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Mitigating the Impacts of Climate Change on the Built Environment

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Preface

This report provides information about the development of the 'Easy Guide to Being a Climate-Friendly Kiwi' – a mitigation tool to help the building and construction industry prepare for the direct and indirect impacts of climate change on the built environment. The tool follows on from, and is complementary to, the adaptation advice presented in 'Coping with Climate Change'; BRANZ Bulletin 414 (May, 2001).

Acknowledgments

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This work was funded by the Foundation for Research, Science and Technology, from the Research for Industry Fund.

Note

This report is intended for researchers interested in advice on climate change mitigation in New Zealand, and for those among the intended audience of the tool who want more detailed technical information.

MITIGATING THE IMPACTS OF CLIMATE CHANGE ON THE BUILT ENVIRONMENT

BRANZ Study Report SR 118 (2003) **Rachel Hargreaves**

REFERENCE

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EXECUTIVE SUMMARY

This report provides information about the development of the 'Easy Guide to Being a Climate-Friendly Kiwi' – a mitigation tool to help the construction industry prepare for the direct and indirect impacts of climate change on the built environment.

The main objective of the Guide is to improve the ability of the building industry to reduce greenhouse gas emissions and thus minimise the industry's contribution to the enhanced greenhouse effect, and subsequent climate change. The focus of this tool is primarily on homeowners and small – to medium-sized businesses, but includes practical mitigation tips that can be employed by a wide variety of building and construction-related groups. It also includes a New Zealand-specific carbon calculator for individuals and small businesses to calculate their energy-related carbon emissions. The derivation of the associated emission factors used in the calculator is the main focus of this report.

CONTENTS

Page No.

UNITS

CO_2	Carbon dioxide
CO_2/kWh	Amount of carbon dioxide produced per kilowatt-hour of electricity generated
kg	Kilogram
kWh	Kilowatt-hour (amount of energy to run a 1000 Watt heater for 1 hour, or a 100 watt light bulb for 10 hours)
l	Litre
MJ	Megajoule (a joule is a unit of energy, a megajoule is 10^6 joules)
TJ	Terajoule (10^{12} joules)
t	Tonne

ABBREVIATIONS

BRANZ	Building Research Association of New Zealand
EECA	Energy Efficiency and Conservation Authority
LPG	Liquified Petroleum Gas
MED	Ministry of Economic Development
NIWA	National Institute of Water and Atmospheric Research
UNFCCC	United Nations Framework Convention on Climate Change

1. BACKGROUND

1.1 Climate Change and New Zealand's Response

The climate is in a constant state of change. We know that Earth's climate has naturally varied over the past thousand years, and for millennia before that, for a variety of reasons (Ministry for the Environment, 1997). Climate change itself is not the concern; it is the current rate of change and the causative factors that are creating threats and opportunities for all communities around the world. These threats and opportunities will be evident in the urban environment as much as, if not more than, those predicted for our primary industries. The most significant effects will be related to increased temperatures (building overheating), more extreme precipitation (coastal and inland flooding, landslips and erosion), and wind events (storms and cyclone damage) (Camilleri, 2000).

Government activity to address the impacts of climate change is orchestrated via two key legislative mechanisms; the United Nations Framework Convention on Climate Change (UNFCCC), and the Kyoto Protocol. New Zealand signed the UNFCCC in 1992, and signed and ratified the Kyoto Protocol in 1997 and 2002 respectively. The Kyoto Protocol is an international treaty requiring ratifying countries to meet reduction targets of greenhouse gases relative to their 1990 levels between 2008-2012. The greenhouse gases under scrutiny are carbon dioxide, methane, nitrous oxide, hydroflurocarbons, perfluorocarbons, and sulphur hexafluoride.

1.2 The Importance of Mitigation

The magnitude of climate change depends on the future emissions of greenhouse gases and the measures undertaken to reduce these. The term 'mitigation' refers to measures taken to reduce greenhouse gas emissions. It is clear from government strategies and programmes released to date, e.g., National Energy Efficiency and Conservation Strategy, the Waste Strategy, and the Transport Strategy, that there is a strong focus on mitigatory measures, particularly energy efficiency, to meet New Zealand's targets.

However, until New Zealand's domestic climate change policy is finalised[1] and the methodologies for reporting and verifying emissions are developed, it is difficult for any mitigation initiative to provide definitive answers as to what actions will be required. This lack of certainty is of concern to businesses and other groups who may have to report their emissions inventory and prove any reductions made, especially in the light of any Kyoto-related trading or project-based mechanism.

Because of this concern, and because of the potential of significant impacts on the built environment, BRANZ has attempted to provide support and advice to the New Zealand building industry in this regard. The 'Easy Guide to Being a Climate-Friendly Kiwi' is a paper-based publication focusing on greenhouse gas reduction measures for homes and small to medium-sized businesses.

[1] At the time of development of the Guide, the government's climate change policies were under consultation.

1.3 The Easy Guide to Being a Climate-Friendly Kiwi

The Guide begins by illustrating what climate change is, describes greenhouse gases and where they come from, and highlights the emissions that an individual is directly responsible for. The remainder of the booklet is dedicated to taking action to reduce emissions. For electricity use, there are tips on lighting, appliances, water heating, insulation and windows, as well as others on transport, reducing paper use and other recycling opportunities. A 'Quick Tips' section is also included along with lists of relevant web page links to further sources of information and web-based carbon calculators.

Most importantly, the Guide includes a New Zealand-specific carbon calculator for individuals or businesses to work out their emissions on a monthly or yearly basis (see Appendix 1). The calculator was included as a 'measure to manage' instrument, based on the premise that you cannot manage (or reduce) your emissions if you do not know what they are. The calculator is paper-based and simplistic; the focus is on CO2 emissions from energy, heating, transportation, and waste minimisation. There are two calculator charts in the Guide, one each for the home and the office.

The development of the calculators was based on information provided by BRANZ staff and other experts in this field. At the time of development of the Guide, no central government emission factors were available. Since publication, the Energy Efficiency and Conservation Authority, and the Ministry for Economic Development have provided some guidance. However, for the purposes of this tool, any discrepancy in emission factors is unlikely to be of concern, as the target audience (individuals, families and small to medium-sized businesses) is most likely to use the calculators as an internal benchmark, not as a compliance tool. Used in this way, the accuracy of the emissions factors is less crucial, as long as they stay the same during the period of measurement.

2. CO_2 EMISSION FACTORS

Greenhouse gas emission factors come from a range of sources. The factors used in this report have been taken from the most reliable New Zealand sources/data (where available) at the time of writing (September 2002). They are by no means definitive. They are also likely to change as the government provides clarification of what the official factors will be. There is on-going work with many of the factors in question, in particular electricity, and so it is essential that anyone using these factors has the most up-to-date information available to be able to reliably verify their emissions. Refer to the Ministry for Economic Development (MED, www.med.govt.nz) or the Energy Efficiency and Conservation Authority (EECA, www.eeca.govt.nz) for the latest information.

The emission factors used in the development of the BRANZ mitigation tool were calculated as follows.

2.1 Electricity

The choice of whether to use the marginal figure or the national average figure for electricity generation continues to be a point of debate. Not only is the choice of emission factor a point of contention, the actual value of the respective figures is questionable. Based on the information that was available at the time of writing, the following arguments are presented:

The emission factor for average national electricity is 0.1 kg of CO_2/kWh (Camilleri, 2000), depending on the amount of available hydro generation capacity (under normal circumstances, hydro provides two-thirds of NZ's electricity needs). Any problems with water availability causes a large increase in output from fossil fuel thermal stations (MED, 2001). The emission factor for thermal electricity is 0.64 kg CO_2/kWh (Camilleri, 2000). Because any electricity savings in the home or office would normally cause a drop in output from thermal stations, the marginal figure of 0.64 would, in theory, be the most effectual factor to use to encourage energy savings.

However, to use the marginal figure could suggest (to the uninformed) that typically there is no hydro (or geothermal, or wind) contribution to annual electricity output. This is simply not realistic and discredits the calculation. Also, because the remainder of the emission factors used in the calculator charts did not use marginal figures, it would be inconsistent to use the marginal figure for electricity and not for the others – considering that we are trying to engender similar attitude changes for heating, transportation and paper use.

Therefore, the number of kilowatt-hours is multiplied by the national emission factor of 0.1 kg CO_2/kWh to get total kg of CO_2.

2.2 Gas

If the home or office has mains gas, the emission factor of 0.19 kg CO_2/kWh (Camilleri, 2000, 60) is used to calculate kilograms of CO_2 per kWh. This figure is for the average New Zealand gas stream.

2.3 Heating

Bottled gas
The net calorific value of LPG is 46.1 MJ/kg with a CO_2 emission factor of 60.4 t CO_2/TJ (Baines, 1993, 30). Therefore, 1 kg of LPG used equates to 2.78 kg of CO_2 emitted.

Diesel
The net calorific value of diesel (automotive gas oil) is 35.8 MJ/l with a CO_2 emission factor of 68.3 t CO_2/TJ (blended heating oil) (Baines, 1993, 34-35). Therefore, 1 litre of diesel used equates to 2.45 kg of CO_2 emitted.

Coal
The gross calorific value of coal (all sub-bituminous coals) is 22.6 MJ/kg with a CO_2 emission factor of 91.2 t CO_2/TJ (Baines, 1993, 19-21). Sub-bituminous coal is the category of coal selected as per figures used in MED 2001, 'Energy Greenhouse Gas Emissions'. Therefore, 1 kg of coal used equates to 2.06 kg of CO_2 emitted.

2.4 Wood

The net calorific value for undried fuel merchant fuelwood is 10.3 MJ/kg (±20%) (Baines, 1993, 44), with a CO_2 emission factor of 104.2 t CO_2/TJ (MED, 2001, 115). Therefore, 1 kg of wood combusted equates to 1.07 kg of CO_2 emitted. However, wood is considered to be carbon neutral. This means that though the wood emits CO_2 on combustion, this CO_2 was already taken out of the atmosphere when growing.

2.5 Motor Fuel

Petrol (by litre)
The net calorific value of regular gasoline is 32.2 MJ/l with a CO_2 emission factor of 66.6 t CO_2/TJ (Baines, 1993, 34-35). Therefore, 1 litre of petrol used equates to 2.14 kg of CO_2 emitted.

Petrol (by kilometre)
The CO_2 emissions per passenger kilometre for a 1.6 litre petrol car are 0.21 (one person) (Vale, 2001). Therefore, for every kilometre travelled in an average car (1.6 litre) with only one occupant, 0.21 kg of CO_2 is emitted. Although car engine sizes are getting bigger, the greatest number of vehicles on New Zealand's roads have engine sizes of 1400-1600 cc (MfE, 2002). Figures for one-occupant motor vehicle trips were chosen as a worst-case scenario as a means of encouraging a change of behaviour (in other words, the more people in the vehicle, the better). For any one organisation, there may be a range of different vehicles in the fleet. For simplification, it is assumed that the majority of fleet vehicles have engine sizes of 1400-1600 cc, and the majority of trips taken have only one occupant.

Diesel (by litre)
The net calorific value of diesel (automotive gas oil) is 35.8 MJ/l with a CO_2 emission factor of 68.7 t CO_2/TJ (Baines, 1993, 34-35). Therefore, 1 litre of diesel used equates to 2.46 kg of CO_2.

Diesel (by kilometre)
In terms of kilometres, a 1.9 litre diesel car with one occupant emits 0.15 kg of CO_2 per kilometre (Vale, 2001). For diesel vehicles, there may a range of vehicle sizes. For

simplification, it is assumed that the majority of vehicles will be 1.9 litres with the majority of trips taken with one occupant.

2.6 Other Travel

Air
Internal/domestic air flights (short haul, non-transcontinental) with 65% occupancy equate to 0.26 kg of CO_2 per kilometre per person (Vale, 2001). For international travel, the number of kilometres travelled is multiplied by 0.18 kg of CO_2 per km to get total kg of CO_2 (www.safeclimate.net/calculator, 2002).

Train
By far the greatest train usage (electric) is in Wellington, but other (diesel) train services do operate in other parts of NZ. Electric trains produce 0.17 kg of CO_2 per passenger kilometre (50% occupancy), and diesel trains produce 0.13 kg of CO_2 per passenger kilometre (22% occupancy) (Vale, 2001).

Bus
Based on travel at peak times with 65% occupancy produces 0.02 kg of CO_2 per passenger kilometre (Vale, 2001).

Ferry
Based on figures for a non air-conditioned monohull ferry with 20% occupancy of 0.45 kg of CO_2 per passenger kilometre (Vale, 2001).

Cycling and walking
Zero fossil fuel-related emissions.

Note: the use of occupancy rates in the travel figures raises the same kind of concerns, though on a much smaller scale, of whether you take the marginal figure or the average figure for electricity use. If you commute, are you responsible for the emission solely at the time of travel, or for your share of the overall emissions of the mode of transport? It is possible to make a good argument whichever way you look at it.

2.7 Paper use

The total number of reams is multiplied by average weight per ream to get total weight of office paper. Disposal methods are the proportion sent to landfill (rubbish), the proportion to be recycled, and the proportion to be incinerated. The rubbish proportion is multiplied by an emission factor of 5.3 kg of CO_2 per kg of paper; the recycled portion is multiplied by 0.01; the incinerated portion is multiplied by 0.62 (based on conversions from 'www.americanforests.org/resources/ccc').

2.8 Summary

The carbon footprint, for which an individual or business is responsible, is the sum of the above calculations. The score is an estimate of the carbon dioxide produced as a result of energy, transportation and paper use. Benchmarks are not provided, although the number of trees required to offset one tonne of CO_2 is provided (six trees per tonne), as is the maximum figure of emissions each New Zealander should not exceed for the country to meet its reduction targets (6,300 kg per year).

3. CONCLUSIONS AND FUTURE DIRECTIONS

New Zealand is a small island nation with much to lose (and gain) from climate change. It would appear that, in general, New Zealand's built environment is currently not well placed to minimise the identified risks or maximise benefits. The government has ratified the Kyoto Protocol. This sends a clear signal that climate change is an important issue for the New Zealand building industry (and the public) to focus on. It is important that practical mitigation solutions are developed for the sustainability of New Zealand's urban environment. As buildings have a relatively long life with slow turnover, tools that give specific advice on how to mitigate for climate change now (i.e., before the first commitment period of the Kyoto Protocol) are both timely and relevant.

The BRANZ mitigation tool, the 'Easy Guide to Being a Climate-Friendly Kiwi', aims to assist the public and small-business owners to reduce their greenhouse emissions at home and at the office. It includes a carbon calculator to increase understanding of where greenhouse gas emissions come from and which aspects of daily life can be changed to reduce these. In summary, it is an educational and informative tool to highlight the connections between an individual's actions and the subsequent impact on the climate.

While the Guide is a paper-based publication at present, possible future directions include the development of the carbon calculator into an interactive web-based programme for enhanced ease of use and increased sophistication. For example, as part of the 'kilometres travelled by car' section, drop-down menus giving the type of car, number of passengers, type of fuel, etc., could be included. To avoid duplication of effort, an investigation into combining other New Zealand specific carbon footprinting tools is also recommended (joint initiatives with NIWA, Landcare Research, and the Climate Change Programme, are some examples).

Many people have a poor understanding of climate change, of how it is going to impact on them, and what to do about it. There is a sense that it is a problem for so-called 'big business', and is therefore somewhat removed from an individual's direct sphere of influence. The 'Easy Guide to Being a Climate-Friendly Kiwi' is one tool that shows people what they can do about mitigating the effects of climate change in their everyday lives.

4. REFERENCES

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5. APPENDIX 1: Calculator charts

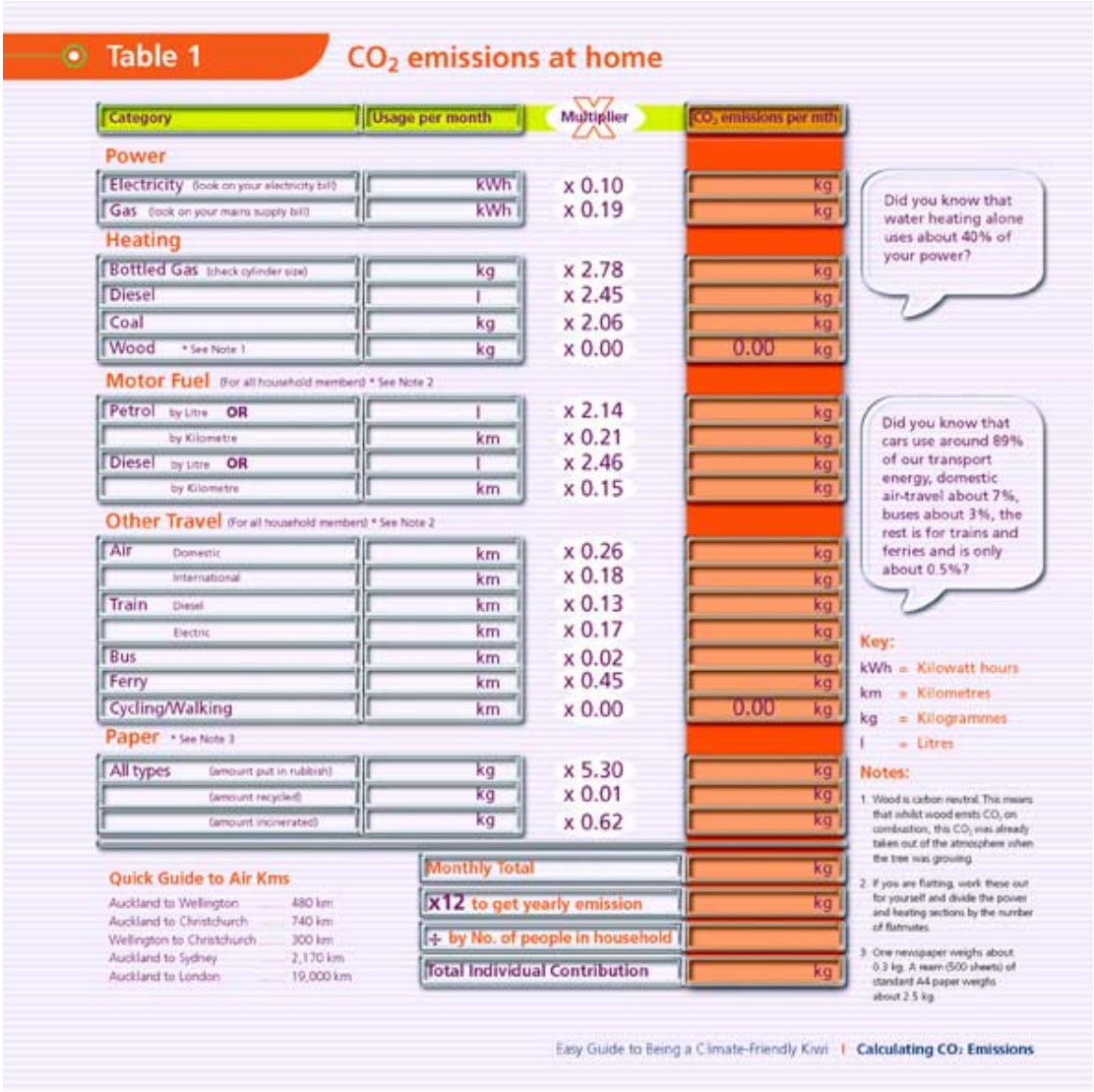

Table 1 CO_2 **emissions at home**

Category	Usage per month		Multiplier	CO_2 emissions per mth	
Power					
Electricity (look on your electricity bill)		kWh	x 0.10		kg
Gas (look on your mains supply bill)		kWh	x 0.19		kg
Heating					
Bottled Gas (check cylinder size)		kg	x 2.78		kg
Diesel		l	x 2.45		kg
Coal		kg	x 2.06		kg
Wood * See Note 1		kg	x 0.00	0.00	kg
Motor Fuel (For all household members) * See Note 2					
Petrol by Litre OR		l	x 2.14		kg
by Kilometre		km	x 0.21		kg
Diesel by Litre OR		l	x 2.46		kg
by Kilometre		km	x 0.15		kg
Other Travel (For all household members) * See Note 2					
Air Domestic		km	x 0.26		kg
International		km	x 0.18		kg
Train Diesel		km	x 0.13		kg
Electric		km	x 0.17		kg
Bus		km	x 0.02		kg
Ferry		km	x 0.45		kg
Cycling/Walking		km	x 0.00	0.00	kg
Paper * See Note 3					
All types (amount put in rubbish)		kg	x 5.30		kg
(amount recycled)		kg	x 0.01		kg
(amount incinerated)		kg	x 0.62		kg
			Monthly Total		kg
			x12 to get yearly emission		kg
			÷ by No. of people in household		
			Total Individual Contribution		kg

Did you know that water heating alone uses about 40% of your power?

Did you know that cars use around 89% of our transport energy, domestic air-travel about 7%, buses about 3%, the rest is for trains and ferries and is only about 0.5%?

Key:
kWh = Kilowatt hours
km = Kilometres
kg = Kilogrammes
l = Litres

Notes:
1. Wood is carbon neutral. This means that whilst wood emits CO_2 on combustion, this CO_2 was already taken out of the atmosphere when the tree was growing.
2. If you are flatting, work these out for yourself and divide the power and heating sections by the number of flatmates.
3. One newspaper weighs about 0.3 kg. A ream (500 sheets) of standard A4 paper weighs about 2.5 kg.

Quick Guide to Air Kms

Auckland to Wellington	480 km
Auckland to Christchurch	740 km
Wellington to Christchurch	300 km
Auckland to Sydney	2,170 km
Auckland to London	19,000 km

Easy Guide to Being a Climate-Friendly Kiwi | **Calculating CO_2 Emissions**

Figure 1: Calculator chart for the home

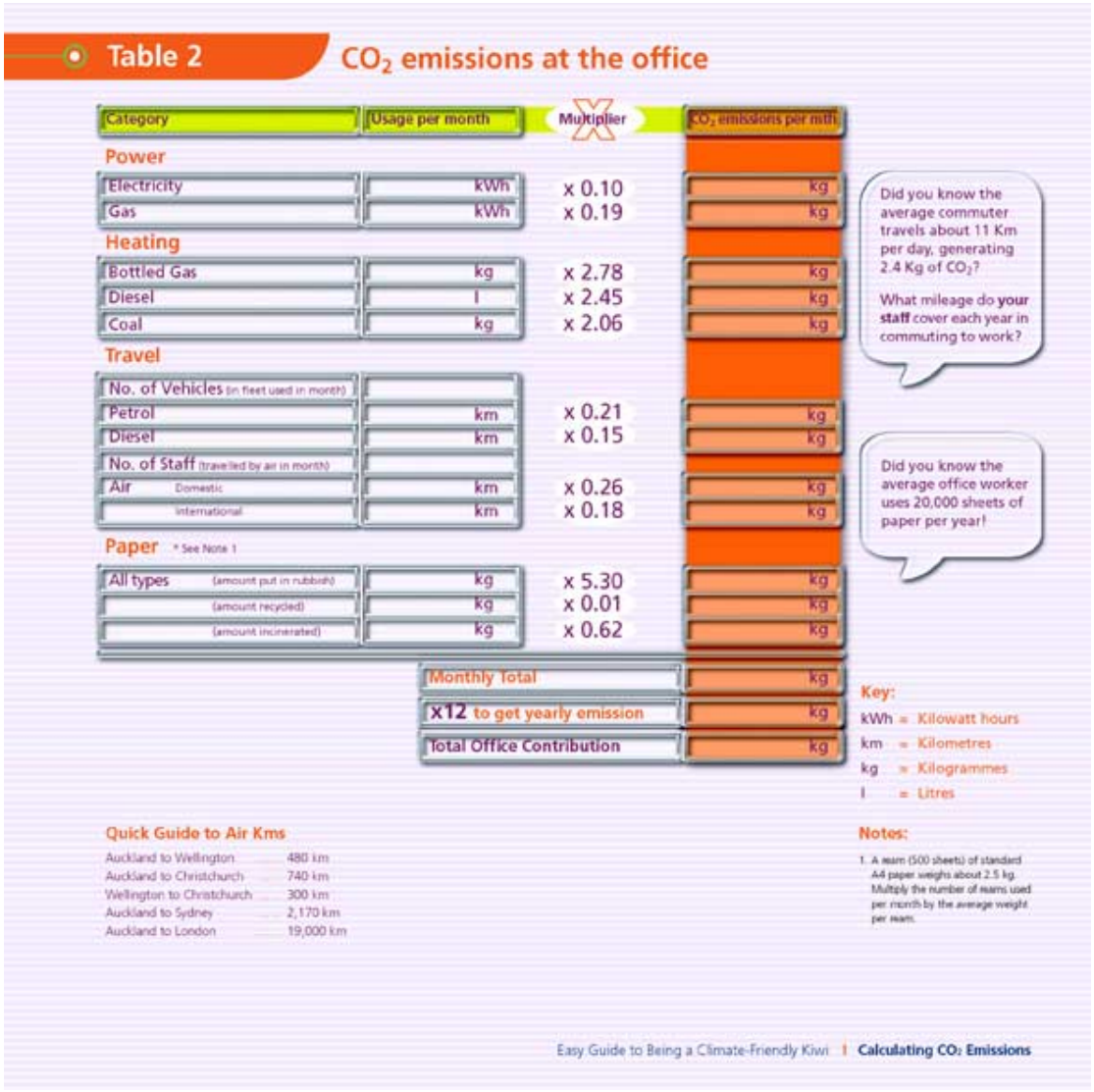

Figure 2: Calculator chart for the office