

Association for the Conservation of Energy

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Carbon calculators – a comparison

1 Introduction

This paper compares online carbon calculators available free of charge to UK household energy consumers, it follows a method similar to that laid out in Jonas Gunnarsson's paper - "It must be Yeti! – Tracking carbon footprints on the web"¹ which compared carbon calculators in Sweden. It looks at around 20 calculators and seven have been chosen for comparison. The selection aims to cover the most popular calculators from a variety of sources (Government, NGO, Utility company and sellers of carbon offsetting).

The calculators were compared using a fictional family which attempts to approximate an average UK lifestyle. The emissions outputs were compared and the calculators marked on six criteria as devised by Gunnarsson.

Guidance on carbon emissions attributable to each energy source is frequently updated and in response so are the assumptions used by carbon calculators with varying delays. The results given here were compiled in August 2009.

2 The Family

The family consists of two working parents and two school age children, they live in a suburban, three-bedroom, semi-detached house. The house is heated by a gas boiler and has loft insulation

¹ (Gunnarsson 2009)

and draught-proofing. The adults have a car each and the children take the bus two miles to school. In addition they each take one return European flight a year and two inter-city train journeys a year. Their life-style is in general not consciously eco-friendly and they tend to eat meat once a day. Full details of the family can be seen in appendix A.

3 Criteria

The same criterion and scoring system as Gunnarsson were used to allow some comparison to the results of his paper.

User-friendliness

This point is always more or less subjective. To prevent the results from being interfered with this criterion it can only be marked with 1 or 2 points:

1 point = The calculator is difficult to understand and use,

2 points = The calculator works well and is easy to use.

Scope (as important factor weighted with 2.0)

1 point = Only one emission source is considered, for example "housing"

2 points = Two emission sources are considered: for example "housing" and "transportation",

3 points = Three or more emission sources are considered.

Calculation method (as weighted with 1.5)

0 point = The calculations are not explained at all,

1 points = The calculations are explained but they are based on many assumptions,

2 points = The calculation method is clear and thoroughly explained.

Input data

1 point = The data can only be entered in one way: as a standard value, cost or kWh,

2 points = The data can be entered in several ways,

3 points = Different ways to enter data are possible; the calculator helps with examples and templates.

Advices and guidance

1 point = No help or suggestions for improvement,

2 points = Tips and some facts about how much each change affects the result,

3 points = Detailed guidance how to lower carbon emissions and how different options affect the result.

Presentation of results

1 point = Only the amount of CO₂ per person and year is reported without any comparisons,

2 points = CO₂ emissions are reported and compared with the average in the country,

3 points = CO₂ emissions are reported, compared with the average and with the threshold required for sustainable development.

Comments for each calculator on these criteria can be seen in Appendix B.

4 Results

The exercise has produced a wide range of results both in the quality score of the calculators available and the total household emissions calculated.

Table 1: quality score results and total household emissions

Calculator	User-friendliness	Scope	Calculation Method	Input data	Advice and Guidance	Presentation of results	Score	Household emissions (tonnes of CO ₂ per year)
BP	1	2	0	1	2	2	10	10.9
CO ₂ Balance	2	2	0	2	1	1	10	17.2
NEF	2	2	0	2	3	2	13	15.3
Carbon Footprint	2	3	0	2	2	3	15	35.6
WWF	2	3	1	1	3	2	15.5	38.4
Act On CO ₂	2	2	2	3	3	2	17	15.4
Resurgence	1	3	2	3	2	3	18	36.5

There appears to be a positive correlation between the quality score of the calculator and the level of emissions calculated with the higher quality scoring calculators giving higher emission estimates. The Act On CO₂ calculator lies outside of this main trend as it gives relatively low household emissions compared to other calculators with similar quality scores.

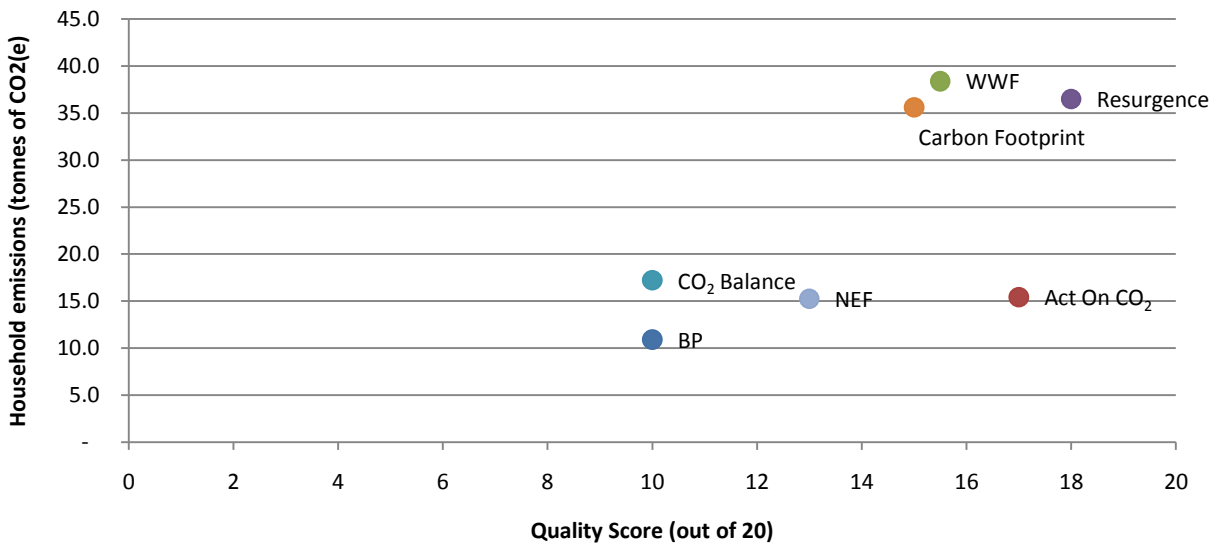


Figure 1: Total emissions calculated vs quality score of calculator

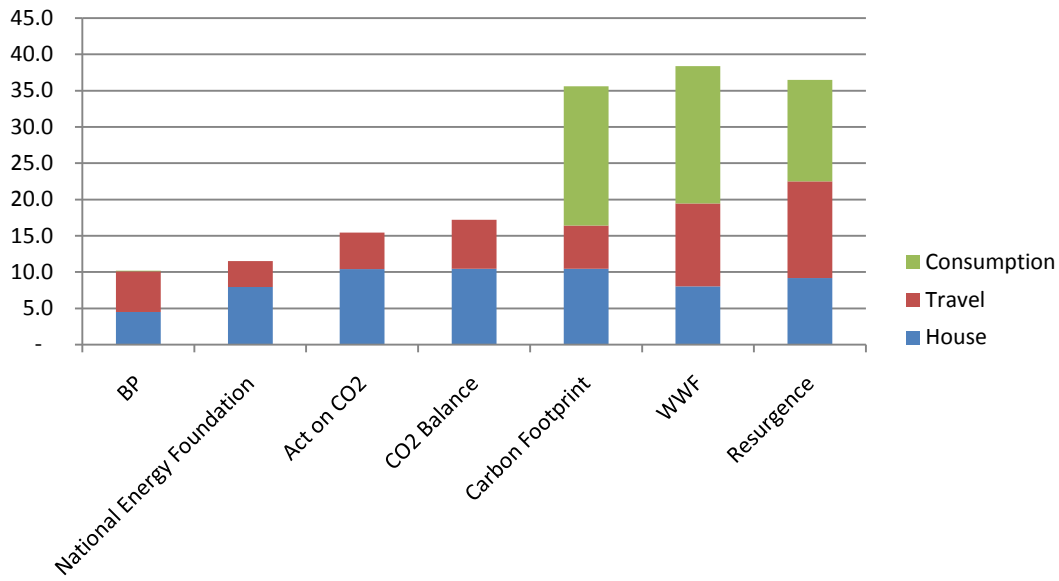


Figure 2: Breakdown of footprints by emission source in tonnes of CO₂(e)

The variance in total emissions is largely due to the inclusion or exclusion of indirect carbon emissions relating to goods and services consumed by the family. There is also a good deal of spread in the results relating to travel. Looking at this in detail in the table below, the variation can be seen to arise mostly from the family’s single annual flight, with WWF and resurgence attributing around eight tonnes of CO₂ compared with BP’s estimate of less than one tonne.

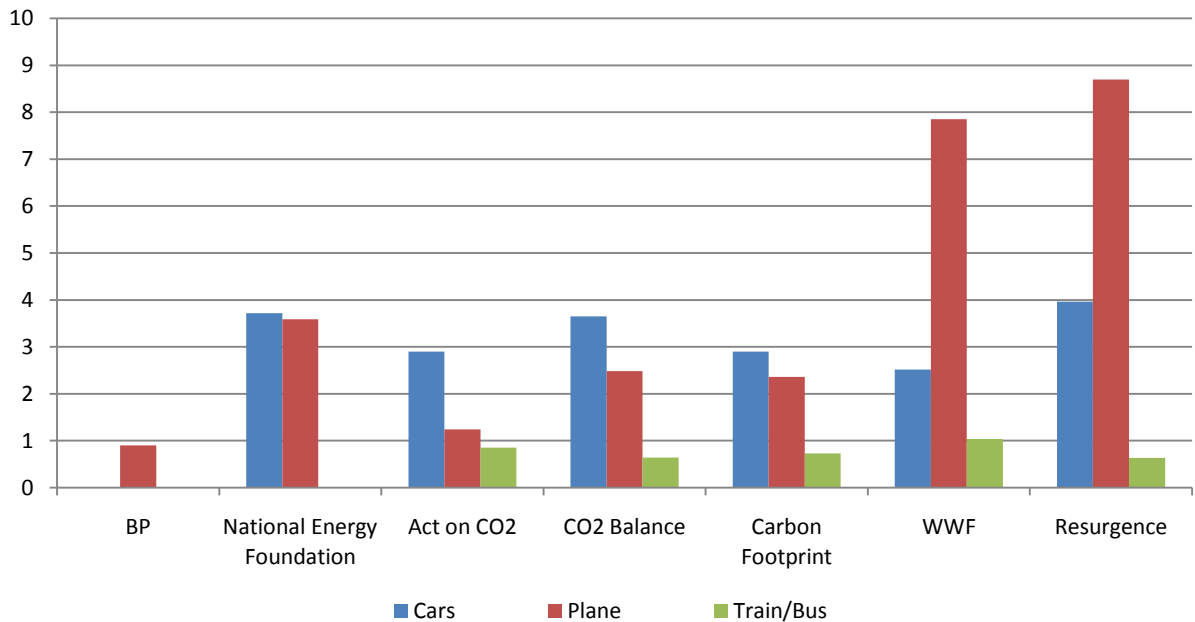


Figure 3: Break down of transport emissions in tonnes of CO₂(e)*

*This chart shows travel emissions only where it has been possible to separate the transport modes, it does not show the full transport emissions given by each calculator.

The range of emissions for transport can be mostly attributed to the estimate for the annual short haul return flight taken by the family. Variation in estimates for train and bus travel are quite consistent, as are those for car use. The estimates for plane travel vary widely with BP and WWF obvious outliers.

4.1 In-depth look at aviation emissions

The wide variation in emissions estimated can be accounted for by the estimates used by some of the calculators in estimating the flight distance and the radiative forcing factor used. Radiative forcing is the additional impact of greenhouse gas emissions at altitude (including water vapour, contrails, NOx etc) which may indicatively be accounted for by applying a multiplier. DEFRA/DECC guidelines do not include a radiative forcing factor and state that “The appropriate factor to apply is subject to uncertainty but was estimated by the IPCC in 1999 to be in the range 2-4, with current best scientific evidence suggesting a factor of 1.9.”²

Table 2: Aviation emissions

Organisation	Emissions (tonnes of CO ₂ (e))	Calculated from..
BP	0.9	Number of short-haul flights a year
Act on CO ₂	1.24	Full details, no radiative forcing factor
WWF	7.85	Estimated flying hours, include radiative forcing (2.7)
Carbon Footprint	2.36	Full details, includes radiative forcing (1.9)
Resurgence	8.7	Flying hours
National Energy Foundation	3.59	Full details, include radiative forcing (2.7)
CO ₂ Balance	2.48	Full details, includes radiative forcing (1.9)

BP gives a very low estimate for the flight, 0.6 tonnes using the HTML calculator or 0.9 tonnes using the flash version. It takes inputs of the number of short haul flights and number of long haul flights and advises that these are defined as approximately 300 miles and 3,000 miles respectively. Inputting a flight from Luton to Alicante (approximately 940 miles one way) as short haul seriously underestimates the distance travelled. Counting each flight as three short haul flights increases the emissions to 1.8 or 2.7 tonnes.

Resurgence gives the highest estimate, this is partly due to its conversion from hours of flight to distance, it equates easy Jet’s flight time of around 2.5 hours to a distance of 1,250 miles. The true distance is closer to 940 miles, reducing the emissions by this factor brings them down to 6.5 tonnes.

Act on CO₂, Carbon Footprint, NEF and CO₂ Balance all ask for exact airports for the flight details. Taking radiative forcing factors out of the equation we get a very similar base emission from each calculator of around 1.2 tonnes which is consistent with DEFRA’s guidance of 0.0937 kg CO₂ per km.

² (DEFRA / DECC 2009)

WWF have the second highest estimate and use a radiative forcing factor of 2.7 derived from the IPCC's AR4 report. Taking radiative forcing out of the equation they give 2.9 tonnes, more than double the base of 1.2 that calculators measuring exact flight distances have used.

4.2 In-depth look at household emissions

There is some agreement between calculators using energy bills to calculate emissions with three of the seven giving the same answer of 10.4 tonnes. These seem to be based on 2009 DEFRA recommendations³. Variation in these factors may arise where calculations are based on older guidance.

Table 3: Household emissions

Organisation	Emissions (tonnes of CO ₂ (e))	Calculated from..
BP	4.5	House/lifestyle questions
Act on CO ₂	10.4	Utility bills
WWF	8.0	House/lifestyle questions
Carbon Footprint	10.4	Utility bills
Resurgence	9.2	Utility bills
National Energy Foundation	7.9	Utility bills
CO ₂ Balance	10.4	Utility bills

The calculators in the table below gave the option of estimating emissions from heating, lighting and appliances from questions about the structure of the house and the family's use of appliances.

Table 4: Home emissions estimated from building structure and lifestyle

Organisation	Emissions (tonnes of CO ₂ (e))
BP	4.5
Act on CO ₂	6.6
WWF	8.0
National Energy Foundation	5.2

³ (DEFRA / DECC 2009)

5 Conclusions and recommendations

The Government's Act on CO₂ carbon calculator gives low estimates of household emissions when compared to the other high quality scoring websites. We would recommend that this calculator should include estimates of emissions resulting from consumption of goods and service and review its position on the inclusion of a radiative forcing factor when dealing with emissions from flights.

Better guidance around the issue of radiative forcing is required particularly where carbon offsetting is being sold. In some cases customers are asked whether or not to include these factors in their off-setting with little or no background information.

The science behind calculating personal carbon emissions is fast moving and currently lacks consensus in some areas, such as the role of radiative forcing in aviation emissions. As such the creators of carbon calculators must choose the assumptions on which their calculators are based. It is important that these assumptions are available to the user and that they ensure that these are updated to reflect the most recent scientific guidance.

The factor which has the largest impact on the final carbon footprint is the scope of the calculator and in particular if it includes emissions from consumption of goods and services. Creators of carbon calculators must make users aware of any limitations in the scope of their calculators.

Appendix A – The Family

Family

2 Working parents
2 School age children
Combined income £50k

House specs

Size	3 Bedroom Semi-detached
Age	1970-1990
Location	Suburban
Loft insulation	300mm
Cavity wall insulation	None
Draft proofing	Yes
Double Glazing	None
Energy Efficient Lighting	None (20 normal bulbs)
Micro Generation	None
Heating	Gas, old style boiler 5-10 years old

Bills

	<u>kWh</u>	<u>£</u>
Gas (heating)	32,570	£1,164
Electric (lighting, cooking and 10% additional heating)	2,980	£353
Appliances	3,979	£471

Lifestyle

Leave TV on standby?	No
Bathing	Shower mostly
Heating/Lighting	Not careful
Recycling	Glass/Cans/Paper
Pets	None

Stuff

	<u>Annual spend</u>
DIY tools	£25
Bath products	£100-300

Appliances

	Age		
Fridge freezer	3 years	A rated	7 runs per week
Dish washer	3 years	A rated	5 runs per week
Washing Machine	3 years	A rated	2 runs per week
Tumble dryer	3 years	A rated	4 hrs per day
LCD TV	1 year	32"	1 hr per day
14" TV	5 years	14"	
freeview box			
DVD player			
Laptop			
Desktop			
Router/modem			
Inkjet printer			

Transport

	<u>Mileage</u>	<u>engine size</u>	<u>fuel</u>
Car 1	8000 miles	1.8	petrol
Car 2	3000 miles	1.2	petrol

serviced annually, tyre pressure not maintained, do not drive smoothly, air con used sparingly

<u>Mode</u>	<u>Journey</u>	<u>distance miles per year</u>
Bus	2 mile journey to school	1,560
Train	2, 300 mile journeys per year per person	4,800
Flights	1 short haul per year each	Luton to Alicante

Appendix B – The carbon calculators

BP

BP's 'Energy Calculator' is part of the Environment and Society section of their website which gives details the socially and environmentally responsible work done by BP and what can be done by their customers.

Web: <http://www.bp.com/productlanding.do?categoryId=9027931&contentId=7050864>

User Friendliness

- This international Calculator is quick to fill out and requires only estimated details. It has a flash version which did not run smoothly on my PC and an HTML alternative. Strangely the two versions gave different results, this is partly due to differences in input bands (broader in HTML version) but not entirely, some other calculations or assumptions must differ between these versions.

Scope

- The Calculation covers Household energy use with some lifestyle questions relating to energy efficiency, private and public transport and flights.

Calculation Method

- No explanation of the method is given, the quick estimated nature of this calculator requires many assumptions.

Input Data

- Inputs are simple but inflexible, for example in the question 'do you have cavity wall and loft insulation? - yes/no' does not allow you to select one or the other. Flights are simply split into short and long haul, other transport can only be done in miles per year.

Advice and Guidance

- General advice given on reducing emissions and articles on BP's environmental and social policy.

Presentation of results

- The footprint is broken down into Household Energy, Vehicle Travel, Air Travel and Waste and the total is compared to the national average.

Act On CO₂

The official government calculator is part of the Act On CO₂ campaign and is also used by the Energy Saving Trust and as the engine behind Google's carbon footprint app.

Web: <http://campaigns2.direct.gov.uk/actonco2/home.html>

User Friendliness

- This can be quite a lengthy process as a good deal of information is required and each data item is entered on a new page which can be slow for poor internet connections. The interface is generally simple to use and easy on the eye.

Scope

- Covers heating and lighting, appliances and Travel.

Calculation Method

- The calculation is all behind the scenes although the calculator is open source and a methodology paper is available on the site so that those interested can discover the assumptions used.

Input Data

- Quite a lot of detail about the household is required, number of lightbulbs, age and energy rating of appliances and how often they are used. Inputs are generally flexible, it ask about lifestyle as well as annual figures from an energy bill to personalise the 'action plan' or estimate bills if they are not provided.

Advice and Guidance

- Tailored advice is given once the calculation is completed with a wide range of suggestions with external links to further information or suppliers of efficient appliances etc. Selecting up to six actions you can recalculate your foot print to see the impact of the changes.

Presentation of results

- It gives a full breakdown of the carbon footprint plus a comparison to UK averages. Also visualises emissions in terms of Car trips London to Manchester, lightbulbs left on, party balloons of gas etc.

WWF

Environmental NGO WWF provides this calculator which focuses on personal lifestyle change.

Web: <http://footprint.wwf.org.uk/>

User Friendliness

- This quick and visually pleasing calculator concentrates on life style questions and rough estimates of energy usage. This calculator gives footprints for individuals rather than for a household.

Scope

- Covers home and travel and has detailed sections on food and consumer goods that other calculators often exclude.

Calculation Method

- The calculation method is very much behind the scenes and many assumptions have been made.

Input Data

- Most inputs are rough estimates and can only be given in one way – car travel is only in hours per week for example.

Advice and Guidance

- Gives the opportunity to join a discussion forum with advice on reducing emissions.

Presentation of results

- Results are given as the number of earths required to sustain your lifestyle if everyone on the planet was like you. A footprint is also given in tonnes of CO₂ and broken down into Home, Travel, Stuff and Food.

Resurgence

Resurgence is an environmental and spiritual magazine which boasts that its calculator was voted 'best on the web' in an (un-cited) independent study of carbon calculators. This calculator has no fancy interface which makes it more flexible to use but may put off some users.

Web: <http://www.resurgence.org/resources/carbon-calculator.html>

User Friendliness

- This is the only calculator found that can be completed on paper, the online version is basically a spreadsheet which makes it flexible and the calculations easy to follow if you are conversant in MS Excel. The instructions are quite lengthy and might put off some people.

Scope

- Covers home and travel and uses a salary based system to estimate an 'industry share' of indirect carbon from consumption.

Calculation Method

- Most calculations are spelt out and conversion factors are given and explained, the Excel format makes calculations easy to follow for those who use it often, the paper format gives full instructions for each step of the calculation.

Input Data

- Inputs are flexible with options for total mileage or space to input frequent journeys in the travel section.

Advice and Guidance

- Site does not give advice but has links to suppliers of green energy and products and has discussion forums.

Presentation of results

- A full breakdown of the carbon footprint is given, per capita emissions for UK average, UK government targets and sustainable levels of emissions are given for comparison.

CO₂ Balance

CO₂ Balance provides carbon offsetting for businesses and individuals. It has a tie-in with Google's carbon calculator. The primary purpose of this tool is to sell carbon offsetting, as such, inputs must be precise and simple to ensure it is clear what has been offset.

Web: <http://www.co2balance.uk.com/>

User Friendliness

- The calculators are quick and easy to use.

Scope

- Has calculators for homes and car, train and air travel.

Calculation Method

- No explanation of calculations are given.

Input Data

- For household energy, inputs must be in kWh or pounds from energy bills and for travel mileage must be given with a choice of car sizes. There is no way to estimate these factors from house size etc.

Advice and Guidance

- None given.

Presentation of results

- Each component is calculated separately and no total is shown for comparison.

Carbon Footprint

This carbon management consultancy offers carbon off-setting for home and business.

Web: <http://www.carbonfootprint.com/calculator.aspx>

User Friendliness

- The calculator is quick and easy to use if energy bills and travel mileage figures are to hand.

Scope

- Has calculators for homes and car, train and air travel but also an estimate for life-style related indirect energy usage.

Calculation Method

- Not explained

Input Data

- Inputs allow multiple data types, bill in £ or kWh, fuel consumption or make and model. There is no option of estimating values by entering details of your house and appliances.

Advice and Guidance

- General efficiency advice and the option of a newsletter with carbon saving advice is given.

Presentation of results

- Results are broken down into Home, each transport mode and secondary emissions. The total is compared to the UK average and world target of sustainable emissions.

National Energy Foundation

The National Energy Foundation is an independent educational charity that works with people and businesses to combat climate change by reducing their carbon emissions. Their calculator 'The Carbon Workout' is part of a large educational website about reducing CO₂ emissions.

Web: <http://www.nef.org.uk/actonCO2/carboncalculator.asp>

User Friendliness

- The calculator is clear and straight forward to use.

Scope

- It covers household, car and flight emissions but does not cover other forms of transport.

Calculation Method

- Details of the calculation method are not readily available and many assumptions are used, some inconsistencies were found in the calculation method and NEF expect maintenance and upgrade later this year.

Input Data

- Input data is quite flexible with more than one input format option for most data items.

Advice and Guidance

- The calculator allows the user to make pledges of actions to reduce their footprint. The calculator is also part of a larger education website designed to encourage individuals and businesses to reduce their emissions.

Presentation of results

- Results are broken down into Household, Car and Air travel, the total is compared to UK average and UK target emission levels.

6 Bibliography

DEFRA / DECC. "2009 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting." DECC. 2009. <http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm>.

Gunnarsson, Jonas. "It must be Yeti! – Tracking carbon footprints on the web." *ECEEE*. 2009.