “2016 4% Low”, as [they say] atmosphere CO<sub>2</sub> accumulations will cease at that time due to the CO<sub>2</sub> sinks contracting more slowly than CO<sub>2</sub> emissions.

The error in this methodology becomes quite obvious once it is revealed they show that the greatest increase of CO<sub>2</sub> acidification in the ocean, accompanies the greatest increase of CO<sub>2</sub> accumulation in the atmosphere [90%-ile], but with the smallest increase of CO<sub>2</sub> accumulation in the ocean and *conversely*, the smallest increase of CO<sub>2</sub> acidification in the ocean, accompanies the smallest increase of CO<sub>2</sub> accumulation in the atmosphere [10%-ile], but with the greatest increase of CO<sub>2</sub> accumulation in the ocean.

This is obviously nonsense and also contradicts a recent Met Office statement which says: -

*“As the oceans acidify they are less able to absorb further CO<sub>2</sub>, accelerating climate change because more man-made emissions remain in the atmosphere.”*