

User Guide to the MacKay Carbon Calculator



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Any enquiries regarding this publication should be sent to us at: <u>mackaycarboncalculator@beis.gov.uk</u>

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Introduction

The MacKay Carbon Calculator calculates the future UK energy consumption and greenhouse gas emissions based on user choices about how much ambition the UK should have for each of the main means (or 'levers') of decarbonisation.

These levers range from demand side factors such as how we heat our homes, to supply side factors like how we generate electricity. The Calculator model provides a framework for anyone to understand the factors that are most significant in shaping the UK's future energy system. The model is an updated version of the original UK 2050 Calculator published in 2011.

There are two different online interactive versions of the MacKay Carbon Calculator each with user-controlled levers of decarbonisation:

- My2050 (https://my2050.energysecurity.gov.uk) with 15 levers
- MacKay Carbon Calculator (<u>https://mackaycarboncalculator.energysecurity.gov.uk</u>), a more detailed online tool with 45 levers, which has two modes of operation (2050 & 2100)

In addition to the online versions, the full Excel® model which has 160 levers can be downloaded at <u>https://www.gov.uk/guidance/carbon-calculator</u>.

This user guide relates to the MacKay Carbon Calculator online tool.

How to use the Calculator

The sections below explain the Calculator operation and features, and how the Calculator model works.

Calculator Operation and Features

The Calculator allows users to create a decarbonisation pathway to 2050 and beyond, by choose the ambition level for the forty-five levers of decarbonisation and seeing the effect on UK territorial greenhouse gas (GHG) emissions in the GHG meter and supporting graphs for each sector of the energy system.

Levers: Listed on the left hand side of the screen, the levers are the user controls which are grouped under lever headings (e.g. Transport, Buildings) in a drop-down list. The user chooses the level of ambition level for each lever of decarbonisation ranging from Level 1 (minimal effort to decarbonise) to Level 4 (maximum plausible effort) by clicking on the square boxes which



Figure 1: A screenshot of the MacKay Carbon Calculator webtool showing features

correspond to the desired ambition level, so creating a decarbonisation 'pathway'. The decarbonisation ambition represented by each ambition level was developed in a series of workshops involving over 100 energy stakeholders in 2018. All levers have an initial default setting of Level 1 (minimal effort to decarbonise). Fractional levels of ambition can be chosen by clicking repeatedly on the same square. Hovering over the chosen ambition level causes a pop-up message to appear indicating what that ambition level represents. A one-page pdf information sheet about the lever can be downloaded by clicking on the lever name. The setting of all levers can be reset to the default (Level 1) using the 'reset levers' button. An 'Example Pathways' dropdown allows the user to set all levers to Level 2 or 3 (as an aid to developing a pathway) or to choose an example Illustrative Net Zero pathway developed by the Energy Systems Catapult (ESC).

Emissions Meter: A meter on the right hand side of the screen shows the resulting GHG emissions (expressed as a percentage reduction in carbon dioxide equivalent emissions) in 2050 for the users chosen pathway. The top of the meter (0%) is the baseline for measurement of reductions in carbon emissions (1990). The bottom of the meter (-100%) represents a 100% reduction in emissions relative to the 1990 baseline hence corresponding to the UK target of Net Zero. The default meter reading on opening the tool is -35% which represents the reduction in GHG emissions that the UK will achieve if ambition for all levers remains at only Level 1.

Lever Alarms: There are three lever alarms located in the bottom right of the screen with warnings about ambition level, speed of deployment and biomass resource availability. These alarms are activated if the user chooses a pathway which results in ambition that is at or beyond plausible ambition for these parameters.

Results Graphs: Results for the pathway chosen by the user are shown in some thirty graphs. The default display is Overview, which has 2 pages of graphs with page 1 showing UK GHG emissions and primary energy consumption, and page 2 showing cumulative GHG emissions and final energy consumption. A number of other outputs broken down by energy sector can be seen by choosing a different output page in the blue header above the graphs. The page names mirror the lever headings (Transport, Buildings etc.). A final output page which can be seen by scrolling to the right of the blue header shows energy imports, energy map and energy flows (Sankey diagram).

2100 Mode: On the bottom left of the screen is a 'switch to 2100 mode' button. The Calculator default mode is 2050 and shows graphs with a timeline extending to 2050 in which the lever deployment start and end dates are preset to dates stated in the lever one page information sheet and proposed as being realistic by expert stakeholder. Switching to 2100 mode extends the timeline of graphs to 2100 and allows the user to manually change the deployment start and end dates for levers in order to see the impact it will have.

How the Calculator Model Works

Figure 2 is a visual representation of how sectors and energy types link together.





The model calculates the energy demand represented by the user's pathway, and then adjusts the energy supply to meet this demand. If the user pathway results in supply exceeding demand, the Calculator uses a priority order to determine which supply lever ambition is met first, and only applies the ambition for lower priority supply levers to the extent needed to meet demand. The priority order corresponds to the order in which levers are listed under the lever headings, and is also shown fully in the one page pdf information sheets which can be downloaded by clicking the lever name.

Any deficit in energy supply not met by domestic low carbon energy is supplemented with imported low carbon energy (biomass, low carbon hydrogen) or with fossil fuels. The model then calculates the resulting GHG emissions.

Many graphs within the Calculator show indirect emissions which are emissions arising from fuel production such as electricity generation. The Calculator calculates the total indirect emissions, and then applies them to sector emissions pro-rata.

How to design a pathway

- 1. You can begin either from the default starting position (Level 1) of minimal effort to decarbonise, or can select an example pathway for a higher level of baseline ambition (e.g. all Level 2) and work from there.
- 2. Decide how to create your pathway using the 45 model levers, which represent the principal possible actions available to influence the future energy system. The levers are grouped under six lever headings:

Transport: Demand for different modes of transport, the distance people travel as well as types of vehicles and fuels used (which include electricity, hydrogen, hybrid and biofuel).Buildings: Demand and methods for supplying heating and the deployment of insulation measures.Demand for and efficiency of lighting, appliances and air conditioning.

Industry: Energy and emissions intensity of industrial process including fuel switching and Carbon Capture and Storage (CCS).

Carbon dioxide (CO2) reduction: Conversion or substitution of fuel in the gas grid, methods of supplying hydrogen demand as well as the application and performance of carbon capture and storage and greenhouse gas removal technologies.

Electricity: Methods of electricity generation and the deployment of storage and balancing capacity. **Land use, bio-energy and waste transformations:** Farming yield and efficiency, reductions in waste and using land for forestry and bio-crops.

Note that decisions made on the demand side (how we use energy) will determine the amount of energy supply needed. Decisions on the supply side (how we produce energy) will impact the amount of primary energy needed.

3. For each lever you should select your level of ambition. These levels are described qualitatively in terms of the effort to decarbonise:

Level 1: 'Minimal effort' Level 2: 'Ambitious but reasonable effort' Level 3: 'Very ambitious effort' Level 4: 'Maximum plausible effort'

Level 1 can be interpreted as 'business as usual', but may be more or less ambitious than this. When using the 2100 mode of the online tool or the Excel® model, you also have the option to select the time frame over which you would like each lever ambition to start and end.

- 4. See the impact of your decisions in the results graphs. There are many output graphs shown on results pages whose names mirror the lever headings (Transport, Buildings etc.).
- 5. You can bookmark your pathway for future reference and can share with others since the url includes your pathway as a sequence of numbers and letters at the end.

Note that there are many interactions between levers, and as a result, high ambition for a given lever may not have the anticipated effect on emissions unless matched by ambition on other levers. For example, the decarbonisation benefits of electric vehicles can only be fully realised if electricity generation has been decarbonised, whilst the benefits of hydrogen are only seen if hydrogen generation is made low carbon using the hydrogen levers.

A particular interaction that is specific to the UK concerns the levers for forestry and biofuels which won't take effect unless land is freed from other uses using the 'Farming Yield and Efficiency' lever, because almost all land in the UK that is suitable for forestry and biofuels is already in use, mainly for livestock.

Note also that some decarbonisation choices require a combination of levers. For example to represent hydrogen boilers for homes, it is necessary to have low ambition for heat pump levers and high ambition for hydrogen gas grid share (a 'CO2 Removal and Gases' lever).

For any questions relating to the MacKay Carbon Calculator, please contact the mailbox at <u>mackaycarboncalculator@beis.gov.uk</u>.

This publication is available from: <u>https://www.gov.uk/guidance/carbon-calculator</u>

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