

Methodology for GHG estimation

Regional workshop of the Anglophone Cluster

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A TRANSPARENCY SYSTEM

The GHG inventory provides a basis for:

- verifying the fulfillment of the Parties' NDC:s (13.7b PA) and
- the accounting of the Parties' NDC:s (4.13 PA).



Under the Paris Agreement, Parties have agreed to establish an enhanced transparency framework

- will build on the existing transparency arrangements under the United Nations Framework Convention on Climate Change (UNFCCC).

COP 24

The Paris Agreement Rulebook:

- will be negotiated at COP24
- aim to clarify how key parts of the agreement are to be implemented; such as
 - the **Transparency Framework**,
 - the design and accounting of countries' nationally determined contributions (NDCs) and
 - the global review that will take place every fifth year from 2023 onwards with the aim of contributing to increased ambition.

PARIS AGREEMENT

Article 13. § 7

Each Party **shall** regularly provide the following information:

- (a) A **national inventory report** of anthropogenic emissions by sources and removals by sinks of **greenhouse gases**, prepared using good practice methodologies accepted by the Intergovernmental Panel on Climate Change and agreed upon by the Conference of the Parties serving as the meeting of the Parties to this Agreement
- (b) Information necessary to track progress made in implementing and achieving its nationally determined contribution under Article 4.

NATIONAL COMMUNICATIONS

Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention

§ 14. Each non-Annex I Party **shall**, as appropriate and to the extent possible, provide in its national inventory, on a gas-by-gas basis and in units of mass, estimates of anthropogenic emissions of...

- **carbon dioxide (CO₂)**,
- **methane (CH₄)** and
- **nitrous oxide (N₂O)** by sources and removals by sinks.

NATIONAL COMMUNICATIONS

§ 15. Non-Annex I Parties are **encouraged**, as appropriate, to provide information on anthropogenic emissions by sources of...

- hydrofluorocarbons (HFCs),
- perfluorocarbons (PFCs) and
- sulphur hexafluoride (SF₆).

NATIONAL COMMUNICATIONS

§ 16. Non-Annex I Parties are **encouraged**, as appropriate, to report on anthropogenic emission by sources of other greenhouse gases such as...

- carbon monoxide (CO),
- nitrogen oxides (NO_x) and
- non-methane volatile organic compounds (NMVOCs).

FIVE SECTORS

Emissions/removals are reported from 5 main sectors

1. Energy (Stationary & Mobile combustion)
2. Industrial processes and product use (IPPU)
3. Agriculture
4. Land use, land use change and forestry (LULUCF)
5. Waste

2006 IPCC GUIDELINES METHODOLOGY

<https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html>

2006 IPCC Guidelines Top

- Vol.1 GGR
- Vol.2 Energy
- Vol.3 IPPU
- Vol.4 AFOLU
- Vol.5 Waste

Other Language Versions:

- Arabic
- Chinese
- French
- Russian
- Spanish

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2006 IPCC Guidelines for National Greenhouse Gas Inventories

Cover, Foreword and Preface

Overview

Glossary

List of Contributors *1

*1: Corrected chapter(s) as of April 2007.

The series consists of five volumes:











[Volume 1 General Guidance and Reporting](#)



[Volume 2 Energy](#)

2006 IPCC GUIDELINES METHODOLOGY

2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy

Chapter	Chapter Name
-	Cover Page of Volume 2 
1	Introduction 
2	Stationary Combustion  *1
3	Mobile Combustion  *4
4	Fugitive Emissions  *2 *10
5	Carbon Dioxide Transport, Injection and Geological Storage 
6	Reference Approach 
Annex 1	Worksheets  *6

2006 IPCC GUIDELINES SOFTWARE

<https://www.ipcc-nggip.iges.or.jp/software/index.html>

Inventory Software

IPCC Inventory Software

Available Now !


The IPCC Inventory Software (Version 2.54) implemented Tier 2 methods for most categories under Energy, IPPU and Waste Sectors.

The IPCC Inventory Software implements the simplest Tier 1 methods in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and as such is useful to users of all versions of the IPCC Guidelines. From Version 2.54, the Software implements Tier 2 methods in the 2006 IPCC Guidelines for most categories under Energy, IPPU and Waste Sectors (please see [Tier2_coverage.xlsx](#)). The TFI is currently working on making it compatible with the Tier 2 methods for AFOLU Sector.

This software has a number of improvements over [earlier software for the Revised 1996 Guidelines](#), including:

- Standalone software that does not require any additional software or internet access
- Covers all inventory categories but can also be used for management of specific sectors
- Allows different parts of the inventory to be developed simultaneously
- Data entry in worksheets following 2006 IPCC Guidelines for ease-of-use
- Provides default data from 2006 IPCC Guidelines but gives users the flexibility to use their own country-specific information

Download

- [Inventory Software Ver 2.54 \(released on 6 July 2017\)](#) >> Please read the [note](#) carefully before using the software.
- [User Manual \(Ver 2.54\)](#) 

Home IPCC

IPCC-TFI Home

Organization

Publications

Inventory Software

Meetings

2019 Refinement

FAQs

Links

Emission Factor Database (EFDB)

Electronic Discussion Group (EDG)



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IPCC honoured with the
2007 Nobel Peace Prize



Svenska MiljöEmissionsData

ENERGY SECTOR

- Usually a key category and the most important sector regarding greenhouse gas emissions.
- Contributes with around 75 percent of the total greenhouse gas emissions in developed countries.
- Mobile combustion causes about 40 % of the total greenhouse gas emissions in developed countries.

THE METHODOLOGY

Low Tier

Feasible
Inaccurate



High Tier

Complex
Accurate

Tier 1

- Low resolution activity data
- Default emission factors
- Basic methods

Tier 2

- High resolution activity data
- Country specific emission factors
- More elaborated methods

Tier 3

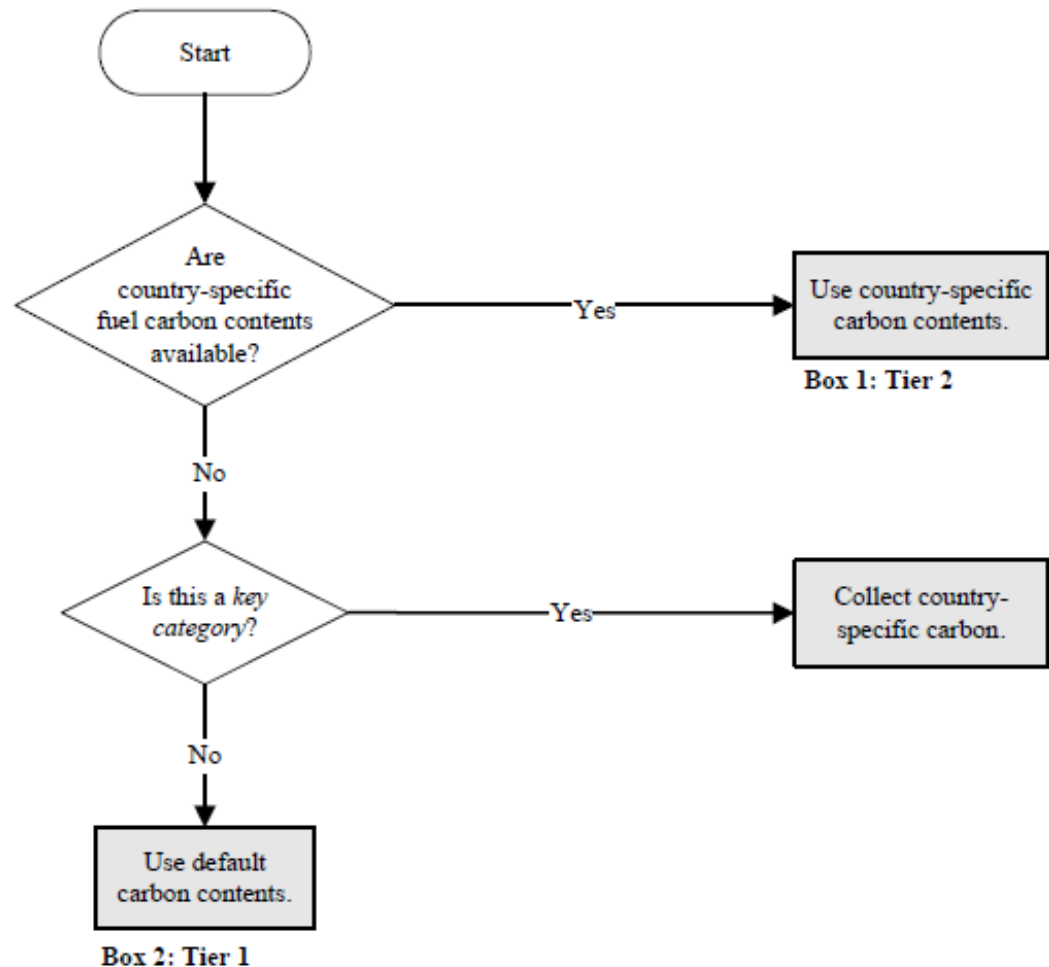
- Models...

DECISION TREE - TIER

Figure 3.2.2

Decision tree for CO₂ emissions from fuel combustion in road vehicles

- Decision tree for Tier/method
- Different decision trees depending on subsector and emission in the transport sector.
- Example of decision tree for CO₂ emissions from road transport.



KEY CATEGORIES

A key category is a source or sink category that has a significant influence on:

- *a country's total inventory of greenhouse gases in terms of the absolute level,*
- *the trend,*
- *the uncertainty in emissions and removals.*

→ Higher Tier

COMMON REPORTING FORMAT - CRF

- All emission data should be reported according to decided CRF (Common reporting format) tables
- Allows for comparability

CRF CODES: TRANSPORT

- 1A3a: Civil Aviation
- 1A3b: Road Transportation
 - 1A3bi Cars
 - 1A3bii Light duty trucks
 - 1A3biii Heavy duty trucks and buses
 - 1A3biv Motorcycles
- 1A3c: Railways
- 1A3d: Navigation
- 1D: International Bunker (memo item)
- CO2 from Biomass (memo item)

CRF CODES: WORKING MACHINERY

- 1A2gvii Working machinery: **Industry**
- 1A3eii Working machinery: **Other**
- 1A4aai Working machinery: **Commercial/Institutional**
- 1A4bii Working machinery: **Residential**
- 1A4cii Working machinery: **Agriculture/Forestry**
- 1A4cii Fishing

METHODS TO ESTIMATE CO₂ EMISSIONS

EMISSIONS OF CO₂

- Most carbon is emitted as CO₂ immediately
- Small fraction emitted as non-CO₂ gases
 - CH₄, CO, NMVOCs (non-methane volatile organic compounds)
 - Oxidizes eventually to CO₂ in the atmosphere
- Fraction of carbon oxidised
 - assumed to be 1 in default CO₂ emission factors

BASIC STEPS TO ESTIMATE CO₂

1. Collect activity data
2. Convert activity data to a common energy unit
3. Select CO₂ emission factor for each fuel type
4. Estimate the total emissions of CO₂ from fuels combusted.

1. ACTIVITY DATA

- Fuel consumed (represented by fuel sold)
 - Most CRF codes (for Tier 1)
- Vehicle kilometers
 - Road traffic (For Tier 2 & 3 AND CH₄ & N₂O)

In general, the first approach (fuel sold) is appropriate for CO₂

BASIC STEPS TO ESTIMATE CO₂

1. Collect activity data
2. Convert activity data to a common energy unit
3. Select CO₂ emission factor for each fuel type
4. Estimate the total emissions of CO₂ from fuels combusted.

2. COMMON ENERGY UNIT

- Convert fuel data to a common energy unit
→ use Net Calorific Values (NCV)
- Calorific values used should be reported
- Good practice to use country-specific NCV
→ especially for key categories.
- Default NVC may be used when national NCV are not available

2. COMMON ENERGY UNIT

2006 IPCC GL. Volume 2, chapter 1

TABLE 1.2. Default net calorific values (NCVs)

<https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html>

https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf

IPCC Emission factor database – very few NCV

<https://www.ipcc-nggip.iges.or.jp/EFDB/main.php>

BASIC STEPS TO ESTIMATE CO₂

1. Collect activity data
2. Convert activity data to a common energy unit
3. Select CO₂ emission factor for each fuel type
4. Estimate the total emissions of CO₂ from fuels combusted.

3. SELECT CO₂ EMISSION FACTOR

- CO₂ emission factors - based on carbon content.
- 100% oxidation of the fuel carbon.
- Good practice → Country-Specific Emission Factors
→ Especially for key categories.
- Default EF - when national EF are not available.
- IPCC Emission Factor Database → EF appropriate to local fuel quality and composition.
- The emission factors used, should be documented.

3. SELECT CO₂ EMISSION FACTOR

2006 IPCC GL. Volume 2 (Energy); Chapter 1. Introduction

Table 1.4. Default CO₂ emission factors for combustion

https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf

2006 GL. Volume 2 (Energy); Mobile combustion

Ex. Table 3.2.1. Road transport default CO₂ emission factors

https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

IPCC Emission factor database

<https://www.ipcc-nggip.iges.or.jp/EFDB/main.php>

BASIC STEPS TO ESTIMATE CO₂

1. Collect activity data
2. Convert activity data to a common energy unit
3. Select CO₂ emission factor for each fuel type
4. Estimate the emissions of CO₂ from fuels combusted.

4. ESTIMATE CO₂ EMISSION

- Good practice to estimate the emissions of CO₂ using country-specific net-calorific values (NCV) and country-specific CO₂ emission factors.
- Tier 2 is enough to estimate CO₂

$$\text{CO}_2 = \text{Activity data} \times \text{NCV} \times \text{EF CO}_2$$

TIER 1-3 TO ESTIMATE CO₂ EMISSIONS

1. Tier 1 to estimate CO₂ emissions
2. Tier 2 to estimate CO₂ emissions
3. Tier 3 to estimate CO₂ emissions

TIER 1 . CO₂ EMISSION

$$\text{Emission CO}_2 = \sum_a [Fuel_a \cdot NCV_a \cdot EF_a]$$

Emission = Emissions of CO₂ (kg)

NCV_a = Net Calorific Value (TJ/ton)

Fuel_a = Fuel sold /consumed (ton)

EF_a = Emission Factor (kg/TJ) (C content *44/12)

a = Type of fuel (petrol, diesel, natural gas, LPG etc.)

TIER 1-3 TO ESTIMATE CO₂ EMISSIONS

1. Tier 1 to estimate CO₂ emissions
2. Tier 2 to estimate CO₂ emissions
3. Tier 3 to estimate CO₂ emissions

TIER 2 . CO₂ EMISSION

Tier 2 = Tier 1 except:

- Country-specific emission factor for CO₂ is used.
- CO₂ EF may be adjusted to take account of unoxidised carbon.

TIER 1-3 TO ESTIMATE CO₂ EMISSIONS

1. Tier 1 to estimate CO₂ emissions
2. Tier 2 to estimate CO₂ emissions
3. Tier 3 to estimate CO₂ emissions

TIER 3 . CO₂ EMISSION

- Not possible to produce significantly better results for CO₂ than by using Tier 2.
- To reduce uncertainties → efforts should concentrate on improving AD and to produce country specific emission factors.
- Another uncertainty component → the use of fuel by Non-Road Mobile Machinery (NRMM).

METHODS TO ESTIMATE CH₄ AND N₂O EMISSIONS

TIER 1-3 TO ESTIMATE CH₄ & N₂O EMISSIONS

1. General overview of CH₄ & N₂O emissions
2. Tier 1 to estimate CH₄ & N₂O emissions
3. Tier 2 to estimate CH₄ & N₂O emissions
4. Tier 3 to estimate CH₄ & N₂O emissions

1. GENERAL OVERVIEW OF CH₄ & N₂O EMISSIONS

- Emission factors depend on vehicle technology, fuel and operating characteristics.
- CH₄ and N₂O emissions are significantly affected by the distribution of emission controls.
- Higher tiers takes into account populations of different vehicle types and their respectively different pollution control technologies.
- **Non-Annex I Parties** → focus on collecting data on the number of vehicles with catalytic emissions control devices that operate in their country.

1. GENERAL OVERVIEW OF CH₄ & N₂O EMISSIONS

- **Tier 1:** Fuel-based emission factors. Tier 1 default EF available for all relevant direct greenhouse gases and may be used if not possible to estimate fuel consumption by vehicle type.
- **Tier 2:** Fuel-based emission factors specific to vehicle subcategories.
- **Tier 3:** Detailed & country-specific data. May involve emission models. Emission factors by vehicle activity levels (e.g., VKT) for each vehicle subcategory and possible road type. *Vehicle subcategories* are based on vehicle type, age, and emissions control technology.

TIER 1-3 TO ESTIMATE CH₄ & N₂O EMISSIONS

1. General overview of CH₄ & N₂O emissions
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3. Tier 2 to estimate CH₄ & N₂O emissions
4. Tier 3 to estimate CH₄ & N₂O emissions

2. TIER 1 TO ESTIMATE CH₄ & N₂O EMISSIONS

$$\text{Emission} = \sum_a [Fuel_a \cdot NCV_a \cdot EF_a]$$

Emission = Emissions of CO₂ (ton)

Fuel_a = Fuel sold /consumed (ton)

NCV_a = Net Calorific Value (TJ/ton)

EF_a = Emission Factor (ton/TJ) (C content *44/12)

a = Type of fuel (petrol, diesel, natural gas, LPG etc.)

TIER 1-3 TO ESTIMATE CH₄ & N₂O EMISSIONS

1. General overview of CH₄ & N₂O emissions
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4. Tier 3 to estimate CH₄ & N₂O emissions

3. TIER 2 - CH₄ & N₂O FROM ROAD TRAFFIC

$$\text{Emission} = \sum_{a b c} [\text{Fuel}_{a b c} \cdot \text{EF}_{a b c}]$$

Emission = Emission in kg.

Fuel_{a b c} = Fuel consumed (TJ) (as represented by fuel sold)

EF_{a b c} = Emission factor (kg/TJ)

A = Fuel type (e.g., diesel, gasoline, natural gas, LPG)

b = Vehicle type

C = Emission control technology (such as uncontrolled, catalytic converter, etc)

- Vehicle type should follow the reporting classification 1.A.3.b (i to iv) (i.e., passenger, light-duty or heavy-duty for road vehicles, motorcycles)
- Preferably split by vehicle age to enable categorization of vehicles by control technology (e.g., inferring technology adoption as a function of policy implementation year).

3. TIER 2 - CH₄ & N₂O FROM NON ROAD MOBILE MACHINERY

$$Emissions = \Sigma(Fuel_{(ij)} \bullet EF_{(ij)})$$

Emissions = Emissions (kg)

Fuel_(i,j) = Fuel consumed (as represented by fuel sold) (TJ)

EF_(i,j) = Emission factor (kg/TJ)

i = Vehicle/equipment type

j = Fuel type

For Tier 2, emissions are estimated using country-specific and fuel-specific emission factors which, if available, are specific to broad type of vehicle or machinery.

3. TIER 2 - CH₄ & N₂O FROM RAILROAD

$$Emissions = \sum (Fuel_i \bullet EFi)$$

Emissions = emissions (kg)

Fuel_i = fuel consumed (as represented by fuel sold) by locomotive type i, (TJ)

EF_i = emission factor for locomotive type i, (kg/TJ)

i = locomotive type

Emissions of CH₄ and N₂O are estimated using country-specific and fuel-specific emission factors.

The emission factors, if available, should be specific to broad locomotive technology type

3. TIER 2 - CH₄ & N₂O FROM NAVIGATION

$$Emissions = \Sigma(Fuel_{(ab)} \bullet EF_{(ab)})$$

a = fuel type (diesel, gasoline, LPG, bunker, etc.)

b = water-borne navigation type –
i.e. type of ship/boat or engine type by type of ship or boat

- fuel consumption by fuel type
- country-specific emission factors by classification of modes (e.g. ocean-going ships and boats), fuel type and engine type (e.g. diesel)

The EMEP/Corinair emission inventory guidebook (EEA, 2005) offers a detailed methodology for estimating ship emissions based on engine and ship type and ship movement data.

TIER 1-3 TO ESTIMATE CH₄ & N₂O EMISSIONS

1. General overview of CH₄ & N₂O emissions
2. Tier 1 to estimate CH₄ & N₂O emissions
3. Tier 2 to estimate CH₄ & N₂O emissions
4. Tier 3 to estimate CH₄ & N₂O emissions

4. TIER 3 - CH₄ AND N₂O FROM ROAD TRAFFIC

$$\text{Emission} = \sum abcd [\text{Distance } abcd \bullet EF \text{ } abcd] + \sum C \text{ } abcd$$

Emission = emission in kg

Distance $abcd$ = distance travelled (VKT) during thermally stabilized engine operation phase for a given mobile source activity (km)

EF $abcd$ = emission factor (kg/km)

C $abcd$ = emissions during warm-up phase (cold start) (kg)

a = fuel type (e.g., diesel, gasoline, natural gas, LPG)

b = vehicle type

c = emission control technology (such as uncontrolled, catalytic converter, etc.)

d = operating conditions (e.g., urban or rural road type, climate, or other environmental factors)

4. TIER 3 - CH₄ AND N₂O FROM ROAD TRAFFIC

Tier 3 often use emission models such as EEA's COPERT model for road traffic.

COPERT 4

A software tool used to calculate air pollutant and greenhouse gas emissions from road transport.
Consistent with the 2006 IPCC Guidelines

<https://www.emisia.com/>

4. TIER 3 - CH₄ AND N₂O FROM NON ROAD WORKING MACHINERY

$$Emissions = \Sigma [N_{ij} \bullet H_{ij} \bullet P_{ij} \bullet LF_{ij} \bullet EF_{ij}]$$

Emission = emission in kg.

N_{ij} = source population

H_{ij} = annual hours of use of vehicle i (h)

P_{ij} = average rated power of vehicle i (kW)

LF_{ij} = typical load factor of vehicle i (fraction between 0 and 1)

EF_{ij} = average emission factor for use of fuel j in vehicle i (kg/kWh)

i = off-road vehicle type

j = fuel type

Detailed modelling tools available for estimating off-road emissions using Tier 3 methodology: e.g., NONROAD (USEPA 2005a?) and COPERT.

4. TIER 3 - CH₄ AND N₂O FROM RAIL ROAD & NAVIGATION

Tier 3 method not available.

CH₄ AND N₂O EMISSIONS

Road transport activity data

- Check data with equipment counts or vehicle sales/import/export data/road worthy test
- Base assumptions of vehicle type and emission control technology on vehicle vintage data (model year of sale) and assumed activity level (i.e. vkt/vehicle)
- Consider national emission standards, leaded gasoline prevalence and compliance with standards

INTERNATIONAL BUNKER AND BIOMASS

INTERNATIONAL BUNKER FUELS

- CO₂ emissions from fuels used by ships or aircraft for international transport → should not be included in the national total.
- Bunker fuel emissions should be mentioned in a separate table as a memo item

BIOMASS FUELS

- CO₂ emissions from combustion of biofuels, used by transports, should not be included in the national emission of CO₂ from fuel combustion
- Reported as a memo item only
- Non-CO₂ emissions from biomass combustion *should* be estimated and reported under the Energy Sector!

IPCC SOFTWARE AND REPORTING TABLES

- Software to aid in preparation of greenhouse gas inventories
- Provides IPCC default (i.e. Tier 1) methods
- National factors can be used where available

<http://www.ipcc-nggip.iges.or.jp/software/>

USEFUL INTERNET LINKS

2006 IPCC Guidelines for National Greenhouse Gas Inventories

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

IPCC Emission factor database

<http://www.ipcc-nggip.iges.or.jp/EFDB/main.php>

United Nations Framework Convention on Climate Change

<http://unfccc.int/2860.php>