Australian Government

Department of Climate Change

National Greenhouse Accounts (NGA) Factors

Updating and replacing the AGO Factors and Methods Workbook

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- Table 1 updated with emission factors for additional fuels.
- Amended emissions formula for Municipal wastewater treatment.
- Minor corrections to example calculations.

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www.climatechange.gov.au

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Introduction

The *National Greenhouse Accounts (NGA) Factors* has been prepared by the Department of Climate Change and replaces the *AGO Factors & Methods Workbook.*

Unless otherwise stated, the emission factors listed in this document have been taken from the *Technical Guidelines for the Estimation of Greenhouse Emissions and Energy at Facility level.* The *Technical Guidelines* are available on the Department of Climate Change website and have been designed to support reporting under the *National Greenhouse and Energy Reporting Act 2007*, once the first reporting period under the Act commences on 1 July 2008.

The emission factors reported here have a general application to a broader range of greenhouse emissions inventories, and are not intended to be restricted in their use to reporting under the Act.

The default emission factors listed in these Guidelines have been estimated by the Department of Climate Change using the Australian Greenhouse Emissions Information System (AGEIS) and are determined simultaneously with the production of Australia's National Greenhouse Accounts. This ensures that consistency is maintained between Reporters' inventories at company or facility level and the emission estimates presented in the National Greenhouse Accounts. The emission factors are referred to in this document as National Greenhouse Accounts (NGA) default emission factors.

More information on the estimation methods employed in the National Greenhouse Accounts is available in the *Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks* series. The methods used at the national level, and reflected in the factors reported here, are consistent with international guidelines and are subject to international expert review each year.

Reporters under the National Greenhouse and Energy Reporting System may utilise NGA default emission factors listed in the *Technical Guidelines* in the preparation of emission inventories or they may choose to utilise information on emission factors available at facility level, under certain conditions. Guidance is provided to assist Reporters that choose to use their own information on emission factors. See the *Technical Guidelines* for more details.

The emission factors reported in this publication replace those listed in the *AGO Factors and Methods Workbook*, released in December 2006. Updated emission factors reflect changes in composition of the fuel mix used to produce electricity; revisions to fuel consumption data previously published by official sources and changes in emissions estimates reported in the national inventory. In addition, the ongoing implementation of new international guidelines for emissions estimation methodologies - the *2006 IPCC Guidelines for the Preparation of National Inventories* - have also generated some minor revisions to some emission factors.

Past published emission factors reflected the best information available at the time of their release and may remain valid for particular programmes. Updates to emission factors for past years presented in this document do not necessarily imply any need to revise estimates of emissions for previous years - approaches to updating past emission estimates will depend on the particular details of individual greenhouse reporting programs.

NOTE FOR GREENHOUSE CHALLENGE PLUS MEMBERS!

Greenhouse Challenge Plus Programme members can use the **Online System for Comprehensive Activity Reporting (OSCAR)** to enter activity data (electricity and fuel use, etc.) and have their emissions calculated automatically. A logon and password can be obtained from your industry adviser. OSCAR uses the latest emission factors as reported in this workbook.

Alternatively, members can use this workbook to complete their annual progress reports (see: www.greenhouse.gov.au/challenge).

- For less complex emission profiles, members can use the spreadsheet calculator which incorporates the most commonly used emission factors (see: www.greenhouse.gov.au/challenge).

1 Key definitions and terms

Direct and indirect emissions

Participants for many Australian Government programmes are required to report both direct and some indirect greenhouse gas (GHG) emission estimates.

Direct emissions are produced from sources within the boundary of an organisation and as a result of that organisation's activities. These emissions mainly arise from the following activities:

- generation of energy, heat, steam and electricity, including carbon dioxide and products of incomplete combustion (methane and nitrous oxide);
- manufacturing processes which produce emissions (for example, cement, aluminium and ammonia production);
- transportation of materials, products, waste and people; for example, use of vehicles owned and operated by the reporting organisation;
- fugitive emissions: intentional or unintentional GHG releases (such as methane emissions from coal mines, natural gas leaks from joints and seals); and
- on-site waste management, such as emissions from landfill sites.

For example, a company with a car fleet would report greenhouse gas emissions from the combustion of petrol in those motor vehicles as direct emissions. Similarly, a mining company would report methane escaping from a coal seam during mining (fugitive emissions) as direct emissions and a cement manufacturer would report carbon dioxide released during cement production as direct emissions.

Emission factors for calculating direct emissions are generally expressed in the form of a quantity of a given GHG emitted per unit of energy (kg CO_2-e /GJ), fuel (t CH_4/t coal) or a similar measure. Emission factors are used to calculate GHG emissions by multiplying the factor (e.g. kg CO_2/GJ energy in petrol) with activity data (e.g. kilolitres x energy density of petrol used).

Indirect emissions are emissions generated in the wider economy as a consequence of an organisation's activities (particularly from its demand for goods and services), but which are physically produced by the activities of another organisation. The most important category of indirect emissions is from the consumption of electricity. Other examples of indirect emissions from an organisation's activities include upstream emissions generated in the extraction and production of fossil fuels, downstream emissions from transport of an organisation's product to customers, and emissions from contracted/outsourced activities. The appropriate emissions factor for these activities depends on the parts of upstream production and downstream use considered in calculating emissions associated with the activity.

Types of emission factors

The world of emission factors can become confusing—the following is provided to clarify the purpose of the types of emissions factors in this workbook.

Firstly, it is important to note that an emission factor is activity-specific. The activity determines the emission factor used. The scope that emissions are reported under is determined by whether the activity is within the organisation's boundary (direct—scope 1) or outside it (indirect—scope 2 and scope 3).

- **Direct (or point-source) emission factors** give the kilograms of carbon dioxide equivalent (CO_2-e) emitted per unit of activity at the point of emission release (i.e. fuel use, energy use, manufacturing process activity, mining activity, on-site waste disposal, etc.). These factors are used to calculate **scope 1 emissions**.

- **Indirect emission factors** are used to calculate **scope 2 emissions** from the generation of the electricity (or steam or heating/cooling) **purchased and consumed** by the reporting organisation as kilograms of CO_2-e per unit of electricity consumed. Scope 2 emissions are physically produced by the burning of fuels (coal, natural gas, etc.) at the power station or facility.

o Following *The GHG Protocol*, scope 2 emissions are allocated to the organisation that owns or controls the plant or equipment where the electricity is consumed. The electricity consumer reports only the emissions from the electricity they use under scope 2, and reports the emissions associated with transmission and distribution (T&D) losses under scope 3. Companies that own or control T&D networks report the emissions associated with all T&D losses on their networks under scope 2.

- **Various emission factors** can be used to calculate **scope 3 emissions**. For ease of use, this workbook reports **specific 'scope 3' emission factors** for organisations that:

(a) burn fossil fuels: to estimate their indirect emissions attributable to the extraction, production and transport of those fuels; or

(b) consume purchased electricity: to estimate their indirect emissions from the extraction, production and transport of fuel burned at generation and the indirect emissions attributable to the electricity lost in delivery in the T&D network.

More broadly, scope 3 emissions can include:

- Disposal of waste generated (e.g. if the waste is transported outside the organisation and disposed of);
- Use of products manufactured and sold;
- Disposal (end of life) of products sold;
- Employee business travel (in vehicles or aircraft not owned or owned by the reporting organisation);
- Employees commuting to and from work;
- Extraction, production and transport of purchased fuels consumed;
- Extraction, production and transport of other purchased materials or goods;
- Purchase of electricity that is sold to an end user (reported by electricity retailer);
- Generation of electricity that is consumed in a T&D system (reported by end user);
- Out-sourced activities; and
- Transportation of products, materials and waste.

In many cases, emissions from these activities can be calculated with the emission factors provided in this document. For example, if a company decides to report on emissions from an off-site activity, and has the necessary data, then the direct (or point-source) emission factor could be used to calculate emissions, and these emissions would be reported as scope 3. For fuel use, the company would use the same direct emission factor to calculate scope 3 emissions from off-site combustion of a fuel as it would to calculate scope 1 emissions from on-site combustion of the same fuel.

- A **<u>'full fuel cycle emission factor'</u>** gives the quantity of emissions released per unit of energy for the entire fuel production and consumption chain. This term is not used in *The GHG Protocol*.

- For fuel combustion, the full fuel cycle emission factor is the sum of the direct emission factor for the fuel and the specific 'scope 3' emission factor for the emissions from the extraction, production and transport of the fuel.

- For the consumption of purchased electricity, the full fuel cycle emission factor is the sum of the 'scope 2' indirect emission factor for emissions from fuel combustion at the power station and the specific 'scope 3' emission factor for emissions from the extraction, production and transport of that fuel and for emissions associated with the electricity lost in T&D.

Which emissions factor to use?

Australian Government programmes often require organisations to consider the full greenhouse impact of their activities in terms of direct and indirect emissions (including upstream and downstream activities). For energy-related emissions in particular, organisations may use the appropriate emission factors for scopes 1, 2 and 3 to calculate both their direct and indirect emissions.

The **Online System for Comprehensive Activity Reporting (OSCAR)** automatically calculates emissions in the different scopes, using the latest emission factors as reported in this workbook.

The Greenhouse Challenge Plus Programme covers both direct and some indirect emissions.

- Transport fuel emissions under Greenhouse Challenge Plus are reported as scope 1 emissions from the combustion of the fuel only. OSCAR also calculates scope 3 emissions.
- All other fuel and energy use (including electricity) emissions are reported for the complete fuel cycle from extraction to consumption. Direct fuel combustion emissions are reported under scope 1, electricity consumption under scope 2, and indirect emission from fuel extraction are calculated with specific 'scope 3' emission factors.
- Waste emissions are calculated using consistent factors for off-site disposal - reported under scope 3.

1.1 Information sources

The principle sources of information used in developing this workbook include:

Australian Bureau of Agricultural and Resource Economics (2007) Fuel and Electricity Survey – Fuel Codes, www.abareconomics.com/publications_html/surveys/surveys/surveys.html, Commonwealth of Australia, Canberra.

Australian Bureau of Agricultural and Resource Economics (2007) Energy in Australia 2006, produced for Department of Industry, Tourism and Resources, pages 77-79, Commonwealth of Australia, Canberra.

American Petroleum Institute (2004) *Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Gas Industry 2004*.

Australian Greenhouse Office (2007a), *National Inventory Report 2005*, Commonwealth of Australia, Canberra.

Australian Greenhouse Office (2007b), *National Greenhouse and Energy Reporting System, Regulations Discussion Paper,* Commonwealth of Australia, Canberra

Australian Greenhouse Office (2006a), *AGO Factors & Methods Workbook*, December 2006, Commonwealth of Australia, Canberra.

Australian Greenhouse Office (2006b), *AGO Generator Efficiency Standards - Technical Guidelines*, December 2006, Commonwealth of Australia, Canberra.

Department of Climate Change (forthcoming), *National Inventory Report 2006*, Commonwealth of Australia, Canberra.

Department of Climate Change, (2007) Technical Guidelines for Estimation of Greenhouse Emission and Energy at Facility level, Commonwealth of Australia, Canberra.

Energy Supply Association of Australia (2007), *Electricity, Gas Australia 2007*.

Intergovernmental Report on Climate Change (2006), *2006 IPCC Guidelines for National Greenhouse Gas Inventories*; Japan.

Intergovernmental Report on Climate Change (2000), *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, Japan

Intergovernmental Report on Climate Change (1997), *1996 IPCC Guidelines for National Greenhouse Gas Inventories*; Japan.

International Aluminium Institute (2006), *The Aluminium Sector Greenhouse Gas Protocol, Addendum to the WRI/WBCSD GHG Protocol*.

International Energy Agency (2005), *Energy Statistics Manual*, 2005, Paris.

National Greenhouse Gas Inventory Committee (NGGIC) (2007), *Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006*, Commonwealth of Australia, Canberra.

US EPA, International Aluminium Institute (2003), *Protocol for Measurement of Tetrafluoromethane (CF_4) and Hexafluoroethane (C_2F_6) Emissions from Primary Aluminium Production*.

World Business Council for Sustainable Development / World Resources Institute, *The Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard*, Revised edition.

World Business Council for Sustainable Development, (2005), *CO_2 Accounting and Reporting Standard for the Cement Industry- The Cement CO_2 Protocol*, June 2005.

Wilkenfeld, George, and Associates Pty Ltd(forthcoming), *Australia's National Greenhouse Gas Inventory, End Use Allocation of Emissions*, Report to the Department of Climate Change, Commonwealth of Australia, Canberra.

1.2 Additional information and web sites

Greenhouse Challenge Plus Programme
www.greenhouse.gov.au/challenge

Australian National Greenhouse Gas Inventory and related topics
www.climatechange.gov.au/inventory/index.html

Intergovernmental Panel on Climate Change (IPCC) National Greenhouse Gas Inventories Programme
www.ipcc-nggip.iges.or.jp

United Nations Convention on Climate Change and related topics including the Kyoto Protocol
www.unfccc.int

The Greenhouse Gas Protocol Initiative (convened by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI))
www.ghgprotocol.org

National Greenhouse Accounts (NGA) Factors

1 Energy

This section addresses the estimation of emissions in the energy sector and includes emission factors for:

- the stationary combustion of solid, gaseous and liquid fuels (section 1.1);
- the mobile combustion of liquid and gaseous fuels for transport (section 1.2);
- the consumption of purchased electricity (section 1.3); and
- the extraction of fossil fuels (section 1.4).

The approach to calculating GHG emissions may depend on the programme or purpose for which they are being used and this should be confirmed, if necessary, prior to estimation.

1.1 Stationary energy emissions (non-transport)

1.1.1 Fuel combustion emissions (excluding natural gas)

The following formula can be used to estimate greenhouse gas emissions from the combustion of each type of fuel listed in Table 1. (For emissions from the consumption of *purchased* electricity, use Table 5.)

GHG emissions (t CO_2-e) = Q x EC x EF_{oxij} /1000

where: Q is the quantity of fuel in tonnes or thousands of litres (sourced from inventory or supplier invoices or production records),

EC is the energy content of fuel in GJ/tonne or GJ/kL in Column A, Table 1, and

EF_{oxij} is the relevant emission factor. Table 1 reports the emission factor for scope 1 (the direct/point source EF for fuel combustion emissions) (column B), the emission factor for scope 3 (the indirect EF for fuel extraction emissions) (column C) and the full fuel cycle emission factor (Column D) in kg CO_2-equivalent (CO_2-e) per GJ. The full fuel cycle emission factor is the sum of the emission factors for scope 1 and scope 3. Division by 1000 converts kg to tonnes.

Emissions are generally expressed in tonnes of CO_2-e, which includes CO_2 and the global warming effect of the relatively small quantities of CH_4 and N_2O emitted. Most of the emissions occur at the point of final fuel combustion, but there are also indirect emissions associated with the production and transport of the fuel. Organisations can apply the EF for scope 1 to calculate their direct emissions from fuel combustion, and the EF for scope 3 to calculate their indirect emissions associated with fuel extraction. For reporting under

Greenhouse Challenge Plus, emissions factors for scope 1 and scope 3 should be used to separately calculate and report direct and indirect emissions.

Separate calculations should be carried out for each fuel type.

Table 1: Fuel combustion emission factors (Stationary Energy)

Fuel combusted	Location	Energy content (gross) [a]	EF for scope 1	EF for scope 3 [b]	Full fuel cycle EF = B+C
		A	B	C	D
		GJ/t or GJ/kL	kg CO_2-e/GJ	kg CO_2-e/GJ	kg CO_2-e/GJ
Solid Fuels		**GJ/t**			
Black coal for electricity	NSW	22.5	89.3	8.7	98.1
Black coal for electricity	Queensland	21.4	91.1	2.0	93.1
Black coal for electricity	Western Australia	19.9	93.1	2.3	95.4
Black coal for electricity	South Australia	-	95.9	0.9	96.8
Lignite—Brown coal	All states	10.2	93.2	0.3	93.5
Coking coal (metallurgical coal)	All states	30.0	90.2	20.7	111.0
Black coal—uses other than for electricity and coking	All states	27.0	88.5	4.6	93.1
Brown coal briquettes	All states	22.1	93.6	10.7	104.3
Coke oven coke	All states	27.0	117.4	8.3	125.7
Industrial waste (tyres)	All states	26.3	80.1	NA	80.1
Municipal materials recycled for energy (non-biomass)	All states	10.5	87.2	NA	87.2
Wood/wood waste—non-residential uses [c]	All states	16.2	1.3	NA	1.3
Wood/wood waste — residential uses [c]	All states	16.2	15.6	NA	15.6
Sulphite lyes (black liquor) [c]	All states	12.4	0.7	NA	0.7
Bagasse (other primary solid biomass) [c]	All states	9.6	1.5	NA	1.5
Other primary solid biomass (other than bagasse) [c]	All states	12.2	1.8	NA	1.8
Charcoal [c]	All states	31.1	5.2	NA	5.2
Municipal materials recycled for energy (biomass) [c]	All states	12.2	1.8	NA	1.8

Fuel combusted	Location	Energy content (gross) [a]	EF for scope 1	EF for scope 3 [b]	Full fuel cycle EF = B+C
		A	B	C	D
		GJ/t or GJ/kL	kg CO_2-e/GJ	kg CO_2-e/GJ	kg CO_2-e/GJ
Liquid Fuels		GJ/kL			
Crude oil	All states	38.2	69.2	5.3	74.6
Other natural gas liquids	All states	46.5 GJ/t	60.7	5.3	66.0
Motor gasoline (petrol)	All states	34.2	67.1	5.3	72.4
Aviation gasoline	All states	33.1	66.7	5.3	72.0
Aviation turbine fuel (jet kerosene)	All states	36.8	69.1	5.3	74.5
Kerosene	All states	37.5	68.4	5.3	73.8
Heating oil	All states	37.3	69.0	5.3	74.4
Diesel (Automotive Diesel Oil)	All states	38.6	69.5	5.3	74.8
Fuel oil	All states	39.7	73.1	5.3	78.4
Lubricants and greases	All states	38.8	27.9	2.1	30.0
Liquefied aromatic hydrocarbons (benzene, toluene, and xylene)	All states	34.4	69.2	5.3	74.5
Solvents used for combustion	All states	34.4	69.2	5.3	74.5
Other petroleum products nec (including waste oils)	All states	34.4	69.2	5.3	74.5
Liquefied Petroleum Gas	All states	25.5	59.9	5.3	65.3
Naphtha	All states	31.4	69.0	5.3	74.4
Refinery feedstock	All states	40.8	69.2	5.3	74.5
Petroleum coke	All states	34.2 GJ/t	91.0	5.3	96.3
Refinery gas and liquids	All states	42.9 GJ/t	54.3	5.3	59.6
Refinery fuel - coke	All states	34.2/GJ/t	91.0	5.3	96.3
Biofuels					
Ethanol (molasses)[c]	All states	23.4	0.0	54.8	54.8
Ethanol (wheat starch waste)[c]	All states	23.4	0.0	54.5	54.5
Biodiesel (Canola) [c]	All states	23.4	0.0	62.1	62.1
Biodiesel (tallow) [c]	All states	23.4	0.0	57.2	57.2

Fuel combusted	Location	Energy content (gross) [a]	EF for scope 1	EF for scope 3 [b]	Full fuel cycle EF = B+C
		A	B	C	D
		GJ/t or GJ/kL	kg CO_2-e/GJ	kg CO_2-e/GJ	kg CO_2-e/GJ
Gaseous Fuels		**GJ/m^3**			
Natural Gas (incl. coal seam gas)	Refer to Table 2	39.3×10^{-3}	Refer to Table 2	Refer to Table 2	Refer to Table 2
Coal mine waste gas	All states	37.7×10^{-3}	56.7	NA	56.7
Coke oven gas	All states	18.1×10^{-3}	36.9	NA	36.9
Town gas	All states	39.0×10^{-3}	60.0	NA	60.0
Landfill gas [c]	All states	37.7×10^{-3}	4.8	NA	4.8
Sludge gas [c]	All states	37.7×10^{-3}	4.8	NA	4.8

Notes: All emission factors incorporate relevant oxidation factors.

a. Energy measured as gross calorific equivalent. b. The EF for scope 3 is indirect emissions from the extraction, production and transport of the specified fuel. c. Under international guidelines, the CO_2 released from combustion of biogenic carbon fuels is not reported under facility totals.

Sources: Department of Climate Change (2007).

Example: Calculation of Emissions Generated from diesel

An island resort located off the coast of Queensland uses 100 thousand litres (kL) of diesel for non-transport purposes each year. As a Greenhouse Challenge Plus member, emission factors for scope 1 and scope 3 should be used to calculate scope 1 direct combustion emissions and scope 3 indirect emissions as follows:

Scope 1 GHG Emissions (t) = Activity (KL) x Energy Content of Fuel (GJ/kL) x EF (kg CO_2-e/GJ) /1000

= (100 x 38.6 x 69.5)/1000= 268 t CO_2-e

Scope 3 GHG Emissions (t) = Activity (t) x Energy Content of Fuel (GJ/t) x EF (kg CO_2-e/GJ) /1000

= (100 x 38.6 x 5.3)/1000= 21 t CO_2-e

1.1.2 Gaseous fuels

Natural gas is usually supplied at either high or low pressure, depending on the scale of use. Major users are those supplied at high pressure and with an annual usage of more than 100,000 gigajoules. Estimates of Scope 3 and full fuel cycle emissions may be calculated using the following formula:

Emissions (tonnes CO_2-e) = $Q \times EF_{oxij}$ / 1000

where:

Q is the quantity of natural gas consumed and expressed in GJ and sourced from supplier invoices/meters

EF_{oxij} is the relevant emission factor from the Table below, by state and territory, and for small users and large users, incorporating oxidation effects

Division by 1000 converts kilograms to tonnes.

Small users are defined as consuming less than 100,000 gigajoules per year.

Table 2: Emission factors for the consumption of natural gas

State or territory	Small User			Large User		
	EF for scope 1	EF for scope 3	Full fuel cycle EF =A+B	EF for scope 1	EF for scope 3	Full fuel cycle EF =A+B
	A	B	C	D	E	F
	kg CO_2-e/GJ	kg CO_2-e/GJ	kg CO_2-e/GJ	kg CO_2-e/GJ	kg CO_2-e/GJ	kg CO_2-e/GJ
Gaseous Fuels						
Natural gas - New South Wales and ACT	51.3	14.8	66.1	51.3	14.2	65.5
Victoria	51.3	5.9	57.3	51.3	5.8	57.1
Queensland	51.3	6.0	57.3	51.3	5.4	56.8
South Australia	51.3	19.4	70.7	51.3	18.6	69.9
Western Australia	51.3	7.6	58.9	51.3	7.0	58.3
Tasmania	51.3	-	-	51.3	5.8	57.1
Northern Territory	51.3	5.7	57.1	51.3	5.7	57.0

Source: Department of Climate Change (2007). Notes: All emission factors incorporate relevant oxidation factors. a. Energy measured as gross calorific equivalent. b. The EF for scope 3 is indirect emissions from the extraction, production and transport of the specified fuel. c. Under international guidelines, the CO_2 released from combustion of biogenic carbon fuels is not reported under facility totals.

Under the **Greenhouse Challenge Plus** and **Greenhouse Friendly Certification**, *emissions factors for scope 1 and scope 3* should be used to separately report direct and indirect emissions (either columns A and B or columns D and E depending on the size of the user).

Example: Calculation of Emissions Generated from Natural Gas Consumption

A New South Wales retailer uses 9000 GJ of natural gas each year. Its emissions are calculated as follows:

Scope 1 GHG Emissions = Q x EF / 1000 = 9000 x 51.3 / 1000 = 462 t CO_2-e

Scope 3 GHG Emissions = Q x EF / 1000 = 9000 x 14.8 / 1000 = 133 t CO_2-e**.**

1.2 Transport fuels

Estimates of emissions from the consumption of transport fuels may be estimated with the following formula:

GHG emissions (t CO_2-e) = Q (kL) x EF_{oxij}

OR

GHG emissions (t CO_2-e) = Q (GJ) x EF_{oxij} / 1000

where: Q is the quantity of fuel in thousands of litres or GJ (sourced from inventory or supplier invoices or production records).

EF_{oxij} is the relevant emission factor. Emission factors for combustion of transport fuels are reported in Table 3 in both kg CO_2-e per GJ and tonnes of CO_2-e per kL. These comprise scope 1 (point source/fuel combustion) emission factors (Columns B or C), scope 3 (indirect/fuel extraction) emission factors (columns D or E) and the full fuel cycle emission factors (Columns F or G), all including CO_2 and non-CO_2 gases. For reporting under **Greenhouse Challenge Plus**, emissions factors for scope 1 and scope 3 should be used to separately calculate and report direct and indirect emissions. Division by 1000 converts kg to tonnes.

Table 3: Fuel combustion emission factors (Transport Fuels)

Fuel	Energy content	EF for scope 1		EF scope 3		Full fuel cycle emission factor [d]	
	A	B	C	D	E	F	G
	GJ/kL	kg CO_2-e/GJ	t CO_2-e/kL	kg CO_2-e/GJ	t CO_2-e/kL	kg CO_2-e/GJ	T CO_2-e/kL
Motor gasoline (petrol)	34.2	67.0	2.3	5.3	0.2	72.3	2.5
Diesel (Automotive Diesel Oil)	38.6	69.8	2.7	5.3	0.2	75.2	2.9
Aviation gasoline	33.1	67.1	2.2	5.3	0.2	72.4	2.4
Aviation turbine	36.8	69.6	2.6	5.3	0.2	74.9	2.8
Fuel oil	39.7	73.5	3.0	5.3	0.2	78.9	3.2
Liquefied petroleum gas	26.2	60.2	1.6	5.3	0.1	65.5	1.7
Biofuels							
Ethanol (molasses)[b]	23.4	0.4	0.0	54.8	1.3	54.8	1.3
Ethanol (wheat starch waste)[b]	23.4	0.4	0.0	54.5	1.3	54.5	1.3
Biodiesel (Canola) [b]	23.4	0.4	0.0	62.1	1.5	62.5	1.5
Biodiesel (tallow) [b]	23.4	0.4	0.0	57.2	1.3	57.6	1.3
	GJ/m³		t CO_2-e/m³	kg CO_2-e/GJ	t CO_2-e/m³	kg CO_2-e/GJ	t CO_2-e/m³
Natural gas (LDV) [c]	0.0393	57.0	0.0022	11.4	0.0005	68.4	0.0027
Natural gas (HDV) [c]	0.0393	53.6	0.0021	11.4	0.0005	65.0	0.0026

Source: Department of Climate Change 2007, Table 78.

Notes: All emission factors incorporate relevant oxidation factors (sourced from the DCC's National Inventory Report). a The emission factors for natural gas engines are indicative only. Many natural gas engines, whether dual fuel or dedicated, emit significant amounts of unburnt fuel to the atmosphere. This level of methane is dependent on a range of factors and varies from system to system. An accurate emissions factor therefore requires measurement of at least CO_2 and CH_4 for each engine type. b. Under international guidelines, the CO_2 released from combustion of biogenic carbon fuels is not reported under energy combustion. DCC estimates, derived from 'Appropriateness of a 350 Million Litre Biofuels Target', December 2003, CSIRO, ABARE, BTRE. The emission factors reported here are default factors - to be used in the absence of better data on emissions that may result, for example, on actual production methods employed. c. LDV stands for Light Duty Vehicles, e.g. forklifts, and HDV stands for Heavy Duty Vehicles, e.g. buses.

Under **Greenhouse Challenge Plus** and **Greenhouse Friendly Certification**, *emissions factors for scopes 1 and 3* (either column B and D or C and E depending on fuel data units) should be used to separately report direct and indirect emissions.

Example: Calculation of emissions generated from transport fuels consumed

A New South Wales freight company consumes 2000 kL of petrol and 3000 kL automotive diesel (transport) per annum. The scope 1 direct GHG emissions are calculated as follows:

Emissions (t CO_2-e) = Q (kL) x EF (t CO_2-e/kL)

Petrol scope 1 GHG emissions = 2,000 x 2.3 = 4,600 t CO_2-e

Diesel scope 1 GHG emissions = 3,000 x 2.7 = 8,100 t CO_2-e

Total scope 1 GHG emissions = 4,600 + 8,100 = 12,700 t CO_2-e

1.3 Explosives

The use of explosives in mining leads to the release of greenhouse gases. The activity level is the mass of explosive used (in tonnes). Emissions are calculated using the EFs from Table 4.

Table 4: Industrial Processes emission factors for explosive use

Emission factor for scope 1	
Explosive type	**Tonne CO_2/tonne product**
ANFO	0.17
Heavy ANFO	0.18
Emulsion	0.17

Source: AGO 2006a.

1.4 Indirect emissions (electricity end use)

Indirect emission factors for the consumption of purchased electricity are provided in Table 5. (Emission factors for the burning of fuel to generate electricity are reported in Tables 1 and 2.) Following the international reporting framework of the World Resources Institute/World Business Council for Sustainable Development - known as *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard* ('*The GHG Protocol*') - this section provides factors for both 'scope 2' and 'scope 3' categories.

State emissions factors are used because electricity flows between states are constrained by the capacity of the inter-state interconnectors and in some cases there are no interconnections. The factors estimate emissions of CO_2, CH_4 and N_2O expressed together as carbon dioxide equivalent (CO_2-e). The greenhouse gas emissions in tonnes of CO_2-e attributable to the quantity of electricity used may be calculated with the following equation.

GHG emissions (t CO_2-e) = Q x EF / 1000

where: Q (Activity) is the electricity consumed by the reporting organisation expressed in kWh, and

EF is the relevant emission factor expressed in kg CO_2-e/kWh in Columns A, C and E, Table 5.

<u>**OR**</u>

GHG emissions (t CO_2-e) = Q x EF / 1000

where: Q (Activity) is the electricity consumed expressed in GJ, and

EF is the relevant emission factor expressed in kg CO_2-e/GJ in Columns B, D and F, Table 5.

Emission factors are reported for scope 2, scope 3 and the full fuel cycle (the sum of scope 2 and scope 3). The emission factor for scope 2 covers emissions from fuel combustion at power stations associated with the consumption of purchased electricity from the grid.

The emission factor for scope 3 covers both the emissions from the extraction, production and transport of fuels used in the production of the purchased electricity (i.e. fugitive emissions and stationary and mobile fuel combustion emissions) and also the emissions associated with the electricity lost in transmission and distribution on the way to the consumer (from both fuel combustion and fuel extraction)—see the *Technical Guidelines* for more details on the emission factor definitions.

Greenhouse Challenge Plus members should use the factors to separately calculate and report their scope 2 and scope 3 emissions.

Division by 1000 converts kg to tonnes.

Table 5: Indirect emission factors for consumption of purchased electricity from the grid—for end users (not distributors)

Financial year	EF for scope 2		EF for scope 3		Full fuel cycle EF (EF for scope 2+EF for scope 3)	
	A	B	C	D	E	F
	kg CO_2-e/kWh	kg CO_2-e/GJ	kg CO_2-e/kWh	kg CO_2-e/GJ	kg CO_2-e/kWh	kg CO_2-e/GJ
NSW and ACT	0.89	249	0.17	47	1.06	295
VIC	1.22	340	0.08	23	1.31	364
QLD	0.91	252	0.13	37	1.04	289
SA	0.84	233	0.14	39	0.98	272
WA (SWIS)	0.87	242	0.10	29	0.98	271
TAS	0.12	35	0.01	2	0.13	37
NT	0.69	190	0.11	30	0.79	221

Source: Department of Climate Change 2007.

Notes: a The emission factors should be applied to the amount of electricity actually consumed (i.e. the amount shown on the electricity bill). b kg CO_2-e/GJ is the same as kt CO_2-e/PJ and Gg CO_2-e/PJ. Transmission and distribution (T&D) network operators should refer to the footnote in appendix 3.

Example:

A company in New South Wales consumes 100,000 kWh of purchased electricity from the grid.

Scope 2 GHG Emissions (t CO_2-e) = (100,000 x 0.89) / 1000 = 89 tonnes.

Scope 3 GHG Emissions (t CO_2-e) = (100,000 x 0.17) / 1000 = 17 tonnes.

1.5 Extraction and distribution of coal, gas and petroleum

Coal

Emissions from the production of coal may be estimated from the following formula:

GHG Emissions (tCO_2-e) = (Q x EF (CO_2-e)/1000) - Erec

where: Q (Activity) is the mass of fuel produced (tonnes), and

EF is the relevant scope 1 (point source) emission factor in kg CO_2-e /tonne in Column C of Table 6 below. Division by 1000 converts kg to tonnes. The CO_2-e estimate (Column C) is the sum of CO_2 (Column A) and CH_4 (represented as CO_2-e in Column B).

Erec is the emissions recovered and utilised for energy production or flared

Table 6: Emission factors for the production of coal (fugitive)

Activities related to extraction of coal (fugitive)	Emission factor (kg CO_2-e/ tonne raw coal)		
	CO_2	CH_4	CO_2-e
	A	B	C
Coal			
Class A (Gassy) underground mines—NSW	NA	305.3	305.3
Class A (Gassy) underground mines—Queensland	NA	305.3	305.3
Class B (Non-gassy) underground mines	NA	8.4	8.4
Open cut mines—NSW	NA	45.5	45.5
Open cut mines—Queensland	NA	17.1	17.1
Open cut mines—Tasmania	NA	14.2	14.2
Open cut mines—Other	NA	0.0	0.0

Source: Department of Climate Change 2007.

Post Mining Activities

Fugitive emissions of methane from mined coal take account of the *in situ* content of the methane that escapes post-mining. Reporters that engage in the production of coal may estimate emissions from this source using the NGA default methodology:

$E_a = Q \times EF / 1000$

where:

E_a is the estimated emissions in tonnes of CO_2-e
Q is the mass of raw coal produced (tonnes)
EF is the emission factor in kilograms CO_2-e per tonne in Table 6
Division by 1000 converts kilograms to tonnes

Post-mining emissions are associated with bituminous black coal mined in underground Class A (gassy) mines but not with black coal mined in underground Class B (non-gassy) mines, open cut mines or with brown coal (NGGIC, 2007).

Table 7: Post-mining activities—emission factors

Post-mining activities	Emission factor (kg CO_2-e/ tonne raw coal)		
	CO_2	CH_4	CO_2-e
	A	B	C
Coal			
Post mining activities associated with gassy underground mines	NA	13.9	13.9

Source: Department of Climate Change 2007.

Petroleum and gas

Emissions from the production of petroleum and gas may be estimated from the following formula:

GHG Emissions (tCO_2-e) = Q x EF (CO_2-e)/

where: Q (Activity) is the mass of throughput in tonnes, PJ of oil transported or stored, or TJ of gas and

EF is the relevant scope 1 (point source) emission factor in tonnes CO_2-e / unit of activity

Table 8: Oil exploration—NGA default emission factors

Operation or process source	Emission factor (tonnes CO_2-e/tonnes throughput)			
	CO_2	CH_4	N_2O	CO_2-e
Mobile offshore and land based drilling units				
Production testing				
Gas flared	2.8	0.7	0.03	3.5
Liquid flared	3.2	0.007	0.07	3.3

Source: Department of Climate Change 2007.

Table 9: Oil production (other than venting and flaring) —NGA default emission factors

Operation or process source	Emission factor (tonnes CO_2-e/tonnes throughput)	
	CH_4	CO_2-e
Fugitive emissions		
Internal floating tank	8.4×10^{-7}	8.4×10^{-7}
Fixed roof tank	4.2×10^{-6}	4.2×10^{-6}
Floating tank	3.2×10^{-6}	3.2×10^{-6}
General leaks	1.2×10^{-3}	1.2×10^{-3}

Source: Department of Climate Change 2007.

Table 10: Oil transport—NGA default emission factors

Operation or process source	Emission factor (tonnes CO_2-e/PJ of oil tankered)	
	CH_4	CO_2-e
Crude oil transport (domestic)	15.7	15.7

Source: Department of Climate Change 2007. The crude oil transport subsector includes methane emissions associated with the marine, road and rail transport of crude oil. Emissions result largely from three types of activities: loading, transit, and ballasting

Table 11: Oil refining and storage—NGA default emission factors

Operation or process source	Emission factor (tonnes CO_2-e/PJ oil)	
	CH_4	CO_2-e
Crude oil refining	15.7 tonnes CO_2-e per PJ of oil refined	15.7 tonnes CO_2-e per PJ of oil refined
Crude oil storage	2.9 tonnes CO_2-e per PJ of oil stored	2.9 tonnes CO_2-e per PJ of oil stored

Source: Department of Climate Change 2007.

Table 12: Refinery gas flaring—NGA default emission factors

Operation or process source	Emission factor (tonnes CO_2-e/tonnes flared)			
	CO_2	CH_4	N_2O	CO_2-e
Flares	2.7	0.1	0.03	2.9

Source: Department of Climate Change 2007.

Table 13: Natural gas production and processing—NGA default emission factors

Operation or process source	Emission factor (tonnes CO_2-e/tonnes throughput)	
	CH_4	CO_2-e
Natural gas production and processing (other than venting and flaring) Fugitive emissions —Internal floating tank	8.4×10^{-7}	8.4×10^{-7}
Fixed roof tank	4.2×10^{-6}	4.2×10^{-6}
Floating tank	3.2×10^{-6}	3.2×10^{-6}
General leaks	1.2×10^{-3}	1.2×10^{-3}

Source: Department of Climate Change 2007.

Table 14: Natural gas transmission—NGA default emission factors

Operation or process source	Emission factor (tonnes CO_2-e/km pipeline length)		
	CO_2	CH_4	CO_2-e
Natural gas transmission	0.02	8.7	8.7

Source: Department of Climate Change 2007. Transmission mains are defined as high-pressure pipelines greater than 1050 kilopascals, as used in the Energy Supply Association of Australia natural gas statistics.

Natural gas distribution—UNFCCC Category 1.B.2.b.iv

The boundary between natural gas transmission and distribution is generally taken to be the city gate regulator stations at which gas pressures are reduced from transmission pressures to sub-transmission pressures. For the purposes of this methodology, natural gas distribution comprises low, medium and high-pressure reticulation ≤ 1050 kilopascals.

Greenhouse gases emitted from utility pipeline systems are estimated from the following equation:

$$E = S_p \times \%UAG_p \times 0.55 \times C_{i,p}$$

Where:

E is the total mass of greenhouse gas emitted from the gas distribution system in utility pipelines system (in tonnes CO_2-e)

S is the total gas utility sales from the pipeline system (in terajoules)

%UAG is the percentage of unaccounted for gas in a state’s pipeline system, relative to the amount issued annually by gas utilities (see Table 15)

C is the natural gas composition factor for natural gas supplied from the state pipeline system (in tonnes CO_2-e per terajoule) (see Table 15)

0.55 represents the portion of unaccounted for gas allocated as leakage (Department of Climate Change forthcoming).

Table 15: Natural gas combustion emission factors and unaccounted for gas loss factors

State	Unaccounted for gas (a)%	Natural gas composition factor (a)(tonnes CO_2-e/TJ)	
	UAG	CO_2	CH_4
NSW and ACT	2.40	0.8	328
VIC	2.75	0.9	326
QLD	2.63	0.8	317
SA	4.00	0.8	328
WA	2.55	1.1	306
NT	0.10	0.0	264
TAS	0.40	0.9	326

Source: Department of Climate Change 2007.

Table 16: Flaring—NGA default emission factors

Operation or process source	Emission factor (tonnes CO_2-e/tonnes flared)			
	CO_2	CH_4	N_2O	CO_2-e
Flares	2.9	0.7	0.03	3.7

Department of Climate Change 2007.

2 Industrial processes including use of synthetic gases)

Greenhouse gas emissions from industrial processes other than from combustion of fuels for energy may be estimated by using the emission factors described in this section. These emission factors are national average emissions factors and can be used in the absence of plant- or company-specific data.

2.1 Mineral, chemical and metal products

Table 17: Industrial processes-emission factors and activity data

Source	Emission factor for scope 1 CO_2-e by gas (t) (direct / point source EF)						Activity data required
	CO_2	CH_4	N_2O	PFC	SF_6	CO_2-e	
	A	B	C	D	E	F	
Cement clinker (plus cement kiln dust lost)	0.534					0.534	Q= clinker produced (plus the quantity of cement kiln dust calcined) (t)
Commercial lime production	0.675					0.675	Q= commercial lime produced (t)
In-house lime production	0.730					0.730	Q= In-house lime produced (t)
Limestone use	0.396					0.396	Q= limestone used (t)
Dolomite use	0.453					0.453	Q= dolomite used (t)
Soda ash use	0.415					0.415	Q= soda ash used (t)
Aluminium production	1.59			(CF_4) 0.26 (C_2F_6) 0.05		1.89	Q= aluminium produced (t)
Iron & Steel – crude steel production		0.009				0.009	Q= crude steel (t)

Note: a. See explanation below under heading 'Emission from reductant use in iron and steel production'. b. Clinker emission factor also accounts for total organic carbon in the raw meal. Source: Department of Climate Change 2007.

The general methodology employed to estimate emissions associated with each industrial process involves the product of activity level data, e.g. amount of material produced or consumed, and an associated emission factor per unit of consumption/production according to:

$$E_j = Q_j \times EF_j$$

where:

E_j is the process emission (t/yr) of CO_2-e from industrial sector *j*,

$\mathbf{Q_j}$ is the amount of activity or production of process material in industrial sector *j* (tonnes/yr unless otherwise specified), and

$\mathbf{EF_j}$ is the relevant emission factor in t CO_2-e per tonne of production in Column F, Table 17.

Example: **Calculation of emissions generated from cement clinker production**

A company produces 20,000 tonnes of cement clinker and 130 tonnes of cement kiln dust is lost per annum. The GHG emissions are calculated as follows:

Emissions (t CO_2-e) = (Q x EF)

Clinker production = 20,000 tonnes

Cement kiln dust production = 130 tonnes

Clinker emission factor (t/t) = 0.534

Cement kiln dust emission factor (t/t) = 0.534

CO_2-e emissions (t) = (20,000 x 0.534) + (130 x 0.534) = 10,749 tonnes CO_2-e each year

2.2 Synthetic gases

Table 18: Industrial Processes emission factors and activity data for synthetic gases

Equipment type	Default annual loss rates	
	HFCs	SF_6
Commercial air conditioning—chillers	0.09	
Commercial refrigeration - supermarket systems	0.23	
Industrial refrigeration including food processing and cold storage	0.16	
Gas insulated switchgear and circuit breaker applications		0.005 [a]

Source: IPCC 2006. a Department of Climate Change 2007.

Example: Calculation of emissions generated from the operation of a commercial chiller

A company operates a commercial air conditioning-chiller, which contains 160 kg charge of HFC134a.

Applying the annual leakage rate of 0.09 (i.e. 9%) gives:

An annual loss of HFC134a (kg) = 0.09 x 160 kg = 14.4 kg of HFC134a.

Multiplying the 14.4 kg of HFC134a by its global warming potential of 1300 (from Appendix 3), gives a total annual emission of 19 tonnes of CO_2-e.

3 Waste to landfill and wastewater treatment

3.1 Introduction

Estimates of Scope 3 greenhouse gas emissions associated with the disposal of waste can be calculated by the formula, data variables and emission factors contained in Tables 19 to 22. Separate calculations should be carried out for each waste type.

Methane (CH_4) vented to the atmosphere is considered an emission as this action would be adding to atmospheric CH_4. The emissions are multiplied by 21 to calculate the carbon dioxide equivalent (CO_2-e) emissions.

Where methane from waste biomass is recovered and flared or combusted for energy, the CO_2 emitted is not counted as an emission but regarded as part of the natural carbon cycle. The total amount of CH_4 recovered is therefore regarded as saved (not emitted) so long as it does not enter the atmosphere as CH_4.

Where waste material is diverted from landfill to recycling or to energy use, the reporting organisation will have less emissions attributed to its activities because less waste is going to landfill.

3.2 Municipal solid waste

Municipal solid waste that is ultimately disposed of in a well-managed landfill is estimated to produce methane in accordance with the formula:

GHG Emissions (t CO_2-e) = $[((Q \times DOC \times DOC_F \times F_1 \times 16/12) - R) \times (1 - OX)] \times 21$

$= [(Q \times DOC) / 3 - R)] \times 18.9$, using default values in Table 19

Table 19: Waste variables and default values

Variable	Default values
Q (Activity)	Quantity of municipal solid waste expressed in tonnes and sourced from waste records or contractor invoices
DOC	Degradable Organic Carbon expressed as a proportion of the particular waste type and contained in Table 20.
DOC_F	Fraction of degradable organic carbon dissimilated for the waste type produced with a default value of 0.5.
F_l	Carbon fraction of landfill gas which has a default value of 0.50
16/12	Conversion rate of carbon to methane
R	Recovered methane from wastewater in an inventory year, measured/expressed in tonnes
OX	Oxidation factor which has a default value of 0.1 for covered, well-managed landfills (and a value of 0 for uncovered landfills)
21	CH_4 global warming potential used to convert the quantity of methane emitted to CO_2-e from the quantity of waste produced

Note: The CH_4 recovered must be subtracted from the amount generated before applying the oxidation factor because only the landfill gas that is not captured is subject to oxidation.

Table 20: Waste mix methane conversion factors

Waste types	**Default DOC proportion**	**Conversion factor CO_2-e (t=tonnes)**
	A	B
Paper and paper board	0.4	t x 2.5
Textiles	0.24	t x 1.5
Textiles synthetics	0	t x 0
Wood and straw	0.43	t x 2.7
Garden and park	0.2	t x 1.3
Food	0.15	t x 0.9
Co-mingled	0.15	t x 0.9
Medical waste (tissue, fluids, pharmaceuticals)	0.05	t x 0.3
Concrete/metal/plastics/glass	0	t x 0

Note: Source National Greenhouse Gas Inventory Committee (2006). The proportions represent the quantity of DOC of the various waste types in the mix that may be available for conversion to methane.

If waste is measured by volume and not by weight, conversion factors are available in Appendix 2.

Organisations that do not know the composition of their waste can use Table 21, which gives the weighted average emission factors for the municipal, commercial and industrial, and construction and demolition waste categories. These are simplified categories only for organisations that do not have their own waste mix data.

Table 21: Waste emission factors for total waste disposed to landfill by broad waste stream category

Waste types	**Municipal solid waste**	**Commercial and industrial waste**	**Construction and demolition waste**
	A	**B**	**C**
Emission factor (t CO_2-e/t waste)	1.11	1.66	0.25

Note: Organisations that have data on their own waste streams and waste mix should use that data.

Sources: Derived from Department of Climate Change forthcoming.

Example: Calculation of emissions generated from solid waste

A higher education facility produced a total solid waste stream of 240 tonnes which was disposed of in the local landfill. This waste comprises 140 tonnes of food waste, 50 tonnes of paper/paper board, 10 tonnes of garden and park waste and 40 tonnes of concrete/metal/plastic/glass waste. No methane (R) was recovered. As each waste stream needs to be treated separately, their greenhouse gas emissions (GHG) are calculated as follows:

GHG emissions (t CO_2-e) = Qt x EF (Table 14, Column B)

Food = 140 x 0.9 = 126 tonnes CO_2-e

Paper = 50 x 2.5 = 125 tonnes CO_2-e

Garden = 10 x1.3 = 13 tonnes CO_2-e

Plastic/Glass = 40 x 0 = 0 tonnes CO_2-e

Total Waste GHG emissions = 264 t CO_2-e

Example: Calculation of emissions generated from waste of unknown composition

A commercial company in the finance industry disposes 1 kilotonne of waste.

GHG emissions (t CO_2-e) = Q x EF (Table 21, Column B) = 1000 t x 1.66 = 1660 t CO_2-e

3.3 Municipal wastewater treatment

Total greenhouse gas emissions from municipal wastewater are the sum of emissions from wastewater treatment and sludge treatment. The total quantity of wastewater treated depends on the population that is generating wastewater.

The following formula should be used to measure the CO_2-e emissions from treating municipal wastewater. This formula is most relevant to local government authorities.

GHG Emissions (t CO_2-e) = $[(((P \times DC_w) \times (1 - F_{sl}) \times Fan \times EF_w)) + (P \times DC_w \times F_{sl} \times Fan_{sl} \times EF_{SL})) - R] \times 21$

The parameters used in the above equation are explained in Table 22 together with a listing of the various default values.

Example: Calculation of emissions generated from municipal wastewater

A local government wastewater treatment plant services a population of 20,000 people. Based on internal records, the average amount of BOD that is removed as sludge is 0.54. The treatment plant does not recover any methane. Their CO_2-e greenhouse gas emissions are calculated as follows:

BOD calculation:

BOD_w (tonnes) = Population x DC_w / 1000

= 20,000 x 22.5/1000

= 450 tonnes BOD

Emissions from wastewater treatment calculation:

GHG emissions (tonnes CO_2-e) = BOD x (1-F_{sl}) x Fan x EF_w x 21

= 450 x (1-0.54) x 0.8 x 0.65 x 21

= 2260 tonnes CO_2-e

Emissions from sludge calculation:

GHG emissions (tonnes CO_2-e) = BOD x F_{sl} x EF_{sl} x 21 = 450 x 0.54 x 0.29 x 0.65 x 21

= 962 tonnes CO_2-e

Total emissions:

Sum of wastewater (minus recovery) and sludge GHG emissions = 3222 tonnes CO_2-e

Table 22: Municipal waste variables and default values

Variable	Default values
P	The population served and measured in 1000 persons and sourced from waste treatment records
DC_w	The quantity in kilograms of Biochemical Oxygen Demand (BOD) per capita per year of wastewater. In the event that no waste analysis data is available, a default value of 22.5 kg per person per year can be used
BOD_w	Biochemical Oxygen Demand (BOD) in kilograms of BOD per year which is the product of DC_w and population
F_{sl}	Default fraction of BOD removed as sludge. Should be readily available from internal records of wastewater treatment plants (default value of 0.54)
EF_w	Default methane emission factor for wastewater with value of 0.65 kg CH_4/kg BOD
EF_{sl}	Default methane emission factor for sludge with value of 0.65 kg CH_4/kg BOD (sludge)
Fan	Fraction of BOD anaerobically treated. This value varies according to wastewater treatment type. IPCC defaults are: Managed aerobic treatment – 0 Unmanaged aerobic treatment – 0.3 Anaerobic digester/reactor – 0.8 Shallow anaerobic lagoon (<2 metres) – 0.2 Deep anaerobic lagoon (>2 metres)– 0.8
Fan $_{sl}$	Fraction of sludge BOD treated anaerobically (default value of 0.29)
CH_4 - GWP	21 – the Global Warming Potential of CH_4 used to convert the CH_4 emitted from wastewater to CO_2-e
R	Recovered methane from wastewater in an inventory year, measured/expressed in tonnes

3.4 Industrial wastewater treatment

Total greenhouse gas emissions from industrial wastewater are the sum of emissions from wastewater treatment and sludge treatment and depends on the quantity of output produced.

If your organisation operates an industrial wastewater treatment plant then the following formula should be used to estimate its greenhouse gas emissions. Emissions from industrial wastewater are estimated based on its organic content, measured as Chemical Oxygen Demand (COD). This enables the quantity of degradable carbon to be derived, which is the determinant of the quantity of CH_4 emitted.

Total GHG Emissions (t CO_2-e)

$= [(Prod \times W_{gen} \times COD_{con} \times (1 - F_{sl}) \times Fan \times EF_w) + (Prod \times W_{gen} \times COD_{con} \times F_{sl} \times EF_{sl}) - R] \times 21 / 1000$

$= [Prod \times W_{gen} \times COD_{con} \times ((1 - F_{sl}) \times Fan \times EF_w + F_{sl} \times EF_{sl}) - R] \times 21 / 1000$

If a company does not have any company-specific data on the fraction of degradable organic component removed as sludge (F_{sl}) and emission factors (EF_w and EF_{sl}), a simplified alternative formula for Industrial Wastewater (including sludge) emissions may be used:

Total GHG Emissions (t CO_2-e) $= [Prod \times W_{gen} \times COD_{con} \times 0.1949 - R] \times 21 / 1000$

Without the variable Prod, the above equations give emissions in tonnes of CO_2-e per tonne of output. The parameters used in the equations are explained in Table 23 together with a listing of the various default values.

Table 23: Industrial waste variables and default values

Variable	Default values
Prod	Total production of goods in tonnes.
W_{gen}	Wastewater generation rate in cubic metres (m^3) or kilo litres (kL) per tonne of product. Sourced from company discharge and production data. (1 m^3 of water = 1 kL)
COD_{con}	Chemical Oxygen Demand (COD) concentration in kilograms of COD per m^3 (or kL) of wastewater sourced from company discharge and production data.
COD	Chemical Oxygen Demand in kilograms, which is a measure of the organic content of the wastewater and is the product of Prod, W_{gen} and COD_{con}. i.e. COD (kg) = Prod (t) x W_{gen} (m^3/t or kL/t) x COD_{con} (kg/m^3 or kg/kL).
F_{sl}	Default fraction of degradable organic component removed as sludge. Should be readily available from internal records of wastewater treatment plants (default value of 0.15).
EF_w	Methane emission factor for industrial wastewater (default value of 0.25 kg CH_4/kg COD).
Fan	Fraction of BOD anaerobically treated. This value varies according to wastewater treatment type. IPCC defaults are: Managed aerobic treatment – 0 Unmanaged aerobic treatment – 0.3

Variable	Default values
	Anaerobic digester/reactor – 0.8 Shallow anaerobic lagoon (<2 metres) – 0.2 Deep anaerobic lagoon (>2 metres)– 0.8
EF_{sl}	Methane emission factor for industrial wastewater sludge (default value of 0.25 kg CH_4/kg COD (sludge)).
R	Recovered methane from wastewater in an inventory year, measured/expressed in tonnes.
21	Global Warming Potential of CH_4 used to convert the CH_4 emitted from wastewater to carbon dioxide equivalent (CO_2-e).

Example 1: Calculation of emissions generated from industrial wastewater

An industrial wastewater treatment plant produces 26 m^3 of wastewater per one tonne of product. Internal records show that the Chemical Oxygen Demand concentration (COD_{con}) has a value of 3.0 kg per m^3 of wastewater. Approximately 5% of the COD is removed as sludge. Consequently, for each tonne of output, methane emissions (with no recovery) are converted to CO_2-e in tonnes from:

GHG Emissions (t CO_2-e/t of product)

$= [(W_{gen} \times COD_{con} \times (1 – F_{sl}) \times Fan \times EF_w) + (W_{gen} \times COD_{con} \times F_{sl} \times EF_{sl}) – R] \times 21 / 1000$

$= 26 \times [((3 \times (1 – 0.05) \times 0.3 \times 0.25) + (3 \times 0.05 \times 0.25)) – R] \times 21 / 1000$

= 0.138 tonnes of CO_2-e per tonne of product

COD calculation:

For 1 t of product, COD (kg) = Production x Wastewater generation rate x COD concentration

= 1 x 26 x 3

= 78 kg COD

Emissions from wastewater treatment calculation:

GHG Emissions (kg CO_2-e/t of product) = COD x (1 – F_{sl}) x Fan x EF_w x 21

= 78 x (1 – 0.05) x 0.3 x 0.25 x 21

= 117 kg CO_2-e per tonne of product

Emissions from sludge calculation:

GHG Emissions (kg CO_2-e/t of product) = COD x F_{sl} x EF_{sl} x 21

= 78 x 0.05 x 0.25 x 21

= 21 kg CO_2-e per tonne of product

Total emissions:

Total GHG emissions per tonne of product

= 138 kg CO_2-e per tonne of product

Example 2: Calculation of emissions generated from industrial wastewater

A company treats 312 ML wastewater in-house annually. The wastewater passes through a series of treatment tanks.

COD concentrations vary through the system and average the following values. (Note that in this example COD_{con} is expressed in mg/L, which is the same as kg/ML, rather than in kg/kL as above.)

Tank		COD_{con} in mg/L (kg/ML)
1	Tank 1	11026
2	Anaerobic	3125
3	Anaerobic	1198
4	Aerated (aerobic)	1000
5	Settling Pond	867
6	Storage 1	441
7	Storage 2	367

The wastewater leaves the Tank 1 at 11,026 mg/L. The anaerobic process reduces the COD concentration from 11,026 to 3125 mg/L. The sludge remains in each different treatment pond and is settled in a settling pond. The ponds have not been cleaned out since the plant commenced 10 years ago.

1. The wastewater leaves Tank 1 and enters the anaerobic stage at a concentration of 11026 mg/L.

2. The wastewater leaves the anaerobic stage and enters the next anaerobic stage at a concentration of 3125 mg/L. This means that 11026 – 3125 = 7901 mg/L degrades anaerobically.

3. The wastewater leaves the anaerobic stage and enters the aerobic stage at a concentration of 1198 mg/L giving an additional 3125 – 1198 = 1927 that degrades anaerobically. It then decomposes aerobically leaving the pond at a concentration of 1000 mg/L. It may be assumed that from this point onwards all organic content (COD) ultimately degrades anaerobically.

4. This interpretation means that 7901 + 1927 + 867 = 10,695 mg/L degrades anaerobically (10,695 kg COD/ML or 10.695 t COD/ML).

Therefore, emissions produced = 10.695 (t COD/ML) x 0.25 (kg CH_4/kg COD) x 312 (ML)

= 834.21 t CH_4

= 17,518 t CO_2-e.

4 Agriculture

4.1 Introduction

This section covers the estimation of emissions from grazing, cropping, and horticulture; and from agricultural burning. Advice for **Greenhouse Challenge Plus** members is provided in section 4.3 below and general advice for other organisations is provided in section 4.4 below.

Emissions from other on-farm activities are accounted for in other sections:

- Vehicle fuel use is covered in Section 1.2 *Transport fuels*;
- The burning of fuels in plant and equipment is covered in Section 1.1.1 *Fuel combustion emissions (excluding natural gas)* and in Section 1.1.2 *Natural gas*;
- Land conversion and tree planting are addressed in Section 5 *Land-use change and forestry (vegetation sinks)*. Section 5 gives advice on estimating (1) emissions of carbon dioxide (CO_2) from the conversion of forest to pasture or cropland but not from other agricultural sources whose emissions are assumed to be removed again in the following growing season, and (2) removals of CO_2 by forest plantations and large-scale tree planting.

4.2 Greenhouse gas emissions from agriculture

Emissions of greenhouse gases are produced on agricultural lands as a result of a number of natural and human-induced processes. These include the decay or burning of biomass, feed digestion by ruminant livestock, the addition of nitrogen fertiliser and animal manure, crop residues returned to the soil, nitrogen fixation, nitrogen leaching and runoff, atmospheric deposition, and the anaerobic decomposition of organic matter during flood irrigation.

The principal greenhouse gases estimated for agriculture are methane (CH_4) and nitrous oxide (N_2O). Emissions and removals of CO_2 from agriculture (i.e., biological on-farm sources) are covered in Section 5.

The main agricultural sources of CH_4 are the digestion of feed by livestock, manure management and 'savannah burning' (i.e., the burning of pastoral grassland and woodland). The main agricultural source of N_2O is soils, primarily as a result of the use of nitrogen-based fertilisers on crops and pastures. Manure management and savannah burning are also sources of N_2O. Crop residue burning produces some CH_4 and N_2O.

Greenhouse gas emissions represent a loss of valuable resources from farming systems. There is a wide range of actions that land managers can take in order to enhance the efficiency with which these resources are used, thereby reducing their greenhouse impacts and improving productivity at the same time. Further information on greenhouse gas emissions from agriculture and options to manage emissions can be found at: www.climatechange.gov.au/agriculture

4.3 Reporting agricultural emissions for Challenge Plus members

The capacity to accurately calculate emissions for individual properties is still being developed. Greenhouse Challenge Plus Programme members are therefore not currently required to report on greenhouse gas emissions from land-based sources.

Unlike emissions from other sectors, emissions from agriculture are inherently difficult to measure or estimate. They occur over vast areas, they fluctuate (often wildly) over time, and are influenced markedly by management and environmental factors. Research aimed at improving capacity for accurate emission calculations at enterprise, property, and regional scales is currently underway.

For further information on greenhouse and agriculture issues, including options for cost-effective emissions reductions, visit: www.climatechange.gov.au/agriculture

For information on emissions reporting in the agriculture sector contact:

Assistant Director - Land Sector Analysis and Technology

Department of Climate Change

GPO Box 787

Canberra ACT 2601

Email: agriculture@climatechange.gov.au

Tel: 02 6274 1974 Fax: 02 6274 1326

4.4 Estimating agricultural emissions

State and national-level estimates of greenhouse gas emissions from agriculture are prepared using the methodology set out in the *Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006: Agriculture.*

Organisations wishing to report emissions from their agricultural operations may draw on this national methodology to make indicative estimates, but should note that the methodology uses regional averages not directly applicable to specific operations dependent on local conditions.

5 Land-use change and forestry (vegetation sinks)

5.1 Introduction

Actively growing forests take up (sequester) carbon from the atmosphere. The amount of carbon stored in an undisturbed forest can increase over time, until trees are mature and growth is balanced by decay. Natural events, e.g. fire and pest attack, and management actions such as harvesting reduce forest carbon stocks. Forest planting can also result in greenhouse gas emissions, e.g. from soil disturbance. Where sequestration exceeds emissions, a forest is a sink. If tree planting has been undertaken or is planned to offset greenhouse gas emissions, the amount of carbon sequestered will need to be estimated.

Clearing of forest produces greenhouse gas emissions from the burning and decay of cleared vegetation and changes in soil carbon.

5.2 National accounting approach

The accounting approach for land use change and forestry activities under Australian Government programmes reflects the approach taken to these activities in preparing Australia's national greenhouse gas inventory. This aims to ensure that project-level reporting under Australian Government programmes is consistent with Australia's national inventory reporting.

5.2.1 Activities covered under Australia's national inventory

Australia reports greenhouse gas emissions and carbon sequestration from land use change and forestry to track progress towards its target of limiting 2008–2012 emissions to 108% of 1990 levels, and to meet obligations under the United Nations Framework Convention on Climate Change (UNFCCC). Australia uses the rules and definitions developed internationally under the Kyoto Protocol to measure progress towards it 108% emissions target. Forestry activities (afforestation and reforestation) included under these Kyoto provisions are those that establish a forest of trees:

- with a potential height of at least two metres and crown cover of at least 20 per cent; and
- in patches greater than 0.2 hectare in area, and (for reasons of detectability) a minimum width of 10 metres; and
- since 1 January 1990, on land that was clear of forest at 31 December 1989; and
- by direct human induced methods, such as planting, direct seeding, or the promotion of natural seed sources; and
- within Australia.

Under the UNFCCC, accounting requirements cover a broader range of forestry activities, including the growth, harvesting and regrowth of all managed native forests and plantations (including plantations that meet the above criteria as well as plantations established prior to 1 January 1990 or on land cleared after 31 December 1989).

Land use change, or deforestation, refers to the deliberate, human-induced removal of forest cover (trees with a potential height of at least two metres and crown cover of at least 20 per cent in patches greater than 0.2 hectare in area) and replacement with a non-forest land use.

Estimation of emissions for land use change is the same under UNFCCC and Kyoto Protocol arrangements.

5.2.2 Accounting method

The national greenhouse gas account for land-based activities is estimated by the National Carbon Accounting System (NCAS). The NCAS is a model-based accounting system supported by resource inventories, field studies and remote sensing methods.

The National Carbon Accounting Toolbox (the Toolbox) allows access to NCAS modelling and data, providing a set of tools for tracking carbon stock changes in forests, including carbon sequestration and losses, e.g. through harvesting. Use of the Toolbox ensures that project-level carbon accounts for forest sinks are determined on a similar basis to Australia's national reporting.

Carbon accounting for forest sinks is based on the stock change approach. The change in carbon stocks over a period of time is calculated using the formula:

$$\Delta C_{\mathrm{i}} = C_{\mathrm{i}} - C_{\mathrm{i}-1}$$

where: ΔC_{i} = change in carbon stocks in year i

C_{i} = carbon stocks in year i

$C_{\mathrm{i-1}}$ = carbon stocks in the year before year i

This approach provides for estimating the annual amount of carbon added to, or lost from, a forest's carbon stocks.

5.3 Accounting method for Greenhouse programme participants

Greenhouse programme participants should use the National Carbon Accounting Toolbox to estimate greenhouse gas accounts for land use change and forestry activities.

Carbon stock changes can be estimated using the Data Builder function of the Toolbox. By entering the latitude and longitude of a forest into the Data Builder, users can access NCAS data for that location and generate a carbon stock change estimate. Users may also input specific data such as rainfall records to generate a more customised estimate.

Carbon sequestration is generally reported in either tonnes of carbon or tonnes of carbon dioxide. It is important to note which is being used. The carbon in trees is not in the form of carbon dioxide and is often reported as elemental carbon. The Toolbox provides carbon sequestration estimates in terms of tonnes of carbon per hectare (t C/ha). To express a quantity of carbon as an amount of carbon dioxide,, the carbon value can be multiplied by 3.67 (this is a simple conversion that does not take into account other gases).

The Toolbox covers cycling of carbon in forests and forest soils. Capability to account for non-carbon dioxide greenhouse gases is currently being developed through the NCAS, and will be incorporated in a future version of the Toolbox.

Other emissions associated with a forest sink project, e.g. from fuel use in machinery, should also be estimated. Preceding sections of this workbook provide relevant guidance.

5.4 Reporting of land use change and forestry activities under Greenhouse Challenge Plus

Greenhouse Challenge Plus Programme members should estimate and report carbon sequestration and greenhouse gas emissions for all land use change and forestry activities (as defined above).

Approaches for reporting net emissions (which may be positive or negative) for forestry activities reflect the differences between UNFCCC and Kyoto provisions described above.

Net emissions associated with **forest sink activities (afforestation and reforestation)** that contribute to Australia's 108% emissions target (i.e. those meeting the criteria listed above in Section 5.2.1) are to be included in annual emissions inventories. Only the annual increase in carbon stocks occurring in the inventory year can be recognised.

Net emissions associated with **other forestry activities** as reported nationally under UNFCCC requirements should be separately listed in the member's annual progress report, but cannot be included in the member's inventory.

Members are encouraged to focus on forest sink activities that can contribute to Australia's 108% emissions target. This is likely to enable compatibility with other abatement initiatives and may assist participation in emerging forest sink offset markets.

Greenhouse Challenge Plus reporting arrangements for forestry activities will be further refined to assist in aligning members' annual inventories with the national accounting approach. Further information will be provided in the Greenhouse Challenge Plus Reporting Guidelines currently under development. Emissions from any land use change activities should be included in all annual emissions inventories.

5.5 Further information and advice

Further information on the National Carbon Accounting Toolbox is available at: www.climatechange.gov.au/ncas

A free copy of the Toolbox may be obtained by emailing postal details to: ncas@climatechange.gov.au

The publication *Planning forest sink projects – a guide to forest sink planning, management and carbon accounting* (www.climatechange.gov.au/nrm/publications/forestsinks-planning.html) provides further information on forest sinks. Other publications on forest sink planning, management and investment are available on the DCC website.

For more information and advice on carbon accounting for forest sinks contact:

Land Sector Policy and Programmes team

Department of Climate Change

Email: gnrm@climatechange.gov.au

Tel: 02 6274 1485

Appendix 1 Greenhouse Gas Global Warming Potentials

The Global Warming Potential (GWP) is an index used to convert relevant non-carbon dioxide gases to a carbon dioxide equivalent (CO_2-e) by multiplying the quantity of the gas by its GWP in the table below.*

Table 24: Global Warming Potentials

Gas	Chemical formula	IPCC 1996 Global Warming Potential
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Hydrofluorocarbons HFCs		
HFC-23	CHF_3	11,700
HFC-32	CH_2F_2	650
HFC-41	CH_3F	150
HFC-43-10mee	$C_5H_2F_{10}$	1,300
HFC-125	C_2HF_5	2,800
HFC-134	$C_2H_2F_4$ (CHF_2CHF_2)	1,000
HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1,300
HFC-143	$C_2H_3F_3$ (CHF_2CH_2F)	300
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	3,800
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	140
HFC-227ea	C_3HF_7	2,900
HFC-236fa	$C_3H_2F_6$	6,300
HFC-245ca	$C_3H_3F_5$	560
Hydrofluoroethers (HFEs)		
HFE-7100	$C_4F_9OCH_3$	500
HFE-7200	$C_4F_9OC_2H_5$	100
Perfluorocarbons PFCs		
Perfluoromethane (tetrafluoromethane)	CF_4	6,500
Perfluoroethane (hexafluoroethane)	C_2F_6	9,200
Perfluoropropane	C_3F_8	7,000
Perfluorobutane	C_4F_{10}	7,000
Perfluorocyclobutane	c-C_4F_8	8,700
Perfluoropentane	C_5F_{12}	7,500
Perfluorohexane	C_6F_{14}	7,400
Sulphur hexafluoride	SF_6	23,900
Indirect gases		

Gas	Chemical formula	IPCC 1996 Global Warming Potential
Carbon monoxide	CO	not applicable
Oxides of nitrogen	NO_x	not applicable
Non-methane volatile organic compounds (NMVOCs)	various	not applicable

*These GWP factors are those specified for calculating emissions under Kyoto accounting provisions.

Appendix 2 Units and conversions

Table 25: Metric prefixes

Abbreviation	Prefix	Symbol
10^{15} (10^6x10^9)	Peta (million billion [thousand trillion])	P
10^{12} (10^3x10^9)	Tera (thousand billion [trillion])	T
10^9	Giga (billion)	G
10^6	Mega (million)	M
10^3	kilo (thousand)	k
10^2	hecto	h
10^1	deca	da
10^0	- (e.g. gram)	g
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p

Table 26: Unit equivalences

10^{15} grams (Petagram)	Gigatonne (Gt)
10^{12} grams (Teragram)	Megatonne (Mt)
10^9 grams (Gigagram)	kilotonnes (kt) (10^3 tonnes)
10^6 grams (million grams)	1 tonne
kg/GJ (10^3g/10^9J)	Gg/PJ (10^9g/10^{15}J)
Mg/PJ (10^6g/10^{15}J)	g/GJ 10^0g/10^9J)

e.g. 423,000 Gg is equivalent to 423,000 kt and to 423 Mt

Energy and power units

Unit of energy: Joule

Unit of power (rate of energy usage): Watt

Table 27: Energy conversion factors

Conversion factors		
1 Watt	= 1 Joule/Sec	
3600 Watt-seconds	= 1 Watt-hour (3600 seconds in one hour)	
1 Watt-hour	= 3600 Joules	
1000 Watt-hours	= 1Kilowatt hour (kWh)	
1 kWh	= 3.6×10^{6} Joules = 3.6 MJ	
1 kWh	= 3.6×10^{-3} GJ	
1 GJ	= 278 kWh	
1 PJ	= 278×10^{6} kWh = 278 GWh	
(A) For conversion from first unit to second unit:	**(B) Multiply quantity in first unit by conversion factor:**	**(C) To calculate quantity in second unit:**
kWh to J	kWh x 3.6×10^{6}	Joules
J to kWh	J x $1/3.6 \times 10^{-6}$	kWh
kWh to MJ	kWh x 3.6	MJ
MJ to kWh	MJ x 0.278	kWh
kWh to GJ	kWh x 3.6×10^{-3}	GJ
GJ to kWh	GJ x 278	kWh
kWh to PJ	kWh x 3.6×10^{-9}	PJ
PJ to kWh	PJ x 278×10^{6}	kWh

Table 28: Municipal solid waste volume to weight conversion factors

Material type	Volume to weight
Paper	0.09
Textiles	0.14
Wood	0.15
Garden	0.24
Food	0.50
Co-mingled	0.12

Example: Conversion of waste volume to weight

If a member has 100m^3 of co-mingled waste per annum, then the weight of this waste is:

100 x 0.12 = 12 tonnes.

Note: Volume to weight conversions is an inexact science and conversion factors change if materials are compacted.

Appendix 3 Revised electricity emission factors for end users, 1990–2007

These time series estimates are provided for information. Previously published estimates were provisional and have been revised for this Workbook using emissions data in the latest state and territory greenhouse gas inventories and revised fuel consumption, interstate electricity trade and electricity transmission and distribution loss data. For most programs, the publication of these revised factors does not necessarily imply any need to revise past estimates of emissions. Previously published emission factor estimates may remain applicable and are available from the Department of Climate Change.

Table 29: Emissions factors for consumption of purchased electricity by end users, 1990–2007

Financial year	EF for scope 2		EF for scope 3		Full fuel cycle EF (EF for scope 2+EF for scope 3)	
	A	B	C	D	E	F
	kg CO_2-e/kWh	kg CO_2-e/GJ	kg CO_2-e/kWh	kg CO_2-e/GJ	kg CO_2-e/kWh	kg CO_2-e/GJ
NEW SOUTH WALES and AUSTRALIAN CAPITAL TERRITORY						
1990	0.90	250	0.16	45	1.06	295
1995	0.86	239	0.16	44	1.02	284
2000	0.87	241	0.17	46	1.03	287
2005	0.89	247	0.17	46	1.06	293
2006	0.89	247	0.17	47	1.06	294
2007 [p]	0.89	249	0.17	47	1.06	295
VICTORIA						
1990	1.24	345	0.21	58	1.45	403
1995	1.25	346	0.15	40	1.39	387
2000	1.30	360	0.12	33	1.42	394
2005	1.26	349	0.06	17	1.32	365
2006	1.24	344	0.08	21	1.32	366
2007[p]	1.22	340	0.08	23	1.31	364
QUEENSLAND						
1990	0.96	268	0.13	36	1.10	304
1995	0.97	271	0.13	36	1.10	307
2000	0.92	255	0.13	37	1.05	292
2005	0.90	251	0.14	38	1.04	290
2006	0.91	252	0.13	38	1.04	289
2007[p]	0.91	252	0.13	38	1.04	289
SOUTH AUSTRALIA						
1990	0.81	225	0.20	56	1.01	281
1995	0.87	241	0.19	52	1.05	292
2000	0.92	257	0.17	46	1.09	303
2005	0.89	247	0.15	42	1.04	289
2006	0.87	242	0.14	39	1.01	281
2007[p]	0.84	233	0.14	39	0.98	272

Financial year	EF for scope 2		EF for scope 3		Full fuel cycle EF (EF for scope 2+EF for scope 3)	
	A	B	C	D	E	F
	kg CO_2-e/kWh	kg CO_2-e/GJ	kg CO_2-e/kWh	kg CO_2-e/GJ	kg CO_2-e/kWh	kg CO_2-e/GJ
WESTERN AUSTRALIA—South-West Interconnected System (SWIS)						
1990	0.91	253	0.16	46	1.08	299
1995	0.92	256	0.14	40	1.07	296
2000	0.92	256	0.12	34	1.04	290
2005	0.85	235	0.10	29	0.95	264
2006	0.85	236	0.10	29	0.95	265
2007^p	0.87	242	0.10	29	0.98	271
TASMANIA						
1990	0.06	17	0.01	3	0.07	21
1995	0.02	5	0.00	1	0.02	6
2000	0.01	2	0.00	0	0.01	2
2005	0.04	10	0.01	2	0.04	12
2006	0.05	13	0.01	2	0.06	15
2007^p	0.12	35	0.01	2	0.13	37

Notes:

- These time series estimates are provided for information. Previously published estimates were provisional and have been revised for this Workbook using emissions data in the latest state and territory greenhouse gas inventories and revised fuel consumption, interstate trade and transmission and distribution loss data. For most programs, the publication of these revised factors does not necessarily imply any need to revise past estimates of emissions. Previously published emission factor estimates may remain applicable and are available from the Department of Climate Change.
- Data for 1990–2006 are Department of Climate Change estimates derived from George Wilkenfeld and Associates (forthcoming). Emission factors are representative of the state's primary electricity grid. To minimise volatility emission factors are calculated as a three-year average.
- p indicates Department of Climate Change provisional estimates for 2007 based on NEMMCO data. Provisional data are not available for Western Australia for 2007, so estimates for the preceding year have been extrapolated.
- Scope 3 emission factors for transmission and distribution network operators are lower as they include only emissions attributable to the extraction, production and transport of fuels and not emissions attributable to the electricity lost in transmission and distribution networks. Transmission and distribution network operators should use the scope 2 factors in the table above and the following scope 3 factors for 2007: NSW and ACT: 0.085kg CO_2-e/kWh, VIC: 0.008kg CO_2-e/kWh, QLD: 0.024kg CO_2-e/kWh, SA: 0.083kg CO_2-e/kWh, WA: 0.035kg CO_2-e/kWh, TAS: 0.005kg CO_2-e/kWh, NT:0.063 kg CO_2-e/kWh.
- Data are for financial years ending in June.
- Sources: Department of Climate Change estimates derived from George Wilkenfeld and Associates (2007). Primary data sources comprise generator survey returns to the Department of Climate Change, ABARE, ESAA and NEMMCO data.