Personal Project:

Documentation:

Carbon Footprint Model in Excel for PCAS

2011 – 2012 PCAS

Name: **Cheng Yu, CHIANG**

ID: **3989 2654**

Date: **Feb 18, 2012**

Acknowledgement

I would like to take this opportunity to thank for support from

Dr. Brian Stewart

Dr. Bryan Storey

Gateway Antarctica

PCAS 2011-2012 Batch

Scott Base @ Antarctica

Antarctica New Zealand

for giving me the Antarctica learning, understanding, and life experience on the Ice.

Objective

The purpose of this Carbon footprint excel model intends to establish a reference point for carbon dioxide (CO_2/kg) generated during PCAS operation in Antarctica.

Based on best available factors sourced, the excel model aims to produce immediate Carbon dioxide estimations for the purposes of

- Decision making ;
- Management Reviews

It is also to bring awareness for human activity-generated CO_2 emissions in an Antarctic context.

Assumption

The calculations derived from the excel model estimate CO_2 (kg) generated during Antarctic Field operation from departure day (Christchurch) till the day of return from Scott Base, Antarctica.

The activities designed for excel model exercise are based on PCAS Antarctic visit 2011/2012. (See Appendix I)

Antarctica field transportation specifications[1] are based on Antarctica New Zealand Field Manual 2011-2012.

The conversion factors for primary emission are based in New Zealand context, predominately derived from online Carbon Footprint Calculator[2] .

In principle, factors including conversion for secondary emissions are based on public available databases.

- Department for Environment, Food and Rural Affairs (DEFRA) – UK
- World Resource Institute Green House Gas Protocol
- Vehicle Certification Agency – UK
- US Environmental Protection Agency (EPA, USA)
- Environmental Protection Authority – Victoria, Australia.
- Standard Association (CAS) GHG Registries – Canada
- New Zealand's Environmental Protection Authority – New Zealand.

[1] such as Snowmobile, Hägglunds, Kässbohrer and helicopters,
[2] http://www.carbonfootprint.com/calculator.aspx

Stage of Developments

Activity	Components	Hours Spent
Business Understanding		
	PCAS Schedule	1
	CO_2 Emission Rationale	30
	Antarctic Factors	8
	Special Requirement: Aviation	12
Data Understanding		12
Data Preparation		
	Collection: Scott Base	8
	Collection: Conversion Factors	120
	Integration	8
	Profiling and Selection	6
Modelling		
	Conceptualisation	12
	Building Exercise	6
	Cloud Mitigation and testing	4
Evaluation and Deployment		
	Validation and Back testing	6
	Documentations	20
	Closure (including cloud language justifications)	4

Technology

Excel 2003:

Taking account of compatibility issues, Microsoft Office Excel 2003 offers essential formulas for lookup functions, basic database requirements as well as its presentation for reporting.

For PCAS Carbon Footprint model, user will only require basic knowledge in Excel to undertake its calculation.

The implementation for designing model is based on Microsoft Office Excel 2003, and the model would simulate same functions in Microsoft Office Excel 2007 and 2010.

Specific functions for structuring excel models are “Name Range”, “OR”, “Index”, “Sum”, “If”, “ISBLANK”, “lookup”, “Validation” and “Hyperlink”.

Cloud Technology: Google Doc

The solution for operation capacity will also include "cloud technology" on Google Doc. It enables the model to operate across different computer environments[3] and supports online collaboration features for future improvement.

Conceptual Framework

Carbon Footprint: CO_2 v.s. CO_2 e

Various literatures and industrial researches defined Carbon footprint differently. Carbon footprint becomes generic synonym.

Source	
BP (2007)	The carbon footprint is the amount of carbon dioxide emitted due to your daily activities – from washing a load of laundry to driving a carload of kids to school.
Carbon Trust (2007)	… a methodology to estimate the total emission of greenhouse gases (GHG) in carbon equivalent from a product across its life cycle from the production of raw material used in its manufacture, to disposal of the finished product (excluding in use emissions). …. A technique for identifying and measuring the individual greenhouse gas emissions from each activity within a supply chain process step and the framework for attributing these to each output product (we [The Carbon Trust] will refer to this as the product's 'carbon footprint'" (Carbon Trust 2007, p.4)
Global Footprint Network(2007)	The demand on biocapacity required to sequester (through photosynthesis) the carbon dioxide (Co2) emission from fossil fuel combustion.
ISA (2007)	The carbon footprint is a measure of exclusive total amount of carbon dioxide emission that is directly and indirectly caused by an activity or is accumulated over the life stage of a product.
Landcare (2011)	Greenhouse gas (GHG) footprinting, also more commonly referred to as carbon footprint, determines the total volume of GHG emitted, in carbon equivalents (CO_2e), across the entire supply chain (life cycle) of a product or service.
The UN International Panel on Climate Change (IPCC)	Emission concept is based on that the producer is responsible for CO_2 emission. A country with a large industrial base, such as China, will often have higher emission, while service-based economy will have smaller level.

There are distinctions between Carbon dioxide (CO_2) and Greenhouse gases (CO_2e). The fuels burned are converted to CO_2 rather than CO_2e. Most of emission factors available are based on vehicle fuel consumption and are measured in World Business

[3] Such as Windows NT, Windows 2000, Vista, Mac, Linus …etc.

Council for Sustainable Development (WBCSD) and World Resources Institute (WRI) protocol. (GHG Protocol).

There are no commonly accepted factors for measuring additional GHG emission from burning vehicle fuel. [4] To comply with the most common international standard, this excel model will only determine CO_2 emission.

Technical Rationale

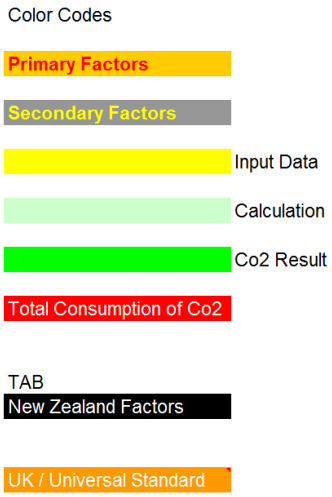
The criteria to excel model design associates features in "User Friendly", "Time factors" and "Easy Mainteance":

User Friendly: Five Steps

"Step-to-Step features" and "direct link" features allow user to follow the model and procedures. Five-Steps-Project entry simplifies input required, while capturing the majority of activity data.

Excel model also use color coding to define operating functions.

- Color Yellow indicates input data required. This section is the only required input from user.
- Color Lime indicates logic / calculation process. It is the logic block to connect activities and factors.
- Color Green indicates specific CO_2 emissions outcome in kg.
- Color Red indicates total CO_2 emission outcome after calculation.



Data Type	Description	Examples
Primary Data	Observed data[11] collected from specific facilities owned or operated by the reporting company or a company in its supply chain	The reporting company surveys its suppliers and collects product-level data or scope 1 and 2 emissions data from specific facilities in its supply chain.
Secondary Data	Generic or industry average data from published sources that are representative of a company's operations, activities, or products	Data from life cycle inventory databases, literature studies, environmentally-extended input-output models[12]; Intergovernmental Panel on Climate Change (IPCC) default emission factors; industry associations; etc.

When primary or secondary data of sufficient quality are not available, two estimation methods may be used to fill data gaps:

- Use of extrapolated data
- Use of proxy data

Tab colors distinguish factors in New Zealand (Black) and Universal Standards (Gold).

[4] http://www.liveneutral.com/calculator_white_paper

Time Factors: Calendar Format

Due to uncertainties in weather conditions in Antarctica, both activities and PCAS program duration could vary.

The model adapts “calendar fomat” to measure Vemissions. The calendar format breaks down into daily activities to derive better possible implications with flexibility to justify for Antarctica visit duration, up tp 31 days.

Easy Maintenance: Manual input / Automatic update

Database tab contains direct link to public domain. User can update conversion factors by inputing data mannually or automatic update by internet connection.

Structure

The structure of model consists of three major categories:

- Database
- Calculaiton / Logic
- Presentation

Database:

Rather than keeping conversion factors in the dark, the database stores conversion factors in separate tabs but still under the same excel worksheet, color coding by its orgins.

Due to availibility of conversion factors, Excel model captures major conversion factors from Co2 emission source in New Zealand context.

Secondary Factors allow user to customise desired selections, up to ten factors, accordingly.

The design of database accommodates the needs for Antarctica operation and the Co2 emissions arrive by fuel efficiency factors.

Calculation / Logic:

Calculations involve two major themes: Primary factors and Secondary factors.

Primary factors measure Co2 emissions from power and transportation usage. Based on available information, power measures units of “kWh”, “litres” and “tonnes”.

Power	Units
Electricity	kWh
Natural Gas	kWh
Heating Oil	Litres

Coal	Tonnes
LPG	Litres
Propane	Litres
Wood	Tonnes

Transportation tools measure travel distances.

Transportation	Distance
Bus	km
Coach	km
National Rail	km
International Rail	km
Tram	km
Tube	km
Taxi	km

Special vehicles use mixed approach; measuring hours of use and travel distances.

Antarctic Factors	Mixed
Helicopter	Hour
Snowmobile	km
Hägglunds	Km
Kässbohrer	Hr

Secondary factors measure amount of CO_2 emission associated in dollar values in different product categories. At micro level, by taking advantage of available data from UK government, the secondary emission conversion factors will process its calculation in dollar value / CO_2 kg.

Secondary	Estimated Dollar value
Micro-activities	Dollar Value

Secondary factors look into micro-activities while primary factors considering larger scope at macro level of Co2 emissions.

Presentation:

The format of presentation calculates on daily basis, for total up to 31 days calendar. This accommodates uncertainties in Antarctica weather conditions as well as varieties from daily operation that it gives better measures in Co2 emission.

Methodology References Reviews

A few of Carbon Footprint methodologies were taking parts in selection process, along with references sites for its calculations and format. The following section lists summary of each and technical coverage for future references.

1. PAS 2050

    a. PAS 2050: How to assess the carbon footprint of goods and services [5]
    b. PAS 2050:2011 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services

Similar to ISO series of product, PAS 2050 is the product of elaborated research and studies undertaken on British standard. It outlines standards and assessment guideline for specific requirements for Carbon emission calculations, contained demonstrated case study.

2. ISO 14064 Series and ISO/DIS 14067: Carbon footprint of product – requirement and guidelines for quantification and communication.

ISO series provide international recognise standards for emission calculations. It has continuously evolved its calculation methodologies.

3. State Government of Victoria, Australia: Ecological Footprint Measuring our impact on the environment

    a. Sharon Ede presentation on UEA World Environment Day Meeting 2007[6].

    b. Ecological Footprint Calculator: Event[7]

Australia Victoria government provides a few worksheets for calculating emissions. Currently, there are five types of calculators. Those are:

- Personal
- School
- Retail
- Retail Centre
- Event Management

Each category adopts its approach to measure emission impacts and conversion factors do not reveal to the public.

The format of event management provides good practice for measuring PCAS operation.

[5] http://www.bsigroup.com/pas2050
[6] http://www.epa.vic.gov.au/ecologicalfootprint/docs/sharon-ede's-presentation.pdf
[7] http://www.epa.vic.gov.au/ecologicalfootprint/calculators/event/introduction.asp

4. International Civil Aviation Organisation, ICAO (http://www2.icao.int/en/carbonoffset/Pages/default.aspx.)

The international civil aviation organisation provides the best available Co2 emission data for air travel. The estimation gives detailed Co2 level based on the distance between major airports.

Its research paper profile various aircrafts associated with fuel consumption, passenger capacity, cargo loading and travel distance between airports.

The travel distances between airports factor in the great circle distance[8] and its conversion arrived by average fuel consumption per passenger.

5. World Resource Institute:
    a. Working 9 to 5 on Climate Change: An office Guide

This document presents a quick carbon dioxide emission calculation at mid-range scale from daily activities. The conversion factors are based on UK, mostly derived from PAS 2050.

Secondary factors from excel model has included this aspects on micro level activities.

6. Environmental Indicator by United Nations Statistics Division
    a. Greenhouse Gas Emission Co2 Emission in 2007[9]

7. Carbon Dioxide Information Analysis Centre (http://cdiac.ornl.gov/)

    a. http://mercury.ornl.gov/cdiac/
    b. http://cdiac.ornl.gov/by_new/bysubjec.html#carbon

8. Carbon Inventory Methods: Handbook for Greenhouse Gas Inventory, Carbon Mitigation and Roundwood Production Projects

This reference book details technical aspects of calculation in great details. It outlines various frameworks for carbon emission estimates. It is technical driven and its coverage offers solutions for the differences in land features and habitations.

9. GHG protocols

This is commonly used for carbon emission accounting. It contains varieties of resources for calculation needs. Its range covers sector specific, guideline and customisation model.

The customisation portion provides guideline needed for calculating Antarctica factor vehicles.[10]

[8] The shortest distance between any two points on the planet surface
[9] http://unstats.un.org/unsd/environment/air_co2_emissions.htm
[10] http://www.ghgprotocol.org/calculation-tools

Limitations & Assumptions

Under estimation impacts

Regardless of current conservative approach in Co2 emission estimates, the estimation could remain lower than the actual due to altitude impact by air travel, remaining effect at atmosphere, loading factors, lack of established infrastructure impact studies and lack of recognised factors. It should seek for further justifications in future development.

Aviation Factor: Radiative Forcing

To calculate Co2 Emission from air travel, radiative forcing is additional impact of emission factor at altitude, including water vapour, contrails, NOx etc.

Current DEFRA / DECC 2011 GHG guideline[11] states that " there is currently uncertainty over the other non-Co2 climate change effect of aviation which have been indicatively been accounted for by applying multiplier in some cases.,

IPCC (Intergovernmental Panel on Climate Change) special report in "Aviation and Global Atmosphere"[12] in November 2000 gives clear definition of radiative forcing.

> *The Radiative Forcing Index (RFI)-the ratio of total radiative forcing to that from CO_2 emissions alone-is a measure of the importance of aircraft-induced climate change other than that from the release of fossil carbon alone.*
>
> *In 1992, the RFI for aircraft is 2.7; it evolves to 2.6 in 2050 for the Fa1 scenario. This index ranges from 2.2 to 3.4 for the year 2050 for various E- and F-type scenarios for subsonic aviation and technical options considered here. The RFI increases from 2.6 to 3.4 with the addition of HSCTs (scenario Fa1H), primarily as a result of the effects of stratospheric water vapor. Thus, aircraft-induced climate change with RFI > 1 points to the need for a more thorough climate assessment for this sector.*
>
> *By comparison, in the IS92a scenario the RFI for all human activities is about 1, although for greenhouse gases alone it is about 1.5, and it is even higher for sectors emitting CH_4 and N_2O without significant fossil fuel use.*

[11] http://www.defra.gov.uk/publications/files/pb13625-emission-factor-methodology-paper-110905.pdf
[12] http://www.grida.no/publications/other/ipcc_sr/?src=/climate/ipcc/aviation/064.htm

DEFRA guideline suggests a factor of 1.9 and other industrial practices for aviation emission factors range from 1.9 to 3.4.

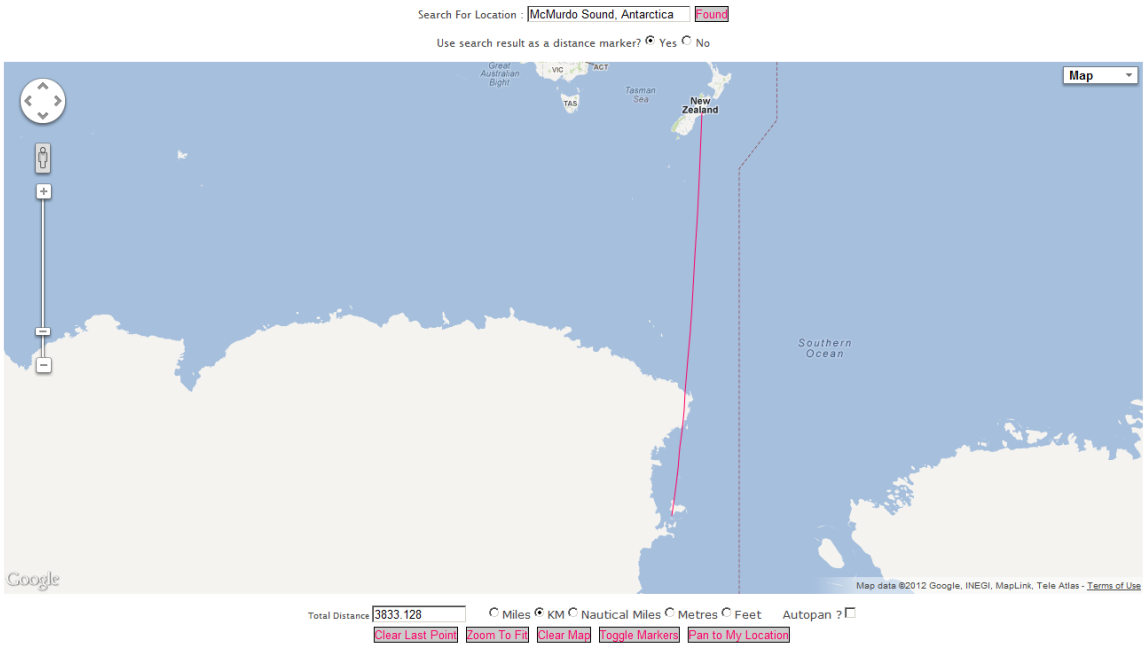
Source	Radiative Factor
WWF	2.7
EPA, Victoria Government	2.7[13]
Carbon Footprint	1.9
National Energy Foundation	2.7
Co2 Balance	1.9

Antarctica Factors: McMurdo Sound Airport

Most Carbon emission calculators use quantitative factors from ICAO (International Civil Aviation Organisation) to weigh up carbon aviation factors. McMurdo Sound Airport is not on its airport list; therefore, one of difficulties is to obtain McMurdo Sound airport travel information.

The website daft logic (http://www.daftlogic.com/projects-google-maps-distance-calculator.htm) provide distance calculator to compute two or more appoints from Google Map.

Based on its mapping calculator, distance between Christchurch international airport to McMurdo Sound Airport, Antarctica is 3833.159km. Total distance of travel is 7666.318 km (returned travel). Presumably, total flight hours are nine hours.



[13] http://www.epa.vic.gov.au/climate-change/carbon-management/Worksheet_3-Flights.pdf

Current model has three options for Co2 emissions calculating between Christchurch and McMurdo Airport:

- Airport Simulation
- Time Factor
- Distance

Solution one: Simulation, "Christchurch" factor

Given available destinations from ICAO site, there are twenty-five direct flights from Christchurch airport, including both domestic and international flights. ICAO calculator has Co2 emission estimation per passenger per route (see table below).

The travel distance between Christchurch to Singapore (8404 km) offers the closest distance for Christchurch to Antarctica simulation, including Radiative Forcing Index factor.

Christchurch – SIN = is the assumption from available pool collected

	CHRISTCHURCH	KM	kg/Co2
NZ	Auckland	760	92.12
NZ	Blenheim	245	52.76
AUS	Brisbane	2494	220.45
NZ	Chatham Is	885	186.03
NZ	Dunedin	315	40.1
AUS	Gold Coast	2404	197.23
NZ	Hamilton	668	66.43
NZ	Hokitika	151	37.28
NZ	Invercargill	465	53.42
MY	Kauala Lumpur	8687	1260.04
Aus	Melbourne	2404	211.24
Fiji	Nadi	2897	277.89
NZ	Napier / Hastings	573	84.85
NZ	Nelson	249	46.17
NZ	New Plymouth	513	73.49
NZ	Palmerston North	435	52.57
NZ	Queenstown	348	47.82
Cook Island	Rarotonga	3557	553.66
NZ	Rotorua	671	56.85
SG	Singapore	8404	1282.07
AUS	Sydney	2126	195.22
NZ	Tauranga	716	99.63
NZ	Wanaka	296	58.18
NZ	Wellington	303	53.57

This solution holds the factors of "Christchurch" and "New Zealand" as the origin. It offers confidence in environment variables for calculation. Current model includes those cities from its drop down list. It allows user to seek differences among various destination travelling from Christchurch.

Solution two: Time factor, "Flying hours"

This approach takes account of travelling time and variations occur between types of travel and distances. The differences are based on the altitudes and the distance of journey as higher altitudes result in greater emissions.

Assuming plane flying at 850km per hour, excluding rediative forcing, UK department for Transport Journey indicates 134.3 kg Co2 per hour (0.158kg Co2/km) .

National Energy Foundation[14] has indication of 150 kg Co2 per hour under the same assumption. (850km / hr)

The Quaker Green Action calculator assumes 350 kg Co2 per hour (3 passengers)[15]

Wikipedia[16] provides indicator by Finland[17] using the following measures:

- Carbon emission per passenger kilometre by domestic, short distance (less than 463km) indicates 257 g/km
- Carbon emission per passenger kilometre by domestic, long distance (greater than 463km) indicates 177 g/km Co2
- Carbon emission per passenger kilometre by distance flight indicates 113 glm Co2.

For our purpose in time factor simulation, the model takes the average of 134.3 kg, 150 kg, and 350 kg / 3 persons to arrive 1202.9 kg Co2 / hr.

Solution three: Distance factor

Current best practice to derive aviation emission factor will consider factors by the fuel it uses[18].

PCAS operation takes Antarctica travels by U.S military Boeing C-17 Globemaster III. Currently, it is using 50-50 blend of JP-8 and Syntroleum FT fuel[19] that the fuel efficiency ratio is yet ready in the market.

[14] http://www.nef.org.uk/greencompany/co2calculator.htm
[15] http://www.ethicalconsumer.org/commentanalysis/features/carboncalculators.aspx
[16] http://en.wikipedia.org/wiki/Environmental_impact_of_aviation#cite_note-12
[17] http://lipasto.vtt.fi/yksikkopaastot/henkiloliikennee/ilmaliikennee/ilmae.htm
[18] Jet Fuel, Aviation Gasoline and others.
[19] http://en.wikipedia.org/wiki/Jet_fuel

For the purpose of distance calculation, it uses commonly available factor for our model.

Given the distance between Christchurch international airport and McMurdo Sound airport at 7666.318 km, current conversion factor uses the factor 113g per km[20] for Co2 emission calculation.

Alternative Factor: 3.157 rate per seat basis

With known amount of fuel, research from Environmental Change Institute at University of Oxford [21] also suggests general burning rate at 3.157 kg Co2 / kg Fuel multiplier. However, current model does not include this factor because this factor varied by per seat basis in civil aviation craft.

Antarctica Factors: Antarctica Transportations @ Scott Base

Transportations at extreme environment have specific requirements and Co2 emission studies do not have its conversion ratio for calculation.

PCAS 2011/2012 encountered a few types of transportation on the field in the following list:

1. Public Bus / Coach (Day 1 and last day)
2. Van (operated by different operators in Antarctica)
3. Community Bus (operated by different operators in Antarctica)
4. Snowmobile
5. Hägglunds (For site visit)
6. Helicopter

[20] http://en.wikipedia.org/wiki/Environmental_impact_of_aviation
[21] Jardine (2009), "Co2 emission per seat can be calculated by multiplying by an emission factor of 3.157 kg Co2/kg Fuel. It should be noted that this is Co2 only and does not include a multiplier for the additional climate impact of emission at altitude."
http://www.eci.ox.ac.uk/research/energy/downloads/jardine09-carboninflights.pdf

For those transpirations at Scott Base, conversion ratios utilize fuel efficiency to derive its Co2 emission rate. Those calculations are based on "UK Greenhouse Gas Inventory for 2008" and "Digest of United Kingdom Energy Statistics (Dukes)".[22]

Converting fuel types by unit volume				CO_2
Fuel Type	Amount used	Units	x	kg CO_2 per unit
Aviation Spirit		litres	x	2.2119
Aviation Turbine Fuel		litres	x	2.5218
Burning Oil		litres	x	2.5299
CNG		litres	x	0.4746
Diesel		litres	x	2.6413
Gas Oil		litres	x	2.7667
LNG		litres	x	1.2272
LPG		litres	x	1.4902
Natural Gas		cubic metre	x	2.0230
Petrol		litres	x	2.3018

The current assumption is using "Petrol" to derive its conversion factors for specific transportation.

Based on Antarctica New Zealand Field 2011-2012, the following contains its fuel efficiency rate for conversion.

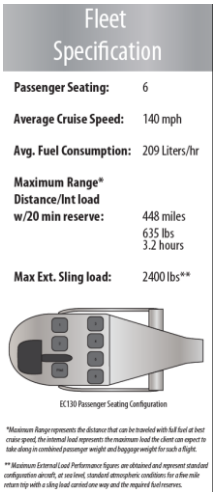
Vehicle

Snowmobile	10	km / 4.5	litre
Hägglunds BV 206	1	km / 1	litre
Helicopter - BH 212	400	litre	per hour

Based on Eurocopter EC130 B4 technical paper, EC 130 B4 has following character.

Vehicle

Helicopter - EC130 B4	209	litre	per hour


Fleet Specification

Passenger Seating: 6

Average Cruise Speed: 140 mph

Avg. Fuel Consumption: 209 Liters/hr

Maximum Range* Distance/Int load w/20 min reserve: 448 miles 635 lbs 3.2 hours

Max Ext. Sling load: 2400 lbs**

EC130 Passenger Seating Configuration

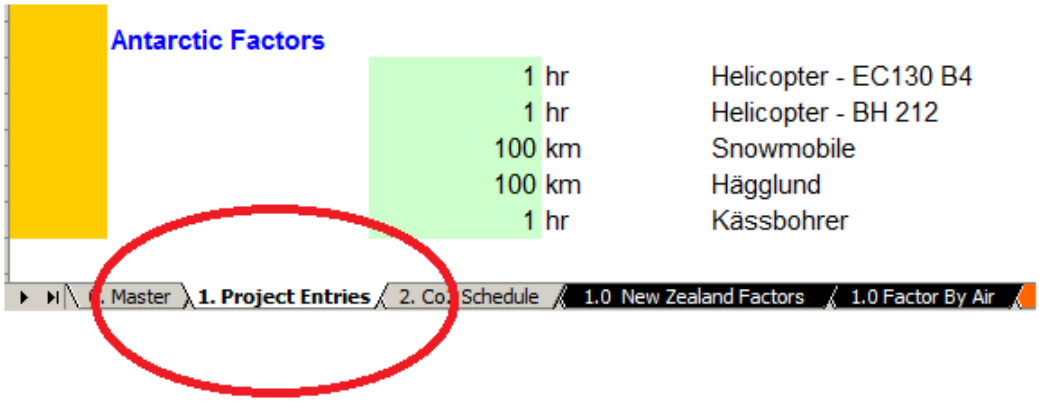
*Maximum Range represents the distance that can be traveled with full fuel at best cruise speed, the internal load represents the maximum load the client can expect to take along in combined passenger weight and baggage weight for such a flight.

** Maximum External Load Performance figures are obtained and represent standard configuration aircraft, at sea level, standard atmospheric conditions for a five mile return trip with a sling load carried one way and the required fuel reserves.

[22] http://www.decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx

User Instructions: Five-Step

To start with calculation, it requires user input in “Project Entries” tab.



Step 1: Total Participants

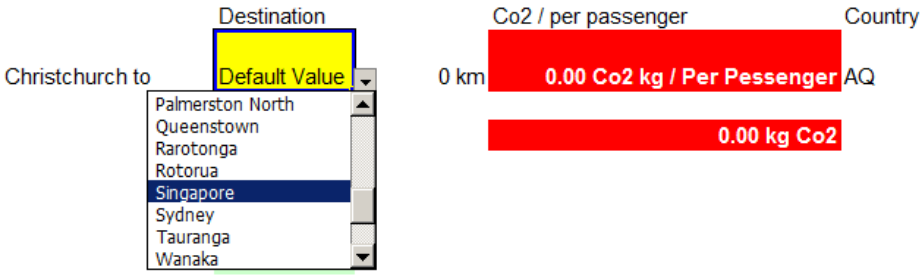
Fill in total participants from PCAS operation, including instructors, visiting scholars, students and others.

Step 2: Air Flight factors

There are three recommendations under this session; simulation by distance, time factor and distance factor.

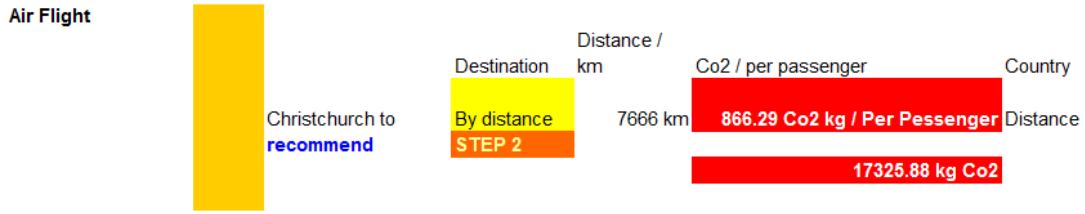
Simulation: Singapore

This recommendation holds the factor of “Christchurch” and simulates its calculation by ICAO flight emission results. Based on the actual route in Christchurch, other destinations are also available from the list.



Distance Factor

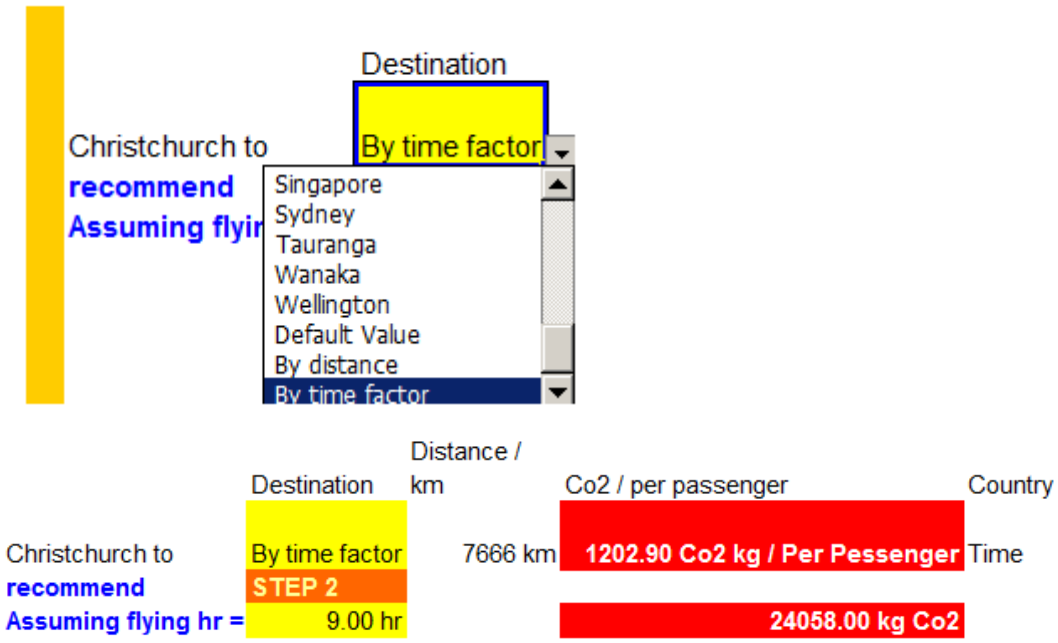
Distance factor is another recommended option.
It takes accounts of total travel distance and use conversion factor 0.113 per kilometre.



Time factor

Time factor assumes total 9 hours travelling time. User will be able to justify flying hour.

The justification in flying hour will take effect in Carbon emission calculation if it chooses time factor selection from the list.

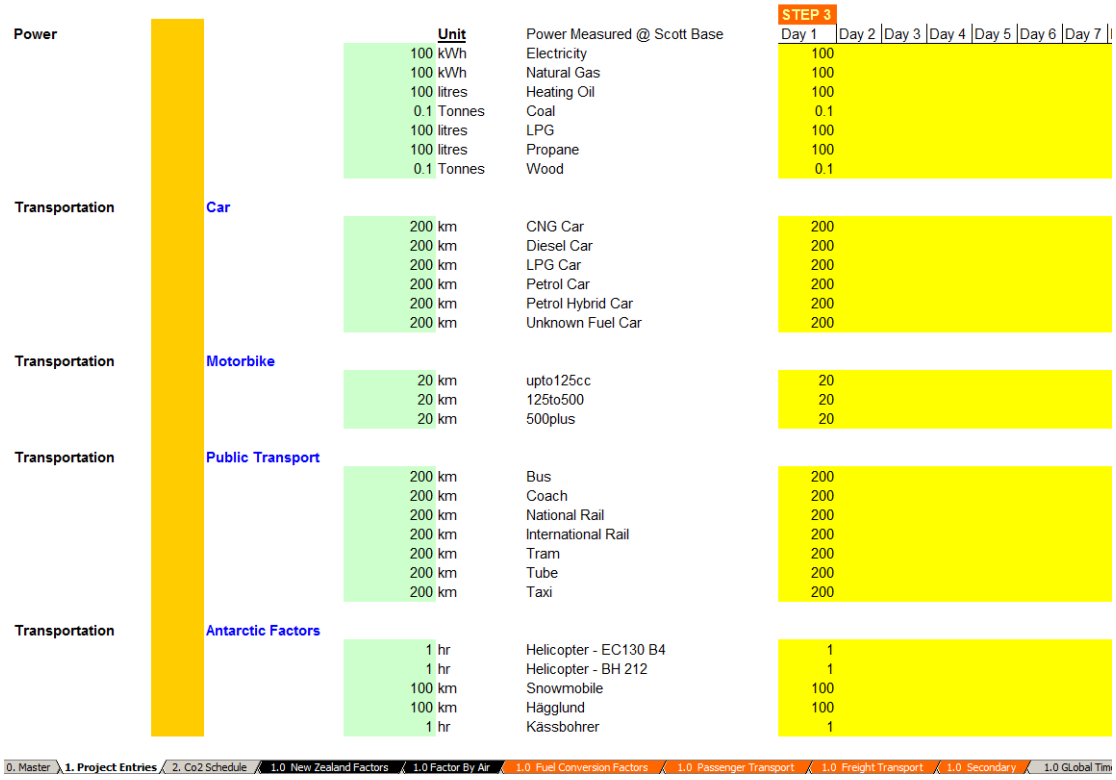


Step 3: Primary Factors: Energy and Transportation

This session requires user to input energy and transportation data. Currently format is set to base on daily basis.

It requires as much information as possible, subject to availability.

To calculate specific Antarctic elements, those transportations use different unit to measure. (“distance” or “time”)

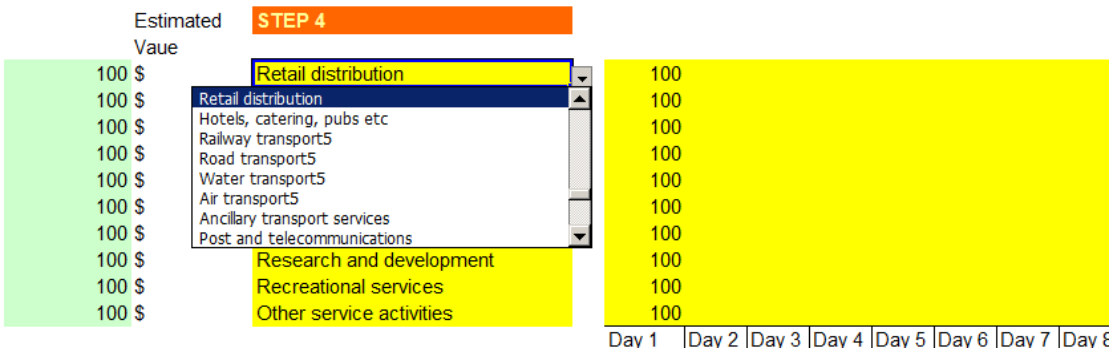


		Unit		STEP 3 Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Power			Power Measured @ Scott Base							
		100	kWh Electricity	100						
		100	kWh Natural Gas	100						
		100	litres Heating Oil	100						
		0.1	Tonnes Coal	0.1						
		100	litres LPG	100						
		100	litres Propane	100						
		0.1	Tonnes Wood	0.1						
Transportation	**Car**									
		200	km CNG Car	200						
		200	km Diesel Car	200						
		200	km LPG Car	200						
		200	km Petrol Car	200						
		200	km Petrol Hybrid Car	200						
		200	km Unknown Fuel Car	200						
Transportation	**Motorbike**									
		20	km upto125cc	20						
		20	km 125to500	20						
		20	km 500plus	20						
Transportation	**Public Transport**									
		200	km Bus	200						
		200	km Coach	200						
		200	km National Rail	200						
		200	km International Rail	200						
		200	km Tram	200						
		200	km Tube	200						
		200	km Taxi	200						
Transportation	**Antarctic Factors**									
		1	hr Helicopter - EC130 B4	1						
		1	hr Helicopter - BH 212	1						
		100	km Snowmobile	100						
		100	km Hägglund	100						
		1	hr Kässbohrer	1						

0. Master | 1. Project Entries | 2. Co2 Schedule | 1.0 New Zealand Factors | 1.0 Factor By Air | 1.0 Fuel Conversion Factors | 1.0 Passenger Transport | 1.0 Freight Transport | 1.0 Secondary | 1.0 GLobal Tim

Step 4: Secondary Factors: Micro-activities calculation

Secondary factors are based on dollar value estimation. User could choose up to ten factors from the list and assign dollar value to each of them.

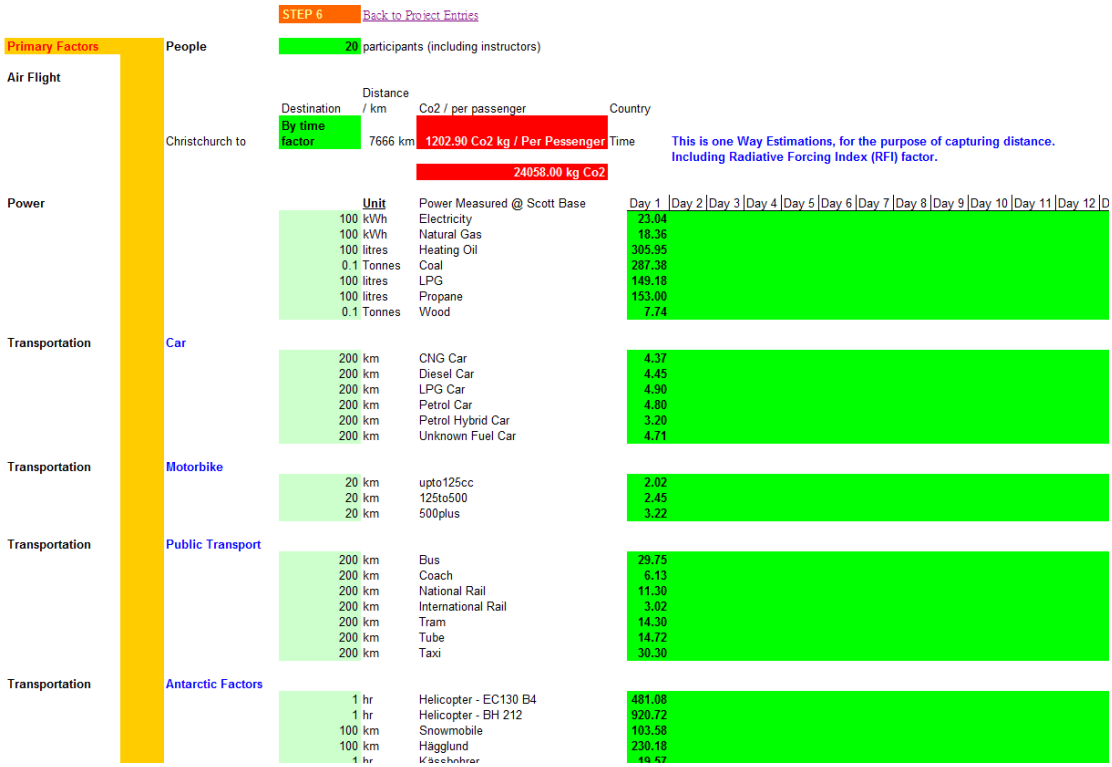


Estimated Vaue	STEP 4		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
100 $	Retail distribution		100							
100 $	Retail distribution		100							
100 $	Hotels, catering, pubs etc		100							
100 $	Railway transport5		100							
100 $	Road transport5		100							
100 $	Water transport5		100							
100 $	Air transport5		100							
100 $	Ancillary transport services		100							
100 $	Post and telecommunications		100							
100 $	Research and development		100							
100 $	Recreational services		100							
100 $	Other service activities		100							

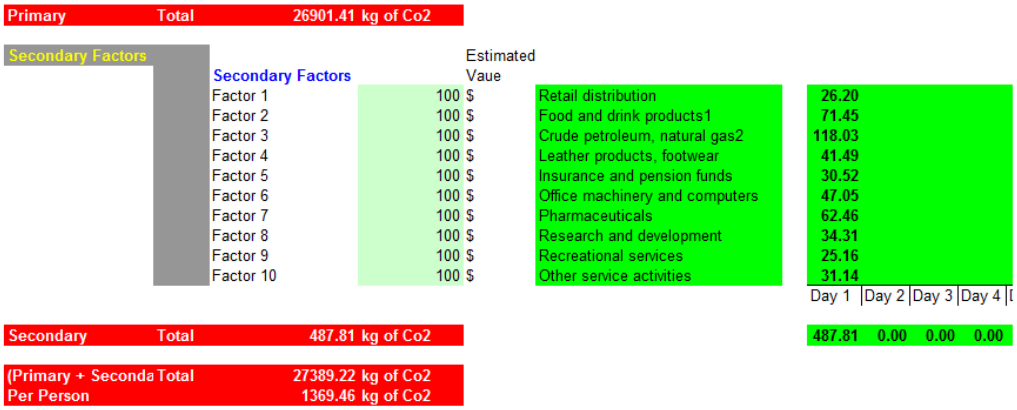
Step 5: Result.

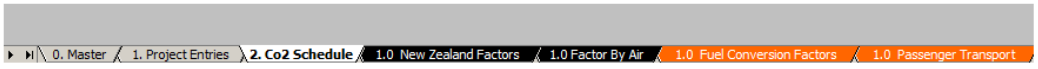
STEP 5 Click Here

By clicking on the link, the final step will lead to the Co2 emission outcome.



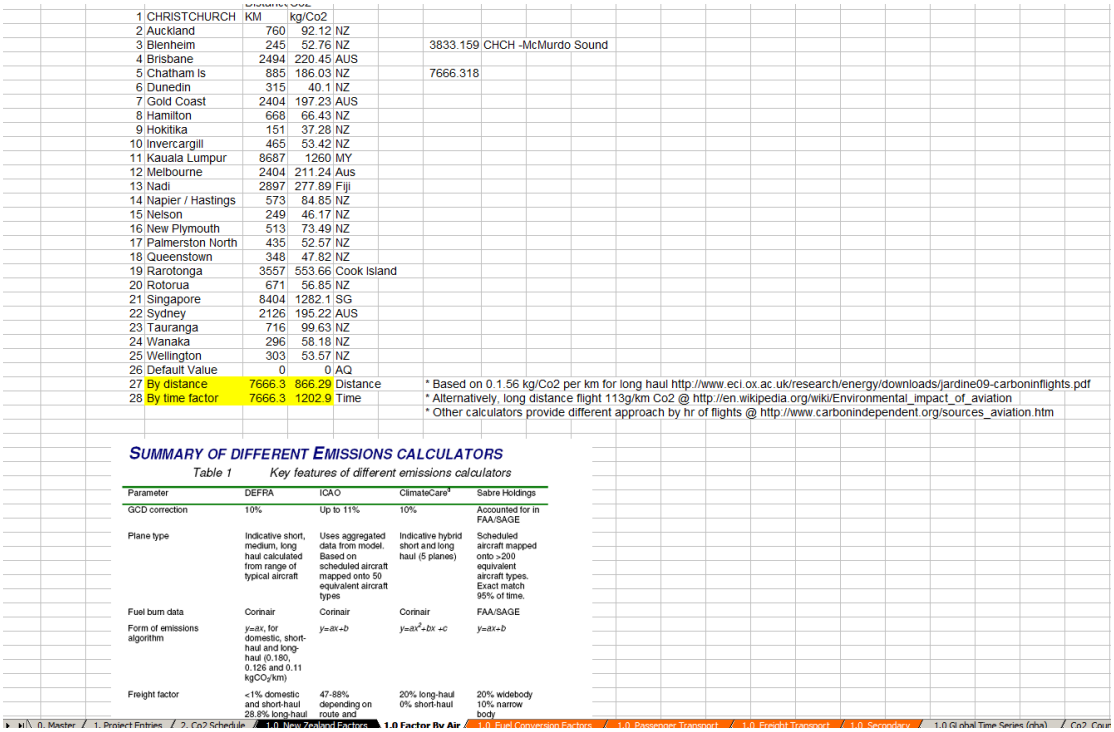
The results are at the bottom of page. It shows emissions from primary factor, secondary factor and the total Co2 emission generated. .





Editing: Conversion Variables

This excel worksheet allows quick editing on its air travel tab. User is able to change those value in yellow cells. Those values determine factors for Air Travel from Christchurch to McMurdo Sound Airport.



	CHRISTCHURCH	KM	kg/Co2			
1	Auckland	760	92.12	NZ		
2	Blenheim	245	52.76	NZ	3833.159	CHCH -McMurdo Sound
3	Brisbane	2494	220.45	AUS		
4	Chatham Is	885	186.03	NZ	7666.318	
5	Dunedin	315	40.1	NZ		
6	Gold Coast	2404	197.23	AUS		
7	Hamilton	668	66.43	NZ		
8	Hokitika	151	37.28	NZ		
9	Invercargill	465	53.42	NZ		
10	Kauala Lumpur	8687	1260	MY		
11	Melbourne	2404	211.24	Aus		
12	Nadi	2897	277.89	Fiji		
13	Napier / Hastings	573	84.85	NZ		
14	Nelson	249	46.17	NZ		
15	New Plymouth	513	73.49	NZ		
16	Palmerston North	435	52.57	NZ		
17	Queenstown	348	47.82	NZ		
18	Rarotonga	3557	553.66	Cook Island		
19	Rotorua	671	56.85	NZ		
20	Singapore	8404	1282.1	SG		
21	Sydney	2126	195.22	AUS		
22	Tauranga	716	99.63	NZ		
23	Wanaka	296	58.18	NZ		
24	Wellington	303	53.57	NZ		
25	Default Value	0	0	AQ		
26	By distance	7666.3	866.29	Distance		
27	By time factor	7666.3	1202.9	Time		

* Based on 0.1.56 kg/Co2 per km for long haul http://www.eci.ox.ac.uk/research/energy/downloads/jardine09-carboninflights.pdf
* Alternatively, long distance flight 113g/km Co2 @ http://en.wikipedia.org/wiki/Environmental_impact_of_aviation
* Other calculators provide different approach by hr of flights @ http://www.carbonindependent.org/sources_aviation.htm

SUMMARY OF DIFFERENT EMISSIONS CALCULATORS

Table 1 Key features of different emissions calculators

Parameter	DEFRA	ICAO	ClimateCare[3]	Sabre Holdings
GCD correction	10%	Up to 11%	10%	Accounted for in FAA/SAGE
Plane type	Indicative short, medium, long haul calculated from range of typical aircraft	Uses aggregated data from model. Based on scheduled aircraft mapped onto 50 equivalent aircraft types	Indicative hybrid short and long haul (5 planes)	Scheduled aircraft mapped onto >200 equivalent aircraft types. Exact match 95% of time.
Fuel burn data	Corinair	Corinair	Corinair	FAA/SAGE
Form of emissions algorithm	$y=ax$, for domestic, short-haul and long-haul (0.180, 0.126 and 0.11 $kgCO_2/km$)	$y=ax+b$	$y=ax^2+bx+c$	$y=ax+b$
Freight factor	<1% domestic and short-haul 28.8% long-haul	47-88% depending on route and	20% long-haul 0% short-haul	20% widebody 10% narrow body

0. Master / 1. Project Entries / 2. Co2 Schedule / 1.0 Factor By Air / 1.0 Fuel Conversion Factors / 1.0 Passenger Transport / 1.0 Freight Transport / 1.0 Secondary / 1.0 Global Time Series (nba) / Co2 Coun

Restrictions

Two restrictions are embedded in Microsoft Excel, but not limited to Google Doc.

- The “project entries” worksheet only allows Yellow cell for data entry as to protect the format of design and formulas.

- The data entry value needs to be greater or equal to zero.

Maintenance

Other online calculators are also available for Carbon footprint calculation. The following list provides credible sites and commonly suggested Carbon footprint calculator.

BP:

Flash Version
http://www.bp.com/iframe.do?categoryId=9036038&contentId=7066737

HTML
http://www.bp.com/carboncalculator.do?categoryId=9036065&contentId=7066752

Department of Energy & Climate Change:
Previously known as Act on Co2 (United Kingdom)

http://carboncalculator.direct.gov.uk/index.html

Carbonfootpring.com

http://www.carbonfootprint.com/calculator1.html

Resurgence

http://www.resurgence.org/education/carbon-calculator.html

National Energy Foundation

http://www.nef.org.uk/actonCO2/carbonworkout.asp

Co2 Balance

http://www.co2balance.com/carbon-calculators/

Liveneutral

http://www.liveneutral.com/calc_splash/
http://www.liveneutral.com/flyneutral/

Direct Government, UK

http://carboncalculator.direct.gov.uk/index.html

Appendix I

Schedule

Day 0	Depart Christchurch	Arrived Antarctica Airport
	Bus	Arrive Scott Base
Day 1	AFT	Packing
	Field	Camp Set up
Day 2	Camp	Huts
	Field Exercise	
Day 3	Camp	Seal
	Geology Visit	Camp
Day 4	Camp	Field Exercise (ICE)
Day 5	Camp	Festival
Day 6	Camp	Seal
	Geology Visit	Camp
Day 7	Camp	Camp Site clean up
	Scott Base	Unpack Bags
	Scott Base Designated Project	
Day 8	Scott Base	Participating Scott Base Tasks
Day 9	Scott Base	Bus
	Antarctica Airport	Christchurch

References

"*2010 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting: Methodology Paper for Emission Factors"*, DEFRA, August 2011.

"An Assessment of the potential effectiveness and strategic fit of personal carbon trading", Department for Environment, Food and Rural Affairs, UK, 2008. (http://www.decc.gov.uk/assets/decc/what%20we%20do/global%20climate%20change%20and%20energy/tackling%20climate%20change/ind_com_action/personal/pct-economic-analysis.pdf)

"*Carbon footprint of product – Requirements and guidelines for quantification and communication"*, International Organisation for Standardization 2012.

Eijgelaar, E., Thaper, C. and Peeters, P., "Antarctic Cruise Tourism: the paradoxes of ambassadorship, "last chance tourism" and greenhouse gas emission.", Journal of Sustainable Tourism, 18:3, 337-354, 2010.

Farreny, R. *el al*, "Carbon dioxide emissions of Antarctic Tourism", Antarctic Science 2011.

"*Guide to PAS 2050: How to assess the carbon footprint of goods and services*", BSI British Standard, Crown 2008 and carbon Trust 2008, 2008.

Jardine, C. N., "*Calculating The Carbon Dioxide Emission of Flights"*, Environmental Change Institute, University of Oxford, February 2009.

"*PAS 2050*:2011 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services", BSI 2011.

Pino, S. P. and Bhatia, P., "*Working 9 to 5 on Climate Change: An office Guide*", World Resources. 2002.