# Annex M – Greenhouse Gas Assessment

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# Vipac Engineers & Scientists

## Tattersall Lander PTY LTD

Bobs Farm Sand Mine

Greenhouse Gas Assessment

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| **Greenhouse Gas Assessment**<br>**Bobs Farm Sand Mine** | |
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## EXECUTIVE SUMMARY

Vipac Engineers & Scientists Ltd (Vipac) was commissioned to prepare a Greenhouse Gas Assessment for the proposed Bobs Farm Sand Mine. The purpose of this report is to calculate the greenhouse gas emissions of the construction and operation of the new facility over the 13-year life of the Project.

This assessment has determined the following:

- The highest annual emissions is 4,958.9 tonnes $CO_2$-e during Phase 4. This is below the 25,000 tonnes $CO_2$-e threshold and therefore emissions do not need to be reported.
- The Life of Project emissions are estimated to be 57,657.7 tonnes $CO_2$-e; and
- When compared to Australia's reported greenhouse gas emissions for 2012 (558.8 million tonnes), the highest annual emissions during Phase 4 is approximately 0.00088% of Australia's total emissions.

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# 1 INTRODUCTION

Vipac Engineers & Scientists Ltd (Vipac) was commissioned to prepare a Greenhouse Gas Assessment for the proposed Bobs Farm Sand Mine. The purpose of this report is to calculate the greenhouse gas emissions of the construction and operation of the new facility over the 13-year life of the Project.

Greenhouse gases (GHG's) are a natural part of the atmosphere; they absorb and re-radiate the sun's warmth, and maintain the Earth's surface temperature at a level necessary to support life. Human actions, particularly burning fossil fuels (coal, oil and natural gas), agriculture and land clearing are increasing the concentrations of the greenhouse gases. This is the enhanced greenhouse effect, which is contributing to warming of the Earth.

Greenhouse gases include water vapour, carbon dioxide ($CO_2$), methane, nitrous oxide and some artificial chemicals such as chlorofluorocarbons (CFCs). Water vapour is the most abundant greenhouse gas. These gases vary in effect and longevity in the atmosphere, but scientists have developed a system called Global Warming Potential to allow them to be described in equivalent terms to $CO_2$ (the most prevalent greenhouse gas) called equivalent carbon dioxide emissions ($CO_2$-e). A unit of one tonne of $CO_2$-e (t $CO_2$-e) is the basic unit used in carbon accounting. An emissions inventory, or 'carbon footprint', is calculated as the sum of the emission rate of each greenhouse gas multiplied by the global warming potential.

# 2 BIBLIOGRAPHY

Department of Environment. (2015). *National Greenhouse Accounts (NGA) Factors Workbook.* Canberra: Department of Environment.

Hammond, Professor Geoff and Jones, Craig. (2008). *Inventory of Carbon and Energy (ICE).* Bath: University of Bath.

# 3 PROJECT DESCRIPTION

The proposed Bobs Farm Sand Mine project comprises:

- The establishment of a quarry/pit to extract and process sand at a rate of approximately 750,000 tonnes per annum, from a total sand resource of approximately 8-10 million tonnes. The estimated life of the extraction process is 13 years;
- The construction of extractive materials processing and transport infrastructure;
- The transportation of extractive materials off-site via roads; and
- The rehabilitation of the site.

Sand will be extracted from the site by two main mining methods:

- Dry mining utilising excavator and haul trucks to remove dry sand products from the pit areas above the water table for processing prior to export, and
- Wet mining utilising a dredge and pump line system to pump wet raw sand materials for processing prior to export.
- An overview of the developmental stages during the Project life is provided in ***Table 1***.

***Table 1: Overview of Proposed Operations***

| Phase | Operational Year | Annual Throughput (tonnes) | Method | Equipment |
|---|---|---|---|---|
| Phase1 | Year 1 | 150,000 | Stripping of topsoil and dry mining (Stripping Phase) | 1x 35 tonne excavator<br>1x 22 tonne excavator<br>2x 44 tonne dump trucks<br>2x 23 tonne loaders |
| Phase 2 | Year 2 | 250,000 | Dry mining Construction Stage and Year 1 Extraction/Production) | 1x 12/10 suction cutter dredge<br>1x 22 tonne excavator<br>1x 44 tonne dump trucks<br>2x 23 tonne loaders |
| Phase 3 | Year 3 | 450,000 | Dry mining (Initial Extraction Stage down to water-table) | 1x 12/10 suction cutter dredge<br>1x 22 tonne excavator<br>1x 44 tonne dump trucks<br>2x 23 tonne loaders |
| Phase 4 | Years 4 - 13 | 700,000 | Wet production (Final Extraction – production below the water-table down to a depth of -15m below the water-table) | 1x 12/10 suction cutter dredge<br>1x 22 tonne excavator<br>1x 44 tonne dump trucks<br>2x 23 tonne loaders |

The main activities of the Project will be the bulk handling of sand material, utilising mobile plant, general truck movements for the transport of the material to the plant where the sand is screened and washed before being de-watered and stockpiled. The final product will be transported, when necessary from site using trucks.

# 4 REGULATORY FRAMEWORK

The *Commonwealth National Greenhouse and Energy Reporting Act 2007* (NGER Act) established a national framework for corporations to report greenhouse gas emissions and energy consumption. The NGER Act requires corporations to submit an annual report in energy consumption, energy production and greenhouse gas emissions, if any of the following thresholds are met:

- The facility consumes more than 100 terajoules of energy in a financial year or emits greenhouse gases above 25,000 tonnes $CO_2$-e (facility threshold); and
- All Australian facilities collectively consume more than 200 terajoules of energy in a financial year or emit greenhouse gases above 50,000 tonnes $CO_2$-e (corporate threshold).

A facility is defined as an activity, or a series of activities (including ancillary activities), if it involves the production of greenhouse gas emissions, the production of energy or the consumption of energy; and forms a single undertaking or enterprise and meets the requirements of the regulations.

Tattersall Lander will not be required to report under the NGER Act as the Project is not expected to emit more than 25,000 tonnes of $CO_2$-e per year.

# 5 METHODOLOGY

The Department of the Environment (DOE) monitors and compiles databases on anthropogenic activities that produce greenhouse gases in Australia. The DOE has published greenhouse gas emission factors for a range of anthropogenic activities. The DOE methodology for calculating greenhouse gas emissions is published in the National Greenhouse Accounts (NGA) Factors workbook (Department of Environment, 2015). This workbook is updated regularly to reflect current compositions in fuel mixes and evolving information on emission sources.

The scope that emissions are reported, as defined by the NGA Factors Workbook is determined by whether the activity is within the organisation's boundary (Scope 1 – Direct Emissions) or outside the organisation's boundary (Scopes 2 and 3 – Indirect Emissions). The scopes are described below:

- Scope 1 Emissions: 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.);
- Scope 2 Emissions: Indirect emissions from the generation of the electricity purchased and consumed by an organisation as kilograms of $CO_2$-e per unit of electricity consumed; and
- Scope 3 Emissions: Indirect emissions 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 transmission and distribution network.

Scope 1 emissions include those from fuel use by vehicles, coal burnt in boilers and methane from wastewater systems. Scope 2 emissions are from any purchased electricity. Scope 3 emissions are from the emissions resulting from the energy required to manufacture products such as diesel and equipment.

Emission factors used in this assessment have been derived from either the Department of Environment, site-specific information or from operational details obtained from similar emission sources.

The majority of the emission factors used in this report has been sourced from the NGA Factors Workbook (Department of Environment, 2015) as indicated in ***Table 5-1***. The carbon emissions for the embodied energy of materials have been derived from the *Inventory of Carbon and Energy* (Hammond, Professor Geoff and Jones, Craig, 2008).

***Table 5-1: Emission Factors***

| Scope | Emission Source | Emission Factor | Source |
|---|---|---|---|
| 1 | Combustion emissions from diesel (stationary) | 2.71 t $CO_2$-e / kL | NGA Factors Workbook, 2015 |
| | Combustion for transport (general) | 2.29 t $CO_2$-e / kL | NGA Factors Workbook, 2015 |
| 2 | Electricity (purchased in NSW) | 0.84 kg $CO_2$-e / kWh | NGA Factors Workbook, 2015 |
| 3 | Combustion for transport (general) | 0.18 t $CO_2$-e / kL | NGA Factors Workbook, 2015 |
| | Electricity (purchased in NSW) | 0.12 kg $CO_2$-e / kWh | NGA Factors Workbook, 2015 |
| | Diesel consumption | 0.139 t $CO_2$-e / kL | NGA Factors Workbook, 2015 |
| | Embodied energy for concrete | 0.13 kg $CO_2$-e/kg | Hammond and Jones, 2008 |
| | Embodied energy for steel (general) | 1.77 kg $CO_2$-e/kg | Hammond and Jones, 2008 |

For this assessment Scope 1, Scope 2 and Scope 3 emissions have been calculated in accordance with the NGA Factors Workbook methodology.

# 6 QUANTIFICATION OF EMISSIONS

This section will quantify the carbon dioxide equivalent emissions associated with the annual $CO_2$-e emissions and Life of the Project $CO_2$-e emissions are presented.

## 6.1 Embodied Energy of Construction Materials

The upstream emissions have been identified the embodied energy associated with the production of construction materials. The quantities of materials have been provided by Quarry Mining Systems and are shown in ***Table 6-1***. The associated emissions are shown in ***Table 6-2***. The total emissions during the construction phase are 199.3 tonnes $CO_2$-e.

***Table 6-1: Quantity of Construction Materials***

| Item | Concrete ($m^3$) | Steel (kg) |
|---|---|---|
| Weighbridge | 60 | 500 |
| Work Shop | 80 | 600 |
| Admin & carpark | 80 | 400 |
| Screen (18 x 5) | 60 | 600 |
| Wash plant | 40 | 28,000 |
| Cyclone Pad | 25 | 200 |
| Cyclone Tower | - | 15,000 |
| Electricity transformer pad | 10 | 100 |
| **Total** | **355 $m^3$ (852 tonnes)** | **45,400 kg (50 tonnes assumed)** |

***Table 6-2: Construction Material Embodied Energy Emissions ($CO_2$-e tonnes)***

| Emission Source | Scope | Amount of Material (tonnes) | Emissions (t $CO_2$-e) |
|---|---|---|---|
| Embodied energy of concrete | 3 (Embodied) | 852 | 110.8 |
| Embodied energy of steel | 3 (Embodied) | 50 | 88.5 |
| | | **Total $CO_2$-e Emissions (tonnes)** | **199.3** |

## 6.2 Purchased Power

The proposed mine will use electricity from the grid. At present the expected amount of electricity is unknown, however cost estimates allow $3,500 per month. For the purposes of this assessment, a usage of 10,000 kWh per month consumption has been assumed. The emissions are presented in ***Table 6-3***.

***Table 6-3: Electricity Consumption ($CO_2$-e tonnes)***

| Emission Source | Scope | Annual Usage (kL) | Annual Emissions (t $CO_2$-e) |
|---|---|---|---|
| Purchased Electricity | 2 | 120,000 | 100.8 |
| | 3 (embodied) | 120,000 | 14.4 |
| | Total $CO_2$-e Emissions (tonnes) per Annum | | 115.2 |
| | **Project Total $CO_2$-e Emissions (tonnes)** | | **1,497.6** |

## 6.3 Mining Equipment Fuel

The equipment list and associated fuel consumption for each mobile plant has been provided by Quarry Mining Systems. The calculations in ***Table 6-4*** are based on operational activity of eight hour operation per day for 209 days per annum.

***Table 6-4: Mining Equipment Fuel Emissions ($CO_2$-e tonnes)***

| Emission Source | Scope | Diesel Consumption (L/hour) | Emissions (t $CO_2$-e) | | | |
|---|---|---|---|---|---|---|
| | | | Phase 1 | Phase 2 | Phase 3 | Phase 4 (per annum) |
| Excavator (35 tonne) | 1 (Direct) | 35 | 158.6 | - | - | - |
| | 3 (Embodied) | 35 | 8.1 | - | - | - |
| Excavator (22 tonne) | 1 (Direct) | 25 | 113.3 | 226.6 | 226.6 | 226.6 |
| | 3 (Embodied) | 25 | 5.8 | 11.6 | 11.6 | 11.6 |
| Loaders (23 tonne) | 1 (Direct) | 26 | 235.6 | 235.6 | 235.6 | 235.6 |
| | 3 (Embodied) | 26 | 12.1 | 12.1 | 12.1 | 12.1 |
| Haul Trucks (44 tonne) | 1 (Direct) | 36 | 326.2 | 163.1 | 163.1 | 163.1 |
| | 3 (Embodied) | 36 | 16.7 | 8.4 | 8.4 | 8.4 |
| Suction Cutter Dredge | 1 (Direct) | 60 | - | 271.9 | 271.9 | 271.9 |
| | 3 (Embodied) | 60 | - | 13.9 | 13.9 | 13.9 |
| Total $CO_2$-e Emissions (tonnes) per Annum | | | 876.5 | 943.2 | 943.2 | 943.2 |
| Total $CO_2$-e Emissions (tonnes) per Phase | | | 876.5 | 943.2 | 943.2 | 9,431.5 |
| **Project Total $CO_2$-e Emissions (tonnes)** | | | **12,194.3** | | | |

## 6.4 Transport Fuel Emissions (Staff Movements)

The transport fuel emissions have been calculated for staff transport to and fro, from work. It has been confirmed that seven staff will be employed at the sand mine. The following assumptions have been made for this assessment:

- Average fuel consumption per vehicle is 10 litres per 100 km travelled; and
- Average distance is 40 km round trip per day for 209 days per annum.

***Table 6-5*** presents the estimated $CO_2$-e emissions from staff movements.

***Table 6-5: Transport Fuel Emissions from Staff Movements ($CO_2$-e tonnes)***

| Emission Source | Scope | Annual Usage (kL) | Annual Emissions (t $CO_2$-e) |
|---|---|---|---|
| Staff Movements | 1 (direct) | 5.85 | 13.43 |
| | 3 (embodied) | 5.85 | 1.06 |
| Total $CO_2$-e Emissions (tonnes) per Annum | | | 14.49 |
| **Project Total $CO_2$-e Emissions (tonnes)** | | | **188.39** |

### 6.5 Haulage Fuel (from Mine to Customers)

Haul trucks with a payload of 44 tonnes will transport the material from the mine to customers located in the Newcastle or Sydney areas. Some material will be exported out of Australia; these emissions have not been calculated.

The following assumptions have been made for this assessment:

- Average fuel consumption per vehicle is 36 litres per 100 km travelled;
- Average distance is 235 km round trip (assumes average distance between Newcastle and Sydney); and,
- Operational days per year are 209 days.

***Table 6-6*** presents the estimated $CO_2$-e emissions from staff movements.

***Table 6-6: Haulage Truck Emissions ($CO_2$-e tonnes)***

| Emission Source | Scope | Diesel Consumption (L/100 km) | Emissions (t $CO_2$-e) | | | |
|---|---|---|---|---|---|---|
| | | | Phase 1 | Phase 2 | Phase 3 | Phase 4 (per annum) |
| Haul Truck | 1 (Direct) | 36 | 773.0 | 1,289.4 | 2,321.2 | 3,610.7 |
| | 3 (Embodied) | 36 | 58.9 | 98.3 | 177.0 | 275.3 |
| Total $CO_2$-e Emissions (tonnes) per Annum | | | 832.0 | 1,387.8 | 2,498.2 | 3,886.0 |
| Total $CO_2$-e Emissions (tonnes) per Phase | | | 832.0 | 1,387.8 | 2,498.2 | 38,860.2 |
| **Project Total $CO_2$-e Emissions (tonnes)** | | | **43,578.2** | | | |

# 7 SUMMARY OF EMISSIONS

The purpose of this report is to evaluate the greenhouse gas emissions from the operation of the facility. ***Table 7-1*** presents the annual emissions during each phase of the project and the life of project emissions.

The following can be determined:

- The highest annual emissions is 4,958.9 tonnes $CO_2$-e during Phase 4. This is below the 25,000 tonnes $CO_2$-e threshold and therefore emissions do not need to be reported.
- The Life of Project emissions are estimated to be 57,657.7 tonnes $CO_2$-e; and
- When compared to Australia's reported greenhouse gas emissions for 2012 (558.8 million tonnes), the highest annual emissions during Phase 4 is approximately 0.00088% of Australia's total emissions.

***Table 7-1: Summary of Annual Emissions***

| Activity | Annual Emission (t $CO_2$-e) | | | | Life of Project Emissions (t $CO_2$-e) |
|---|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 | Phase 4 (per Annum) | |
| Construction Materials | 199.3 | - | - | - | 199.3 |
| Equipment Fuel | 876.5 | 943.2 | 943.2 | 943.2 | 12,194.3 |
| Transport Fuel (Staff) | 14.5 | 14.5 | 14.5 | 14.5 | 188.4 |
| Electricity | 115.2 | 115.2 | 115.2 | 115.2 | 1,497.6 |
| Haulage | 832.0 | 1,387.8 | 2,498.2 | 3886.0 | 43,578.2 |
| **Total** | **2,037.4** | **2,460.6** | **3,571.1** | **4,958.9** | **57,657.7** |

## Appendix A: GLOSSARY

| | |
|---|---|
| Carbon dioxide equivalent | A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). |
| Climate | Usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands of years. |
| Climate change | Any significant change in measures of climate lasting for an extended period (decades or longer). |
| Emissions | The release of a substance (usually a gas) into the atmosphere. |
| Emissions factor | A unique value for scaling emissions to activity data in terms of a standard rate of emissions per unit of activity (e.g., grams of carbon dioxide emitted per barrel of fossil fuel consumed) |
| Global warming | Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns. |
| Greenhouse effect | Trapping and build-up of heat in the atmosphere (troposphere) near the Earth's surface. Some of the heat flowing back toward space from the Earth's surface is absorbed by water vapour, carbon dioxide, ozone, and several other gases in the atmosphere and then reradiated back toward the Earth's surface. If the atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere will gradually increase. |
| Greenhouse Gas (GHG) | Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases as defined by Australian Regulations: |
| Carbon dioxide ($CO_2$) | naturally occurring gas, and a by-product of burning fossil fuels and biomass, as well as land-use changes and other industrial processes. It is the reference gas against which other greenhouse gases are measured. |
| Methane ($CH_4$) | produced through anaerobic (without oxygen) decomposition of waste in landfills, animal digestion, decomposition of animal wastes, production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion |
| Nitrous oxide ($N_2O$) | a powerful greenhouse gas. Major sources of nitrous oxide include soil cultivation practices, especially the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning. |
| Hydrofluorocarbons (HFCs) | compounds containing only hydrogen, fluorine, and carbon atoms. They were introduced as alternatives to ozone depleting substances in serving many industrial, commercial, and personal needs. HFCs are emitted as by-products of industrial processes and are also used in manufacturing. |
| Perfluorocarbons (PFCs) | a group of human-made chemicals composed of carbon and fluorine only. PFCs do not harm the stratospheric ozone layer, but they are powerful greenhouse gases. |
| Sulphur hexafluoride ($SF_6$) | a colourless gas soluble in alcohol and ether, and slightly soluble in water. A very powerful greenhouse gas used primarily in electrical transmission and distribution systems and as a dielectric in electronics. |

| | |
|---|---|
| Hydrocarbons | Substances containing only hydrogen and carbon including fossil fuels. |
| Metric tonne | Common international measurement for the quantity of greenhouse gas emissions. |
| Natural gas | Underground deposits of gases consisting of 50 to 90 percent methane ($CH_4$) and small amounts of heavier gaseous hydrocarbon compounds. |
| Nitrogen oxides ($NO_X$) | Gases consisting of one molecule of nitrogen and varying numbers of oxygen molecules. Nitrogen oxides are produced in the emissions of vehicle exhausts and from power stations. |
| Ozone (O3) - | A triatomic form of oxygen is a gaseous atmospheric constituent. In the troposphere, it is created both naturally and by photochemical reactions involving gases resulting from human activities (photochemical smog). |

# Appendix B: TECHNICAL CONSIDERATIONS

Climate change is a change in the average pattern of weather over a long period of time. There is evidence that our climate is changing, largely due to human activities. The Fourth Assessment Report, produced by the Intergovernmental Panel on Climate Change (IPCC) in 2007, states global warming is 'unequivocal' and 'most of the observed increase in globally-averaged temperatures since the mid-20th century is very likely due to the observed increase in greenhouse gas concentrations'.

There are multiple lines of evidence that show the Earth's climate system is warming. These include increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. Climate change, however, is not just about global warming; the science indicates that the climate will be altered in many other ways. For example, there will be changes in rainfall patterns and ocean currents, changes to the intensity and frequency of extreme events such as storms, droughts and floods, rising global sea level and ocean acidification.

### Greenhouse Gases & Global Warming Potential

Greenhouse gases are a natural part of the atmosphere; they absorb and re-radiate the Sun's warmth, and maintain the Earth's surface temperature at a level necessary to support life. Human actions, particularly burning fossil fuels (coal, oil and natural gas), agriculture and land clearing, are increasing the concentrations of the gases that trap heat. This is the enhanced greenhouse effect, which is contributing to warming of the Earth.

Greenhouse gases include water vapour, carbon dioxide $CO_2$, methane, nitrous oxide and some artificial chemicals such as chlorofluorocarbons (CFCs). Water vapour is the most abundant greenhouse gas. Its concentration is highly variable and human activities do not directly impact on its amount in the atmosphere. The concentrations of the other greenhouse gases in the atmosphere are directly influenced by human activities. Once released into the atmosphere, many of these gases remain there for a long time.

Standard units of measurement are prescribed for the standard reportable items; emissions of each greenhouse gas are be estimated and reported in tonnes of $CO_2$-equivalent. Conversion factors from tonnes of emissions of each greenhouse gas to tonnes of emissions of carbon dioxide equivalent for that gas are called Global Warming Potentials (GWP) and are listed in ***Table B-1***.

***Table B-1: Global Warming Potentials***

| Greenhouse Gas | | Chemical Formula | Global Warming Potential |
|---|---|---|---|
| Carbon dioxide | | $CO_2$ | 1 |
| Methane | | $CH_4$ | 21 |
| Nitrous oxide | | $N_2O$ | 310 |
| Sulphur hexafluoride | | $SF_6$ | 23,900 |
| Hydrofluorocarbons | 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 |
| Perfluorocarbons | Perfluoromethane | $CH_4$ | 6,500 |
| | Perfluoroethane | $C_2F_6$ | 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 |

The Global Warming Potential figures in the above table are the figures published by the Intergovernmental Panel on Climate Change in Climate Change 1995: The Science of Climate Change (Cambridge, UK: Cambridge University Press, 1996).

**Direct & Indirect Emissions**

Direct emissions are produced from sources within the boundary of an organisation and as a result of the 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 that 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.

Indirect emissions are emissions generated in the wider economy as a consequence of an organisation's activities, but which are physically produced by the activities of another organisation. The most important category of indirect emissions is from the consumption of electricity.