



Method for Measuring Greenhouse Gas Emissions in the ACT

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Foreword

Dealing effectively with the threat of harmful climate change is a major policy challenge for all levels of government. Measurement of greenhouse gas emissions is a critical element in the design and evaluation of policy responses to this challenge. Therefore the Commission welcomes the opportunity, provided by a request for advice from the responsible Minister, to make a contribution to the determination of a methodology for the measurement of GHG emissions in the ACT.

While attention in the national debate tends to focus on high level issues like power generation, a reduction in GHG emissions will only occur if each of us in the community reduces the quantity of emissions-intensive goods and services that we choose to consume. As explained in detail in the body of the Report, when it comes to measuring the emissions in a city-state like the ACT, it is natural to give careful attention to the consumption of such goods and services within the Territory.

Measuring emissions accurately and comprehensively presents significant challenges. Those that arise in the context of measuring emissions in the ACT are discussed in the body of the Report along with the Commission's recommendations for responding to them. Those recommendations are based on judgements that have been strongly influenced by the current availability of data, the current structure of the ACT and national economies, and the current policy stances of Australia's governments. Any or all of these things may be expected to change over time. An estimation method that passes the test of reasonable accuracy today may not do so tomorrow. For that reason, the Commission intends to keep the methodology for measurement of GHG emissions in the ACT under review as it moves into the phase of constructing inventories, starting with 2008–09, with a view to ensuring that the Minister is provided with timely advice on changes that may require refinements to the methodology.

The Commission looks forward to receiving the Minister's determination of the methodology and to commencing the first of the inventories to be conducted with the framework of the *Climate Change and Greenhouse Gas Reduction Act 2010*.

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1 Introduction

The *Climate Change and Greenhouse Gas Reduction Act 2010*¹ (the Act) establishes emissions targets and provides for monitoring and reporting in relation to the targets. Section 11 (Measuring greenhouse gas emissions – determinations) provides that the Minister must determine a method for measuring greenhouse gas (GHG) emissions. In making the determination, the Minister must seek, and have regard to, the advice of an independent entity.

On 27 May 2011, the Minister for the Environment and Sustainable Development, Simon Corbell MLA, wrote to the Commission requesting it to provide advice on an appropriate methodology for measuring GHG emissions, as required by the Act. This paper considers and recommends an appropriate methodology, and provides the formal advice requested by the Minister and as a basis for the required determination.

In considering the methodology, the Commission notes that the objects of the Act are:

- (a) to set targets to reduce greenhouse gas emissions and increase renewable energy use and generation in the ACT; and
- (b) to provide for monitoring of and reporting on progress made in the ACT to meet the targets; and
- (c) to facilitate the government’s development of policies and programs to meet the targets and to address and adapt to climate change; and
- (d) to encourage private entities to take action to address climate change and recognise the entities that take action.

The Commission also notes that, in regard to determining the methodology for measuring emissions, the Act provides that the Minister “must, as far as practicable, ensure consistency with the best national and international practices in relation to measuring GHG emission”.

The Commission further notes that

The ACT Government has taken the view that, to the extent practicable, the ACT should be accountable for the greenhouse gases it causes to be emitted.²

In advising the Minister, the task of the Commission therefore is to determine the extent to which it is practicable to measure the GHG emissions that the ACT causes to be emitted and to identify operational methods by which the extent of those emissions may be quantified. In the paper, Chapter 2 considers the GHGs that the ACT emits, both directly and indirectly in the form of emissions caused to be emitted outside the ACT by activities in the Territory. Chapter 3 considers what should be measured and how measurement occurs outside the ACT, particularly nationally. Chapter 4 addresses the proposed methodology to address the matters raised in the ACT and the government’s climate change agenda.

¹ <http://www.legislation.act.gov.au/a/2010-41/current/pdf/2010-41.pdf>.

² DECCEW, *ACT greenhouse gas emissions: ACT greenhouse gas inventory 2008*, Department of the Environment, Climate Change, Energy and Water (2010) p. 1. Available from http://www.environment.act.gov.au/_data/assets/pdf_file/0015/200175/ACT_Greenhouse_Gas_Inventory_2008.pdf.

2 GHG the ACT causes to be emitted

The Commission commenced its consideration of an appropriate methodology by considering the coverage afforded to the ACT by the *National Greenhouse Gas Accounts* (NGA)³ made available by the Commonwealth government through the *National Inventory Report* and the *National Greenhouse Gas Inventory*. In addition to the national level inventory, the NGA provides emissions estimates at the jurisdictional and sectoral level.

The Commonwealth inventory for the ACT's GHG emissions (and those of other jurisdictions) uses a production approach, which focuses upon the measurement of emissions at their point of production.⁴ These are termed *scope 1* emissions, and are GHG emissions that occur within the geographic boundary of each jurisdiction. Thus, while the NGA uses a number of methods for determining and estimating scope 1 emissions, the focus is on the specific facility or production process where the emissions occur. Under the Commonwealth's approach, both sources of GHG emissions and removals by sinks occurring within the ACT's geographic boundary are covered.⁵

This approach of only measuring scope 1 emissions is consistent with international practice and allows the Commonwealth to produce accounts which reflect both location and sectoral estimates of GHG emissions. From a national policy and program perspective, and also for national reporting purposes, this is the preferred and more useful form of GHG reporting and accounting.

The nature of the ACT economy means, however, that this approach falls short of identifying all the GHG emissions that the ACT causes to occur. The clearest example is in electricity consumption. The NGA attributes emissions caused by the generation of electricity to the region where the generation facility is located. Almost all the power consumed in the ACT is generated outside its borders. Therefore the emissions caused by the generation of electricity to satisfy demand for power in the ACT will, in the NGA, be attributed to regions other than the ACT.

This example suggests that the appropriate way to identify the location of the cause of an emission is to identify the location of the activity that consumes the good or service the production of which gives rise to the emission. The Commission has adopted this approach in developing this advice and recommends that it form the basis for the methodology adopted for the ACT's GHG inventory.

This approach is consistent with the draft *International Standard for Determining Greenhouse Gas Emissions for Cities* published by the Urban Environment Unit of the United Nations Environment Programme, which envisages a three-level or three-scope approach to measurement.⁶ In addition to scope 1 emissions, the draft standard provides classifications for measuring emissions that a city causes to occur outside its borders. Under the draft standard, indirect emissions that occur outside of the ACT as a result of activities that occur within the territory are classified as either *scope 2* or *scope 3* emissions. Scope 2 emissions are defined as emissions from electricity consumption and district heating, steam and cooling. The definition of scope 3 emissions covers all other indirect emissions arising from activities such as:

³ <http://www.climatechange.gov.au/en/government/initiatives/national-greenhouse-energy-reporting.aspx>.

⁴ <http://www.climatechange.gov.au/climate-change/~media/publications/greenhouse-actg/state-territory-inventory-2008.ashx>.

⁵ Sinks are defined as land-use change and forestry activities where sequestration exceeds emissions.

⁶ http://www.unep.org/urban_environment/PDFs/InternationalStd-GHG.pdf.

- electrical transmission and distribution losses
- solid waste disposal
- waste incineration
- wastewater handling
- aviation
- marine
- embodied emissions upstream of power plants
- embodied emissions in fuels
- embodied emissions in imported construction materials
- embodied emissions in imported water
- embodied emissions in imported food.

The Commonwealth’s inventory measures scope 2 emissions (indirect emissions for the generation of purchased electricity) at the state level, but not for the territory. Scope 3 emissions are not measured. In order to measure the GHG emissions caused by the ACT, it is clear that the methodology adopted must include at least some scope 2 and scope 3 emissions. A methodology that includes some scope 2 and scope 3 emissions is effectively a hybrid approach.

There is a clear distinction between the approach in the NGA and that required to capture emissions that the ACT has caused to occur. The approach in the NGA is restricted to scope 1 and attempts to account for the share of national emissions produced from sources within the ACT (sources less sinks). An approach aiming to include GHG caused to be emitted by the ACT must clearly go beyond this and adopt a hybrid production-consumption approach for measuring emissions. Such an approach would provide a more comprehensive measure of emissions in the ACT.⁷

There is a strong consensus in the academic literature that an inventory measuring emissions at a sub-national, regional level needs to be created from a hybrid approach that is based on the production of emissions and consumption activities to which emissions are attributable.⁸ In accounting for indirect emissions the hybrid approach reflects the “activity principle” that is often applied when measuring GHG emissions at a regional level. This principle requires allocating emissions occurring outside the jurisdiction’s geographic region to within the jurisdiction if that is where the consumption activity responsible for the emissions is located.

As noted, one of the principal factors driving the adoption of a hybrid approach is the significance of electricity consumption in cities, which is often generated from fossil-fuel plants located outside the city’s boundary. For example, the scope 2 emissions from electricity consumption represent the major share by far of the total GHG emissions caused by the ACT (63 % in 2008). Measures aimed at reducing the consumption of electricity supplied from high emissions electricity generation plants located in other jurisdictions are therefore likely to be significant in reducing GHG in the ACT.

⁷ Here and subsequently the phrase “emissions in the ACT” is adopted as a shorthand for “GHG caused to be emitted by the ACT”. The Commission takes the view that the use of the former phrase in the Act is intended to be interpreted as shorthand for the latter phrase.

⁸ For examples of combined production and consumption approaches see, Dodman, D., Forces driving urban greenhouse gas emissions, *Current Opinion in Environmental Sustainability*, 3 (2011) 1-5; Kennedy, C. et al, Greenhouse Gas Emissions from Global Cities, *Environmental Science & Technology*, 43 (2009) 7297–7302; Kennedy, C. et al, Methodology for inventorying greenhouse gas emissions from global cities *Energy Policy*, 38 (2010) 4828–4837; and Ramaswami, A. et al, A demand-centered, hybrid life-cycle methodology for city-scale greenhouse gas inventories, *Environmental Science & Technology*, 42(17) (2008) 6455-6461.

Accounting for scope 2 emissions such as this provides policy makers with the information necessary for formulating and targeting mitigation measures in the ACT more effectively.

The move from a scope 1 methodology to a hybrid production-consumption methodology, involving elements from scopes 2 and 3, can be prone to error. In particular, there is the possibility that emissions may be measured or attributed more than once: the *duplication problem*. Any effective measurement scheme needs to avoid double counting emissions. This problem can be addressed by ensuring that every source (or sink) contributing (or removing) emissions to (from) the inventory has those emissions appear either in the scope 1 production-based measure, or in the scope 2 or 3, consumption-based measure, but not in both. In principle, if every state and territory adopted the methodology to be used to measure emissions in the ACT, the sum of those measures across all states and territories should equal national emissions for Australia as measured by the NGA.⁹ Clearly, failure to avoid the duplication problem may give rise to incorrect evaluations of the effectiveness of policy initiatives undertaken to reduce GHG emissions in the ACT.

It has been implicit in moving from scope 1 to scope 1 plus elements from scopes 2 and 3 that there is no emissions producing activity within the borders of the ACT for which at least some portion of its emissions ought to be regarded as caused by the use of its product outside the ACT.¹⁰ Were this to change, the methodology would need to adjust accordingly.

For example, if an electricity generating facility were constructed in the ACT, any emissions it generated would be counted in the scope 1 estimate of ACT emissions in the NGA. If the ACT inventory then separately accounted for all of the emissions associated with satisfying the ACT's demand for electricity, then, to the extent that the a portion of the energy generated by the local facility satisfied local demand, there would be a double count of emissions. Were the local facility to have radically different emissions per unit of electricity produced from the other sources satisfying ACT demand, the scope for confusion is even greater. The safest way to avoid these difficulties would be to take out any emissions counted against the local facility in the NGA and account for all the emissions associated with the satisfaction of the ACT's demand for electricity using a scope 2, consumption, based approach.¹¹

Also, there is a comparison problem arising from inconsistencies between approaches adopted in various jurisdictions. Not all jurisdictions in Australia may adopt a hybrid approach to their emissions inventories. Some may simply adopt the production based, regional breakdown provide by the NGA. While this would mean care is needed in comparing jurisdictional inventories and it may mean that these inventories do not add to the national total, it does not invalidate the ACT government's decision to focus on GHG caused to be emitted by the ACT or its use of an ACT GHG inventory designed to measure the extent of such emissions.

⁹ Hoonweg, D. et al., Cities and greenhouse gas emissions: moving forward, *Environment & Urbanization*, 20(10) (2011) 1-21.

¹⁰ An examination of the makeup of gross value added by industry in the ACT broadly supports such a view (see Australian National Accounts: State Accounts (ABS cat. no. 5220.0)). There is the question of how the disproportionate share of government administration and defence in the ACT (31% versus 4% nationally) ought be treated, given that most of this would Commonwealth government activity. While, for the purposes of this Report, the Commission has not taken up the issue, it may be relevant when evaluating the effectiveness of emissions mitigation initiatives by the ACT government.

¹¹ If the availability of the local facility affected the average emissions intensity of the power consumed in the ACT, this would, of course, need to be reflected in the estimation of emissions.

It is worth noting that this approach to measuring GHG emissions in the ACT is the same as that taken in the ACT GHG inventory for 2008 prepared for the ACT Government.¹² Thus, the methodology recommended in this Report will provide continuity with that earlier work.

¹² http://www.environment.act.gov.au/__data/assets/pdf_file/0015/200175/ACT_Greenhouse_Gas_Inventory_2008.pdf.

3 Practicable measurement

The government, through the Act, clearly intends that the measurement of GHG emissions will result in reports that will be made available for the wider community's information and will be used to inform policy decision making. Thus, a robust, repeatable measurement process is needed that can withstand wide public debate. Both the community and the Legislative Assembly must have confidence in the measurement methodology and data if the Act's objects are to be met. The only guidance on determining the method of measuring GHG emissions is provided in section 11 (3) (b) of the Act, which states that the method must, "as far as practicable, ensure consistency with the best national and international practices in relation to measuring greenhouse gas emissions".¹³

The Commonwealth's methodology for accounting for emissions in the NGA is consistent with current international practices, and complies with the principles established in the United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines,¹⁴ and adopted by the Intergovernmental Panel on Climate Change (IPCC).¹⁵ The five principles included in the guidelines are transparency, consistency, comparability, completeness and accuracy, which are defined as:¹⁶

- *Transparency*: The inventory should provide clear, sufficiently detailed explanations of the assumptions and methodologies employed to allow for its replication and assessment.
- *Consistency*: The inventory should be internally and temporally consistent with respect to the methodologies and data sets used.
- *Comparability*: The inventory should provide estimates of emissions from sources and removals by sinks that are comparable among jurisdictions.
- *Completeness*: The inventory should fully cover all sources and sinks of all greenhouse gases referred to in the IPCC guidelines and any other source and sink categories relevant to the jurisdiction.
- *Accuracy*: The inventory should provide estimates of emissions and removals that are neither over- nor under-estimates, so far as can be judged.

In the Commission's view, the NGA therefore provides a solid base on which to build the methodology for the ACT GHG inventory. The Commission considers that the ACT methodology should adopt the IPCC principles of transparency, consistency and accuracy without reservation. In considering the principles of comparability and completeness, regard must be had to the fact that these were developed to apply to national inventories.

Below the national level, comparability will depend on principles adopted by other jurisdictions and these may differ. For the ACT methodology, the Commission recommends that this principle be given the interpretation discussed earlier, namely that, if every state and territory adopted the methodology to be used to measure emissions in the ACT, the sum of those measures across all states and territories should equal national emissions for Australia as measured by the NGA.

¹³ *Climate Change and Greenhouse Gas Reduction Act 2010*, p.6.

¹⁴ <http://unfccc.int/resource/docs/2006/sbsta/eng/09.pdf>.

¹⁵ <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>.

¹⁶ These definitions are based on, Todorova, S., Lichte, R., Olsson, A. and Breidenich, C., National greenhouse gas inventories: application of the principles of transparency, consistency, comparability, completeness and accuracy, 2003 12th Int. Emission Inventory Conf.—Emission Inventories—Applying New Technologies (San Diego, CA, April–May 2003) (Bonn, Germany: UNFCCC Secretariat) pp.2-3 (available at <http://www.epa.gov/ttn/chief/conference/ei12/poster/todorova.pdf>).

Completeness for the ACT methodology clearly implies coverage of emissions in terms of gases, sources and activities that is consistent with the IPCC guidelines, the United Nations Environment Programme's draft standards and relevant to the ACT.

The Act identifies the following gases as GHG

- carbon dioxide (CO₂)
- methane (CH₄)
- nitrous oxide (N₂O)
- perfluorocarbons (PFCs)
- hydrofluorocarbons (HFCs)
- sulphur hexafluoride (SF₆)
- any other gas prescribed by regulation.

This list of gases covers those adopted in the Kyoto Protocol and used by the Commonwealth in its national inventory. Each gas is converted to its carbon dioxide equivalent (CO₂-e) measure using Global Warming Potentials (GWP) to allow for comparisons and the calculation of total emissions.¹⁷ The extent to which it is practicable to cover all the relevant GHGs for a particular emitting source or activity depends on data availability.

Following the discussion above, the Commission recommends that the ACT GHG inventory encompass scope 1 and scope 2 emissions. Analyses undertaken elsewhere demonstrate the level of complexity involved in covering scope 3 emissions and highlight the potential difficulty and cost involved in obtaining verifiable measurements. The level of difficulty and extent of the cost depends on the availability of comprehensive and reliable data and the purpose of the inventory. In most cases a compromise is needed between a detailed bottom-up and more general top-down approach for collecting data.

An additional problem with including scope 3 emissions in a methodology for the ACT is that they are not recognised in Australia's National Greenhouse and Energy Reporting System Measurement Technical Guidelines (NGER Guidelines). The Commission considers that the cost and time required to obtain accurate local data does not justify the improvement in coverage of the ACT inventory that would be obtained by attempting to cover scope 3 emissions, beyond emissions attributable to electricity generated to cover transmission and distribution losses. Given the low level of relative importance of scope 3 emissions in the ACT, the Commission considers that neither policy design nor evaluation is likely to be seriously compromised by their exclusion from the ACT inventory.

Looking next at the sectors to be covered, the IPCC provides guidelines on sector and sub-sector definitions, with the five main sectors comprising:

- energy (stationary energy and transport)
- industrial processes and product use
- agriculture, forestry and other land use
- waste
- other

¹⁷ Greenhouse gas global warming potentials are available from the *National Greenhouse Accounts (NGA) Factors* (2009) p.51.

The sub-sectors to include under each of the main sectors also depend on the intended purpose of inventory. If the inventory serves as a comprehensive account of GHGs emitted within the ACT then the coverage of sub-sectors will need to be comprehensive. Alternatively, if the inventory is primarily to inform policy makers about where mitigation efforts should be targeted and their effectiveness, then coverage of sub-sectors may be limited to major sources and activities responsible for emissions in the ACT.

To satisfy the Act, the methodology must cover the main sources and activities for emissions in the territory. The ACT differs from other states and the Northern Territory by having only minor emissions attributable to manufacturing and agriculture, and no emissions from mining activities. The major sources of emissions caused by ACT consumption come from fossil fuels used in electricity generated outside the ACT, and from transport fuels and natural gas consumption in the territory.

The NGER Guidelines covers four methods for measuring emissions:¹⁸

- *NGA default method (Method 1)* — uses specific emissions factors from the AGEIS (determined by DCCEE), and is most applicable to measuring emissions from homogenous sources
- *Facility-specific method (Method 2)* — based on sampling and national or international standards relevant to the facility level, and is most applicable to fuels with varying qualities
- *Facility-specific method (Method 3)* — similar to Method 2 but requires documentary standards for sampling and analysis of fuels and raw materials
- *Direct monitoring (Method 4)* — focuses on the actual emissions produced by an activity, which while data intensive may provide greater accuracy.

The NGER Guidelines provide flexibility in the choice of method(s) applied to estimating emissions from each source's fuels and gases depending on method availability. Method 1 is predominately used to calculate emissions in the NGA. Estimates of emissions included in the NGA are available from the web-based Australian Greenhouse Emissions Information System (AGEIS),¹⁹ which provides production data at a state and territory level for the following sectors:²⁰

- energy
- industrial processes
- solvent and other product use
- agriculture
- land use, land use change and forestry (LULUCF)
- waste.

In its coverage of scope 1 emissions, the Commission considers that the NGA for the ACT is deficient in that it does not:

- include emissions from the consumption of natural gas²¹
- include emissions from wood fuel use

¹⁸ DCCEE, *National greenhouse and energy reporting system measurement: Technical guidelines for the estimation of greenhouse gas emissions by facilities in Australia, June 2010*, Department of Climate Change and Energy Efficiency (2010) pp.23-27.

¹⁹ <http://ageis.climatechange.gov.au/>.

²⁰ <http://www.ageis.greenhouse.gov.au/>.

²¹ Scope 1 emissions from the combustion of natural gas consumed in the territory are reported in the NSW state inventory under the Commonwealth's approach.

- provide accurate estimates of transport emissions.

The Commission recommends that the methods specified in Chapter 4 be used to overcome these deficiencies. In addition the Commission recommends that ACT GHG inventory includes:

- emissions from the consumption of electricity within the territory (scope 2 emissions)
- emissions attributable to electricity generated to cover transmission and distribution losses (a portion of scope 3 emissions).

4 The recommended methodology

The Commission recommends that the ACT GHG inventory adopt the sectoral composition recommended by the IPCC. Appendix A shows this composition and its constituent activities relevant for the ACT. The Commission recommends that the approach to measuring emissions for each source and sink be as follows.

4.1 Stationary energy combustion

Emissions caused by the consumption of energy from stationary sources in the ACT include electricity, natural gas and firewood.

4.1.1 Indirect electricity and direct natural gas

Data for the annual consumption of electricity and natural gas in the territory is available from the Commission's annual *Licensed Electricity, Gas, Water and Sewerage Utilities - Compliance and Performance Reports*.²² In the case of electricity, the Commission recommends that allowance be made for transmission and distribution losses since these contribute to the total amount of electrical energy that must be generated in order to satisfy demand in the ACT.²³ The total amount of GreenPower purchased annually within the ACT is subtracted from the sum of electricity consumed and network losses because GreenPower is excluded from the NGA calculation of the scope 2 emissions factor.²⁴ The amount of GreenPower purchased is obtained from quarterly reports available from the GreenPower website.²⁵ The *National Greenhouse Accounts (NGA) Factors* provides both the factor for the "consumption of purchased electricity from the grid" for New South Wales and the ACT.

Electricity generated under the ACT's electricity feed-in scheme²⁶ is accounted for through the distribution loss factor, thereby reducing the amount of distribution losses. The following equation calculates emissions from electricity consumption in the ACT:

$$EIE = \frac{((DL \times TL) \times QE - GP) \times EFE}{1000} \quad (1)$$

Where:

EIE is emissions from electricity consumption expressed in tonnes of CO₂-e

DL is the distribution loss factor for ActewAGL Distribution for the relevant financial year

TL is the transmission loss factor for electricity supplied to the ACT for the relevant financial year

²² http://www.icrc.act.gov.au/utilitieslicensing/compliance_and_performance.

²³ Such an inclusion would be consistent with the approach the Commission takes in establishing a cost base for supply of electricity to ACT customers in determining the transitional franchise tariff (TFT).

²⁴ There are issues with the calculation of the emissions factor for scope 2 electricity consumption that the Commission thinks may become material in the future. While these issues are not material for the 2009 inventory, the calculation of the emissions factor is something the Commission will review in the future.

²⁵ <http://www.greenpower.gov.au/our-audits-and-reports.aspx>.

²⁶ The scheme is established through the *Electricity Feed-in (Renewable Energy Premium) Act 2008*.

QE is the consumption of purchased electricity expressed in kW hours

GP is the consumption of purchased GreenPower expressed in kW hours

EFE is the emissions factor for scope 2 electricity consumption for NSW/ACT in kilograms of CO₂-e emissions per kilowatt hour

The emissions factor for natural gas consumed in the ACT, expressed as tonnes of CO₂-e per gigajoule (tonnes CO₂-e/GJ), is obtained from *Emission factors for the consumption of natural gas: Natural gas distributed in a pipeline* in the annual NGA Factors. Annual emissions are calculated using the following equation:

$$ENG = \frac{QNG \times \sum_j EFNG_j}{1000} \quad (2)$$

Where:

ENG is emissions from natural gas consumption expressed in tonnes of CO₂-e

QNG is the consumption of purchased natural gas less consumption by ACTION Buses expressed in megajoules

EFNG_j is the emissions factor for natural gas combustion for greenhouse gas type $j = \text{CO}_2, \text{CH}_4$ and N_2O in kilograms of CO₂-e per gigajoule.

4.1.2 Wood-fuel emissions

The ACT Government collects data on firewood sales within the territory. Fuel wood activity data for the ACT is, however, somewhat out of date.²⁷ Although it would be possible to commission an update of information on ACT fuel wood activity and emission factors, given that firewood represented less than 0.3 % of the ACT's emissions in 2006–07, it is doubtful that there is sufficient improvement in the accuracy of the ACT GHG inventory to be gained from commissioning such a study. Equation (5) is used to calculate annual emissions, with the following terms redefined:

$$EWF = \sum_i \frac{QWF \times ECWF \times UWF_i \times \sum_j EFWF_{ij}}{1000} \quad (3)$$

Where:

EWF is emissions from wood fuel consumption expressed in tonnes of CO₂-e

QWF is the consumption of dry wood expressed in tonnes

ECWF is the energy content factor for dry wood expressed in gigajoules per tonne

UWF_i is the share of wood fuel consumption used in activity type $i = \text{heating and stoves}$

²⁷ Anderson, G., *ACT greenhouse gas inventory 2006/07*, Report prepared for the [then] ACT Department of the Environment, Climate Change, Energy and Water, pitt&sherry, Canberra (2009).

$EFWF_{ij}$ is the emissions factor for activity type i for greenhouse gas type $j = \text{CH}_4$ and N_2O in kilograms of $\text{CO}_2\text{-e}$ per gigajoule.

4.2 Transport emissions

The 2008 ACT GHG inventory only includes road transport fuels in its estimation of transport emissions. Road transport emissions could be measured based on data for fuel sales within the ACT or the vehicle distance travelled by ACT residents. Neither approach offers a perfect measure of emissions in the ACT. For example, fuel sales data will include purchases, and therefore emissions, by residents outside the ACT. Alternatively, distance travelled data includes emissions occurring outside the territory. On balance the Commission recommends that the inventory should continue to base road transport emissions on fuel sales using ACT fuel sales data collected by the ACT Government. Such an approach would provide estimates that are consistent with estimates of such emissions prior to 2008 provided by earlier work.

Emissions factors for each liquid fuel type are obtained from “Fuel combustion emission factors – liquid fuels and certain petroleum based products for stationary energy purposes” in the NGA Factors. The following equation is used to calculate annual transport emissions:

$$ERT = \sum_i \frac{QRT_i \times ECRT_i \times \sum_j EFRT_{ij}}{1000} \quad (4)$$

Where:

ERT is emissions from road transport vehicles expressed in tonnes of $\text{CO}_2\text{-e}$

QRT_i is the quantity of transport fuel type $i = \text{petrol, diesel, and LPG}$ sold measured in kilolitres and CNG consumed by ACTION Buses expressed in cubic metres.

$ECRT_i$ is the energy content factor for transport fuel type i expressed in gigajoules per kilolitre or gigajoules per cubic metre

$EFRT_{ij}$ is the emissions factor for transport fuel type i for greenhouse gas type $j = \text{CO}_2, \text{CH}_4$ and N_2O in kilograms of $\text{CO}_2\text{-e}$ emissions per gigajoule.

4.3 Emissions from other activities

Emissions for the remaining activities in the ACT listed in Appendix A are all adequately covered by the scope 1 measures in the NGA and, therefore, data for the ACT GHG inventory may be drawn from this source. These activities are:

- fugitive emissions from natural gas distribution
- industrial processes
- agriculture
 - enteric fermentation
 - soils
- land use change and forestry
 - afforestation and deforestation
- waste
 - solid waste disposal on land
 - waste water handling.

5 Conclusion

An extensive review of the methodologies developed in the international literature and that employed by the Commonwealth for the construction of Australia's national GHG inventory concludes that, to satisfy the needs of the ACT Government for an inventory of GHG emissions in the ACT, the methodology employed must be a combination of both production and consumption approaches. The methodology recommended by the Commission in this Report is very similar to that used to produce the 2008 ACT greenhouse gas inventory. Hence, it will be possible to provide historical data on emissions from 1990 that are consistent with the data to be provided by the ACT GHG inventory undertaken under the ACT.

Appendix A Coverage of emissions

Emissions source	NGA emissions activity ¹	ACT GHG emissions covered and data source
Energy	Stationary energy fuel combustion emissions – solid fuels	Wood fuel (biomass) – <i>ACT specific calculation</i>
	Stationary energy fuel combustion emissions – gaseous fuels	Consumption of purchased natural gas – <i>ACT specific calculation</i>
	Stationary energy fuel combustion emissions – liquid fuels	Fuel combustion, other sectors, residential, lawn mowers - <i>AGEIS</i>
	Transport fuel emissions	Petrol, diesel and LPG sales, and CNG consumed by buses – <i>ACT specific calculation</i>
	Indirect emissions from consumption of purchased electricity	Consumption of purchased electricity less GreenPower purchased adjusted for network losses – <i>ACT specific calculation</i>
	Fugitive emissions from fuels	Natural gas, Distribution - <i>AGEIS</i>
Industrial processes including use of synthetic gases	Cement clinker production	NA
	Lime production	NA
	Use of carbonates for the production of a product other than cement clinker, lime or soda ash	NA
	Soda ash use and production	NA
	Ammonia production	NA
	Nitric acid production	NA
	Adipic acid production	NA
	Carbide production	NA
	Chemical or mineral production, other than carbide production, using a carbon reductant	NA
	Iron and steel or other metal production using an integrated metalworks	NA
	Ferroalloy metals	NA
	Aluminium — emissions from consumption of baked carbon anodes in aluminium production	NA
	Aluminium — emissions from production of baked carbon anodes in aluminium production	NA
	Aluminium (perfluorinated carbon compound emissions) – tetrafluoromethane and hexafluoroethane	NA
Other metals	NA	

	Industrial processes — emissions of hydrofluorocarbons and sulphur hexafluoride gases	Consumption of halocarbons and SF ₆ – AGEIS ² /State and Territory GHG Inventory
Waste emissions	Methane released from landfills (other than from flaring of methane)	NA
	Biological treatment of solid waste at the landfill — composting and anaerobic digestion	Solid waste disposal on land - AGEIS ² /State and Territory GHG Inventory
	Wastewater handling (domestic and commercial)	Wastewater handling - AGEIS ² /State and Territory GHG Inventory
	Wastewater handling (industrial) — wastewater treatment	NA
	Wastewater handling (industrial) — flaring of methane in sludge biogas	NA
	Waste incineration — carbon dioxide emissions	NA
Agriculture	State and national-level estimates of greenhouse gas emissions from agriculture are prepared using the methodology set out in the <i>National Inventory Report 2007</i> (p.47)	Enteric fermentation, agricultural soils, manure management - AGEIS
Land-use change and forestry (vegetation sinks)	The National Carbon Accounting System is used to estimate emissions for land-based activities	AGEIS

¹ The NGA emissions activities are those presented in the *National Greenhouse Accounts (NGA) Factors, June 2009*.

² A sub-sector breakdown is shown in the State and Territory GHG Inventory for the ACT but there is no data for sub-sectors for the ACT in AGEIS, only total emissions for the main sector

Appendix B Requirements for the ACT GHG inventory

Emissions covered:	The release of greenhouse gases (Kyoto gases as defined below) expressed as carbon dioxide equivalents (CO ₂ -e) into the atmosphere, which comprises direct releases (scope 1 emissions) and certain indirect releases (scope 2 and scope 3 emissions).
GHGs covered:	For each source of emissions relevant to the ACT the six Kyoto gases (conditional on data availability) - carbon dioxide (CO ₂), methane (CH ₄), nitrous oxide (N ₂ O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF ₆).
Geographic boundary:	The geographic boundary containing the ACT.
Emissions boundary:	<p>Scope 1 emissions - Direct (point source) CO₂-e emissions occurring as a result of activities within the geographic boundary of the ACT.</p> <p>Scope 2 emissions – Energy indirect CO₂-e emissions arising from the generation of purchased electricity brought into and consumed within the geographic boundary of the ACT.</p> <p>Scope 3 emissions – Energy indirect emissions arising from transmission and distribution losses attributable to electricity supplied to the ACT.</p>
Sectors:	<p>GHG source and sink categories based on the sectors defined by the IPCC.</p> <ol style="list-style-type: none">(1) energy:<ul style="list-style-type: none">• stationary energy – indirect emissions from the consumption of electricity from fossil-fuel plants and network losses; emissions from the consumption of natural gas• transport – emissions from road transport• fugitive emissions from fuels – emissions from the distribution of natural gas• wood combusted for heating.(2) industrial processes:<ul style="list-style-type: none">• direct emissions from the transformation of materials and the consumption of synthetic GHGs (halocarbons and SF₆).(3) agriculture:<ul style="list-style-type: none">• enteric fermentation• agricultural soils

- (4) land use, land use change and forestry:
 - CO₂-e emissions and removals from afforestation and reforestation activities.
- (5) waste:
 - solid waste disposal on land
 - wastewater handling.

Appendix C Recommended greenhouse gas emissions measurement method

1. Objects of the determination

This determination sets out the method for the measurement of greenhouse gas emissions arising from sources, and attributable to activities located within, the geographic boundary of the Australian Capital Territory (ACT).

2. Application of the determination

The method determined in this instrument must be used to measure the amount of greenhouse gas emissions in the ACT for the year (the annual emissions amount) in the annual report prepared by the independent entity as required under section 12 of the Act.

3. Emissions covered

The emissions covered by this determination are:

- Scope 1 emissions from:
 - fuel combustion
 - fugitive emissions from fuels
 - industrial processes
 - agriculture
 - land use, land use change and forestry, and
 - waste.
- Scope 2 emissions from the consumption of electricity.
- Scope 3 emissions from electricity transmission and distribution losses.

The annual data on these emissions will be obtained from the National Greenhouse Accounts except for the following:

- indirect electricity
- natural gas consumption
- wood fuel combustion, and
- road transport.

4. Method

The method for calculating the emissions for which annual data will not be obtained from the National Greenhouse Accounts will be made using the following equations:

Equation 1: Stationary energy combustion emissions – indirect electricity

$$EIE = \frac{((DL \times TL) \times QE - GP) \times EFE}{1000}$$

Where:

EIE is emissions from electricity consumption expressed in tonnes of CO₂-e

DL is the distribution loss factor for ActewAGL Distribution for the relevant financial year

TL is the transmission loss factor for electricity supplied to the ACT for the relevant financial year

QE is the consumption of purchased electricity expressed in kW hours

GP is the consumption of purchased GreenPower expressed in kW hours

EFE is the emissions factor for scope 2 electricity consumption for NSW/ACT in kilograms of CO₂-e emissions per kilowatt hour

Equation 2: Stationary energy combustion emissions – natural gas

$$ENG = \frac{QNG \times \sum_j EFNG_j}{1000}$$

Where:

ENG is emissions from natural gas consumption expressed in tonnes of CO₂-e

QNG is the consumption of purchased natural gas less consumption by ACTION Buses expressed in megajoules

EFNG_j is the emissions factor for natural gas combustion for greenhouse gas type *j* = CO₂, CH₄ and N₂O in kilograms of CO₂-e per gigajoule

Equation 3: Stationary energy combustion emissions – wood fuel

$$EWF = \sum_i \frac{QWF \times ECWF \times UWF_i \times \sum_j EFWF_{ij}}{1000}$$

Where:

EWF is emissions from wood fuel consumption expressed in tonnes of CO₂-e

QWF is the consumption of dry wood expressed in tonnes

ECWF is the energy content factor for dry wood expressed in gigajoules per tonne

UWF_i is the share of wood fuel consumption used in activity type *i* = heating and stoves

EFWF_{ij} is the emissions factor for activity type *i* for greenhouse gas type *j* = CH₄ and N₂O in kilograms of CO₂-e per gigajoule

Equation 4: Transport fuel emissions – road transport

$$ERT = \sum_i \frac{QRT_i \times ECRT_i \times \sum_j EFRT_{ij}}{1000}$$

Where:

ERT is emissions from road transport vehicles expressed in tonnes of CO₂-e

QRT_i is the quantity of transport fuel type *i* = petrol, diesel, and LPG sold measured in kilolitres and CNG consumed by ACTION Buses expressed in cubic metres.

ECRT_i is the energy content factor for transport fuel type *i* expressed in gigajoules per kilolitre or gigajoules per cubic metre

EFRT_{ij} is the emissions factor for transport fuel type *i* for greenhouse gas type *j* = CO₂, CH₄ and N₂O in kilograms of CO₂-e emissions per gigajoule

5. Annual report about greenhouse gas emissions and targets

The annual report prepared by the independent entity as required under section 12 of the Act must include the information as calculated in the following table:

Greenhouse Gas Source and Sink Categories		Total (CO ₂ -e) Gg (kilo tonnes)
Total ACT emissions and removals		1+2+3+4+5
1	Energy	A+B
	<i>A Fuel combustion activities</i>	a+b+c+d
	Electricity	a ¹
	Natural gas	b ²
	Transport fuels	c ³
	Fuel wood	d ⁴
	<i>B Fugitive emissions from fuels</i>	e
	Natural gas leakage	e ⁵
2	Industrial processes	f+g
	Consumption of Halocarbons and F ₆	f ⁵
	Other	g ⁵
3	Agriculture	h+i
	Enteric fermentation	h ⁵
	Agricultural soils	i ⁵
4	Land use change and forestry	j
	Afforestation and deforestation	j ⁵
5	Waste	k+i
	Solid waste disposal on land	k ⁵
	Wastewater handling	i ⁵
Total emissions including net CO ₂ from LULUCF		1+2+3+4+5
Total emissions excluding net CO ₂ from LULUCF		1+2+3+5

¹ EIE given by equation 1

² ENG given by equation 3

³ ERT given by equation 5

⁴ EWF given by equation 4

⁵ Data from the Australian Greenhouse Emissions Information System (Department of Climate Change and Energy Efficiency)

Abbreviations and acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics
ACT	Australian Capital Territory
AGEIS	Australian Greenhouse Emissions Information System
Commission	Independent Competition and Regulatory Commission (ACT)
DCCEE	Department of Climate Change and Energy Efficiency (Cwlth)
DECCEW	Department of the Environment, Climate Change, Energy and Water (ACT)
ESDD	Environment and Sustainable Development Directorate (ACT)
GHG	greenhouse gas
GWP	Global Warming Potentials
ICRC	Independent Competition and Regulatory Commission (ACT)
IPCC	Intergovernmental Panel on Climate Change
LULUCF	land use, land use change and forestry sector
NGA	National Greenhouse Gas Accounts
NGER Guidelines	National Greenhouse and Energy Reporting System Measurement Technical Guidelines
UNFCC	United Nations Framework Convention on Climate Change