

The Use of Energy Statistics to Estimate CO₂ Emissions

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Roberta Quadrelli
Head, non-OECD Statistics
Energy Statistics Division



Outline

- ◆ **International context**
- ◆ **About GHG emissions**
- ◆ **Estimation of CO₂ emissions**
- ◆ **CO₂ Estimates for South Africa**
- ◆ **The importance of energy statistics for CO₂ estimation**

GHG emissions: international background

- **1992: United Nations Framework Convention on Climate Change (UNFCCC) at Rio de Janeiro conference:** Stabilization of greenhouse gas concentrations in the atmosphere.
- **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.

Relevant publications for GHG inventories:

- **2000:** *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*
- **2006:** *2006 IPCC Guidelines for National Greenhouse Gas Inventories*

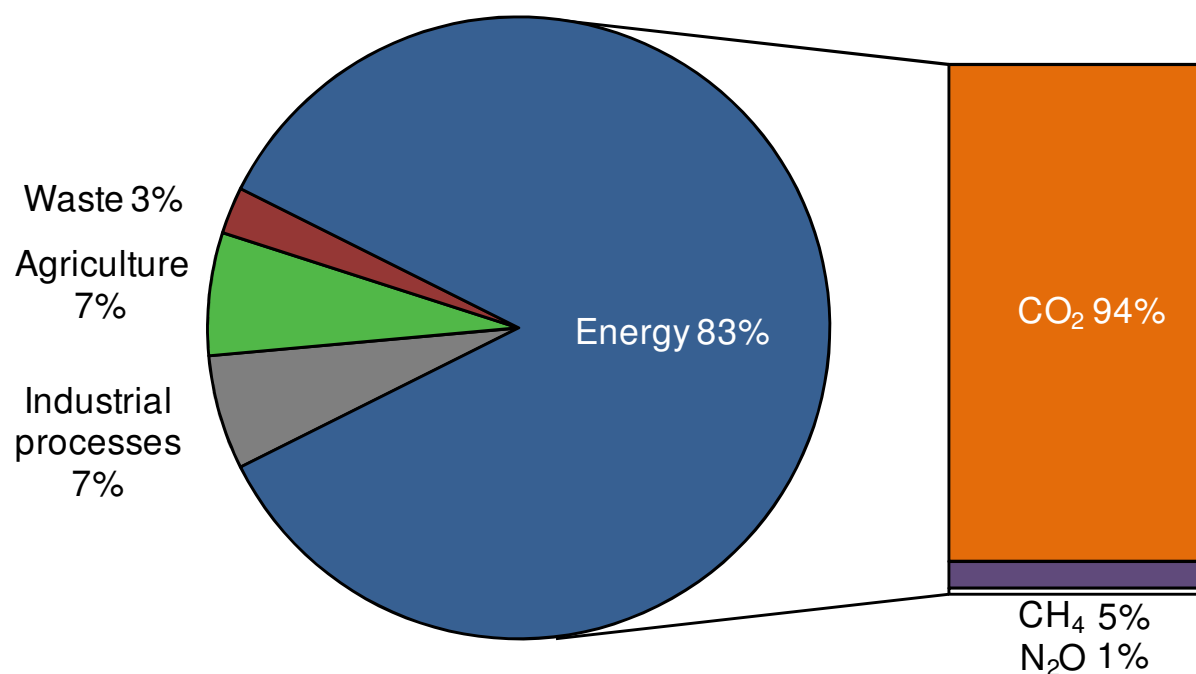
An example of greenhouse gas inventory

Kyoto Protocol submission to UNFCCC of France, 2008

| | |
|---|------------|
| Total CO ₂ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 541,308.13 |
| Total CO ₂ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 471,416.25 |

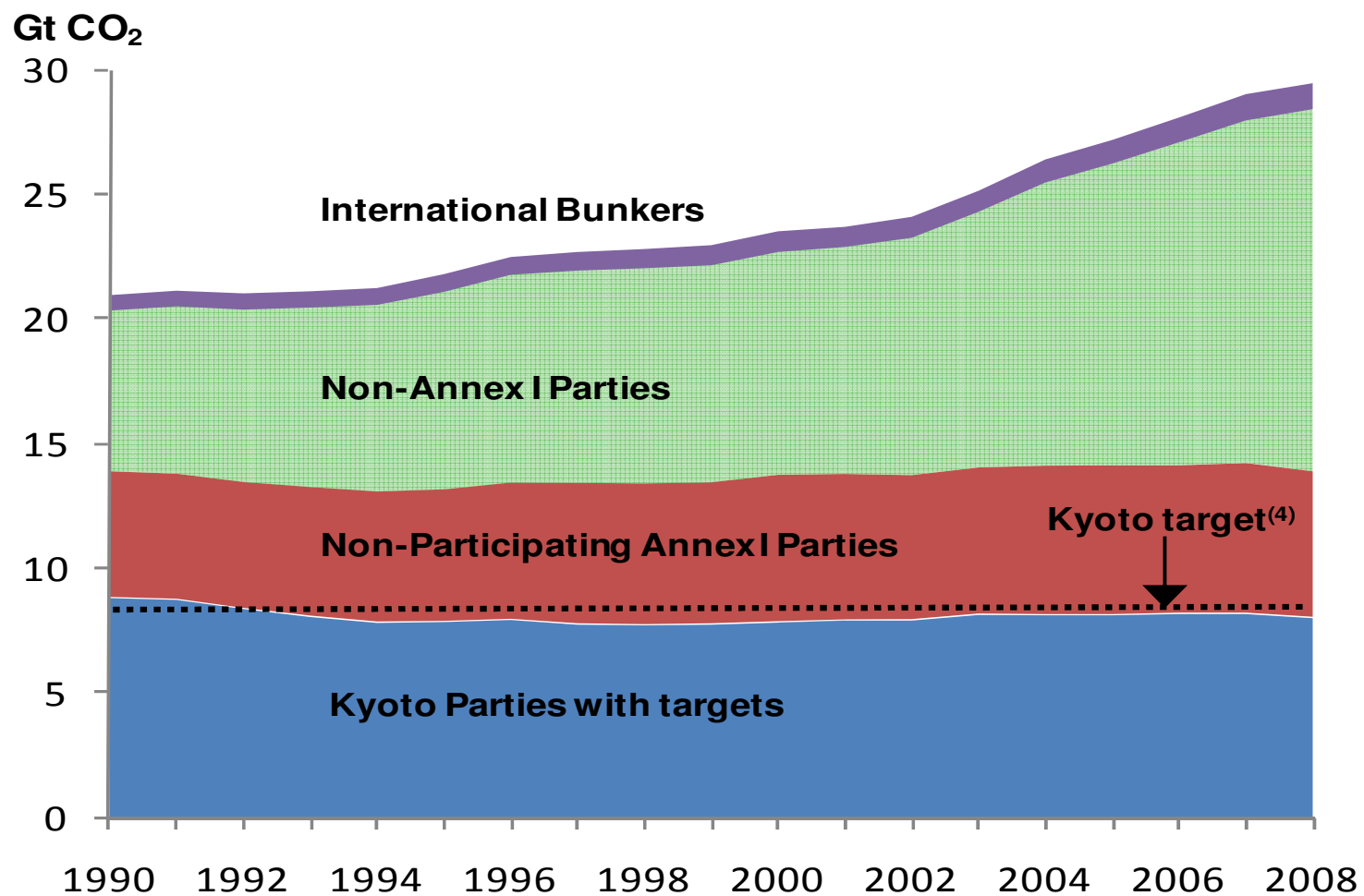
Share of energy in GHG emissions

(Annex I countries)

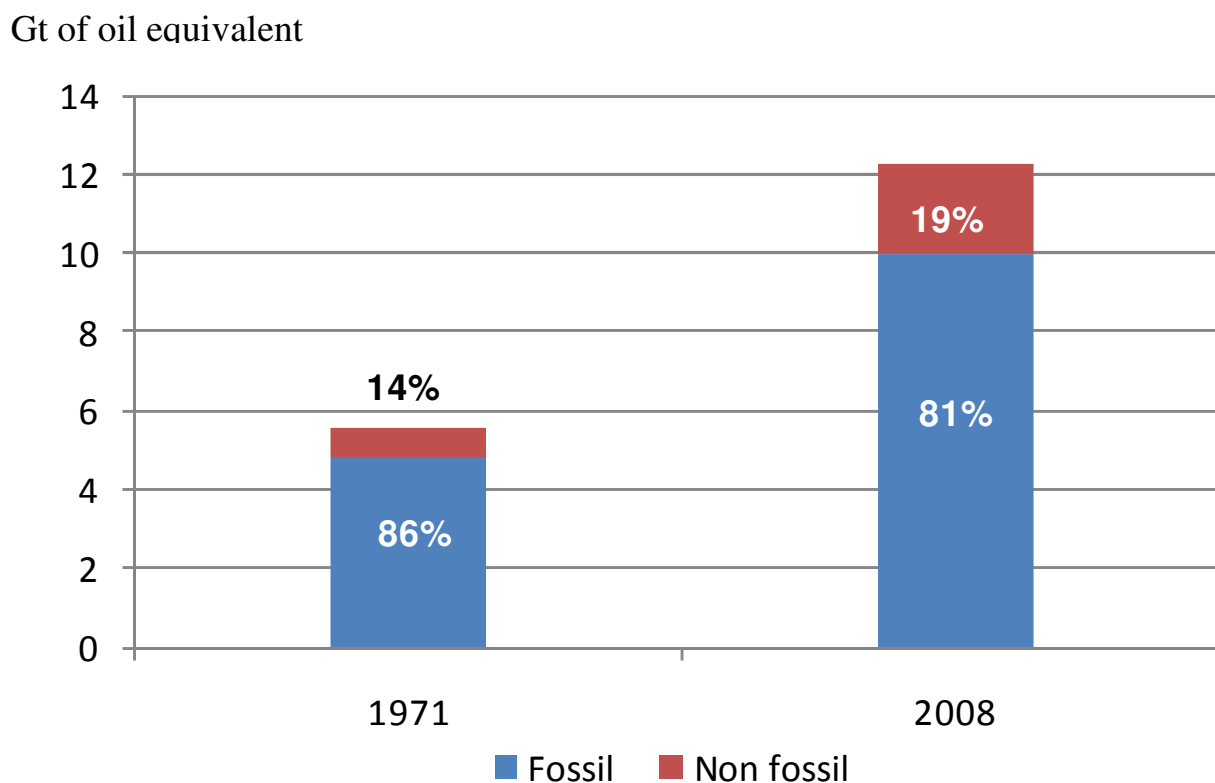


*Use of energy is responsible for the largest share of global GHG emissions.
Emissions from energy are predominantly CO₂.*

Note on Kyoto Protocol

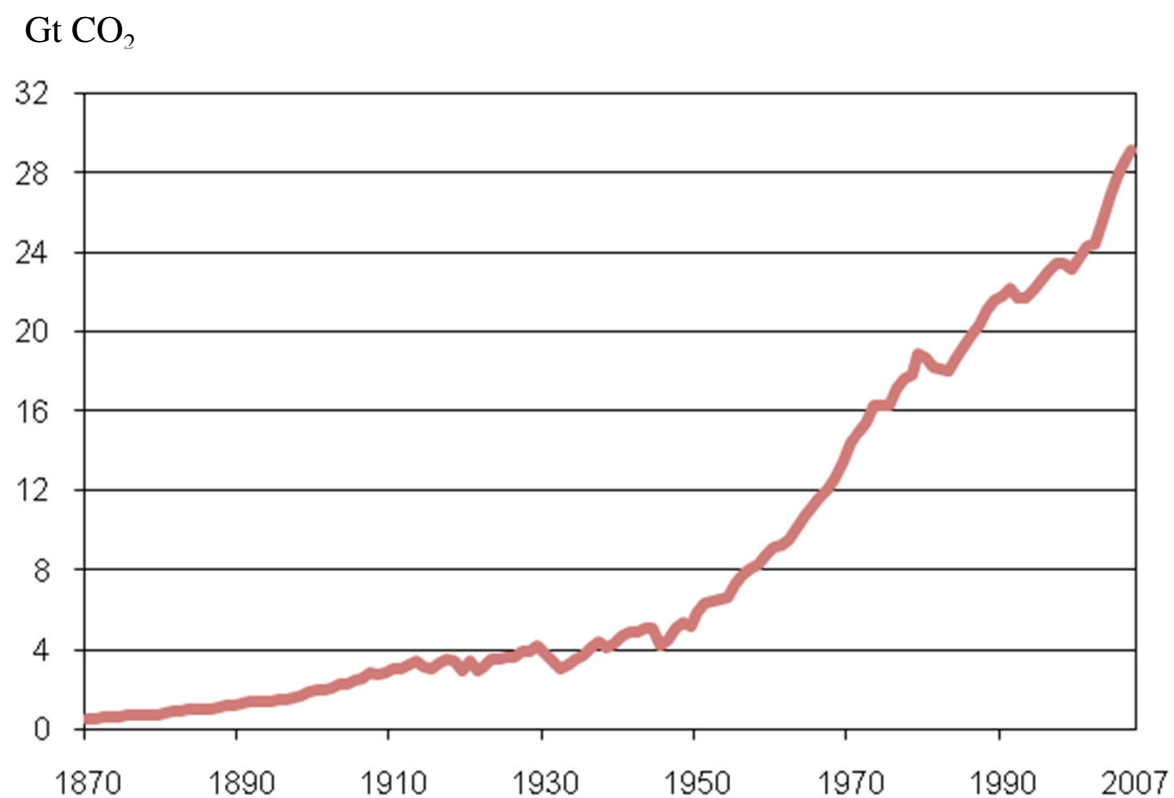


Fossil fuels in the global primary energy supply



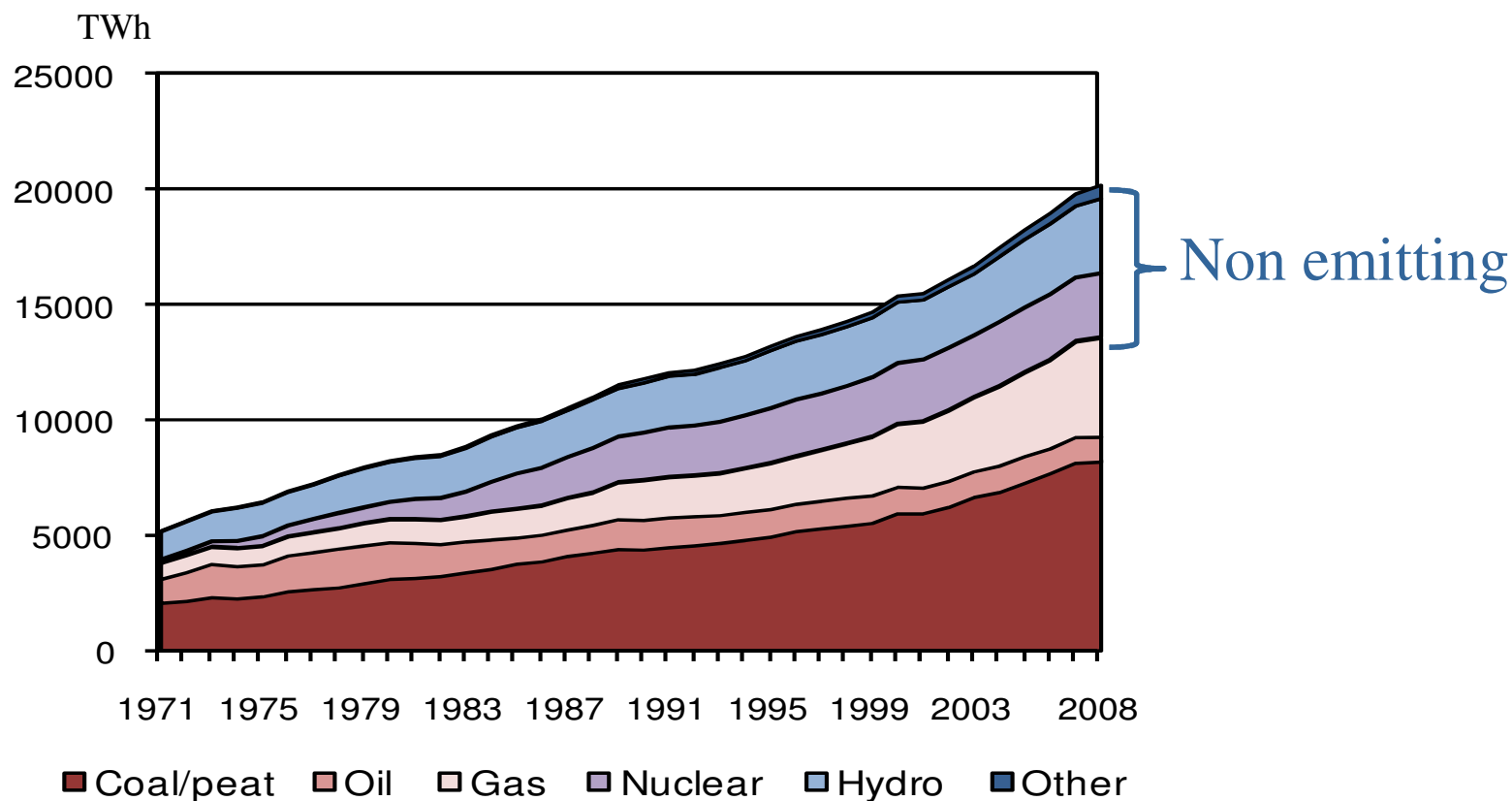
Fossil fuels still satisfy most of the world energy supply.

Trend in CO₂ emissions from fossil fuel combustion



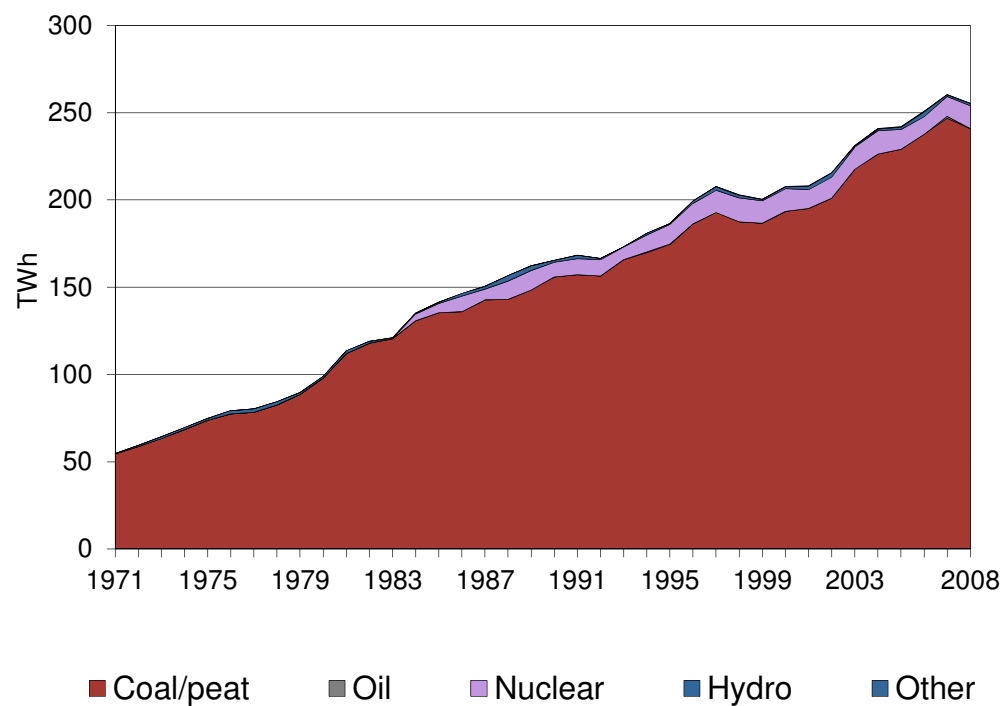
Since 1870, CO₂ emissions from fuel combustion have risen exponentially.

World electricity generation by fuel



Non- and low-emitting sources are growing, but the largest source of electricity generation is still coal.

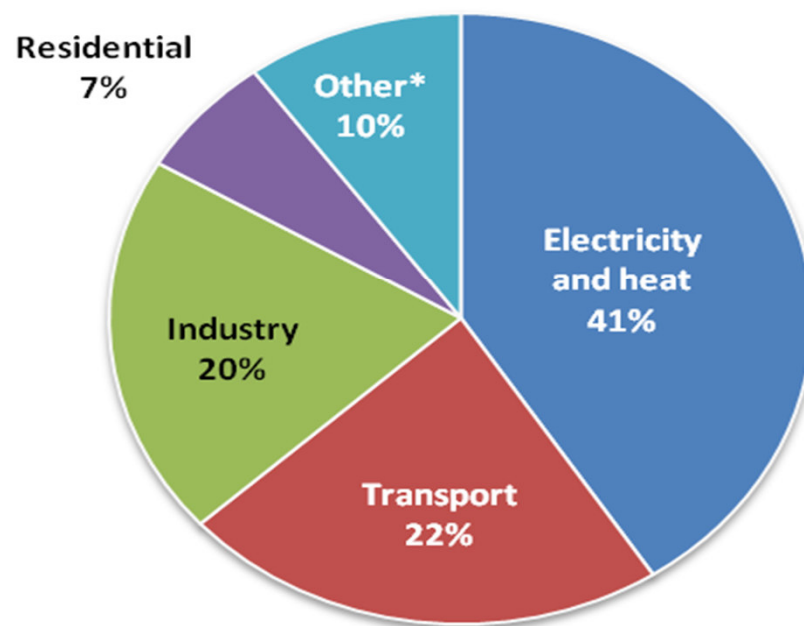
Electricity generation by fuel: South Africa



Coal provides 94% of electricity in South Africa

World CO₂ emissions by sector in 2008

Total emissions: 29.4 Gt CO₂



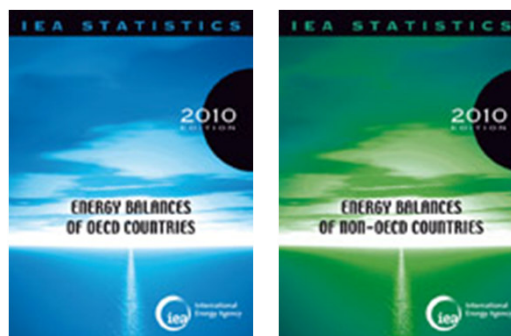
Electricity generation and transport account together for 2/3 of global CO₂ emissions.

How IEA estimates CO₂ emissions from fuel combustion

Energy Statistics



Energy Balances



CO₂
Emissions

IPCC
Methodologies



IPCC Methodologies

- ◆ IEA CO₂ 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 factor

Tier 3

- ◆ More detailed or country-specific methods



Feasibility



Accuracy

IPCC Methodologies

Basic computation for CO₂ emissions based on carbon conservation

- ◆ CO₂ 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:



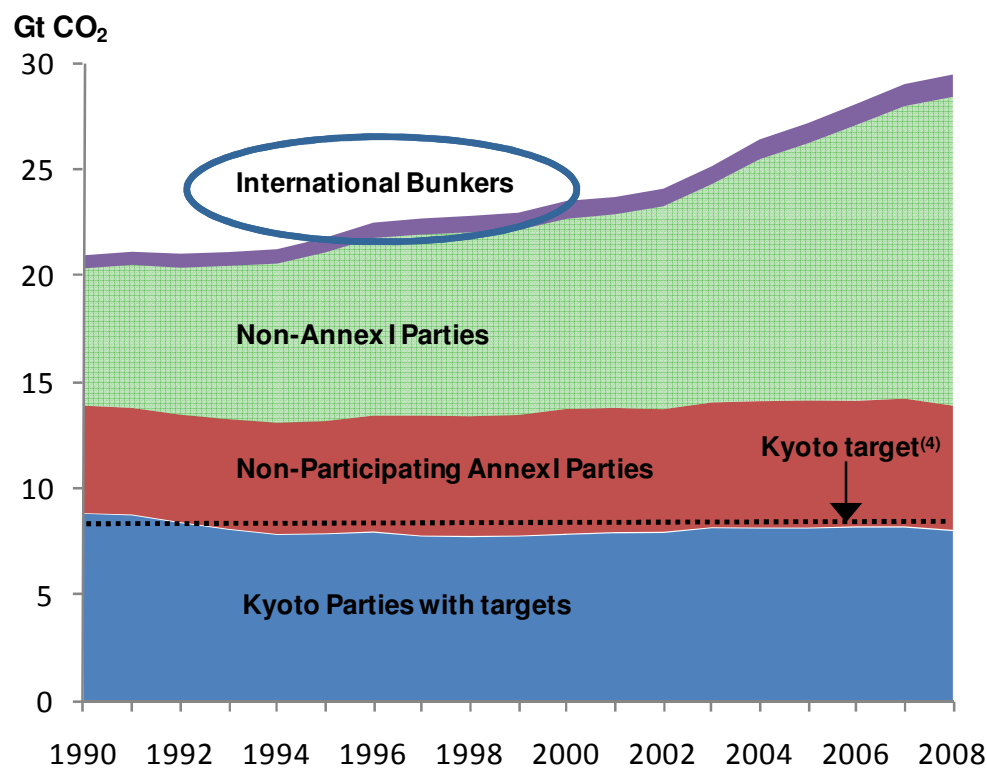
Supply of fuels to the country
Reference Approach



Consumption by end-use sectors
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 CO₂ emissions from fuel combustion.

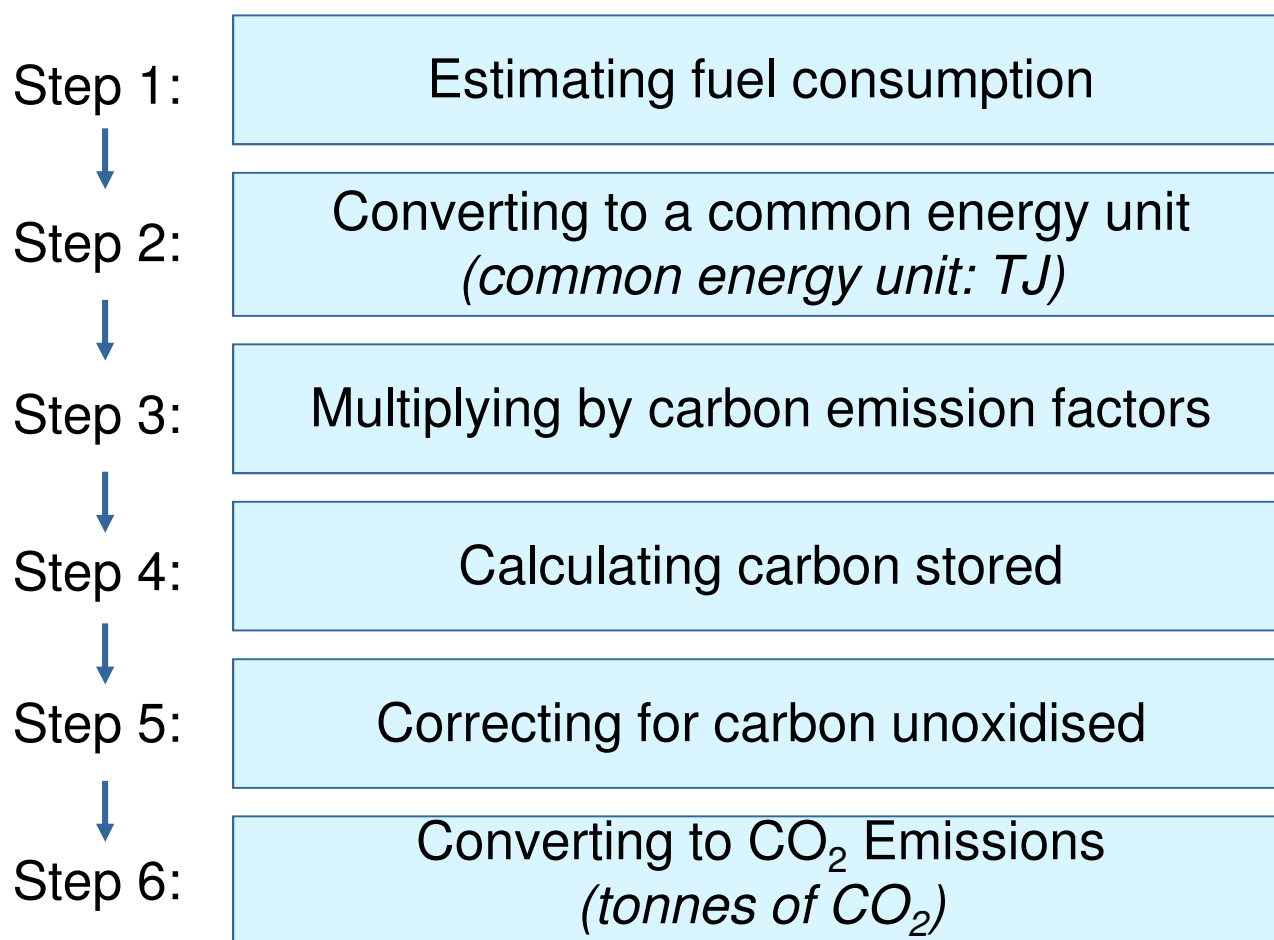
Biomass contains carbon, absorbed by plants through photosynthesis.

However, if biomass is sustainably grown, no additional CO₂ is considered as emitted into the atmosphere.


If there is a change in the biomass stocks, then the CO₂ is accounted for in LULUCF.



Using the Revised 1996 IPCC Guidelines:



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 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 | | | SELECTED NET CALORIFIC VALUES | |
|---|--|-----------------------------|------------------|--|-------------------------------------|
| SUBMODULE | CO ₂ FROM FUEL COMBUSTION (TIER I SECTORAL APP) | | | VALUES | |
| WORKSHEET | STEP BY STEP CALCULATIONS | | | | Factors (TJ/10 ³ tonnes) |
| SHEET | MANUFACTURING INDUSTRIES AND CONSTRUCTION | | | Refined petroleum products | |
| | STEP 1 | STEP 2 | | | |
| | | B | C | | |
| Manufacturing Industries and Construction | | Conversion Factor (TJ/unit) | Consumption (TJ) | | |
| | | | C=(AxB) | | |
| Crude Oil | | | | Gasoline | 44.80 |
| Natural Gas Liquids | | | | Jet kerosene | 44.59 |
| Gasoline | | | | Other kerosene | 44.75 |
| Jet Kerosene | | | | Shale oil | 36.00 |
| Other Kerosene | | | | Gas/diesel oil | 43.33 |
| Gas/Diesel Oil | | | | Residual fuel oil | 40.19 |
| Residual Fuel Oil | | | | LPG | 47.31 |
| LPG | | | | 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 |

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

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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 Fraction of Carbon Stored | H Carbon Stored (Gg C) | I Net Carbon Emissions (Gg C) | | | |
| | | $H=(F \times G)$ | $I=(F-H)$ | | | |
| 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 Fraction of Carbon Oxidised | K Actual Carbon Emissions (Gg C) K=(I×J) | |
| 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

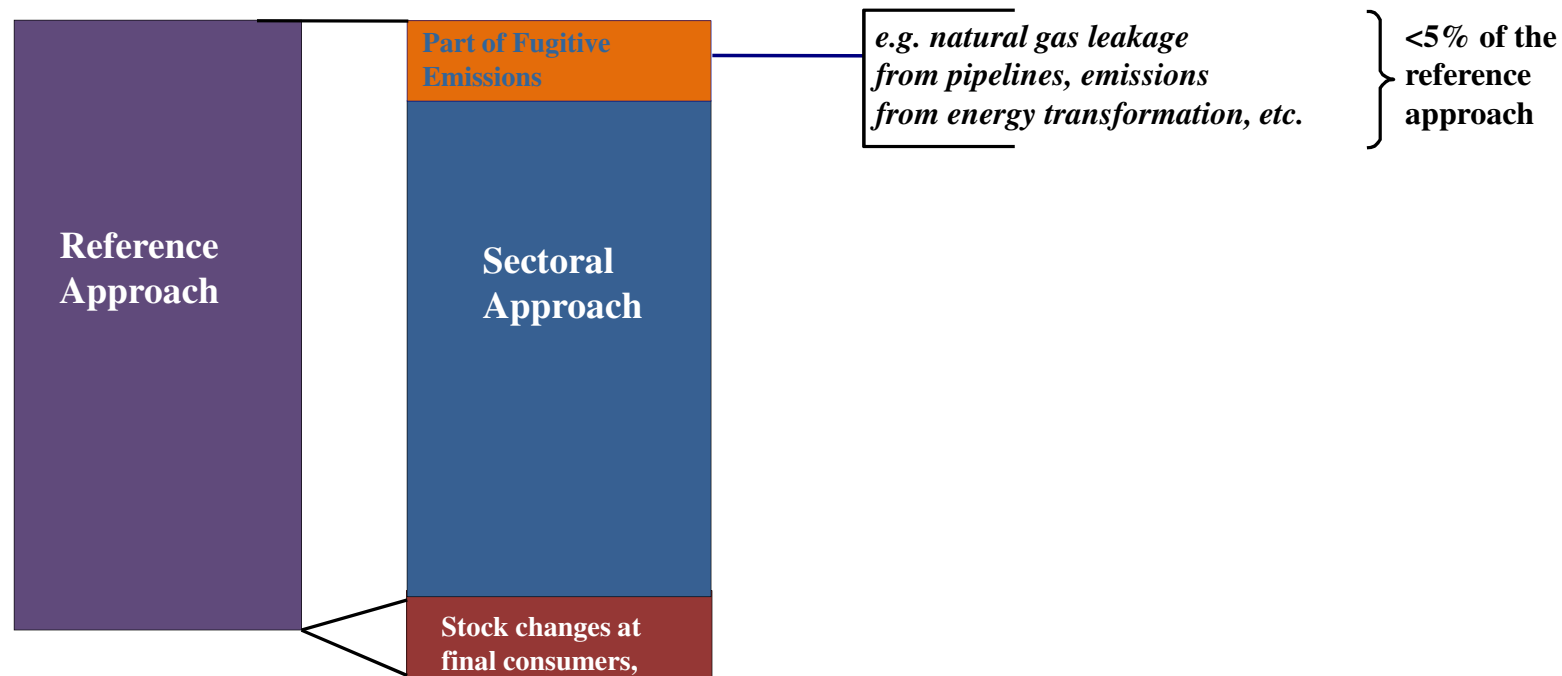
Step 6: Converting to CO₂ Emissions

| 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 Actual CO ₂ Emissions (Gg CO ₂) |
| | | | | | | $L = (K \times [44/12])$ |
| 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 CO₂ to C)

Data Quality: Reference vs. Sectoral Approach

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



Compare Reference Approach and Sectoral Approach to control data quality.

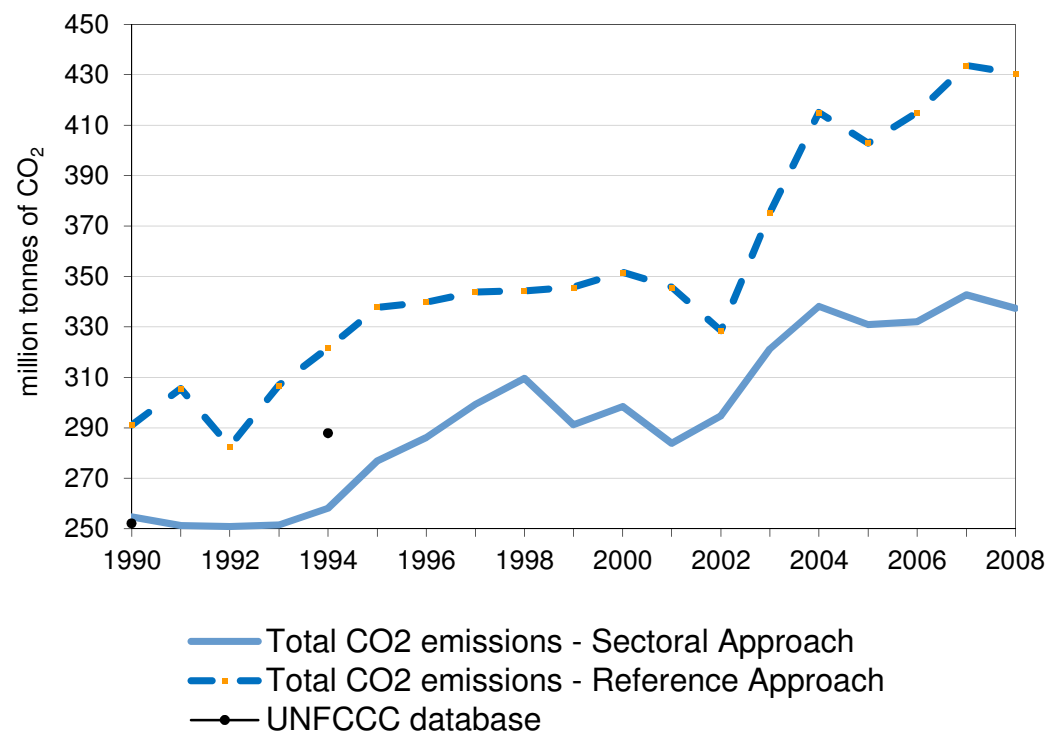
2008 World CO₂ emissions

| | | | | | | % change |
|--|-----------------|-----------------|----------------|--------------|-----------------|--------------|
| <i>million tonnes of CO₂</i> | Coal/peat | Oil | Gas | Other * | Total | 90-08 |
| Sectoral Approach | 12 595.3 | 10 821.0 | 5 861.5 | 103.6 | 29 381.4 | 40.1% |
| Main activity producer elec. and heat | 8 222.8 | 713.3 | 1 992.3 | 34.8 | 10 963.1 | 65.8% |
| Unallocated autoproducers | 448.4 | 150.8 | 387.2 | 38.2 | 1 024.7 | 14.2% |
| Other energy industries | 281.0 | 675.6 | 534.5 | 0.7 | 1 491.9 | 47.8% |
| Manufacturing industries and construction | 3 094.0 | 1 532.2 | 1 291.9 | 25.6 | 5 943.6 | 31.4% |
| Transport | 13.4 | 6 410.3 | 180.9 | - | 6 604.7 | 44.1% |
| <i>of which: road</i> | - | 4 812.9 | 35.5 | - | 4 848.4 | 47.5% |
| Other | 535.7 | 1 338.8 | 1 474.6 | 4.3 | 3 353.4 | 0.4% |
| <i>of which: residential</i> | 299.8 | 631.9 | 973.3 | 0.0 | 1 905.1 | 4.7% |
| Reference Approach | 12 904.8 | 10 982.1 | 5 948.0 | 103.7 | 29 938.6 | 39.1% |
| Diff. due to losses and/or transformation | 282.9 | 49.3 | 78.9 | 0.0 | 411.1 | |
| Statistical differences | 26.6 | 111.9 | 7.5 | 0.1 | 146.0 | |
| <i>Memo: international marine bunkers **</i> | - | 578.2 | - | - | 578.2 | 63.0% |
| <i>Memo: international aviation bunkers **</i> | - | 454.8 | - | - | 454.8 | 76.1% |

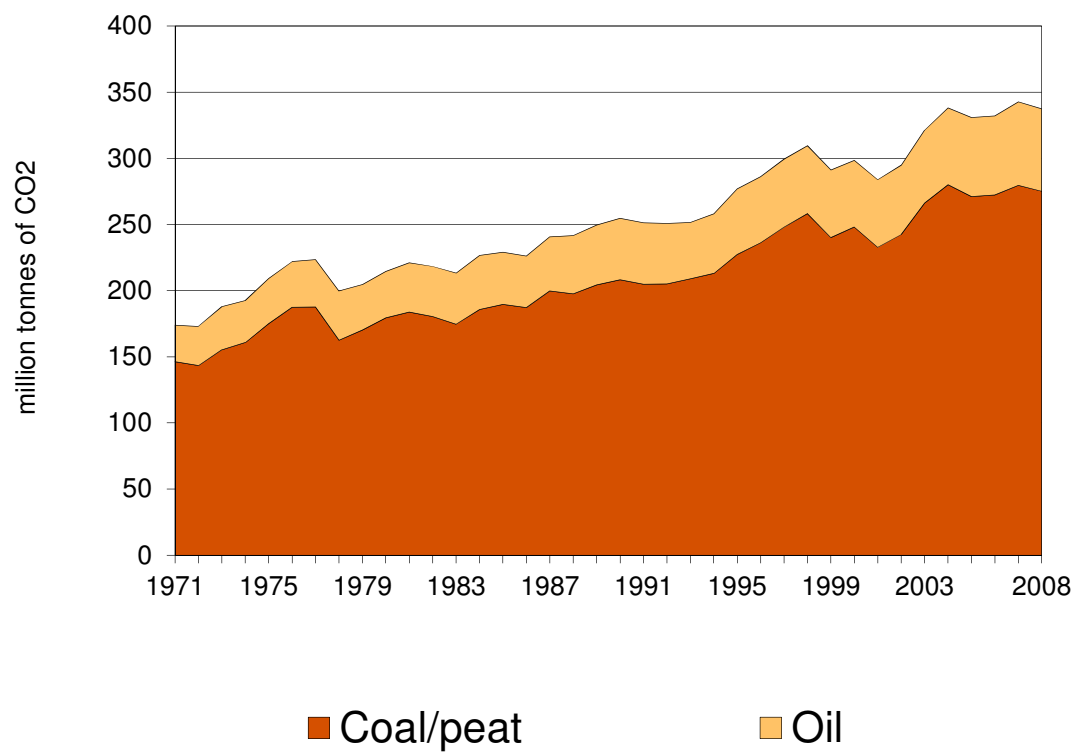
* Other includes industrial waste and non-renewable municipal waste.

** World includes international marine bunkers and international aviation bunkers.

Reference vs. Sectoral Approach: South Africa



CO₂ emissions by fuel: South Africa



Key Indicators: South Africa

| | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 | % change 90-08 |
|---|--------|--------|--------|--------|--------|--------|--------|-------------------|
| CO ₂ Sectoral Approach (Mt of CO ₂) | 254.67 | 276.91 | 298.50 | 330.90 | 332.11 | 342.75 | 337.42 | 32.5% |
| CO ₂ Reference Approach (Mt of CO ₂) | 291.15 | 337.80 | 351.73 | 402.93 | 415.00 | 433.75 | 430.59 | 47.9% |
| TPES (PJ) | 3 804 | 4 394 | 4 619 | 5 271 | 5 394 | 5 624 | 5 631 | 48.0% |
| TPES (Mtoe) | 90.86 | 104.94 | 110.33 | 125.88 | 128.83 | 134.33 | 134.49 | 48.0% |
| GDP (billion 2000 USD) | 110.95 | 115.81 | 132.88 | 160.63 | 169.18 | 177.80 | 183.25 | 65.2% |
| GDP PPP (billion 2000 USD) | 321.98 | 336.11 | 385.64 | 466.18 | 490.99 | 516.02 | 531.82 | 65.2% |
| Population (millions) | 35.20 | 39.12 | 44.00 | 46.89 | 47.39 | 47.85 | 48.69 | 38.3% |
| CO ₂ / TPES (t CO ₂ per TJ) | 67.0 | 63.0 | 64.6 | 62.8 | 61.6 | 60.9 | 59.9 | -10.5% |
| CO ₂ / GDP (kg CO ₂ per 2000 USD) | 2.30 | 2.39 | 2.25 | 2.06 | 1.96 | 1.93 | 1.84 | -19.8% |
| CO ₂ / GDP PPP (kg CO ₂ per 2000 USD) | 0.79 | 0.82 | 0.77 | 0.71 | 0.68 | 0.66 | 0.63 | -19.8% |
| CO ₂ / population (t CO ₂ per capita) | 7.24 | 7.08 | 6.78 | 7.06 | 7.01 | 7.16 | 6.93 | -4.2% |

Key Sources*: South Africa

| IPCC source category | CO ₂ emissions (Mt of CO ₂) | % change 90-08 | Level assessment (%) ** | Cumulative total (%) |
|--|---|-------------------|----------------------------|-------------------------|
| Main activity prod. elec. and heat - coal/peat | 203.31 | 54.0% | 44.2 | 44.2 |
| Road - oil | 42.30 | 51.5% | 9.2 | 53.4 |
| Manufacturing industries - coal/peat | 41.03 | -29.3% | 8.9 | 62.3 |
| Residential - coal/peat | 13.83 | 140.1% | 3.0 | 65.3 |
| Unallocated autoproducers - coal/peat | 9.93 | 16.0% | 2.2 | 67.4 |
| Non-specified other sectors - coal/peat | 7.04 | 91.7% | 1.5 | 69.0 |
| Non-specified other - oil | 5.24 | 82.6% | 1.1 | 70.1 |
| Manufacturing industries - oil | 4.41 | -57.4% | 1.0 | 71.1 |
| Other energy industries - oil | 4.39 | 90.3% | 1.0 | 72.0 |
| Other transport - oil | 3.50 | 209.0% | 0.8 | 72.8 |
| Residential - oil | 2.34 | 28.7% | 0.5 | 73.3 |
| <i>Memo: total CO₂ from fuel combustion</i> | <i>337.42</i> | <i>32.5%</i> | <i>73.3</i> | <i>73.3</i> |

Key source analysis can help identify which sectors would benefit from better quality in energy data, NCVs and emission factors

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 CO₂ 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.**

CO₂ Emissions from Fuel Combustion (2010 Edition)
should be available soon...



Summary tables are available at the following address:
<http://www.iea.org/co2highlights/index.asp>

Thank you