

2050 Calculator Spreadsheet: “How to” Guide

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Introduction

The UK faces major choices about how to move to a secure, low carbon economy over the period to 2050. Should we do more to cut demand, or rely more on increasing and decarbonising the energy supply? How will we produce our electricity? Which technologies will we adopt? The Department of Energy and Climate Change's 2050 Pathway tools help policymakers, the energy industry and the public understand these choices.

For each sector of the economy, four trajectories have been developed, ranging from little or no effort to reduce emissions or save energy (level 1) to extremely ambitious changes that push towards the physical or technical limits of what can be achieved (level 4). The 2050 Pathways tools allow users to develop their own combination of level changes to achieve an 80% reduction in greenhouse gas emissions by 2050, while ensuring that energy supply meets demand. There are three types of 2050 tool, which range from high detail to low detail. These are as follows:

1. The Excel-based 2050 Calculator spreadsheet:
http://www.decc.gov.uk/en/content/cms/tackling/2050/calculator_exc/calculator_exc.aspx
2. The online Webtool:
http://www.decc.gov.uk/en/content/cms/tackling/2050/calculator_on/calculator_on.aspx
3. The online My2050 tool:
<http://my2050.decc.gov.uk/>

This "2050 Calculator: How To Guide" provides a brief overview of how the more detailed Excel-based 2050 Calculator spreadsheet works (# 1 above) and answers some of the key questions that users may have with regard to using this spreadsheet tool. This guide includes:

- Information on how to make a pathway in the spreadsheet;
- a series of summary schematics that set out the broad ways in which certain outputs (emissions, energy supply, energy demand, costs, air pollution emissions and land use) are produced by the Calculator; and
- answers to some commonly asked questions about the Calculator spreadsheet, with questions grouped by broad categories. These "frequently asked questions" provide specific detail on the input assumptions, methodology and outputs of the 2050 Calculator spreadsheet.

This guide does not provide exhaustive detail on all aspects of this Calculator. However, users of the 2050 Calculator spreadsheet can find more detail on the public "wiki", which can be found as follows: <http://2050-calculator-tool-wiki.decc.gov.uk/pages/1>. Links to specific wiki pages are given within this guide to provide supporting information to the specific explanations provided. If users have queries or comments that are not addressed by this guide or by the wiki, then they can address further queries to the 2050 Team, who will do their best to respond. The Team can be contacted at the following e-mail address: 2050pathways@decc.gsi.go.uk.

How do I make a pathway in the spreadsheet?

Users of the 2050 Calculator spreadsheet (referred to as “the Calculator” from here on) can create their own pathway to 2050 as follows:

1. Go to the “Control” worksheet and enter your pathway choice into column E. You can ‘copy’ and ‘paste’ an example pathway (choosing one from columns M to AB) or enter your own. You can use decimals.
2. Press F9 to activate the Calculator
3. View the results of your pathway on the “Control” worksheet, from rows AF onwards.
4. For tips on how to make a good pathway, see: the “Create your pathway” section at: http://www.decc.gov.uk/en/content/cms/tackling/2050/calculator_on/calculator_on.aspx
5. You can paste your pathway from Excel to the Webtool and from the Webtool into Excel (see the answer to “How do you paste a pathway between Excel and the web tool?” below).

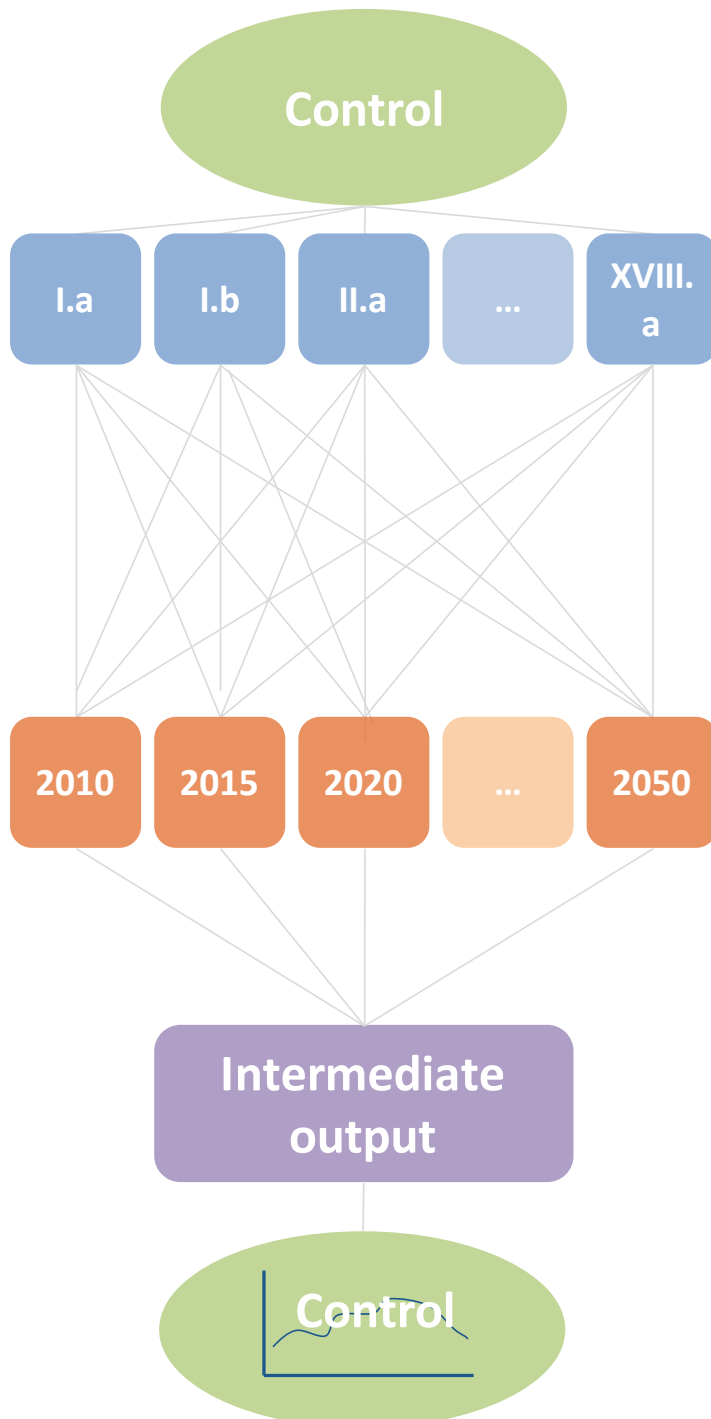
How the Calculator works

This section provides an overview of how the 2050 Calculator spreadsheet works in broad terms. It is composed of a series of figures and tables as follows:

1. Figure 1: this shows how the Calculator produces emission, energy supply and energy demand trajectories;
2. Figure 2: this shows how the Calculator produces costs;
3. Figure 3: this shows how the Calculator produces air quality impacts;
4. Figure 4: this shows how the Calculator produces land use impacts;
5. Figure 5: this shows how a sector sheet works in the Calculator, using the example of onshore wind; and
6. Table 1: this provides a list of the sectors in the Calculator, the names of their corresponding worksheets and the names of their corresponding levers in the Webtool.

Figure 1: how the 2050 Calculator produces emission, energy supply and energy demand trajectories

Worksheet name



What it does

The user enters their preferred pathway by choosing trajectories (1-4) for each energy demand and supply sector of the economy.

Sectors have their own mini model, incorporating the required information to estimate greenhouse gas emissions, energy supplied and energy used for five year intervals to 2050 (a snapshot for each of these years). These worksheets contain the majority of the Calculator's calculations. Table 1 maps the sectors in the "control" worksheet (such as nuclear power) to their corresponding sector worksheets ("II.a") Figure 5 provides more detail, using the onshore wind sector worksheet (III.a).

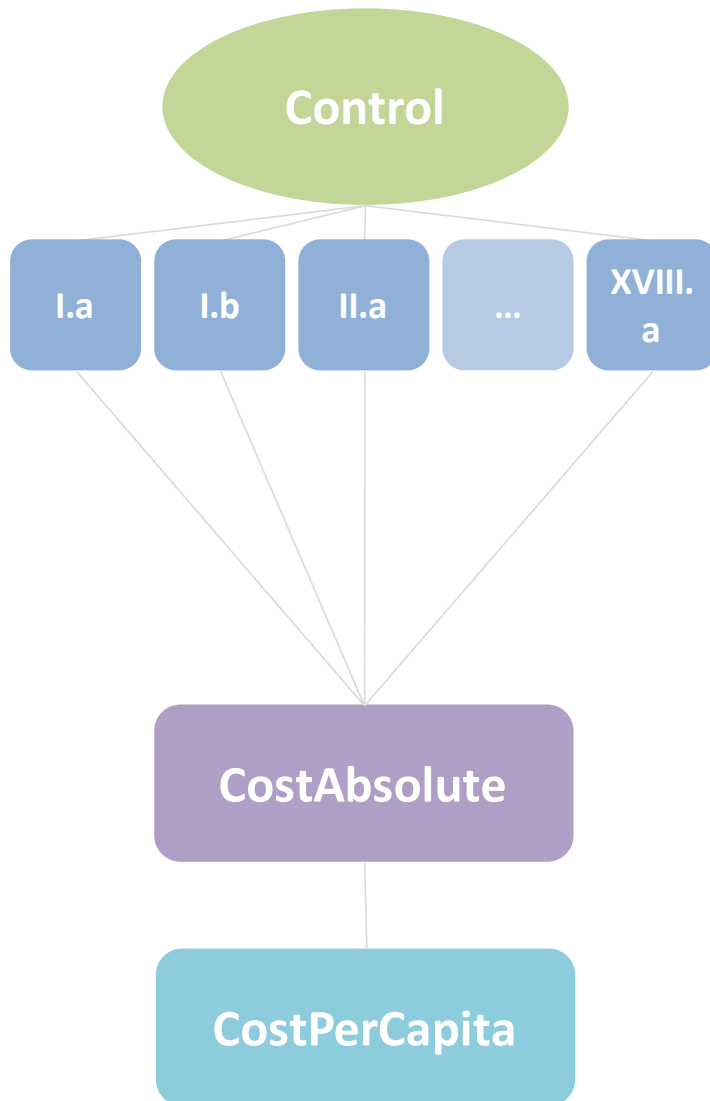
The greenhouse gas emissions, energy supplied and energy used from each sector are gathered together to reveal total emissions, energy supplied and energy demanded for each five year interval to 2050 (a snapshot for each of these years). Each of these "year" worksheets follows the same structure.

Total greenhouse gas emissions, energy supplied and energy used for each year (in five year intervals) are combined to form time series trajectories out to 2050.

Charts of the greenhouse gas emissions, energy supplied and energy used to 2050 feed through to the control sheet, which gives graphical feedback to the user as they explore their preferred trajectories.

Figure 2: how the 2050 Calculator produces costs

Worksheet name



What it does

The **user chooses their preferred pathway by choosing trajectories** (1-4) for each energy demand and supply sector of the economy.

Sectors have their own mini model, incorporating the required information to **calculate the low, point estimate and high capital, operating and fuel costs** for five year intervals to 2050 (a snap shot for each of these years). These worksheets contain the **majority of the Calculator’s calculations**. Table 1 maps the sectors in the “control” worksheet (such as nuclear power) to their corresponding sector worksheets (“II.a”) Figure 5 provides more detail, using the onshore wind sector worksheet (III.a).

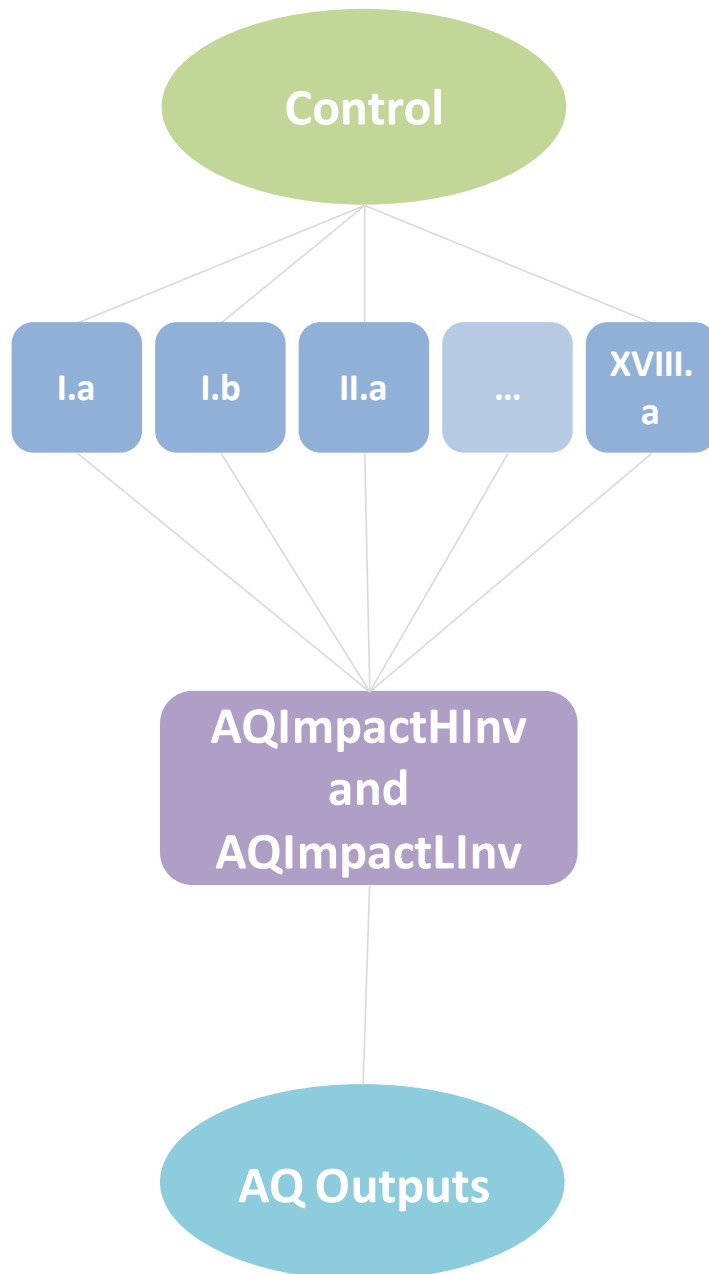
The capital, operating and fuel costs are gathered together to reveal costs **for each five year interval to 2050** (a snap shot for each of these years). The **finance costs** for borrowed capital are calculated in this sheet.

The costs in the “CostAbsolute” worksheet are pulled into the “CostPerCapita” worksheet and converted into **costs per capita**.

More detail on costs can be found on the following website page: <http://2050-calculator-tool-wiki.decc.gov.uk/pages/28>

Figure 3: how the 2050 Calculator produces air quality impacts

Worksheet name



What it does

The **user chooses their preferred pathway by choosing trajectories (1-4)** for each energy demand and supply sector of the UK.

The **air pollution emissions associated with the chosen trajectories are calculated for each sector**. Most sectors have their own mini model, incorporating the required information to estimate air pollution emissions for five year intervals to 2050 (a snap shot for each of these years).

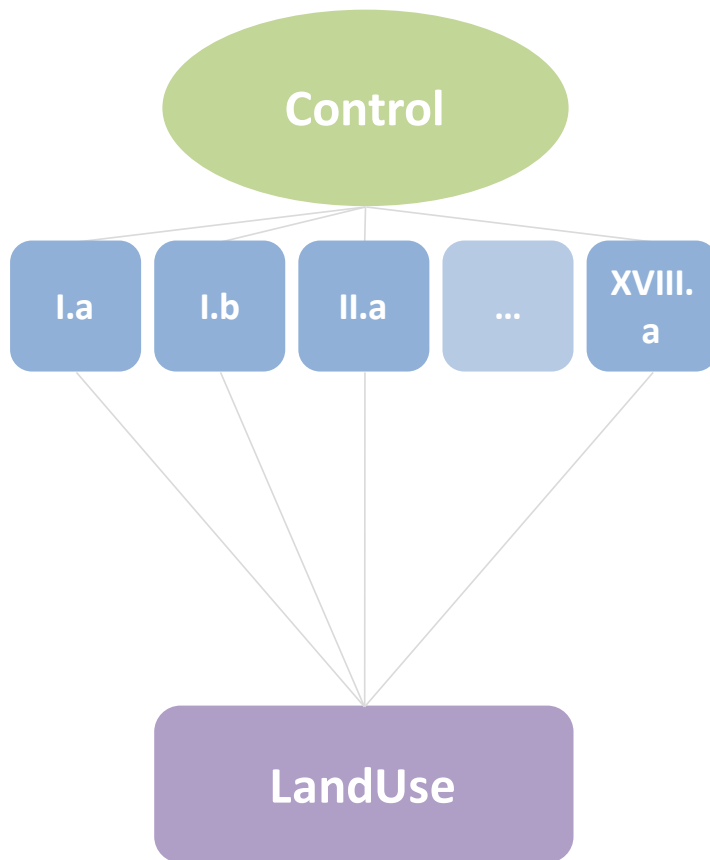
Total air pollution emissions for each of the sectors are combined to form a **time series of air pollution emissions to 2050, under high and low pollution abatement** ("innovation") scenarios. Pollution in each five year period is **converted into human life years that are lost** to pollution.

An **index of air pollution health impacts** is produced. This shows the impact in 2050 of the chosen pathway's air quality impact on human health, **compared with the impact of trajectory 1 effort** in all sectors.

More detail on air quality impacts can be found on the following website page: <http://2050-calculator-tool-wiki.decc.gov.uk/pages/80>

Figure 4: how the 2050 Calculator produces land use impacts

Worksheet name



What it does

The user chooses their preferred pathway by choosing trajectories (1-4) for each energy demand and supply sector of the economy.

Sectors have their own mini model, incorporating the required information to calculate the land use impacts for five year intervals to 2050 (a snap shot for each of these years). These worksheets contain the majority of the Calculator's calculations. Table 1 maps the sectors in the "control" worksheet (such as nuclear power) to their corresponding sector worksheets ("II.a"). Figure 3 provides more detail, using the onshore wind sector worksheet (III.a).

The land use impacts across each sector are gathered together to reveal total land use impacts to 2050. This includes impacts on: UK land area; UK sea area; and overseas land area usage.

Figure 5: how a sector worksheet works (onshore wind example)

Sector worksheet

III.a.1 Onshore wind

Choice of Trajectory	
Component	Trajectory
Trajectory	1

Trajectory assumptions

Onshore wind, new build

Trajectory Description	Notes	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
1	0.61	0.55	0.55	0.55	0.55	-	-	-	-	-	-
2	0.76	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	0.76	1.44	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
4	0.76	1.52	2.10	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Chosen	0.61	0.55	0.55	0.55	-	-	-	-	-	-	-

Onshore wind, retirement

Trajectory Description	Notes	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
1	-	-	-	(0.23)	(0.55)	(0.55)	(0.55)	(0.55)	(0.55)	-	-
2	-	-	-	(0.23)	(0.64)	(1.00)	(1.00)	(1.00)	(1.00)	-	-
3	-	-	-	(0.23)	(0.64)	(1.44)	(1.60)	(1.60)	(1.60)	-	-
4	-	-	-	(0.23)	(0.64)	(1.52)	(2.10)	(2.50)	(2.50)	-	-
Chosen	-	-	-	(0.23)	(0.55)	(0.55)	(0.55)	(0.55)	(0.55)	-	-

Fixed assumptions

Legacy capacity (built prior to end 2007)

Fuel	Plant type	Notes	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
R.02	Onshore wind	[1]	2.1	-	-	-	-	-	-	-	-	-

Capacity factor

Fuel	Plant type	Notes	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
R.02	Onshore wind	[2]	27.3%	30%	30%	30%	30%	30%	30%	30%	30%	30%

Implications

Unit	
Assumed typical turbine size	0.0025 GW/peak
Energy/unit of area	[3] 0.022 TWh/km ²

Tranches

Tranche	Cumulative GW
1	12
2	24
3	36
4	48

Notes

[1] Source for 2007 data: DUKES 2009, Tables 5.5, 5.18, and 7.4. Includes all power producers (not just major power producers)

[2] Capacity factor assumes no energy spilled
2007 capacity factor taken to be 2007 load factor (on an unchanged configuration basis; see DUKES Table 7.4)
Post 2007 figures are 2008 figures, assumed to be constant

[3] Equivalent to a 2.5W/m² actual energy output

Cost assumptions

Capital cost of a 0.0025 GW wind turbine

Delta	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
High estimate	5	5	5	5	5	5	5	5	5	5
Point estimate	(0)	4	4	4	4	4	4	4	4	3
Low estimate	(0)	2	2	2	2	2	2	2	2	2

Operating cost of a 0.0025 GW wind turbine

Delta	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
High estimate	0	0	0	0	0	0	0	0	0	0
Point estimate	-	0	0	0	0	0	0	0	0	0
Low estimate	-	0	0	0	0	0	0	0	0	0

Derived assumptions

Fuel	Description	Notes	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
R.02	Onshore wind	2.1	3.9	6.7	9.4	11.0	8.3	5.5	2.8	0.0	0.0	

Onshore wind

GW	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
Installed capacity	2.1	3.9	6.7	9.4	11.0	8.3	5.5	2.8	0.0	0.0
Capacity factor	27%	30%	30%	30%	30%	30%	30%	30%	30%	30%
Available supply	0.6	1.2	2.0	2.8	3.3	2.5	1.7	0.8	0.0	0.0
Generation	5.0	10.3	17.5	24.8	29.0	21.8	14.6	7.3	0.1	0.1

For information:

#	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
Approximate total 2.5 MW turbines	833	1,569	2,669	3,769	4,405	3,313	2,213	1,113	13	13
Approximate build rate of 2.5 MW turbines	R/yr	245	220	220	220	-	-	-	-	-
Approximate land area covered	km ²	238	471	801	1,131	1,322	994	664	334	4

High estimate of costs

Costs	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
Capital costs	Em	1,140	1,022	1,022	1,022	-	-	-	-	-
Operating costs	Em	156	294	501	707	826	621	415	209	3
Total costs	Em	156	1,434	1,522	1,729	1,848	621	415	209	3

Point estimate of costs

Costs	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
Capital costs	Em	960	847	833	819	-	-	-	-	-
Operating costs	Em	29	54	92	130	152	114	76	38	0
Total costs	Em	29	1,014	939	963	971	114	76	38	0

Low estimate of costs

Costs	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
Capital costs	Em	536	477	474	470	-	-	-	-	-
Operating costs	Em	15	27	47	66	77	58	39	19	0
Total costs	Em	15	564	524	540	547	58	39	19	0

Outputs

Energy produced and required

Vector	Name	Notes	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
Y.02	Electricity (supplied to grid)		5.0	10.3	17.5	24.8	29.0	21.8	14.6	7.3	0.1	0.1
R.02	Wind		(5.0)	(10.3)	(17.5)	(24.8)	(29.0)	(21.8)	(14.6)	(7.3)	(0.1)	(0.1)
Total			-	-	-	-	-	-	-	-	-	-

Information

Information summary

Vector	Information type	Notes	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
R.01	Onshore wind (2.5 W/m ²)	km ²	237.5	470.8	800.8	1,130.8	1,321.6	994.0	664.0	334.0	4.0	4.0
R.02	Installed peak capacity	GW	2.1	3.9	6.7	9.4	11.0	8.3	5.5	2.8	0.0	0.0
R.03	Approximate number of 2.5 MW turbines	#	833	1,569	2,669	3,769	4,405	3,313	2,213	1,113	13	13

Costs

Costs of this physical change

Vector	Name	Notes	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
C1.Low	Low estimate of capital costs		536.1	477.1	473.6	470.0	-	-	-	-	-	-
C2.Low	Low estimate of operating costs		14.6	27.5	46.7	66.0	77.1	58.0	38.7	19.5	0.2	0.2
C1.Point	Point estimate of capital costs		959.6	846.0	833.1	818.4	-	-	-	-	-	-
C2.Point	Point estimate of operating costs		28.7	54.1	92.1	130.0	151.9	114.3	76.3	38.4	0.5	0.5
C1.High	High estimate of capital costs		1,139.6	1,021.9	1,021.9	1,021.9	-	-	-	-	-	-
C2.High	High estimate of operating costs		156.1	294.3	500.5	706.0	826.0	621.3	415.0	208.8	2.5	2.5

assumptions

outputs

Explanation

The onshore wind **trajectory** selected on the **Control worksheet**.

The **build (and retirement) rates** associated with the future numbers of wind turbines specified in the selected trajectories.

Fixed assumptions underlying the model, including; the **existing** onshore wind **capacity** at end 2007, the **capacity factor** (the percent of time the facility is active), the **capacity of a single wind turbine** and the **energy output** per square kilometre of onshore wind.

High, low and point cost estimates for each turbine in 2007 and 2050 used to calculate a cost delta. This is then used to estimate the costs for the intervening five year periods. The same process is used for both **capital costs and operating costs**.

Total generation is calculated by multiplying the installed capacity by the capacity factor. **The number of new and existing turbines** in each period is calculated. **Capital costs** are calculated by multiplying the per turbine cost by the number of new turbines in each period. **Operating costs** are calculated by multiplying the per turbine cost by the total number of turbines existing in each period.

The **energy generation total** calculated above is presented in a **structured table format**.

The **total required area, installed capacity and number** of onshore turbines are presented in a **structured table format**.

The **high, low and point estimates** for capital and operational **costs** are presented in a **structured table format**.

Table 1: 2050 Calculator sectors and levers

Energy supply sectors	Worksheet name	Lever in webtool
Nuclear power	II.a	Nuclear power stations
Carbon Capture Storage (CCS)	I.b	Carbon Capture Storage (CCS)
		CCS power stations
		CCS power station fuel mix
Offshore wind	III.a.2	Offshore wind
Onshore wind	III.a.1	Onshore wind
Wave	III.c.Wave	Wave
Tidal Stream	III.c.TidalStream	Tidal Stream
Tidal Range	III.c.TidalRange	Tidal Range
Biomass/Coal power stations	I.a	Biomass power stations
Solar PV	IV.a	Solar panels for electricity
Solar thermal	IV.b	Solar panels for hot water
Geothermal electricity	III.d	Geothermal electricity
Hydroelectric power stations	III.b	Hydroelectric power stations
Small-scale wind	IV.c	Small-scale wind
Electricity imports	VII.a	Electricity imports
Agriculture and land use	VI.a	Agriculture and land use
		Land dedicated to bioenergy
		Livestock and their management
Volume of Waste & Recycling	VI.b	Volume of waste and recycling
Marine algae	VI.c	Marine algae
Types of fuel from Biomass	V.a	Type of fuels from biomass
Bioenergy imports	V.b	Bioenergy imports
Energy demand sectors		
Domestic passenger transport	XII.a	Domestic passenger transport
		Domestic transport behaviour
		Shift to zero emission transport
		Choice of fuel cells or batteries
Domestic freight	XII.b	Domestic freight
International aviation	XII.c	International aviation
International shipping	XII.e	International shipping
Domestic space heating and hot water	IX.a	Domestic space heating and hot water
		Average temperature of homes
		Home insulation
		Home heating electrification
Domestic lighting, appliances, and cooking	X.a	Home heating that isn't electric
		Domestic lighting, appliances, and cooking
		Home lighting & appliances
Industrial processes	XI.a	Electrification of home cooking
		Industrial processes
		Growth in industry
Commercial heating and cooling	IX.c	Energy intensity of industry
		Commercial heating and cooling
		Commercial demand for heating and cooling
Commercial lighting, appliances, and catering	X.b	Commercial heating electrification
		Commercial heating that isn't electric
		Commercial lighting, appliances, and catering
		Commercial lighting & appliances
Other	XIV.a	Electrification of commercial cooking
Geosequestration	XIV.a	Geosequestration
Storage, demand shifting, interconnection	VII.c	Storage, demand shifting & interconnection
Indigenous fossil-fuel production	XV.b	Indigenous fossil-fuel production

Frequently Asked Questions

This section provides answers to frequently asked questions (FAQs) about the 2050 Calculator spreadsheet. This list of FAQs is not intended to be a complete list, and more questions and answers can be found on the public wiki as follows: <http://2050-calculator-tool-wiki.decc.gov.uk/pages/47> and <http://2050-calculator-tool-wiki.decc.gov.uk/pages/115>. The FAQs are grouped under broad categories as follows:

- Emissions questions;
- Energy supply and demand questions;
- Cost questions;
- Assumption and data questions;
- Excel specific questions; and
- Webtool questions.

Emissions questions

Why are some emissions negative?

In the emissions chart in the “Control” worksheet, you will see that some emissions are negative. The technologies that have particular characteristics that result in negative emissions are as follows:

- **Carbon capture and storage (CCS)** – when gas is burned in a CCS power station, the Calculator applies the natural gas emissions factor to the quantity burned and adds the resulting CO₂ to the model’s total emissions. To account for the fact that these emissions are captured, an equivalent negative quantity of emissions is also added to the total.
- **Biomass** – like all other fuels, when biofuels’ biomass are combusted, the model applies an emissions factor according to its physical state. However, unlike hydrocarbons, biofuels do not produce any CO₂ when burned. UNFCCC accounting guidelines state that countries should treat biomass as an emissions neutral energy source. This is because carbon from the atmosphere is sequestered into the biomass while the feedstock is growing. To account for this, an equivalent negative quantity of emissions is included in the emission calculation. When biofuels are combined with CSS, the above treatments combine, resulting in a negative contribution to the overall CO₂ emission calculation.
- **Geosequestration** - these technologies remove CO₂ directly from the atmosphere and store it in parts of the geochemical system. The amount of CO₂ removed appears as a negative quantity in the emissions calculation.

Energy supply and demand questions

How is biomass allocated across the sectors?

Biomass is produced in the spreadsheet as a result of a combination and interaction of user choices across a number of sectors. The user specifies the amount of domestically produced biomass and how they want this to be converted into different forms (a mix of gaseous, liquid and solid). This is combined with imported biomass to provide the total available biomass. This total biomass is then used up by the sectors that use the corresponding end use forms of fuel. The process works as follows:

- Domestically produced biomass: the quantity of domestically produced biomass is determined by the user's choices in the following sectors in the "Control" worksheet:
 - "land dedicated to bioenergy", cell E22 (with calculations performed in worksheet "V.1a");
 - "livestock and their management", cell E23 (with calculations performed in worksheet "V.1a");
 - "marine algae", cell E25 (with calculations performed in worksheet "V.1c"); and
 - "volume of waste and recycling", cell E24 (with calculations performed in worksheet "V.1b").
- Imported biomass: biomass imports are determined by the user in the "Control" worksheet, cell E27 (with calculations performed in worksheet "V.b").
- Converting total biomass into solid, liquid or gaseous forms: domestically produced biomass is combined and drawn into the worksheet "V.a" as either dry or wet biomass and waste, gaseous waste or first or second generation energy crop inputs. The biomass is converted into either solid, liquid or gaseous hydrocarbons, depending on the trajectory specified in the "type of fuels from biomass" trajectory in cell E26 in the "Control" worksheet. Some energy is lost in the conversion process. The net gaseous, liquid and solid biomass, along with the imported biomass (outlined above), gives total biomass in different forms.
- Uses of biomass: The Calculator assumes that solid biomass can be used in any situation that uses coal (such as a coal power station), liquid biomass can be used in any situation that uses oil (such as a car engine), and gaseous biomass can be used in any situation that uses natural gas (such as heating). Each sector can only use specific forms of energy (such as electricity or liquid hydrocarbons), and these are denoted in each sector's worksheet in the "Outputs: energy produced and required" section. For example, the sectors (and their worksheets) that use liquid hydrocarbons are as follows:
 - biomass/coal power stations ("I.a");
 - agriculture and waste ("VI.a");
 - domestic space heating and hot water ("IX.a");
 - commercial heating and cooling ("IX.c");
 - industrial processes ("XI.a");
 - domestic passenger transport ("XII.a");
 - domestic freight ("XII.b");
 - international aviation ("XII.c");

- international shipping (“XXI.e”);
- fossil fuel production (“XV.a”); and
- fossil fuel transfers (“XVA.a”).

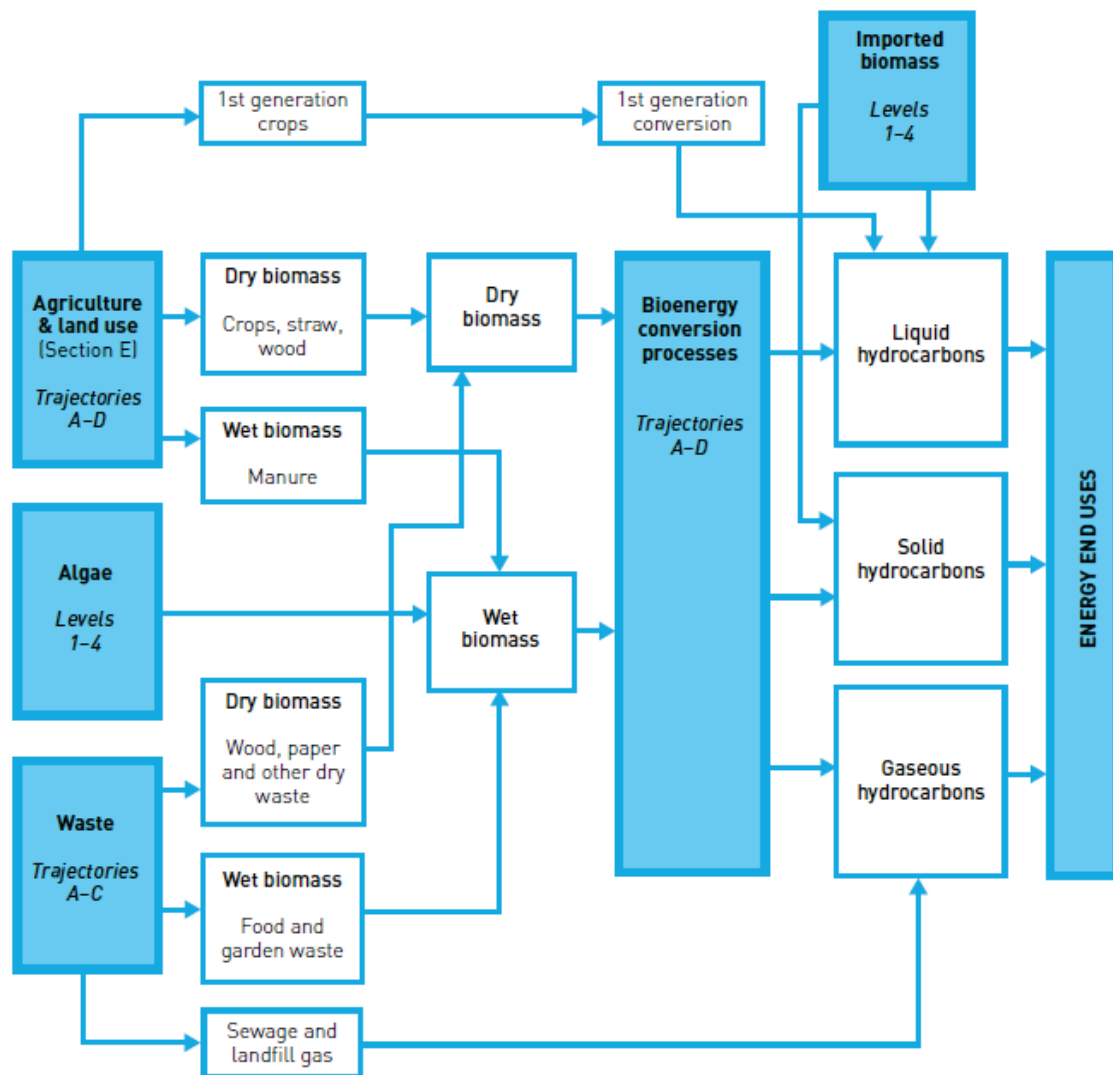
When the user selects options that need a solid fuel in the Calculator, the fuels available are used up in a particular order, as follows: domestic biomass and imported biomass; then domestic coal; and finally imported coal. If a preferential fuel type is not available then the Calculator uses the next type. The same order of preference is assumed for oil and liquid biomass and for natural gas and gaseous biomass, where biomass is used ahead of fossil fuel sources when it is available.

This order of this consumption can be seen in each of the “year” worksheets, as highlighted as follows with an example from the “MARKAL 3.26 Analog” pathway (which can be selected in the “Control” worksheet by ‘copying’ and ‘pasting’ column T into column E).

- In worksheet “2050”, the “MARKAL 3.26 Analog” pathway has 134 TWh of liquid biomass in 2050 available to distribute among the end use sectors that require liquid hydrocarbons, as shown in cell V99 (total liquid biomass is the sum of cell O384 in the “V.a” worksheet and cell O108 in the “V.b” worksheet).
- The total demand for liquid hydrocarbons from the sectors in 2050 is 538 TWh (cell V95 in the “2050” worksheet).
- 404 TWh of non-bio liquid hydrocarbons are “requested” by the model and consumed, which is the difference between the amount of bio and the amount consumed. This is given in cell V104.
- Allocation of biomass to sectors: Therefore the Calculator does not allocate biomass to specific sectors. The Calculator determines the total demand for each fuel type (such as liquid hydrocarbons) by summing the demand across all sectors. The Calculator then ensures that there is sufficient supply to meet this demand, subject to the choices made by the user of the Calculator (see above “uses of biomass” and the FAQ “How does the Calculator ensure there is sufficient energy supply to meet demand?” below). The biomass supply that is determined by the user, as outlined above, is allocated to meet the total demand.

The process outlined above is outlined below in Figure 6.

Figure 6: summary of biomass arising, inter-conversion and end use fuel destinations



How does the Calculator ensure there is sufficient energy supply to meet demand?

The Calculator ensures that any excess demand for solid, liquid and gaseous fuels over and above domestic sources and user defined imports (“Electricity imports” in worksheet “VII.a” and “bionergy imports” in worksheet “V.b”) are met by imports in the form of coal, oil and petroleum products and gas. Those calculations are carried out in the worksheets labelled “2007”, “2010”, “2015”, “2020”, “2025”, “2030”, “2035”, “2040”, “2045” and “2050”, in the “balancing imports” line at row 103. The imports in these worksheets are brought into the “balancing imports” worksheet “XVI.b”. The model does not assume any limit to the quantity of each fuel that could be imported.

How do you change the trajectory definitions (e.g. how can I redefine level 4)?

Each sector has a dedicated worksheet (for example, hydrocarbon fuel generation is in a worksheet called “I.a”). For each sector, the trajectories are defined near the top of the worksheet under a “trajectory assumptions” heading and marked in orange. The trajectories can be redefined by changing the values in each of the rows against each of the trajectories. For example, trajectory 4 of the installed biomass capacity can be amended by changing cells G27 to O27 in the hydrocarbon fuel generation worksheet “I.a”.

Levels 1 to 4 are designed to cover a broad range of possibilities and to test the boundaries of what might be possible. They are intended to reflect the whole range of potential futures that might be experienced in each sector. They are illustrative and are not based on assumptions about future policy and its impacts, and should not be interpreted as such. These levels were agreed following an extensive call for evidence in Summer 2010 and represent a shared view between the UK Government, businesses, academics and green groups on the minimum and maximum effort across sectors. Users are of course free to change these trajectories but they should bear in mind where the level definitions came from.

Cost questions

What discount rate do you use and how do you change it?

The discount rate is set at a default rate of 3.5% for the years 2010 to 2040 and at 3.0% in following years, which follows HM Treasury “Green Book” guidance (http://www.hm-treasury.gov.uk/d/green_book_complete.pdf). A more detailed explanation for why we chose these default discount rates can be found on the public “wiki” (<http://2050-calculator-tool-wiki.decc.gov.uk/pages/107>).

To change the discount rates, open the 2050 “Global assumptions” worksheet in the “2050 Calculator” workbook, and change the values in cells C27 to K27.

What finance cost assumptions do you use and how can you change them?

The default finance cost assumptions (the cost of borrowed capital) vary across the low, point estimate and high cost range.

The time period of repayment varies across each sector but is constant across each sectors’ cost range. The time period is set as either the economic life of the asset or a period of 30 years (whichever is shorter).

The finance costs over the time period for repayment are as follows:

- low costs: 0%
- point estimate of costs: 7% per annum over the payment period; and
- high costs: 10% per annum over the payment period.

An explanation for why these finance rates were chosen can be found on the public “wiki” as follows: <http://2050-calculator-tool-wiki.decc.gov.uk/pages/106>.

To change the default finance rate across all sectors across the low, point estimate and high range, open the “Global assumptions” worksheet in the “2050 Calculator” workbook, and change the values in cells D36 to I36.

To input a finance rate for a specific sector, then do as follows in cells B36 to I65 (the “Finance Cost Table”) in the “Global assumptions” worksheet:

- enter the sector name in column B (such as “IX.a.Heating”), using the same codes as those in the “Structure of the model” worksheet; and

- enter your own finance rate and time period for financing this sector in the “low estimate”, “point estimate” and “high estimate” columns.

Where can you get total costs and cost/person/year? How can you graph these over time?

The total costs are in the “CostAbsolute” worksheet and the costs per person are in the “CostPerCapita” worksheet. The costs are split from left to right by capital, operating, fuel and finance costs, and top to bottom by low, central and high cost estimates for each sector. Each of these cost type / cost range combinations by sector is provided for each 5 year interval up to 2050, to allow the user to create their own graphs or descriptive statistics (by highlighting the relevant data and inserting the desired graph).

Assumption and data questions

How do you change the units?

The units of measurement are defined in the “Preference” worksheet. It is possible to change the energy, power, area and money units of measurement.

What population figures have you used and how do you change them?

The population projections used in the Calculator are central projections sourced from the Office for National Statistics, and are given in a ‘Table’ called “Global.Assumptions” in the “Global assumptions” worksheet. The figures in this ‘Table’ can be edited if the user wants to use different population assumptions.

What GDP growth rate assumptions have you used and how do you change them?

GDP growth is assumed to be 2.0% in each year from 2007 to 2050, based on HM Treasury’s view of long-term growth in the UK. This assumption can be changed by altering the “GDP (2005 £m)” column in the “Global.Assumptions” ‘Table’, in the “Global assumptions” worksheet.

Why are there three 2007 worksheets?

There are three worksheets that contain data for 2007. Table 2 below sets out the data contained in each of these worksheets.

Table 2: explanation of the three 2007 worksheets

Worksheet name	Historic data or data worked out by the Calculator?	Sector definitions used
“2007 (actual, frozen)”	Historic data from Digest of United Kingdom energy statistics (DUKES)	DUKES definitions
“2007 (consistent)”	Historic data from (DUKES)	Calculator definitions
“2007”	Calculator projections	Calculator definitions

Excel specific questions

Why does the Excel version of the Calculator use Microsoft Excel for PCs 2007 and 2010? These versions cannot be opened by users with older versions of Excel.

The only software that the Calculator can run on is Microsoft Excel for PCs 2007 and 2010, and Microsoft Excel for Macs 2011. The reason is that the model includes “structured references” and these have not been implemented by open source Excel alternatives. Structured references were implemented in the “Excel to Ruby programming language” convertor which was released by the Department under an open source licence as part of the source code for the web version of the 2050 Calculator.

Unfortunately this means that people with older versions of Excel cannot open the Calculator. However it is possible to get trial copies of appropriate versions of Microsoft Excel to enable them to access it.

What do ‘Index and Match’ formulae do?

‘Index and Match’ formulae combine two Excel worksheet functions (‘Index’ and ‘Match’) to provide a flexible way of performing a ‘lookup’. The ‘Index’ function returns a specific value from a specified array, according to the row and column numbers stipulated in the formulae. The ‘Match’ function returns the relative position of a given value within a specified array.

The ‘Match’ function can be used in place of either the column or row reference (or both) within the ‘Index’ function. This enables the return of a value within an array by referring to a particular value in the column or row heading (rather than referring to a the row number or column number). Within the Calculator, index and match formulae are largely used in conjunction with other functions, as shown in the example immediately below, where the approach is used together with structured table references.

What is a ‘Structured Table Reference’?

Excel 2007 (and 2010) gives users to the option to identify ‘Tables’ within worksheets, allowing them to manage and analyze the data in that table independently of data outside of the table. The way in which cells within a ‘Table’ are referred within formulae is different, and requires the use of square brackets (e.g. =Table1[#This Row],[Column1]).

In the 2050 Calculator, ‘Tables’ are frequently used in combination with the ‘Index and Match’ function, yielding formulae which resemble the following:

```
=IFERROR(INDEX(INDIRECT($C24&".Outputs["&this.Year&"]"), MATCH(J$5,
INDIRECT($C24&".Outputs[Vector]"), 0)), 0)
```

As shown below in Figure 7, the above formula refers to the worksheet stipulated in cell C24 (“XII.a”), within which there is a table called “XII.a.Outputs”. From this ‘Table’, the value in the T.01 (J5) row and 2010 (this.year) column is returned.

Figure 7: example function combining 'Match', Index' and Table' functions

	A	B	C	D	E	F	G	H	I	J
1										
2					2010					
3					TWh					
4							Heating and cooling	Lighting & appliances	Industry	Road transport
5				Sector			H.01	L.01	I.01	T.01
6										
7				Consumption						
9		IX.a	Domestic space heating and hot water				379.9	-	-	-
10		IX.b	Domestic hot water [UNUSED - See IX.a]				-	-	-	-
11			Total Domestic				379.9	-	-	-
12		IX.c	Commercial heating and cooling				113.4	-	-	-
13		IX.d	Commercial hot water [UNUSED - See IX.c]				-	-	-	-
14			Total Commercial				113.4	-	-	-
15			IX Heating				493.3	-	-	-
19			X Lighting and appliances				-	157.7	-	-
22			XI Industry				-	-	399.1	-
23										
24		XII.a	Domestic				=IFERROR(INDEX(INDIRECT(\$C24&"Outputs["&this.Year&"]"),MATCH(J\$5,INDIRECT(\$C24&"Outputs[Vector]"),0)),0)			
25		XII.b	Domestic freight							83.6

Webtool questions

How do you paste a pathway between Excel and the web tool?

To move a pathway from the Excel "2050 Calculator" to the "2050 Webtool":

- copy the desired pathway values in the Excel model (the section labelled "Your Choice" (column E) in the "Control" worksheet);
- click on the "Share" link in the top right-hand corner of the front page of the Webtool;
- paste the pathway values, copied above, into the displayed text box; and
- click the "Go to this pathway" button.

To move a pathway from the Webtool to the Excel Calculator:

- select your chosen pathway using the 1-4 effort buttons;
- click on the "Share" link in the top right-hand corner of the front page of the Webtool;
- copy the values in the displayed text box;
- paste the pathway values into the section labelled "Your Choice" (column E) in the "Control" worksheet of the Excel model; and
- press F9 to refresh the worksheet.

Where can I see key information about my pathway, such as total electricity generation and electricity capacities, and energy demand for heat and transport?

Click on the "See implications" button in the top left hand corner of the [webtool](#) front page. This will reveal a drop-down menu, from which the "electricity" link can be used to access the results for electricity generation and electricity capacities, along with a selection of other information.