Aidan Kennedy
$CO_2$ Emissions Statistics
Energy Statistics Division

# The Use of Energy Statistics to Estimate $CO_2$ Emissions

**IEA Energy Statistics Training**
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ENERGY STATISTICS



International Energy Agency

# Outline

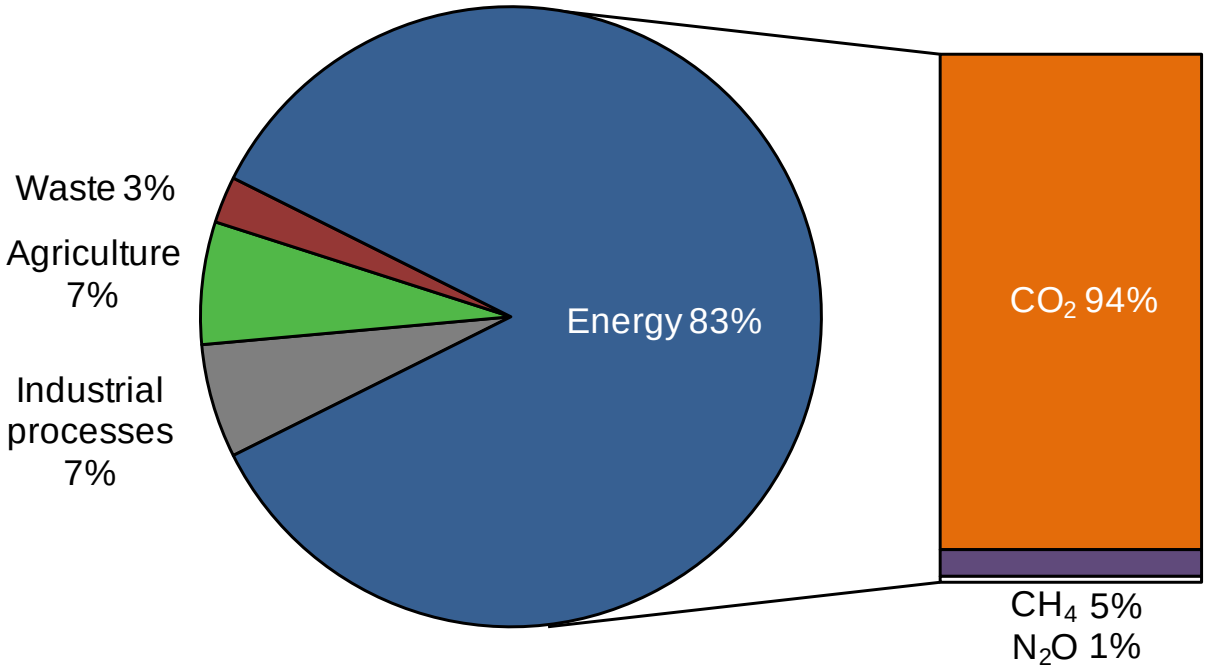
- International context
- About $CO_2$ emissions and how to estimate them
- IPCC Methodologies
- Notes on Bunkers and LULUCF
- Using the *Revised 1996 IPCC Guidelines*: Sectoral Approach
- Data quality
- Examples
- National policy options and the importance of energy statistics

# International Context

**Stabilisation of greenhouse gas concentrations in the atmosphere.**

- **1992:** United Nations Framework Convention on Climate Change (UNFCCC) at Rio de Janeiro conference
- **1995 (1996):** *IPCC Guidelines for National Greenhouse Gas Inventories*
  Development of methodologies for gases not controlled by the Montreal Protocol.
- **1997:** Kyoto Protocol (entry into force 2005)
  Reduction of anthropogenic greenhouse gas emissions for the period 2008-2012 of about 5% compared to 1990.
- **2000:** *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.*
- **2006:** *2006 IPCC Guidelines for National Greenhouse Gas Inventories.*

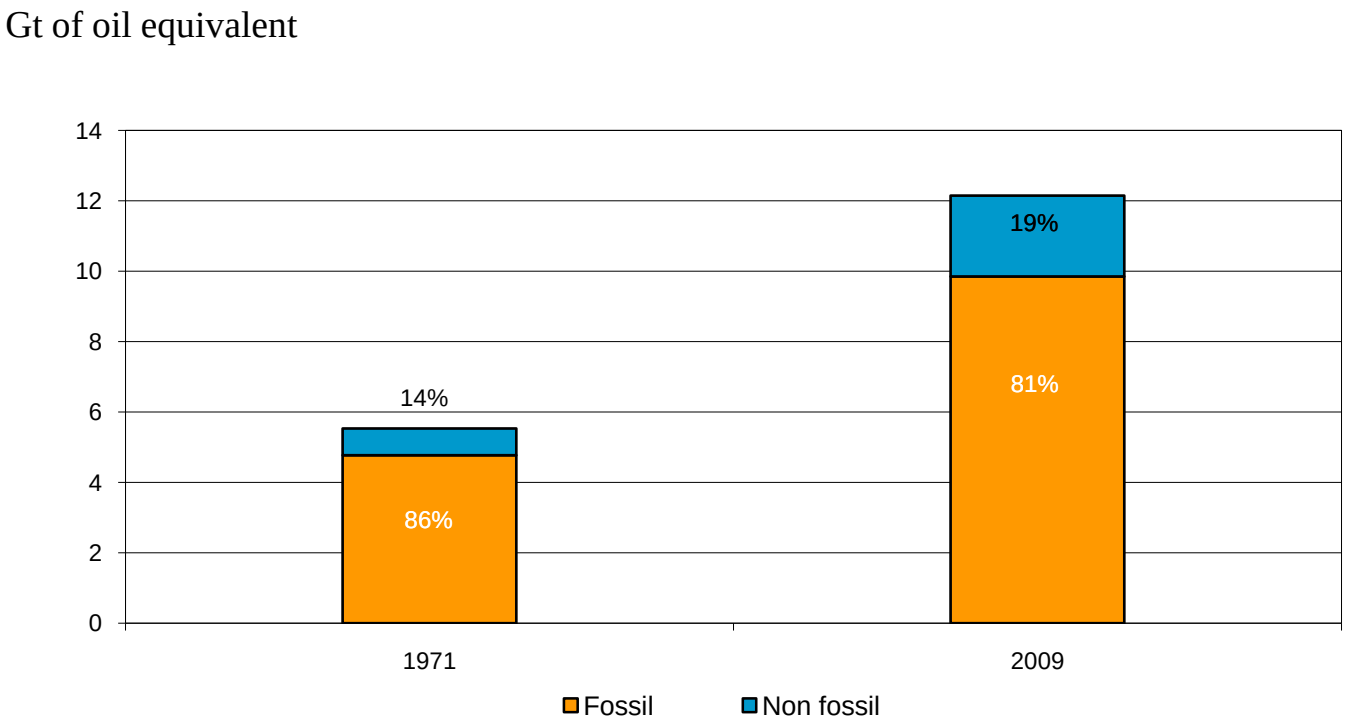
# Share of energy in GHG emissions




*Source: UNFCCC*

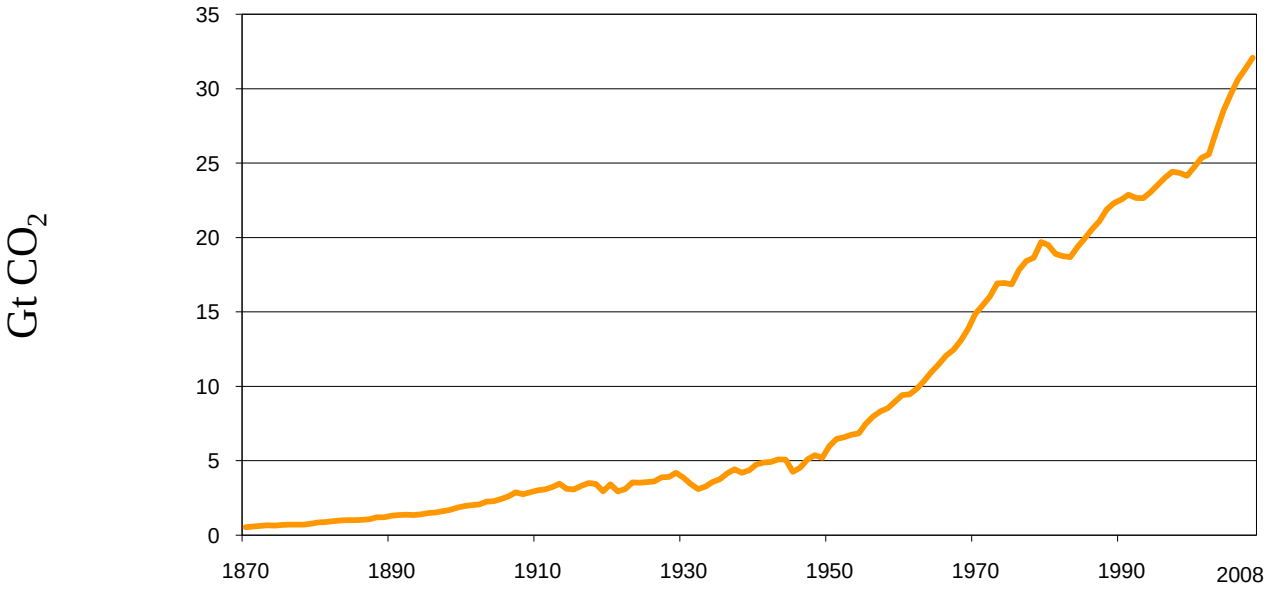
*Key point: Accounting for the largest share of Annex I GHG emissions, energy emissions are predominantly $CO_2$.*

# World primary energy supply




*Key point: Despite growth in renewable energy, fossil fuels still satisfy most of the world's energy supply.*

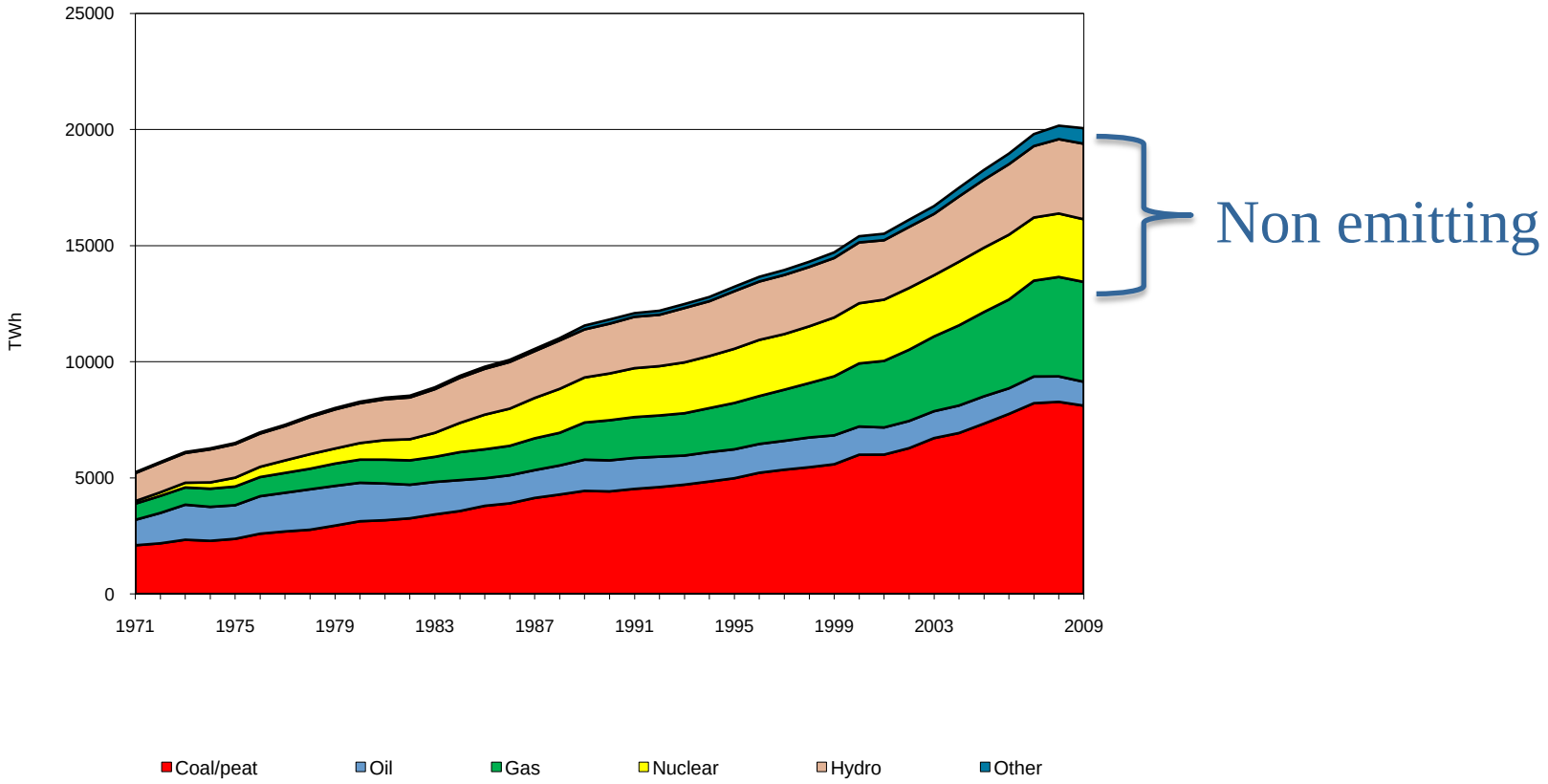
# Trend in $CO_2$ emissions from fossil fuel combustion




*Source: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, US*

*Key point: Since 1870, $CO_2$ emissions from fuel combustion have risen exponentially.*

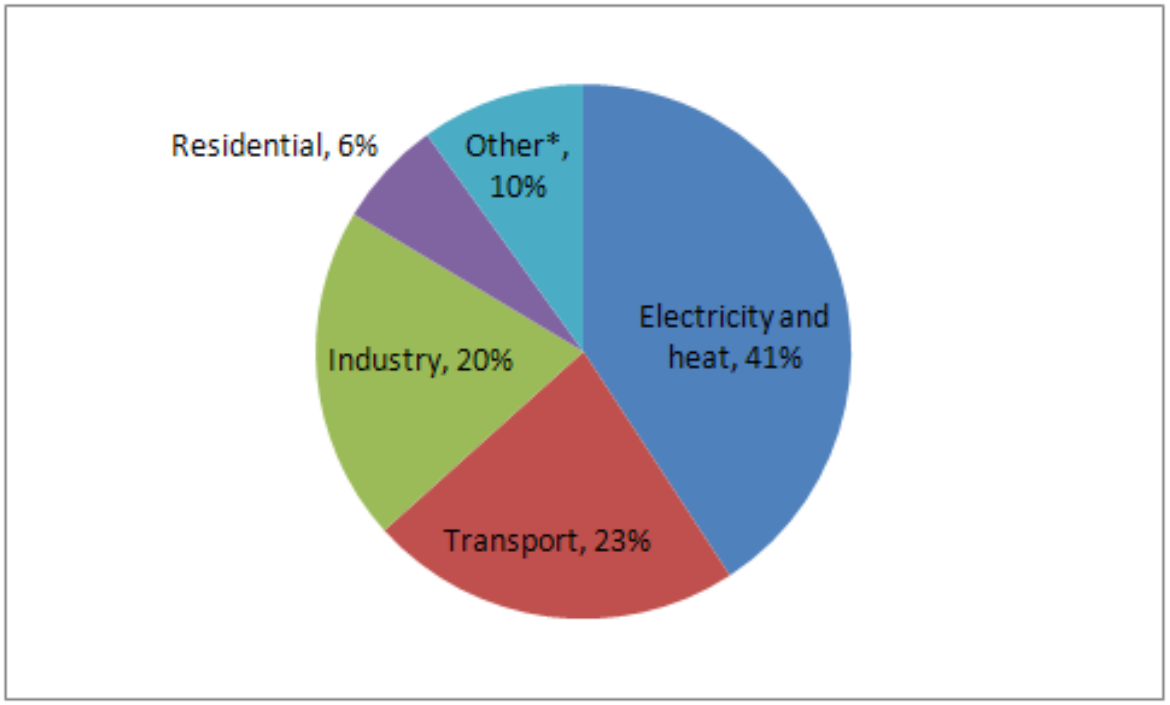
# World electricity generation by fuel




*Key point: Although non- and low-emitting sources are growing, electricity generation is becoming more $CO_2$-intensive as a result of coal use.*

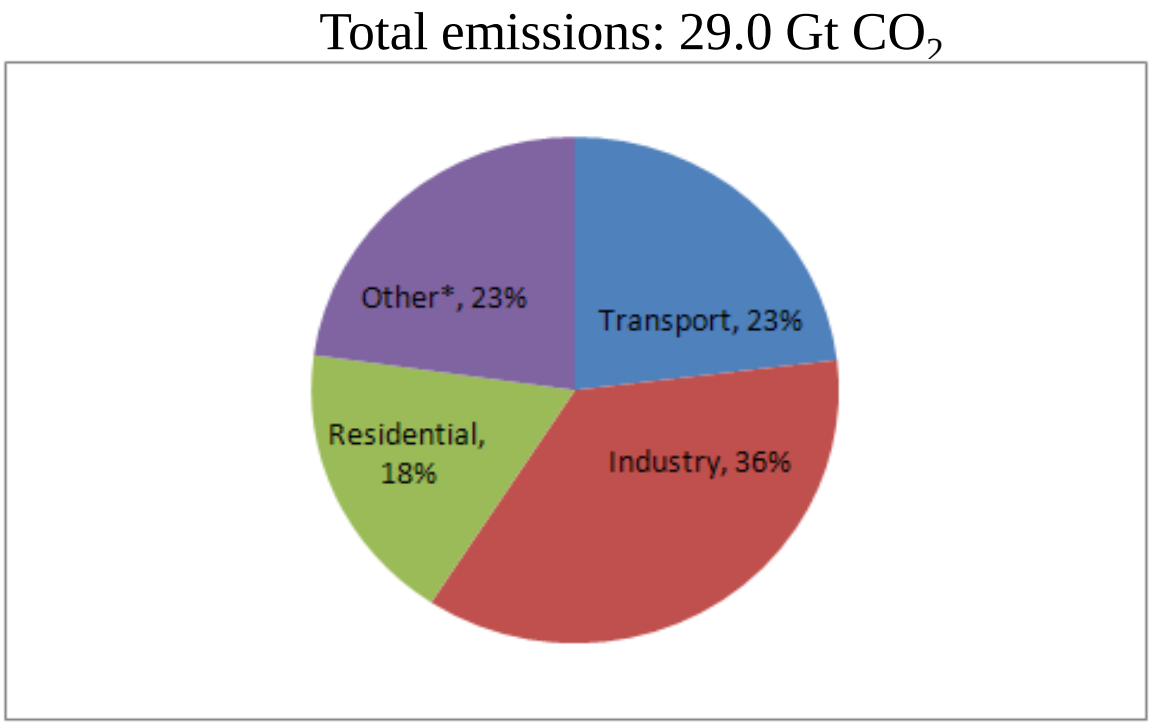
# World $CO_2$ emissions by sector in 2009

Total emissions: 29.0 Gt $CO_2$




*Key point: The combined share of power generation and transport makes up 2/3 of global emissions, up from ~50% in 1971.*

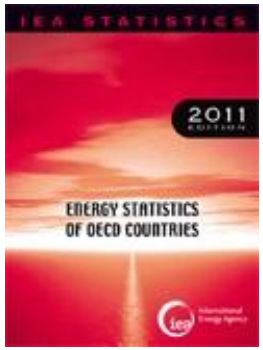
# World $CO_2$ emissions by sector in 2009 with electricity and heat allocated

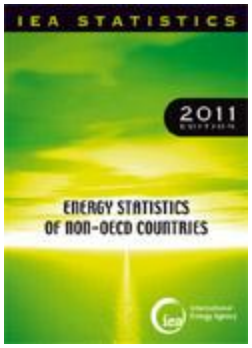



*Key point: When electricity and heat emissions are allocated to their consuming sectors, Industry becomes the largest emitting sector; Transport emissions change only slightly, while Residential and Other increase significantly.*

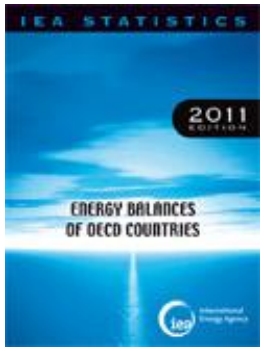
# How IEA estimates $CO_2$ emissions from fuel combustion

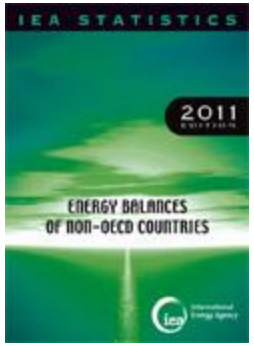
Energy Statistics

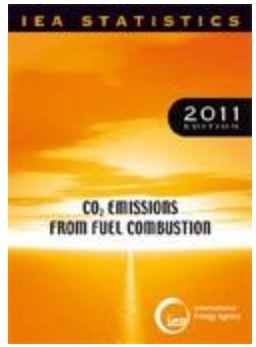



Energy Balances




IPCC Methodologies

$CO_2$ Emissions

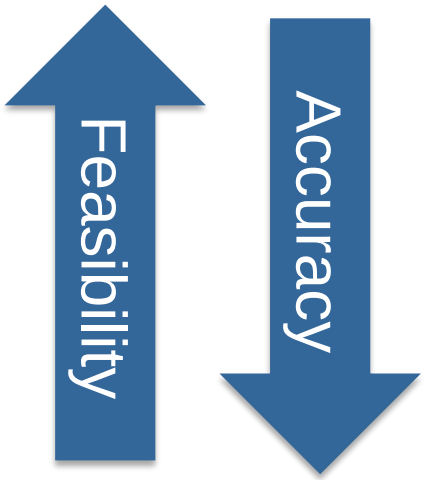
# IPCC Methodologies

- IEA $CO_2$ estimates are calculated using the *Revised 1996 IPCC Guidelines* although the IPCC published new Guidelines in 2006.
- Kyoto Protocol is based on the *Revised 1996 IPCC Guidelines.*

Tier 1
- Simplest method
- Activity data available to all countries

Tier 2
- Technology-specific emission factors

Tier 3
- More detailed or country-specific methods



# IPCC 1996 Guideline Methodologies

Basic computation for $CO_2$ emissions:

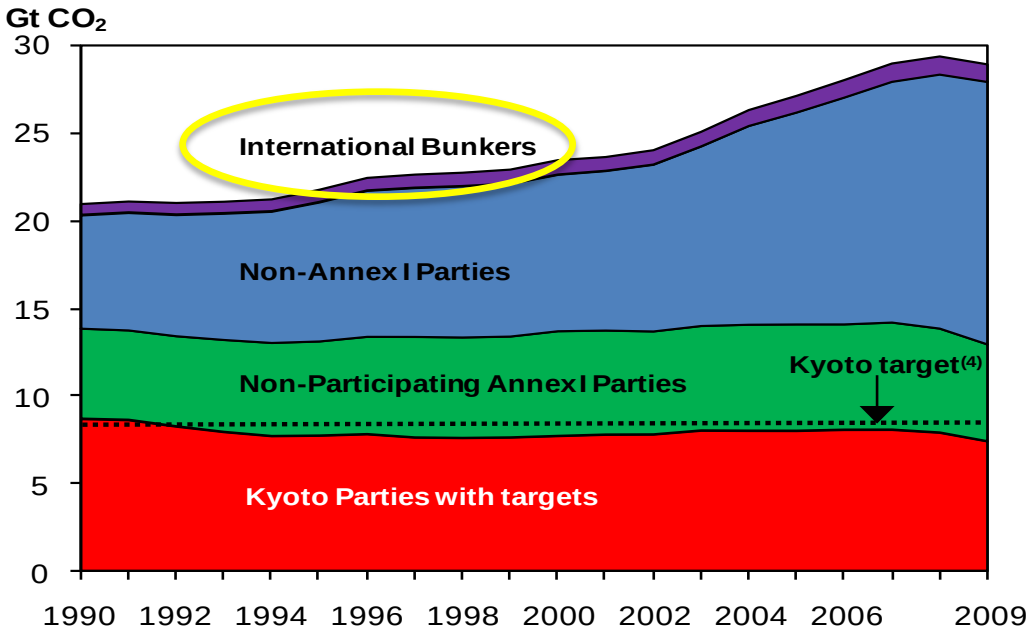
- $CO_2$ emissions by product: **Fuel Quantity x Emission Factor** (with corrections for stored and unoxidised carbon)
- Sum over all different products

**Can be done from two independent sets of data:**

| **Supply** of fuels to the country<br>**Reference Approach** | **Consumption** by end-use sectors<br>**Sectoral Approach** |
|---|---|

# Note on international bunkers

*IPCC Guidelines*: International aviation and international marine bunkers are **not included** in national totals.



# Note on Biomass

*IPCC Guidelines*: Biomass is **not included** in national totals for $CO_2$ emissions from fuel combustion.

Biomass contains carbon, absorbed by plants through photosynthesis.

However, if biomass is sustainably grown, no additional $CO_2$ is considered as emitted into the atmosphere.

If there is a change in the biomass stocks, then the $CO_2$ is accounted for in LULUCF.

# Using the Revised 1996 IPCC Guidelines: Sectoral Approach

| | |
|---|---|
| Step 1: | Estimating sectoral fuel consumption |
| Step 2: | Converting to a common energy unit *(common energy unit: TJ)* |
| Step 3: | Multiplying by carbon emission factors |
| Step 4: | Calculating carbon stored |
| Step 5: | Correcting for carbon unoxidised |
| Step 6: | Converting to $CO_2$ Emissions *(tonnes of $CO_2$)* |

# Step 1: Estimating Sectoral Fuel Consumption

| | | | | | | |
|---|---|---|---|---|---|---|
| **MODULE** | **ENERGY** | | | | | |
| **SUBMODULE** | **$CO_2$ FROM FUEL COMBUSTION (TIER I SECTORAL APPROACH)** | | | | | |
| **WORKSHEET** | **STEP BY STEP CALCULATIONS** | | | | | |
| **SHEET** | **MANUFACTURING INDUSTRIES AND CONSTRUCTION** | | | | | |
| | **STEP 1** | **STEP 2** | | | | |
| **Manufacturing Industries and Construction** | A<br>Consumption | | | | | |
| | | | | | | |
| Crude Oil | | | | | | |
| Natural Gas Liquids | | | | | | |
| Gasoline | | | | | | |
| Jet Kerosene | | | | | | |
| Other Kerosene | | | | | | |
| Gas/Diesel Oil | | | | | | |
| Residual Fuel Oil | | | | | | |
| LPG | | | | | | |

**Separate sheet filled out for each sector:**

Main activity producer electricity and heat
Unallocated autoproducers
Other energy industries
Manufacturing industries and construction
Transport
of which: road
Other sectors
of which: residential

**Units:**
Could be in natural units (e.g. 1000 tonnes) or in energy units (e.g. TJ)

# Step 2: Converting to a Common Energy Unit

| | |
|---|---|
| MODULE | ENERGY |
| SUBMODULE | $CO_2$ FROM FUEL COMBUSTION (TIER I SECTORAL APPR |
| WORKSHEET | STEP BY STEP CALCULATIONS |
| SHEET | MANUFACTURING INDUSTRIES AND CONSTRUCTION |

| | STEP 1 | STEP 2 | | |
|---|---|---|---|---|
| **Manufacturing Industries and Construction** | | B<br>Conversion Factor (TJ/unit) | C<br>Consumption (TJ) | |
| | | | C=(AxB) | |
| Crude Oil | | | | |
| Natural Gas Liquids | | | | |
| Gasoline | | | | |
| Jet Kerosene | | | | |
| Other Kerosene | | | | |
| Gas/Diesel Oil | | | | |
| Residual Fuel Oil | | | | |
| LPG | | | | |

Country-specific NCVs for natural gas and coal are given explicitly in the *Revised 1996 IPCC Guidelines*

| SELECTED NET CALORIFIC VALUES FROM THE 1996 GLS | |
|---|---|
| | *Factors ($TJ/10^3$ tonnes)* |
| **Refined petroleum products** | |
| Gasoline | 44.80 |
| Jet kerosene | 44.59 |
| Other kerosene | 44.75 |
| Shale oil | 36.00 |
| Gas/diesel oil | 43.33 |
| Residual fuel oil | 40.19 |
| LPG | 47.31 |
| Ethane | 47.49 |
| Naphtha | 45.01 |
| Bitumen | 40.19 |
| Lubricants | 40.19 |
| Petroleum coke | 31.00 |
| Refinery feedstocks | 44.80 |
| Refinery gas | 48.15 |
| Other oil products | 40.19 |
| **Other products** | |
| Coal oils and tars derived from coking coals | 28.00 |
| Oil shale | 9.40 |
| Orimulsion | 27.50 |

# Step 3: Multiplying by Carbon Emission Factors

| MODULE | ENERGY |
|---|---|
| SUBM | I SECTORAL APPROACH) |
| WORK | |
| | ONSTI |
| Manufacturing Ind and Construction | |
| | 3) |
| Crude Oil | |
| Natural Gas Liquids | |
| Gasoline | |
| Jet Kerosene | |
| Other Kerosene | |
| Gas/Diesel Oil | |
| Residual Fuel Oil | |
| LPG | |

| CARBON EMISSION FACTORS (CEF) | |
|---|---|
| *Fuel* | *Carbon emission factor (t C/TJ)* |
| **LIQUID FOSSIL** | |
| *Primary fuels* | |
| Crude oil | 20.0 |
| Orimulsion | 22.0 |
| Natural gas liquids | 17.2 |
| *Secondary fuels/products* | |
| Gasoline | 18.9 |
| Jet kerosene | 19.5 |
| Other kerosene | 19.6 |
| Shale oil | 20.0 |
| Gas/diesel oil | 20.2 |
| Residual fuel oil | 21.1 |
| LPG | 17.2 |
| Ethane | 16.8 |
| Naphtha | (20.0) [a] |
| Bitumen | 22.0 |
| Lubricants | (20.0) [a] |
| Petroleum coke | 27.5 |
| Refinery feedstocks | (20.0) [a] |
| Refinery gas | 18.2 [b] |
| Other oil | (20.0) [a] |

| CARBON EMISSION FACTORS (CEF) | |
|---|---|
| *Fuel* | *Carbon emission factor (t C/TJ)* |
| **SOLID FOSSIL** | |
| *Primary fuels* | |
| Anthracite | 26.8 |
| Coking coal | 25.8 |
| Other bituminous coal | 25.8 |
| Sub-bituminous coal | 26.2 |
| Lignite | 27.6 |
| Oil shale | 29.1 |
| Peat | 28.9 |
| *Secondary fuels/products* | |
| BKB & patent fuel | (25.8) [a] |
| Coke oven / gas coke | 29.5 |
| Coke oven gas | 13.0 [b] |
| Blast furnace gas | 66.0 [b] |
| **GASEOUS FOSSIL** | |
| Natural gas (dry) | 15.3 |

# Step 4: Calculating Carbon Stored

| | |
|---|---|
| **MODULE** | **ENERGY** |
| **SUBMODULE** | **$CO_2$ FROM FUEL COMBUSTION (TIER I SECTORAL APPROACH)** |
| **WORKSHEET** | **2 STEP BY STEP CALCULATIONS** |
| **SHEET** | **MANUFACTURING INDUSTRIES AND CONSTRUCTION** |

| | STEP 4 | | | STEP 5 | | STEP 6 |
|---|---|---|---|---|---|---|
| **Manufacturing Industries and Construction** | G<br>Fraction of Carbon Stored | H<br>Carbon Stored (Gg C) | I<br>Net Carbon Emissions (Gg C) | | | |
| | | H=(FxG) | I=(F-H) | | | |
| Crude Oil | | | | | | |
| Natural Gas Liquids | | | | | | |
| Gasoline | | | | | | |
| Jet Kerosene | | | | | | |
| Other Kerosene | | | | | | |
| Gas/Diesel Oil | | | | | | |
| Residual Fuel Oil | | | | | | |
| LPG | | | | | | |

**Default values: fraction of carbon stored**

| | |
|---|---|
| Naphtha* | 0.8 |
| Lubricants | 0.5 |
| Bitumen | 1.0 |
| Coal Oils and Tars | 0.75 |
| Natural Gas* | 0.33 |
| Gas/Diesel Oil* | 0.5 |
| LPG* | 0.8 |
| Ethane* | 0.8 |

*When used as feedstocks

# Step 5: Correcting for Carbon unoxidised

| | | | | | | |
|---|---|---|---|---|---|---|
| **MODULE** | **ENERGY** | | | | | |
| **SUBMODULE** | **$CO_2$ FROM FUEL COMBUSTION (TIER I SECTORAL APPROACH)** | | | | | |
| **WORKSHEET** | **2 STEP BY STEP CALCULATIONS** | | | | | |
| **SHEET** | **MANUFACTURING INDUSTRIES AND CONSTRUCTION** | | | | | |
| | **STEP 4** | | | **STEP 5** | | **STEP 6** |
| **Manufacturing Industries and Construction** | | | | J<br>Fraction of Carbon Oxidised | K<br>Actual Carbon Emissions (Gg C) | |
| | | | | | K=(IxJ) | |
| Crude Oil | | | | | | |
| Natural Gas Liquids | | | | | | |
| Gasoline | | | | | | |
| Jet Kerosene | | | | | | |
| Other Kerosene | | | | | | |
| Gas/Diesel Oil | | | | | | |
| Residual Fuel Oil | | | | | | |
| LPG | | | | | | |

**Default values: fraction of carbon oxidised**

| | |
|---|---|
| Coal | 0.98 |
| Oil and oil products | 0.99 |
| Gas | 0.995 |
| Peat for elec. Generation | 0.99 |

# Step 6: Converting to $CO_2$ Emissions

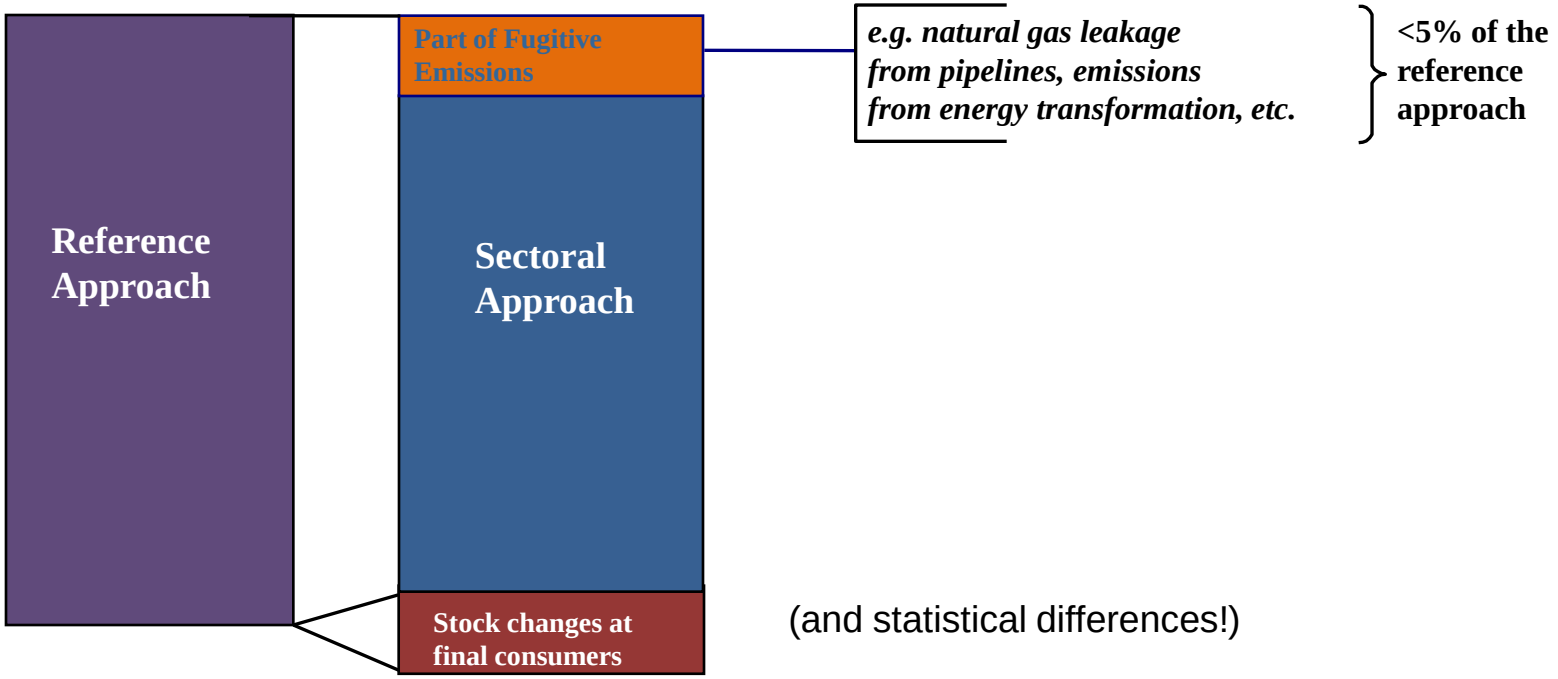
| MODULE | ENERGY | | | | | |
|---|---|---|---|---|---|---|
| SUBMODULE | $CO_2$ FROM FUEL COMBUSTION (TIER I SECTORAL APPROACH) | | | | | |
| WORKSHEET | 2 STEP BY STEP CALCULATIONS | | | | | |
| SHEET | MANUFACTURING INDUSTRIES AND CONSTRUCTION | | | | | |
| | **STEP 4** | | | **STEP 5** | | **STEP 6** |
| **Manufacturing Industries and Construction** | | | | | | L<br>Actual CO2 Emissions (Gg CO2) |
| | | | | | | L=(K x [44/12]) |
| Crude Oil | | | | | | |
| Natural Gas Liquids | | | | | | |
| Gasoline | | | | | | |
| Jet Kerosene | | | | | | |
| Other Kerosene | | | | | | |
| Gas/Diesel Oil | | | | | | |
| Residual Fuel Oil | | | | | | |
| LPG | | | | | | |

**Multiply by 44/12**

(the molecular weight ratio of $CO_2$ to C)

# Data Quality: Reference vs. Sectoral Approach

**Reference Approach** is generally an **upper limit** for **Sectoral Approach**




(and statistical differences!)

*Key point: Comparing the Reference Approach and the Sectoral Approach is one way to control data quality.*

# Data Quality: Comparing IEA and UNFCCC data

A comparison is done on an annual basis between IEA and UNFCCC emissions inventories, in order to highlight and minimise potential errors. There can be many (often legitimate) reasons for differences between the two datasets, including:

- The IEA uses a Tier 1 Method
- The IEA still uses the 1996 guidelines
- Underlying energy data can be different (multiple official sources)
- The IEA uses average NCVs
- The IEA uses average CEFs
- The IEA has no detailed info on carbon stored
- Autoproducers are unallocated in the IEA data
- Military emissions can be treated differently
- IEA data include emissions from coke inputs to blast furnaces
- Units can be different

# 2009 World $CO_2$ emissions

Other only includes industrial waste and non-renewable municipal waste (not biofuels)

Residential only includes emissions from fuels actually combusted in households (hence its relatively small share), not electricity or heat consumption

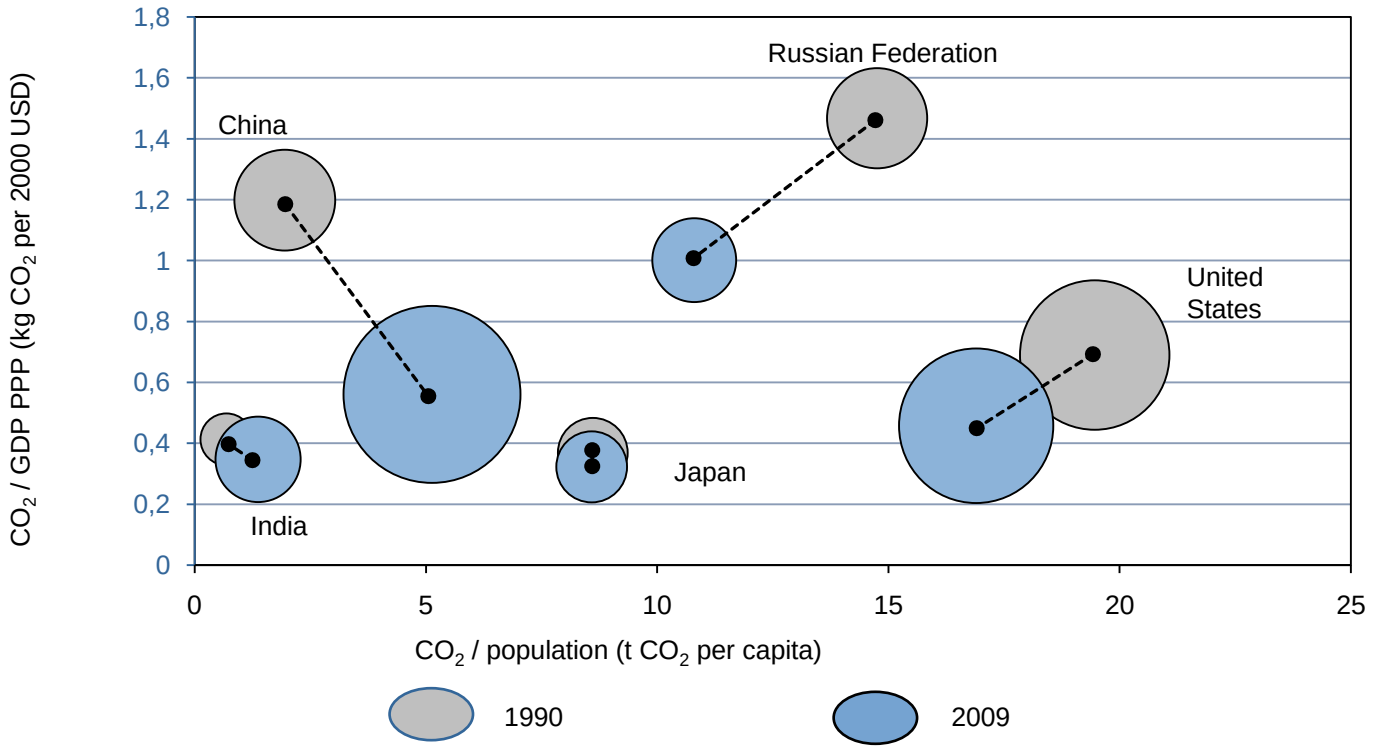
We show both the reference approach and sectoral approach emissions (the difference coming from statistical differences, and losses and transformation)

We show emissions for main activity and autoproducer plants separately (we don't have the required data to allocate autoproducers to their consuming sectors)

| million tonnes | Oil | | | ge 09 |
|---|---|---|---|---|
| **Sectoral Apr** | | | **28 999.4** | **38.3%** |
| Main activity p | | | 10 796.1 | 63.1% |
| Unallocated autoproducers | | | 1 031.0 | 16.2% |
| Other energy industry own use | | | 1 464.1 | 45.6% |
| Manufacturing industries and constructior | | | 5 870.9 | 29.5% |
| Transport | | | 6 543.8 | 42.5% |
| *of which: road* | | | *4 876.6* | 48.3% |
| Other | | | 3 293.4 | -1.1% |
| *of which: residential* | | | | |
| **Reference Approach** | | | | |
| Diff. due to losses and/or transformation | 256.5 | 85.6 | | |
| Statistical differences | 99.2 | 37.4 | | |
| *Memo: international marine bunkers* ** | - | *592.2* | | |
| *Memo: international aviation bunkers* ** | - | *423.4* | | |

* Other includes industrial waste and non-renewable municipal waste.
** World includes international marine bunkers and international aviation bunkers.

# $CO_2$ Intensities of major countries




*Key point: Various $CO_2$ indicators can be used to track countries with different economies against each other.*

# Dealing with Climate Change: National Policy Options

- Emit less (be more efficient, restructure economy)
- Emit differently (switch fuels or processes to deliver same outcome)
- $CO_2$ capture and storage
- Do without (change behaviour)
- Adapt (learn to live with it)

A need for energy statistics to be able to monitor progress of the various policies

# Importance of energy statistics for estimating GHG emissions

- Fossil fuel combustion is the single largest human influence on climate.
- Two sectors, both growing rapidly, represent the bulk of $CO_2$ emissions from fuel:
  - electricity and heat generation
  - transport
- Effective emissions mitigation will require all countries, regardless of energy demand and infrastructure, to use energy in a sustainable manner.
- Up-to-date and accurate information on energy use and GHG emissions is essential for countries to monitor their progress in reducing GHG emissions.

*$CO_2$ Emissions from Fuel Combustion (2011 Edition)* is available now.


A large amount of data is available for free at the following address: http://www.iea.org/co2highlights

Thank you. EMISSIONS@IEA.ORG