22.01.15

Caveats

Using the model

The user should be aware of the following caveats when using the Global Calculator:

- **Regional insights:** the Calculator interprets climate information at a global level; it does not focus on/consider individual countries. Likewise, it calculates energy supply and demand, land use, costs and emissions at a global level. However, it does account for regional issues in the levels 1-4, for example by considering the transport mode options for different types of city around the world, and it includes example pathways which are drawn from analysis that includes country level detail (see the frequently asked questions document for more detail). The global level perspective of the Calculator implies that, for example, in extreme deployment of wind, nuclear, solar and electricity storage, the user is asserting that electricity can be transmitted and distributed to demand without affecting the rate of distribution losses.

- **Short term, detailed questions vs. long term, strategic questions:** the Global Calculator is suited to exploring the available actions to reduce global emissions and for aiding users to understand which actions cause significant emission reductions. The Calculator cannot answer detailed, country-level policy questions, but it can inform global policy direction, such as by highlighting the role for electric vehicles or the role for wind power. It also enables the user to consider the interactions between actions and sectors, (for example, the importance of decarbonising electricity to maximise the benefits of electrifying vehicles) and links up choices in the global energy, food and land systems to their impacts on the global climate. It is not suited, however, to answering short term, country level questions such as "what would a carbon price of $x in the USA do to its energy mix in 2015?".

- **Using the Calculator with other sources of information:** many different models or types of analysis can inform questions about the global energy, land and food systems to 2050 in the context of an evolving climate. The Calculator is a complement to these different tools, which may answer different questions or answer the same questions in different ways. The Calculator may prove most beneficial when used in conjunction with information from a variety of sources and models, the particular mix depending on what questions the user is trying to answer.

- **Adequacy of data:** Best efforts have been made to use data which experts recognise and consider to be fit for purpose. Nevertheless data itself will always be imperfect for a range of reasons, for example: collection issues at source, representativeness, and incompleteness.

- **Modelling the world:** The scientific climate models which the Calculator interprets, as well as the range of other models involved, are each a simplification of reality. While the Calculator was designed to minimize systematic error, and reflect the uncertainty in outputs wherever they have been sampled, we know that not all these sources of uncertainty have been sampled. Thus while the Calculator is intended to be informative of the real world, it should never be seen as a perfect representation of it.

- **Feedback loops / interactions:** The model is user driven and does not automatically take into account potential feedback effects, such as those between supply and demand sectors and levers; consistency of such interaction must be specified by the user. For example, if a user amends their transport "mode" choice to switch a high proportion of travel from private cars to public transport, the model will not increase or decrease transport distance; this allows the user to explore the effects of changes in each. The user is responsible for generating scenarios that are internally consistent. Doing so requires consideration of interactions between sectors. The Calculator aids users to do this by:
  - including example pathways from organisations which have modelled these interactions between sectors at a regional and country level
  - providing warnings (for example, when electricity is oversupplied)
  - explicitly modelling some interactions (the manufacturing sector "produces" vehicles and appliances demanded by the user – see the spreadsheet user guide document on the website)
  - explaining some of the potential interactions in the lever descriptions (found by clicking on the lever names in the online tool)

- **Macroeconomic impacts**: The Calculator does not attempt to account for the impact on the global economy of large changes in energy supply and demand; such changes are possible in some extreme scenarios with multiple level 4 choices. Macroeconomic or geopolitical impacts resulting from high climate change pathways are also not accounted for.

- **Electricity balancing**: the Calculator ensures that electricity supply meets electricity demand at a yearly level by deploying fossil fuel plants to meet any shortfall in yearly supply. It does not model minute-by-minute balancing, but ensures peaks in demand could be met during lulls in supply from intermittent sources, by building gas power plants to ensure the capacity of non-intermittent sources would be sufficient to meet these peaks in electricity demand. However, it does not model the potential curtailment associated with non-dispatchable technologies. For example, if there is a large enough installed capacity of wind and the wind is blowing, electricity supply could exceed demand if there is low enough electricity demand, and so some generation would need to be curtailed. Therefore, in some extreme scenarios of high deployment of non-dispatchable technologies, such as wind, the electricity supply from low carbon sources may be overstated.

- **Water**: the Global Calculator does not model water demand. Certain pathways could exacerbate water stress depending on the type of technologies used and their location.

- **Interactions between climate and land/food/energy systems**: the Global Calculator does not take into account any interactions between the climate outcome and activity in other sectors. In reality it is likely that a large change in global climate would result in significant impacts to other sectors including crop yields, renewable energy output, and heating/cooling requirements in homes. Additionally, the impacts of climate change would impose costs, either of damage or of adaptation. These impacts and costs are not accounted for automatically, but the user may choose to represent such interactions themselves, for example by choosing lower crop yields for higher emission pathways.

- **Post-2050 lever**: The Global Calculator only explicitly models the global land, food and energy systems up to 2050. Beyond 2050 it is thought that potential outcomes for these systems are very uncertain, since they may depend on unknown technological developments or changes in lifestyles and attitudes. However, climate system responses are usually shown to 2100, since the effects of greenhouse gas emissions are cumulative and build up over time; the full effect of emissions to 2050 would not be felt by 2050. Therefore the model includes emissions between 2050 and 2100, but the emissions trajectory over this period is simply asserted by the user. The user can, for example, continue the previous 15 year trend to 2050 out to 2100, or make emissions completely flat from 2050. The Calculator includes no underlying assessment on the feasible emissions between 2050 and 2100; the responsibility lies with the user. Users should note that (especially for high emission pathways) the choice of this lever can be a dominant contribution to the global mean temperature change.

Data and assumptions

We always welcome feedback on our data and methodology. The known potential improvements are provided in our "improvements log" on the website, but a summary is available here:

- **2011 Energy:** the Calculator produces energy implications in a bottom-up way. For example, transport energy demand is calculated as vehicle distance x energy per km, for each vehicle. A few of the sub-sector level energy supply and demand figures determined by the Calculator for the base year 2011 are more than 5% different from credible published sources (such as IEA data). One example is buildings hot water demand in the Calculator for 2011, which is 9% higher than IEA data. In these cases, the data used in the bottom up modelling may need to be improved. However, the sector and sub-sector level energy implications calculated by the model matches with IEA data in the majority of cases and the majority of 2011 input data is considered to be fit for purpose.[1] For example, total buildings energy demand is within 3% of published IEA data. The quality of data in the spreadsheet is indicatively marked with "red / amber / green" ratings to help clarify where the data is strongest and weakest.

- **2011 emissions**: the Calculator produces the emissions implications in a bottom up way. For example, transport emissions are calculated as transport energy demand x the emission factor for fuel. As of January 2015, industrial process emissions (4% of global CO_2e in 2011) are 35% too high and fugitive emissions from fuels (5% of global CO_2e in 2011) are 20% too low. However the majority of emissions by sector match within 5% and global CO_2e in 2011 within the Calculator is within 5% of credible data on published emissions.

[1] Most of the data was supplied by the IEA from *Energy Technology Perspectives 2014* ©OECD/IEA 2014– www.iea.org/etp2014

- **Fixed assumptions:** these are data which are used for implications post-2011 that cannot be chosen by the user. Some of this data could be improved; indicative "red / amber / green" ratings are used in the tool to indicate where the data could be weaker (red) or stronger (green).

- **Costs:** these are highly uncertain (in particular the industry costs) and so the user should not fixate on point estimates. The model also includes a high and low cost for each technology, which can be used to explore the likely range of costs for a given scenario. Please see the cost methodology paper for more information.

- **Climate science:** the user should be aware that the mean temperature rise in the online tool is based on the user-generated CO_2, CH_4, N_2O and SO_2 only, and does not represent other greenhouse gases. The output is based on aggregated data and therefore has a wide range of possible outcomes, reflecting the very simplified nature of the tool. More sophisticated climate modelling tools are available but could not be incorporated within the constraints of the Global Calculator approach.

- **Stakeholder engagement and levels 1-4**: the amount of stakeholder engagement on the levels 1-4 varied across sectors. Most had substantial stakeholder engagement, but the buildings sector had a relatively lower level of engagement outside China, and there was only minor engagement for the industry sub-sectors of paper and timber. This means some of the levels 1-4 could be subject to more scrutiny as they received relatively less stakeholder feedback. For example, lifespan of technologies and the ambition for efficiency improvements for fossil fuel refineries. However other sub-sectors of industry had substantial stakeholder engagement, as did the other main sectors.

Example pathways

The Global Calculator includes example pathways. Some of these were developed by the Global Calculator team to derive the key messages. Other example pathways were mapped into the tool from existing analysis, for example the International Energy Agency's "Energy Technology Perspectives 2014" report, and the University College London's "TIAM" model. These example pathways are inevitably not a perfect match to the original pathways from other models; for example, some of the energy consequences may differ. This is because the Global Calculator uses a different methodology, data and assumptions.