ENERGY AND GREENHOUSE MANAGEMENT TOOLKIT

3

MODULE 3

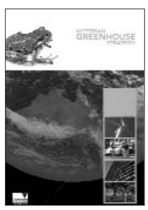
CALCULATING ENERGY USE AND GREENHOUSE EMISSIONS

Victoria
The Place To Be

The *Energy and greenhouse management toolkit* is a Victorian Government initiative developed in partnership by EPA Victoria and the Sustainable Energy Authority Victoria, and funded through the Victorian Greenhouse Strategy.

EPA Victoria
EPA is a Victorian State Government statutory authority established to enable the safe clean and sustainable environment that Victorians seek. Based on a philosophy that prevention is better than cure, EPA Victoria takes an integrated approach to delivering its mission by providing environmental leadership, promoting public awareness and working with all sectors of the community. It also provides best practice guidelines and standards, together with regulation and policing where required.
For further information visit www.epa.vic.gov.au

Sustainable Energy Authority Victoria
The Sustainable Energy Authority Victoria (SEAV) is a State Government statutory authority. SEAV's objective is to accelerate progress towards a sustainable energy future by bringing together the best available knowledge and expertise to develop leading-edge initiatives which provide Victorians with greater choice in how they can take action to significantly improve energy sustainability.
For further information visit www.seav.vic.gov.au



Victorian Greenhouse Strategy (VGS)
Climate change is an issue which impacts on the whole community, including individuals, business and all levels of government. If a truly sustainable solution is to be achieved, all members of the community must play their part. The VGS will facilitate the establishment of partnerships, and build capacity throughout the community for greenhouse action. The development of the VGS has benefited from extensive public consultation and is a significant first step on the long road to addressing the threat of climate change.
For further information visit www.greenhouse.vic.gov.au or call the Department of Natural Resources and Environment Customer Service Centre on 136 186.

Calculating energy use and greenhouse emissions.

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Energy and greenhouse management toolkit

Introduction

The greenhouse gas emissions of an operation are made up of both energy and non-energy related emissions. For most industrial premises, energy-related emissions represent a very large percentage of the total. Therefore, an understanding of energy usage and the conversion of energy units to equivalent emissions is very important.

Without a clear picture of how much energy your organisation consumes, it is very difficult to assess where improvements are possible and where savings can be made.

This module will help you quantify energy consumed, and associated greenhouse gas emissions, using data derived from your energy bills, and to calculate emissions and consumption for existing and proposed items of equipment.

Some guidance is also provided on methodologies for calculation of non-energy emissions.

The assessment of wider environmental impacts is introduced, including an outline of 'lifecycle assessment' and 'eco-footprint' tools.

Greenhouse gases

The industrial and commercial sectors contribute a significant proportion of Australia's greenhouse gas emissions.

There is a range of gases that contribute to the enhanced greenhouse effect. The impacts of these gases vary and so, for simplicity, the emissions effect of each gas is converted to equivalent kilograms of CO_2 (CO_2-e).

The range of greenhouse gases include:

- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)
- hydrofluorocarbons (HFCs)
- perfluorocarbons (PFCs)
- sulphur hexafluoride (SF_6)

Table 1 breaks down the type and source of the most significant gases that contribute to the enhanced greenhouse effect; their global warming potential; and the types of activities that produce greenhouse gas emissions.

Understanding energy bills

Understanding how to read your energy bills has two main benefits:

- you can check that you are being charged correctly; and
- energy consumption and greenhouse gases can be tracked and monitored.

Both of these are essential for keeping control of your energy management system (refer to *Module 4*).

CONTESTABILITY

In Victoria, the electricity and gas industries have been restructured into competitive markets. As a consequence, consumers can now choose from which company they purchase electricity and gas. This choice is referred to as 'contestability'.

Table 1: Types and sources of significant greenhouse gases

Greenhouse gas	Source	Global warming potential*	Activities that contribute
Carbon dioxide (CO_2)	Burning of fossil fuels and land-clearing	1 tonne = 1.0 t CO_2-e	Electricity generation and use; transport
Methane (CH_4)	Agricultural activities; emissions from landfills and wastewater treatment; emissions from fossil fuel production and mining	1 tonne = 21 t CO_2-e	Resource consumption; primary production; waste disposal to landfill
Nitrous oxide (N_2O)	Burning of fossil fuels and vegetation	1 tonne = 310 t CO_2-e	Industrial processes; electricity generation and consumption; transport
Hydrofluorocarbons (HFCs)	Used in refrigeration and air conditioning	1 tonne = 3000 to 5000 t CO_2-e	Industrial processes; building design; refrigeration
Perfluorocarbons (PFCs)	Emitted during aluminium production	1 tonne = 6500 to 9200 t CO_2-e	Manufacturing; resource consumption
Sulfur hexafluoride (SF_6)	Electricity transmission and distribution	1 tonne = 23 900 t CO_2-e	Electricity generation and consumption

* Note: Each greenhouse gas varies in its effect of trapping the sun's heat. The extent of this variation is expressed in terms of its 'global warming potential' (GWP) relative to CO_2. GWP's provide a means of combining the emissions of several greenhouse gases from a particular activity to calculate a total emission figure expressed in terms of CO_2 equivalence. For example, if emissions from a particular activity were 100 tonnes of CO_2 and 1 tonne of methane, the total CO_2 emissions would be 121 tonnes, i.e. (100 t x 1) + (1 t x 21 CO_2-e) = 121 t CO_2-e.
Source: *Victoria's greenhouse gas emissions, 1990–95: Cross-sectoral analysis*, Wilkenfeld,1998.

ELECTRICITY BILLS

Domestic electricity accounts are usually relatively straightforward to interpret. By contrast, electricity bills for large accounts are more complicated.

The relevant information to record is:

- Account number
- Service address (where the power comes in—not necessarily the building's street address)
- Period of the account, particularly the period end date
- Network Tariff code
- Number of days in the billing period
- Consumption, also known as 'usage' or 'energy'. It is often (but not always) divided between:
  - peak energy in kWh
  - off-peak energy in kWh
- Demand, comprised of:
  - 'Billed', 'Contract', 'Minimum Chargeable' or 'Network' demand, in kW or kVA
  - 'Actual' or 'Highest' demand in kW or kVA
- Total cost for the period

These components are typically spread over three or four sections, as shown in Figure 1.

In an electricity bill, there are four main components to your charges.

1. **Retail energy charges:** Typically, these rates are expressed as 'peak' and 'off-peak' charges. Customers can negotiate any structure they prefer from a single flat rate to very complex rates that change according to the time of day, month and season that best matches the needs of a particular business.
2. **Network charges:** For use of the electricity network. The Essential Services Commission regulates these and maximum set charges cannot be exceeded. Each distributor has its own network charges which are generally based on peak and off-peak consumption—cents/kWh, demand—$/kW/annum and standing charge. These fees are charges to the retailer and passed at cost to the customer for the use of the system.
3. **Other charges:** These are mainly regulated market fees that the electricity retailer is subject to, and the cost of providing you with the retail service. 'NEMMCO Charges' is National Energy Market's (NEM) main revenue stream as the market operator. 'NEMMCO Ancillary Services' is for provision of

FIXED (SERVICE) COSTS

	Consumption	Rate	Charge ($)
01/08/99 to 31/08/99			
Retail Energy Charges			
Peak Usage Mon-Fri 7:00am–11pm	243104.94	2.0400	4,959.34
Off Peak Usage (All Other Periods)	80690.16	1.2554	1,012.98
		Total Retail Energy Charges	**$5,972.32**
Network Charges			
Network Peak	243104.94	1.5460	3,758.40
Network Off-Peak	80690.16	0.7150	576.93
Network Standing Charge			284.17
Network Demand	1090	$0.172020	5,812.56
Communications Charge	1	$1.39	43.06
Meter Charges	1	$0.50	15.62
		Total Network Charges	**$10,490.74**
Other Charges			
NEMMCO Ancillary Services	323795.1	0.1150	372.36
NEMMCO Charges	323795.1	0.0562	181.97
Smelter Reduction Payment	323795.1	0.2197	711.38
Meter Charge	1	$1.10	34.22
Demand Adjustment			-79.95
		Total Other Charges	**$1,219.98**
		Bill Total	**$17,683.04**

Contract Demand

DLF=4.51% TLF=.1%
Contract Demand is 1090 kW
Highest actual metered demand this period 969 kW
Meter: Usage: 323795 kWh:

Peak Energy Costs

Off-peak energy costs

Figure 1: A typical example of a contestable electricity bill

services necessary for system operation, such as voltage control. 'Smelter Reduction Payment' is a levy for the Alcoa smelter electricity contract.

4. **Metering charges:** A cost for the provision and maintenance of a new meter and the forwarding of billing data, which is required if you change electricity retailers.

Transmission and distribution loss factors

Transmission and distribution loss factors are used to determine the energy rates. The actual transmission losses (TLF) in each trading interval (normally 30 minutes) are calculated as the difference between energy put into the transmission network by generators and the energy out of the transmission network to customers. Distribution loss factors (DLFs) are used to allocate a share of the losses in a distribution network to the customer connected to that network.

Adding components together

From the electricity bill example (Figure 1) an electricity cost breakdown can be determined as indicated in Table 2.

Maximum demand

Electricity accounts may include a 'demand' charge in the network (distribution) charges section. Electricity demand is the rate at which electricity is consumed, continuously averaged over 15 or 30-minute intervals. Two demand terms are commonly referred to:

- 'network' or 'maximum' demand—the highest demand recorded during the month; and
- 'contract' or 'billed' demand—the demand level at which the demand charges are based. This is equal to the site's historical maximum demand, or the minimum chargeable demand, whichever is the greater. Whenever the contract demand is exceeded by the maximum demand, then the current maximum demand becomes the new contract.

Figure 2 demonstrates the difference between contract and actual demand.

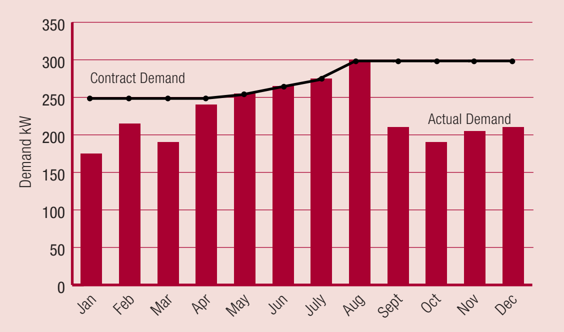

Figure 2: Difference between contract and actual demand

In Figure 2 the minimum chargeable demand is 250 kW.

As the demand charge makes up a sizeable percentage of an electricity bill, it is in your interest to have the charged demand as low as possible. Therefore, if your actual demand is consistently less than the contract demand and it is above the minimum chargeable demand, then you should request a reduction in the charged demand.

Electricity Act 1993—Section 158A tariff order

Attachment 10 of this tariff order states that where a customer requires a reduction in contract demand they must give 12 months written notice to the distribution company serving the site.

The electricity distribution company must then notify the customer in writing within the 12 month period of the new contract demand. However, following the installation by the customer of energy management equipment approved by the distributor, or implementation of a demand management initiative approved by the distributor, this 12 month notice period may be reduced at the discretion of the distributor.

The contract demand requested by the customer is the highest actual demand recorded in the previous 12 months, or the minimum chargeable demand of 120/250 kW (or kVA).

Table 2: Electricity cost breakdown from Figure 1

Description of energy cost	Energy cost calculation	Energy cost $	%
Peak energy	243 105 kWh x (2.0400 + 1.5460 + 0.1150 + 0.0562 + 0.2197) cents/kWh =	9 668.04	55
Off-peak energy	80 690 kWh x (1.2554 + 0.7150 + 0.1150 + 0.0562 + 0.2197) cents/kWh =	1 905.33	11
Demand	Note that this is based on historical highest demand.	5 812.56	32
Fixed (service)	31 days x (9.1667 + 1.3890 + 0.5039 + 1.1039) $/day =	377.07	2
Less refund for demand		– 79.95	
Total		**$17 683.05**	**100**

Greenhouse emissions on electricity bills

The Government has amended the Electricity Industry Act to require electricity retailers to disclose information regarding greenhouse gas emissions on all customer bills. Reporting will be in accordance with guidelines developed by the Essential Services Commission and the Sustainable Energy Authority Victoria. Reporting will commence by 30 December 2002.

Green Power

Green Power is an alternative to coal-generated electricity. It is shown as a proportion of your consumption on your electricity bill.

Green Power is generated from clean, renewable energy sources, such as solar, wind, biomass, wave and hydro power.

When you buy Green Power from your electricity supplier, renewable energy is purchased on your behalf. It is distributed to your business through the grid, in the usual way. By agreeing to pay a small additional charge on your electricity bill, you are replacing conventional electricity with clean, renewable energy.

Energy suppliers use a variety of brand names to identify their renewable energy schemes. A national accreditation program has been developed to ensure that Green Power offered by electricity suppliers is generated from government approved renewable energy sources. The Sustainable Energy Authority monitors this program in Victoria, regularly auditing suppliers to ensure compliance.

Prices of Green Power will vary between suppliers, but will usually cost an additional 2–4 cents per kWh. You can nominate a certain proportion of your consumption on which to pay the Green Power premium.

Refer to the *Green Power business guide* CD for detailed information.

NATURAL GAS BILLS

The relevant information to record from gas bills is:

- Account number
- Service address (where the gas meter is located—not necessarily the building's street address)
- Period of the account, particularly the period end date
- Tariff code
- Number of days in the billing period
- Consumption, also known as 'usage' or 'energy' in MJ
- Total cost for the period

Large accounts may have demand charges expressed as Maximum Hourly Quantity (MHQ) and Maximum Daily Demand (Max Daily).

Natural gas is measured in cubic metres (m^3) but is billed in megajoules (MJ).

MJ are calculated by using the formula:

MJ = cubic metres (m^3) of gas x Pressure Correction Factor x calorific value of the gas (MJ/m^3)

Metered gas flow is corrected to standard conditions by application of a Pressure Correction Factor which will depend on the existing supply or metering pressure.

DATA FROM ENERGY BILLS

Electricity and gas bills are useful for providing information on the 'big picture', including:

- seasonal increases or decreases in average daily electricity use (which may show increased consumption due to increased requirements over summer or winter);
- large differences (over 10%) in the total annual electricity or gas consumption, which may indicate a change in consumption patterns;
- unusual peaks in electricity or gas consumption;
- a high proportion of off-peak electricity use (for example it could indicate plant and equipment operating out of normal operating hours); and
- a comparison of the actual electricity demand versus the contract demand.

Collating historical data

To get a picture of your company's energy use patterns you will need to collate historical data. This can be a very simple process. Use energy accounts from the past 24 months to establish the annual total consumption and cost for each utility. It is often easier to obtain energy data directly from the energy retailer than it is to extract all the data from your own accounts department. Refer to Appendix 2 for information on requesting data from energy suppliers.

Use a spreadsheet to record the forms of energy used (e.g. gas, electricity etc.), consumption and cost. Other tools such as *Energy Smart Tracker* can be used (see software CD provided).

Once you have recorded this information you can then express the different forms of energy as a percentage in respect of both consumption and cost. With a clear picture of how much energy your company consumes, and where it is used, you can then assess where savings can be made. Remember, if you can't measure it, you can't manage it.

ENERGY AUDITING

An energy audit quantifies current energy use and equivalent greenhouse gas emissions and makes recommendations for energy efficiency improvements. Its scope can vary widely, and can include an entire building or plant, or even energy use associated with a specific process. An energy audit provides the baseline of your organisation's current energy use.

Refer to *Module 4* for further information on energy auditing.

SETTING UP AN ENERGY MONITORING AND REPORTING SYSTEM

Successful energy management requires the establishment of a system to collect, analyse and report on the organisation's energy costs and consumption. This will enable an overview of energy use and its related costs, as well as facilitating the identification of savings that might otherwise not be detected. The system needs to record both historical and ongoing energy use, as well as cost information from billing data, and be capable of producing a summary report on a regular basis. This information will provide the means by which trends can be analysed and tariffs reviewed.

Energy consumption monitoring and reporting systems are required to:

- demonstrate savings that would otherwise be difficult to see;
- benchmark energy performance of sites and identify anomalies, especially poor performing sites for priority attention;
- track and trend consumption and demand to monitor site performance;
- assist in the divestment of energy costs to end-users; and
- monitor greenhouse impact.

Data can be entered manually from the energy bills or it can be imported in electronic format. Where the energy consumption of multiple sites is being tracked, energy consumption data is usually best acquired in electronic format from the energy retailer.

Each organisation needs to develop a reporting process that reflects its needs. The secret to success is to keep your reporting process simple, straightforward and timely.

Refer to *Module 4* for information on developing an energy management system.

Data analysis using Energy Smart Tracker

Energy Smart Tracker was developed by the Sustainable Energy Authority Victoria to assist businesses to record and monitor energy consumption and greenhouse gases, and to minimise energy costs.

The program produces basic benchmarks that will help set targets for consumption and scope of total energy use. It displays graphs on seasonal trends, production peaks, energy consumption, energy cost and greenhouse gas emissions for each type of energy.

A CD containing the software is included in the *Toolkit*.

There are also other more sophisticated software packages on the market.

Calculating greenhouse gas emissions

Calculating greenhouse gas (GHG) emissions for energy-related activities is relatively straightforward. Simply multiply the energy consumption figure by the appropriate greenhouse coefficient.

GHG = Energy consumption (kWh, GJ) x GHG coefficient

Greenhouse gas emissions from electricity vary from state to state because different fuels are used to generate it. In Victoria, 1.444 kg CO_2 equivalent is produced for every kilowatt-hour (kWh) of electricity produced. Victoria has the highest figure as its electricity comes from burning brown coal—the most greenhouse-intensive energy type.

For every gigajoule of natural gas used in Victoria, 51.7 kg of CO_2 equivalent are produced.

Green Power (from renewable energy sources) produces no greenhouse gas emissions.

Example

The following example using the total energy consumption from Figure 1 shows the greenhouse gas emissions for that month are:

323 795 kWh x 1.444 kg CO_2-e/kWh = 467 560 kg CO_2-e or 467 t CO_2-e

Use the appropriate value when making conversions from energy to greenhouse gas emissions. An up-to-date list of coefficients is maintained on the AGO website www.greenhouse.gov.au

Table 3: Victorian greenhouse coefficients

	kg CO_2-e produced	Energy unit
Electricity–Victoria	1.444	1 kWh
	0.4011	1 MJ
Natural gas–Victoria	0.0517	1 MJ
Green Power	0	1 MJ

PLANT AND EQUIPMENT

The method for calculating greenhouse gas emissions for individual items of plant or equipment is similar to that described above. Simply multiply the total actual load by the operating hours, and the relevant greenhouse gas coefficient.

GHG = (Total actual load [kW] x operating hours) x GHG coefficient

Example

A Victorian factory has ten water pumps fully loaded at 20 kW each. The pumps continuously operate for 8 hours per day, 300 days per year. What are the annual greenhouse gas emissions?

Total load = 10 pumps x 20 kW = 200 kW

Annual operating hours = 8 hours x 300 days/year = 2400 hours per year

Therefore:

Annual GHG = (200 kW x 2400 hours) x 1.444 kg CO_2-e/kWh = 693 120 kg CO_2-e per year or 693.12 t CO_2-e per year

FURTHER INFORMATION

Energy-related emission methodologies

For more information on energy-related emission methodologies and conversion factors refer to Appendix 3, sourced from the Australian Greenhouse Office publication *Greenhouse challenge: Factors and methods workbook*. The full version of this booklet is available from the AGO at www.greenhouse.gov.au/challenge/html/member-tools/member_tools.html, or go to www.greenhouse.gov.au and follow links: business and industry/challenge/membership tools/technical tools/factors and methods.

Non-energy related emission methodologies

Some industrial processes generate greenhouse gas emissions additional or unrelated to energy use. Methods for calculating these emissions are explained in Appendix 3, Table 1.4.

For emissions estimation methodologies and conversion factors for greenhouse gas emissions generated from landfills and wastewater treatment facilities, refer to the following tools:

- *Environmental guidelines for reducing greenhouse gas emissions from landfills and wastewater treatment facilities*, (publication 722) available on the EPA website www.epa.vic.gov.au or by calling (03) 9695 2722.
- *Greenhouse emissions model for effluent streams*, available on the EPA website www.epa.vic.gov.au. This program enables the user to estimate direct greenhouse gas emissions from the treatment of industrial and domestic wastewater in typical regional wastewater treatment systems, and indirect greenhouse gas emissions from the construction and operation of these systems.
- *Landfill Area Based Spreadsheet (LABS)*, available from the EPA. For landfills that report to NPI, methane generation figures can be calculated using this tool, for conversion to CO_2 equivalents.

Assessing ecological impact

The overall environmental impact of any process, product or activity goes well beyond the emissions directly associated with operation or production. Resource use and other inputs, transport, use of other services, product consumption and waste disposal all contribute. Consideration of the ecological impacts, through the lifecycle of the product or operation, requires both a sophisticated approach for analysis and a clear means of communicating the results.

LIFECYCLE ASSESSMENT

Lifecycle assessment (LCA) is a tool for assessing the environmental impacts of a product, process or activity throughout its lifecycle, from the extraction of raw materials through to processing, transport, use and disposal, commonly referred to as 'the cradle to the grave'. LCA can help businesses to better understand the environmental impacts of their operations, goods and services and to identify the most effective improvements that can be achieved in environmental performance and use of resources. Benefits can include product improvements, process improvement and strategic planning.

Further information on lifecycle assessment can be obtained from the RMIT Centre of Design website www.cfd.rmit.edu.au and also from the AS/NZ ISO

14040:1998, Environmental management—Lifecycle assessment—Principle and framework.

ECO-FOOTPRINT

The ecological footprint (eco-footprint) is a new tool to measure and communicate sustainability. The ecological footprint is an expression of the area of land needed to sustain a given activity in terms of the energy, water, and resources required by that activity. Using eco-footprint the area of land needed to support a household, a school, a business or a society as they currently operate can be estimated.

The development and application of eco-footprint as a measure of sustainability is important to identify and define the impact of our actions upon our environment. It is a potentially powerful communication tool because it quantifies, in a simple, readily understandable way, what effect our everyday activities are having on our environment.

For example, international studies using the eco-footprint concept have shown that if everyone else in the world consumed resources and energy and produced wastes at the same rate as Victorians currently do, we would need at least three Earths to support such behaviours.

Using this measure of our demands on the planet, we can calculate the degree to which simple alternatives to everyday behaviours can reduce the size of our eco-footprint. This message is vital, not only to encourage all Victorians to adopt more sustainable practices, but also to show us how.

EPA has established a series of pilots in partnership with a wide range of organisations and businesses to further investigate the practical applications of the ecological footprint as a communications tool to promote sustainability.

SEAV is supporting an ecological footprint project with the La Trobe University (Bendigo) Centre for Sustainable Regional Communities, involving six towns in Central Victoria.

For further information refer to www.epa.vic.gov.au/Eco-footprint

Further information

For further information on topics covered in this module refer to the following. For information on a wide range of energy and greenhouse topics refer to *Module 7*.

AUSTRALIAN GREENHOUSE OFFICE

The AGO publishes current greenhouse gas emission coefficients for all fuels in all states. It also provides a detailed explanation of how greenhouse gas emissions are produced, and the National Greenhouse Gas Inventory.
www.greenhouse.gov.au

CSIRO ATMOSPHERIC RESEARCH

CSIRO Atmospheric Research provides world-class scientific advice and solutions on issues involving the atmospheric environment and the climatic system. They provide information on predicted climate change scenarios due to the enhanced greenhouse effect and associated environmental impacts.
www.dar.csiro.au

EPA VICTORIA

The Victorian Government authority responsible for regulating and promoting environmental management, the control of pollution on land, in water and air, industrial noise and waste minimisation. EPA has developed pilot projects to investigate the eco-footprint measure as a tool to promote sustainability.
www.epa.vic.gov.au/Eco-footprint

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

The IPCC provides scientific, technical and socioeconomic advice to the world community through its periodic assessment reports on the state of knowledge of causes of climate change, its potential environmental and socioeconomic impacts and options for addressing it.
www.ipcc.ch

RMIT CENTRE FOR DESIGN

The Centre for Design at RMIT can provide information on lifecycle assessment (LCA). Its activities include developing and demonstrating new design methods, tools and processes aimed at improving the environmental performance of products and services.
www.cfd.rmit.edu.au

US GLOBAL CHANGE RESEARCH INFORMATION OFFICE (GCRIO)

The GCRIO provides access to data and information on global change research, adaptation/mitigation strategies and technologies, and global change-related educational resources on behalf of the various US Federal Agencies and Organisations that are involved in the US Global Change Research Program (USGCRP).
www.gcrio.org

Appendix 1
Energy fundamentals

ENERGY UNITS

This Appendix outlines some of the basic terms and concepts used to describe energy generation and consumption.

Joule

The unit for the measurement of energy is the **joule** (J). As the joule is a rather small unit, a prefix is usually added to form a unit multiple of a more convenient magnitude. For example, kilo (1000 times) is combined to joule to form **kilojoule** (kJ).

Natural gas consumption is usually measured in **megajoules** (MJ), where 1 MJ = 1 000 000 J. On large accounts it may be measured in **gigajoules** (GJ), where 1 GJ = 1 000 000 000 J.

Watt

Power is the term used to describe the rate at which energy is used. It is measured in **Watts** (W), which are defined as the number of joules per second, i.e. 1 W = 1 J/s. This unit is also more conveniently used in greater magnitudes such as **kilowatts** (kW), where 1 kW = 1 kJ/s = 1000 J/s; and **megawatts** (MW) where 1 MW = 1000 kW = 1000 kJ/s.

Watt-hours, kilowatt-hours

Electricity consumption is measured in units of **watt-hours** (Wh), or more typically, **kilowatt-hours** (kWh) and **megawatt-hours** (MWh), where 1 MWh = 1000 kWh. 1 kWh means 1 kW of power being used for 1 hour.

Kilowatt-hours relate to megajoules as follows:

1 kWh = 1 kJ/s x 3600 s = 3600 kJ = 3.6 MJ

Demand

Demand is the rate at which energy is consumed.

Consumption = **Demand** x Time

Technically, it is the same unit as power, however it has other connotations.

Electricity demand has traditionally been measured in kW, continuously averaged over 15-minute or 30-minute sample periods. However, Victorian electricity distribution companies are moving to change the units to measure demand to account for the quality of power that is delivered. This new demand unit is the kilovolt-amp (kVA) which measures the 'apparent power' used. The apparent power of a system is the voltage multiplied by the total current used, including current that does no useful work.

For billing purposes, gas demand is measured in MJ/hour (1 MJ/hour = 1 MW/3600) and is averaged over both one-hour and 24-hour sampling periods.

Ampere or Amp

An **Amp** (A) is the measure of electrical current flow.

Volt

The unit of potential difference between two points is the **volt** (V) (commonly called voltage). One thousand volts equals 1 **kilovolt** (kV).

ELECTRICAL TRANSMISSION AND DISTRIBUTION

Victoria's electricity is generated at 21–24 kilovolts (kV). Power is then 'stepped up' through a transformer to be transmitted at 220 kV or 500 kV (in some instances 330 kV is used). The high voltage for transmission reduces power losses associated with high current. From these main transmission lines, the voltage is then 'stepped down' to 66 kV for distribution to each town or suburb, as well as large industrial customers.

From the local distribution point, it is again transformed down to 11 kV or 22 kV and travels to 'pole transformers'. Here it is transformed to 415/240 V power for domestic consumption or to a specific voltage for an industrial user, for example, trams at 600 V.

Transmission and distribution losses are factored into retail energy costs.

Appendix 2 Requesting data from energy suppliers

Start with a copy of a recent energy bill in order to obtain the relevant account numbers and supply addresses as shown on the bills. Then write to your energy retailer(s) and ask for a billing history of consumption and the costs for each billing period. For large electricity accounts, you may have an account manager listed on the invoice to contact. For other accounts, write to the address on the invoice. Sample letters are shown in Figures 3.1 and 3.2.

Date

John Smith
Energy Company
Address (on the invoice)

Dear Mr Smith,

Re: Electricity account data

We are in the process of implementing an energy management system and request your assistance to obtain historical electricity consumption data for the following accounts:

- 8000 0000 0000 zzzz Plant A
- 8000 0000 0001 zzzz Plant B

We require the following monthly account data for the past 24 months for each of the above accounts:

- Meter reading date
- Number of days in billing period
- Peak consumption (kWh)
- Off-peak consumption (kWh)
- Maximum demand (kW or kVA) (if applicable)
- Billed or contract demand (kW or kVA) (if applicable)
- Total cost for the period

Please e-mail the information in MS excel format to xxxx@yyyy.com.au by close of business dd mm yyyy. Alternatively, mail or fax the information if it is not available in electronic format.

Please contact the undersigned if you have any queries.

Yours sincerely,

Figure 3.1: An electricity sample letter

Date

Accounts Department
Energy Company
Address (on the invoice)

Dear Sir,

Re: Gas account data

We are in the process of implementing an energy management system and request your assistance to obtain historical gas consumption data for the following account numbers and sites:

- 8000 0000 0000 zzzz Plant A
- 8000 0000 0001 zzzz Plant B

We require the following monthly (or bi-monthly) account data for the past 24 months for each of the above accounts:

- Meter reading date
- Number of days in billing period
- Consumption (MJ)
- Total cost

Please e-mail the information in MS excel format to xxxx@yyyy.com.au by close of business dd mm yyyy. Alternatively, mail or fax the information if it is not available in electronic format.

Please contact the undersigned if you have any queries.

Yours sincerely,

Figure 3.2: A natural gas sample letter

Appendix 3 Emission estimation methodologies and conversion factors

The following methods for estimating greenhouse gas emissions from energy usage and other sources have been adapted from *Greenhouse challenge: Factors and methods workbook* Version 3 December 2001 produced by the Australian Greenhouse Office. The full version of the workbook, including worked examples, is available from the AGO at www.greenhouse.gov.au/challenge/html/member-tools/member_tools.html, or go to www.greenhouse.gov.au and follow links: business and industry/challenge/membership tools/technical tools/factors and methods.

END-USE ELECTRICITY

If you use electricity, you will need to calculate the indirect greenhouse gas emissions associated with the quantity that you use. To determine the greenhouse gas (GHG) emissions in tonnes of carbon dioxide equivalent (t CO_2-e), the following formula and emission factors should be used.

Formula: GHG emissions (t CO_2-e) = [Activity (Q) x Emission Factor (EF)] ÷ 1000

Where: Activity (Q) is the electricity used and expressed in kWh and sourced from supplier invoices/meters, and Emission Factor (EF) is 1.444 CO_2-e kg/kWh for Victoria.

GAS CONSUMPTION (STATIONARY ENERGY/NON-TRANSPORT)

Natural gas

If you use natural gas for stationary energy/non-transport purposes, you will need to calculate the greenhouse emissions (in tonnes) associated with the quantity that you use. Major users are those with an annual usage of more than 0.1 PJ. To determine these emissions, the following formula and emission factors as appropriate should be used:

Formula: GHG emissions (t CO_2-e) = [Activity (Q) x Emissions Factor (EF)] ÷ 1000

Where: Activity (Q) is the quantity of natural gas consumed and expressed in GJ and sourced from supplier invoices/meters; and Emission Factor (EF) is the point-source kg CO_2-e/GJ coefficient as shown in table 1.1.

Table 1.1: Emissions from combusiont of natural gas

	Point-source emissions factor kg CO_2/GJ	Full fuel cycle emissions kg CO_2/GJ
Using more than 100 000 GJ/year Large users	51.7	63.7
Using less than 100 000 GJ/year Small users	51.7	64.2

LPG (non-transport)

If you use LPG for stationary energy (for non-transport purposes), you will need to calculate the greenhouse emissions associated with the quantity that you use. To determine these emissions, the following formula and emission factors should be used:

Formula: GHG emissions (t CO_2-e) = [Activity (Q) x Energy Content of Fuel (EC) x Emission Factor CO_2-e/kg GJ (EF)] ÷ 1000

Where: Activity (Q) is the quantity of LPG gas consumed, expressed in tonnes and sourced from supplier invoices/meters; Energy Content of Fuel (EC) is the LPG coefficient and has a default value of 49.6 GJ/t; Emission Factor (EF) is the LPG point-source kg CO_2-e/GJ coefficient and with a default value of 59.4 kg CO_2-e/GJ.

PUBLIC ELECTRICITY GENERATION AND TRANSMISSION FACTORS AND METHODS

If your organisation generates electricity for public/private usage you will need to calculate the greenhouse emissions associated with the generation process. To determine these emissions, there are three formulas that can be used in conjunction with each other or independently, depending on your organisation's activities and the information you have available. All three formulas should use the emission factors in Table 1.2.

Separate calculations should be carried out for each fuel type. The formula you should use will depend on whether you are a producer of electricity for public consumption or you are a transmission/distribution organisation. This formula can be used to measure the greenhouse gas emissions directly related to the production of electricity.

Electricity production (formula 1)

Formula 1: GHG emissions (t CO_2-e) = [Activity (Q) x Energy Content of Fuel (EC) x Emission Factor (EF)] ÷ 1000

Where: Activity (Q) is the quantity of fuel measured in tonnes and sourced from inventory or supplier invoices and/or production records. Energy Content of Fuel (EC) is the coefficient for each bulk supply fuel used in the production of electricity and determined by your organisation; and Emission Factor (EF) is the full fuel cycle kg CO_2-e/GJ coefficient for the use of fuels in electricity production.

Transmission (formula 2)

The following formula should be used to estimate the greenhouse gas emissions associated with electricity lost or used in the transmission system. The formula takes into account combustion and indirect emissions from the State electricity systems (based on actual 1999 data) so it is not necessary to use Formula 1.

Formula 2: GHG emissions (t CO_2-e) =
[Activity (Q) x Emission Factor (EF)] ÷ 1000

Where: Activity (Q) is the quantity of electricity lost or used and measured in kWh as documented in the organisation's inventory or production records. Emission factor (EF) is the full fuel cycle kg CO_2-e/kWh coefficient for the production of electricity and has a default value of 1.308 kg CO_2-e/kWh

Distribution (formula 3)

If you are an electricity distribution organisation, the following formula should be used to estimate greenhouse gas emissions associated with electricity lost or used in the distribution system. The formula takes into account combustion and other emissions from State electricity systems so it is not necessary to use Formula 1.

Formula 3: GHG emissions (t CO_2-e) =
[Activity (Q) x Emission Factor (EF)] ÷ 1000

Where: Activity (Q) is the quantity of electricity lost or used and measured in kWh, as documented in the organisation's records. Emission Factor (EF) is the full fuel cycle kg CO_2-e/kWh coefficient for the production of electricity and has a default value of 1.363 kg CO_2-e/kWh.

OTHER STATIONARY FUEL COMBUSTION FACTORS AND METHODS

If your organisation uses coal or other fuels to generate electricity or heat, other than as a public electricity generator, you will need to identify the source of your greenhouse gas emissions from the combustion of each type of fuel. Emissions are generally expressed in tonnes of CO_2-e, which includes the global warming effect of CO_2 as well as the relatively small quantities of CH_4 and N_2O emitted. Most of the emissions occur at the point of final fuel combustion (direct emissions) but there are also emissions associated with the production and transportation of the fuel (indirect emissions). 'Full fuel cycle' emissions include both direct and indirect emissions.

Fuel combustion

Formula: GHG emissions (t CO_2-e) =
[Activity (Q) x Energy Content of Fuel (EC) x Emission Factor (EF)] ÷ 1000

Table 1.2: Fuel combustion emission factors

Fuel combustion	Energy content of fuel (EC) GJ/t, MJ/l, GJ/kl	Point-source emission kg CO_2-e/GJ	Full fuel emissions kg CO_2-e/GJ
Brown coal	Refer specifications of actual fuel Default 10.0 GJ/t	88.3	93.9
Coal used in steel industry	30.0 GJ/t	91.8	112.8
Coal by-products (gaseous)	37	48.5	
Coal by-products (coal tar and BTX)		81	92.5
Brown coal briquettes	22.1 GJ/t	105.0	115.7
Coke	27.0 GJ/t	119.5	131.0
LPG: non-transport	49.6 GJ/t	59.4	67.1
Naphtha	31.4 MJ/l	66.0	73.7
Lighting kerosene	36.6 GJ/kl	69.7	77.4
Heating oil	37.3 GJ/kl	69.7	77.4
Refinery fuel		68.1	75.8
Automotive diesel: non- transport	38.6 GJ/kl	69.7	77.6
Industrial/marine diesel fuel	39.6 GJ/kl	69.7	77.7
Fuel oil	Refer specifications of actual fuel Default 40.8 GJ/kl	73.6	81.5
Natural gas (Victoria)	Consumption measured in GJ	51.7	refer table 1.1
Town gas	Stock measured in GJ	59.4	59.0
Waste methane	Stock measured in GJ	51.0	56.0

COAL, GAS AND PETROLEUM PRODUCTION, TRANSMISSION AND DISTRIBUTION FACTORS AND METHODS

If your organisation produces coal, gas and petroleum products you have a choice of formulas that can be used to determine the emissions from sources such as coal seam methane, use of explosives and crude oil production. The formulas are relatively simple and should be used in conjunction with the emission factors contained in Table 1.3. The product produced will determine your choice of formula.

Oil refinery flaring

Formula: Various gases (t) = tonnes of gas flared (Q) x Emission Factor (EF) or

(GJ) = [gas flared (Q) x Emission Factor (EF)] ÷ 1000

Total t CO_2-e = t CO_2 + t CH_4 x [GWP (CH_4)] + t N_20 x [GWP (N_20)]

Sourced from meters or engineering estimates.

Natural gas processing flaring

Formula: Various gases (t) = [tonnes of gas flared (Q) x Emission Factor (EF)] ÷ 1000

Total t CO_2-e = t CH_4 x [GWP (CH_4)]

Sourced from meters or engineering estimates.

Unaccounted % CH_4 for gas

Formula: % of CO_2 (Q1) x global warming potential CH_4 (21)

% of CO_2 (Q2) x global warming potential CO_2 (1)

Sourced from meters/financial records.

Table 1.3: Coal, gas and petroleum emission factors

Source	Emission Factor (all from NGGI*)
Oil refinery flaring	CO_2 = 2695 kg/t or 47.2 kg/GJ CH_4 = 6.8 kg/t or 0.12 kg/GJ N_2O = 0.081 kg/t or 0.0014 kg/GJ
Natural gas processing (not venting/flaring)	CH_4= 5.74 kg/t Natural gas processing flaring CO_2 = 2690 kg/t CH_4 = 35 kg/t N_2O = 0.081 kg/t
Default for gas production	0.02 kt/PJ

* *National greenhouse gas inventory* workbooks

INDUSTRIAL PROCESSES, INCLUDING REFRIGERANTS AND SOLVENTS, FACTORS AND METHODS

If, through the course of its operation, your organisation undertakes industrial processes such as those listed in Table 1.4, you will need to calculate the associated greenhouse gas emission using the appropriate formula. The formulas contained in Table 1.4 are relatively simple but can only be completed if you have the data variables listed. The industrial processes your organisation undertakes will determine your choice of formula. The formulas are primarily sourced from the *National greenhouse gas inventory* (NGGI) workbooks.

Table 1.4: Industrial processes formulas

Source	Formula	Data variables required	Data source
Refrigerants and solvents			
HFCs in refrigerators/ air conditioning	HFCs (kg): Household CO_2 (t) = [Q x 0.01] + 1000 Other stationary CO_2 (t) = [Q x 0.175] + 1000 Mobile CO_2 (t) = [Q x 0.33] + 1000	Q is the HFC contained in equipment: refrigeration, freight, transport 0.80 kg per car 1.70 kg per truck 6.50 kg/per refrigerated trailer	Equipment specifications
Industrial processes			
Aluminium production	CO_2 (t) = [Q x 1513] + 1000 CF_4 (t) = [Q x 0.2] + 1000 x [GWP (CF_4)] C_2F_6 (t) = Q x 0.02 + 1000 x [GWP (C_2F_6)]	Q = aluminium produced (t)	Records: production
Aluminium production	CO_2 (t) = [Q x 94.2] + 1000	Q = lime by-product produced (t)	Records: production
Iron and steel—crude steel production	CH_4 (t) = [Q x 0.44] + 1000 CO_2-e (t) = [Q x 0.44] x [GWP (CH_4)]	Q = crude steel (t)	Records: production
Iron and steel—calcinations of lime and dolomite	CO_2 (t) = Q x 0.405	Q = lime/dolomite used (t)	Records: production
Cement—oxidation of limestone in clinker/cement/ lime production	Clinker: CO_2 (t) = Q x 0.44 Cement: CO_2 (t) = Q x 0.44 Lime: CO_2 (t) = Q x 0.44	Q = limestone used (t)	Records: production
Cement—oxidation of dolomite in dolomitic lime production	CO_2 (t) = Q x 0.477	Q = dolomite used (t)	Records: production
Magnesium—use of SF_6 as cover gas	SF_6 (t) = Q CO_2-e (t) = Q x 0.44 x [GWP (SF_6)]	Q = SF_6 used (t)	Records: production
Soda ash use	CO_2 (t) = Q x 0.415	Q = soda ash (t)	Records: inventory, production

Glossary

CH_4	methane	km	kilometre	O	production in tones (output)
CO_2-e	carbon dioxide equivalent	kWh	kilowatt hour	p.a.	per annum
EC	energy content of fuel	l	litre	PJ	petajoule
FE	fuel efficiency	m^3	cubic metre	Q	activity
GHG	greenhouse gas	MJ	megajoule	SF_6	sulfur hexafluoride
GJ	gigajoules	MWh	megawatt hour	t	tonne
GWP	global warming potential	NGGI	National greenhouse gas inventory	v	volume
kg	kilogram	NOx	nitrogen oxide	wt	weight
kL	kilolitre				

Table 1.5: Greenhouse gas global warming potential

Gas	Chemical formula	IPPC 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-43-1omee	$C_5H_2F_{10}$	1 300
HFC-125	C_2HF_5	2 800
HFC-134	$C_2H_2F_4(CHF_2CHF_2)$	100
HFC-134a	$C_2H_2F_4(CHF_2CHF_3)$	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
Perfluorocarbons (PFCs)		
Perfluoromethane (tetrafluoromethane)	CF_4	6 500
Perfluoromethane (hexafluoromethane)	C_2F_6	9 200
Perfluoropropane	C_3F_8	7 000
Perfluorobutane	C_4F_8	7 000
Perfluorocyclobutane	C_4F_{10}	8 700
Perfluoropentane	C_5F_{12}	7 500
Perfluorohexane	C_6F_{14}	7 400
Sulfur hexafluoride	SF_6	23 900

Table 1.6: Basic information

Abbreviation	Prefix	Symbol
10^{15} (10^6 x 10^9)	peta (million billion)	P
10^{12} (10^3 x 10^9)	tera (thousand billion)	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)	–
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	u
10^{-9}	nano	n
10^{-12}	pico	p

Table 1.7: Equivalences

10^{15} grams (petagram)	gigatonne (Gt)
10^{12} grams	megatonne (Mt)
10^9 grams	kilotonnes (kt) (10^3 tonnes)
10^6 grams	1 tonne
kg/GJ (10^3 g/10^9 J)	Gg/PJ (10^9 g/10^{15} J)
Unit of energy	joule (J)
Unit of power (rate of energy usage)	Watt (W)

Table 1.8: Conversion factors

1 Watt	= 1 joule
3600 watt-seconds	= 1 watt-hour (3600 seconds in one hour)
1 watt-hour	= 3600 joules
1000 watt-hours	= 1 kilowatt hour
1 kWh	= 3.6 x 10^6 joules = 3.6 MJ

kWh to J	kWh x 3.6 x 106	joules
J to kWh	J x 0.278 x 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 x 10^{-3}	GJ
GJ to kWh	GJ x 278	kWh
kWh to PJ	kWh x 3.6 x 10^{-9}	PJ