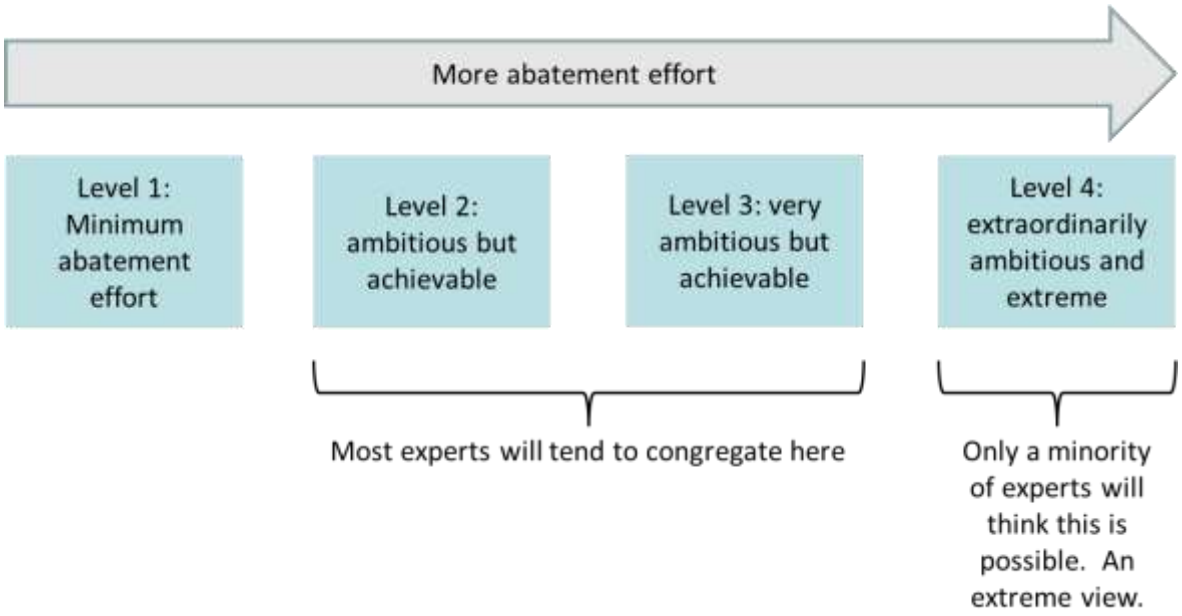
Definition of Level 1 to 4 for the Global Calculator

This note summarises how we have defined level 1 to 4 in the Global Calculator and the thinking behind this. For detail on how specific levers have been calculated, please see the 1-pager for each lever (accessible by clicking on the "i" next to each lever in the tool) or see the more detailed sectoral documentation accessible from www.globalcalculator.org.

Summary

Level 1 to 4 is intended to reflect the minimum to maximum amount of emission reductions (abatement) that could be achieved for each type of "lever" (determinant of emissions). Specifically, for all 40 levers in the Global Calculator, level 1 to 4 is defined as follows:



For all levers, moving from level 1 to 4 will steadily reduce emissions[1]. Note that most experts will tend to agree that level 2 or 3 is the most likely outcome achievable if the world adopts ambitious or very ambitious action. Only a minority of experts will agree that level 4 is achievable.

The 40 levers in the tool are grouped into four different types:

- Lifestyle
- Technology and fuel
- Land
- Demographics and long term

[1] The exception is for the electrification levers. In the Global Calculator, higher electricity demand is automatically met from fossil fuels, so unless the user also supplies more low carbon electricity, then electrification can increase emissions.

The rest of this note sets of detail on how to interpret levels 1 to 4 in the context of these four types of lever and some frequently asked questions.

Lifestyle levers

The lifestyle levers reflect the amount of goods and services that people consume in 2050. For example, distance travelled per person, the mode by which they travel, the temperature to which they heat/cool their homes and the amount of food they eat. These levers have a tangible impact on people's lifestyle.

Level 1

In the context of the lifestyle levers, "minimal abatement effort" is interpreted as the highest growth in consumption of food and energy services that could be considered credible by 2050. This is maximal, unconstrained growth and typically higher than what most experts would regard as "business as usual".

Level 4

"Extraordinarily ambitious and extreme effort" is interpreted here as a revolution in behaviour and the maximum that could be considered socially acceptable and consistent with economic growth. Level 4 is not economic apocalypse: the economy is still assumed to grow, consistent with projections. This can be interpreted as a world in which economic growth and demand for energy services have been decoupled.

Technology and fuel levers

The technology and fuel levers describe which technologies and fuels are used to deliver the energy services that people consume (as set out by the lifestyle levers). For example:

- Transport – whether people drive petrol, hybrid or electric cars
- Buildings – how well insulated their buildings are and whether they use biomass, gas or electric heat pumps to heat/cool these buildings
- Manufacturing – what fuels and technologies the iron, steel, aluminium, cement, chemicals, paper and other industries use
- Electricity – the extent to which we generate our electricity via fossil fuels, CCS, nuclear or renewables.

Level 1

In the context of the technology and fuel levers, "minimum abatement effort" is interpreted as:

- The minimum level of technology roll out. E.g. Level 1 for the "wind", "nuclear" and "CCS" levers is the lowest possible roll out of that technology. For wind, this means not building any new wind turbines and retiring the existing stock of wind when it reaches the end of its life. For nuclear, it is more extreme and assumes turning off existing nuclear plants early (as has been witnessed in Germany and Japan).

- The most carbon intensive technology mix. E.g. Level 1 for the "electric and hydrogen" lever assumes very low penetration of electric and hydrogen vehicles by 2050, with the big majority of vehicles internal combustion engines.
- Inefficient technology. E.g. Level 1 for "fossil fuel efficiency" assumes that power plants generating electricity from fossil fuels are of lower efficiency.

Level 4

Level 4 is defined as "extraordinarily ambitious and extreme". This is a level of technological effort similar to the US Apollo programme. It should reflect the view of the most ambitious stakeholder, backed up with published evidence or calculations. To calculate this, we have sometimes looked at "top runner" rates from other countries and applied these. Level 4 should reflect the maximum that the science and engineering tells us could be possible. Level 4 is not constrained by costs, but could be interpreted as a situation in which there have been major technological breakthroughs that have reduced costs. Here are some specific examples:

- The maximum level of technology roll out. For example, "nuclear" level 4 assumes the maximum build rate for nuclear (this is a judgement based on advice from external experts in nuclear, considering the constraints in the supply chain).
- The least carbon intensive technology mix. E.g. Level 4 for "electric and hydrogen" is the maximum conceivable penetration of these vehicle technologies, specifically: by 2050, over half the vehicle fleet are electric or hydrogen and one third of the fleet are hybrids.
- Highly efficient technology. E.g. Level 4 for "fossil fuel efficiency" assumes implementation of best available technology in fossil fuel plants world-wide in order to improve power plant efficiency.

Land

Land levers specify the productivity of food and biocrop production and also determine how much surplus productive land is available for forest and biocrops.

Level 1

For the land levers, "minimum abatement effort" is interpreted as a very pessimistic view of food and bioenergy yields. For example, this could be consistent with significant climate impacts having an adverse impact on food production, a failure to widely disseminate best practice farming methods (such as co-cropping and multi-cropping), or a world in which there is a move away from irrigation, fertiliser use and genetically modified food

Level 4

For the land levers, "extraordinarily ambitious and extreme" is interpreted as very optimistic food and biocrop yields. For example, this could be consistent with great success in widely disseminating farming best practice, use of genetically modified crops, and intensified livestock production.

Demographics and long term

There are three levers in this grouping:

- Global population: level 1 reflects the highest and level 3 the lowest population projections from the United Nations.
- Urbanisation: level 1 reflects the high/low range projections for the proportion of the world that will live in urban areas by 2050, from the World Urbanisation Prospects.
- Emissions trajectory to 2100: allows the user to specify the emissions path from 2050 to 2100. Note that the Global Calculator only models sectors, technologies and behaviours in the period to 2050. This lever is simply an assertion of what could happen over the next 50 years. It is illustrative and says nothing about how this reduction would be achieved.

Frequently asked questions

Why have you defined level 4 in such an extreme way?

There are three key benefits to defining level 4 in an extreme way:

- **Identify the whole solution space**. Many users find playing with level 4s to be a useful way of contextualising the issues. Even if they don't seriously advocate that level of action, they find it helpful to have an awareness of what the extreme looks like.
- **Common platform for debate**. Level 1 to 4 is inclusive of all credible experts' views, so they can all use the tool as a common platform for debating their proposals. This is important so we can avoid excluding important arguments from the debate.
- **Future is uncertain** Much could change over the next 35 years, e.g. technology breakthroughs, cost reductions, behaviour change. Defining the range too narrowly risks underestimating future uncertainty.

Should setting the lifestyle levers at level 1 be interpreted as higher economic growth and better quality of life than level 4?

No. Level 1 is associated with higher consumption but should not be interpreted as:

- Associated with higher GDP. All the levels are designed to be consistent with GDP projections for the next thirty five years. For example, "product lifespan and demand" level 4 is a world in which the number of manufactured goods demanded is relatively lower because there has been a shift towards consumption of longer lasting, higher value goods (a less "disposable society"); TVs and washing machines last longer so there is less need to buy new ones. However, it is difficult to say if extreme scenarios with many level 4s on the demand side would have an impact on GDP.
- A better quality of life. For example, level 1 for "calories consumed" and "meat consumed" would entail everyone in the world having the same diet as the average European today. But this diet is in excess of healthy eating recommendations, so would result in an increase in obesity and diabetes. Another example is "passenger distance" level 4 which this involves people travelling less far per year; but this could be associated with better city design, so people live closer to work and have less need to travel.

What does the Global Calculator tell us about the distribution of food and energy services between different countries and regions?

The Global Calculator does not model countries and regions. The lifestyle levers are specified on an average per person (or household for the building sector) basis. So the tool does not assert anything

about how consumption of energy services and food is distributed between different regions and countries[2]. It is up to the user to make this judgement for themselves. Some of the 1-pagers (accessible by clicking the ("i" next to each lever on the tool) and sectoral documentation include context on the state of play in different countries/cities today, which the user may find helpful.

What does the Global Calculator tell us about how the roll out of various technologies and fuels would be distributed across countries and regions?

The Global Calculator does not model countries and regions so this information is not available. However the Global Calculator does include some example pathways from other models which do model countries and regions (i.e. the International Energy Agency and TIAM-UCL models). The user could look at the original IEA and TIAM-UCL report or model runs and look at the assumed distribution of technology by country.

Although the Global Calculator does not directly model countries/regions, in many cases it does take account of geographical information when setting the levels. So this could help the user to gain some insights into possible geographical distributions of technology roll out that would be consistent with their pathway. For example:

- The buildings sector separately models urban and rural areas (and the proportion of people with/out access to electricity). Also, the transport sector models three types of urban area, two types of rural and two groups of international journey. From this information, it would be possible for the user to make some inferences about distributions of technologies by country/region/geography type that would be consistent with their pathway choice.
- Levels 1 to 4 for the renewables levers draw heavily from existing research which has looked at the potential for deployment across different regions. So the user could refer back to these source reports to look at what regional distribution was assumed.

In the land levers, level 1 looks excessively pessimistic – why have you set them like this?

Level 1 for crop yields and bioenergy yields in particular are very pessimistic and outside the range of what most experts would consider "likely". However we have set level 1 in this pessimistic way because we want to allow the user to see the *full* range of what experts believe could be possible. Whereas level 4 is very optimistic, level 1 is correspondingly pessimistic. This is intended to be comparable to other sectors (for example, level 1 for nuclear assumes turning off nuclear power plants before the end of their economic life and building no new ones). We are keen to receive feedback on whether these level 1s are appropriate.

[2] The exceptions here are:

- **Passenger transport:** we have explicitly modelled three different types of urban area ("automobile cities" are sprawling cities; "transit cities" are more compact cities; and "booming cities" are new cities which will grow over the next thirty years and have the potential to either become automobile or transit cities), two types of rural area (developed and developing), and two types of international (slow and fast growth areas). From this, it would be possible to draw some inference of passenger transport use by country/region.
- **Residential buildings**: we model four types or household which are urban with electricity, urban without electricity, rural with electricity and rural without electricity.