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

International Workshop on Energy Statistics

Mexico, 2-5 December 2008

# Outline

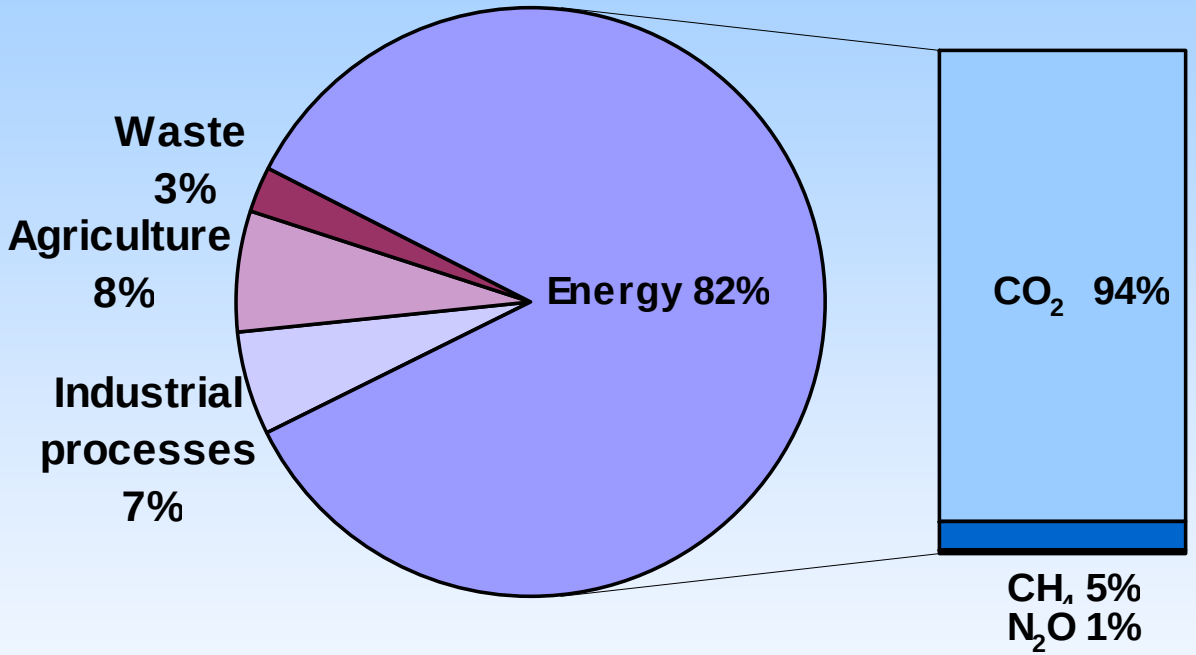
- International context
- About $CO_2$ emissions
- Estimation of $CO_2$ emissions
- Data quality
- Estimates for Mexico
- National policy options and the importance of energy statistics

# International Context

Stabilization of greenhouse gas concentrations in the atmosphere.

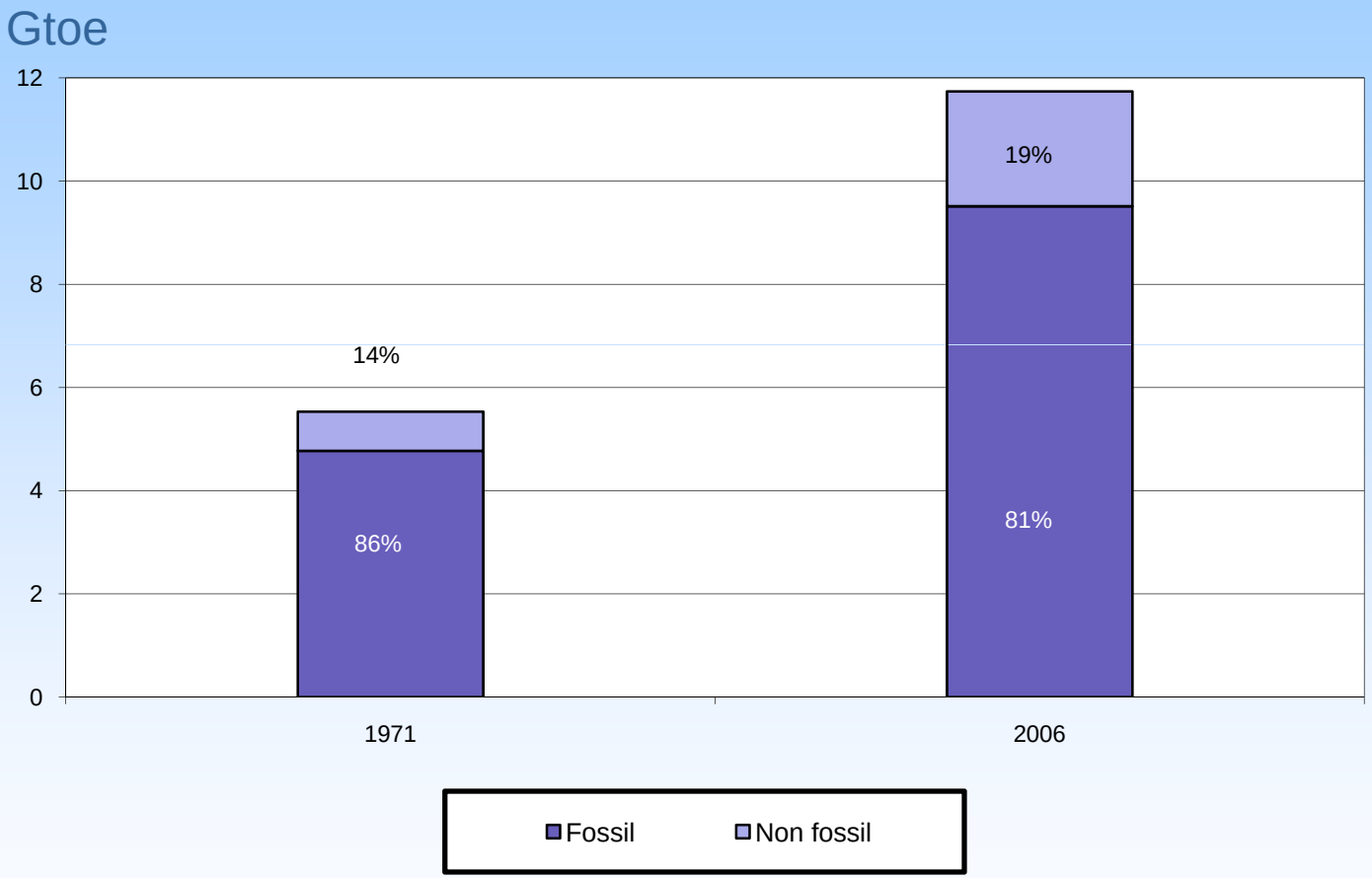
- 1992: United Nations Framework Convention on Climate Change (UNFCCC) at Rio de Janeiro conference
- 1995 (1996): *IPCC Guidelines for National Greenhouse Gas Inventories*
  Development of methodologies for gases not controlled by the Montreal Protocol.
- 1997: Kyoto Protocol (entry into force 2005)
  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



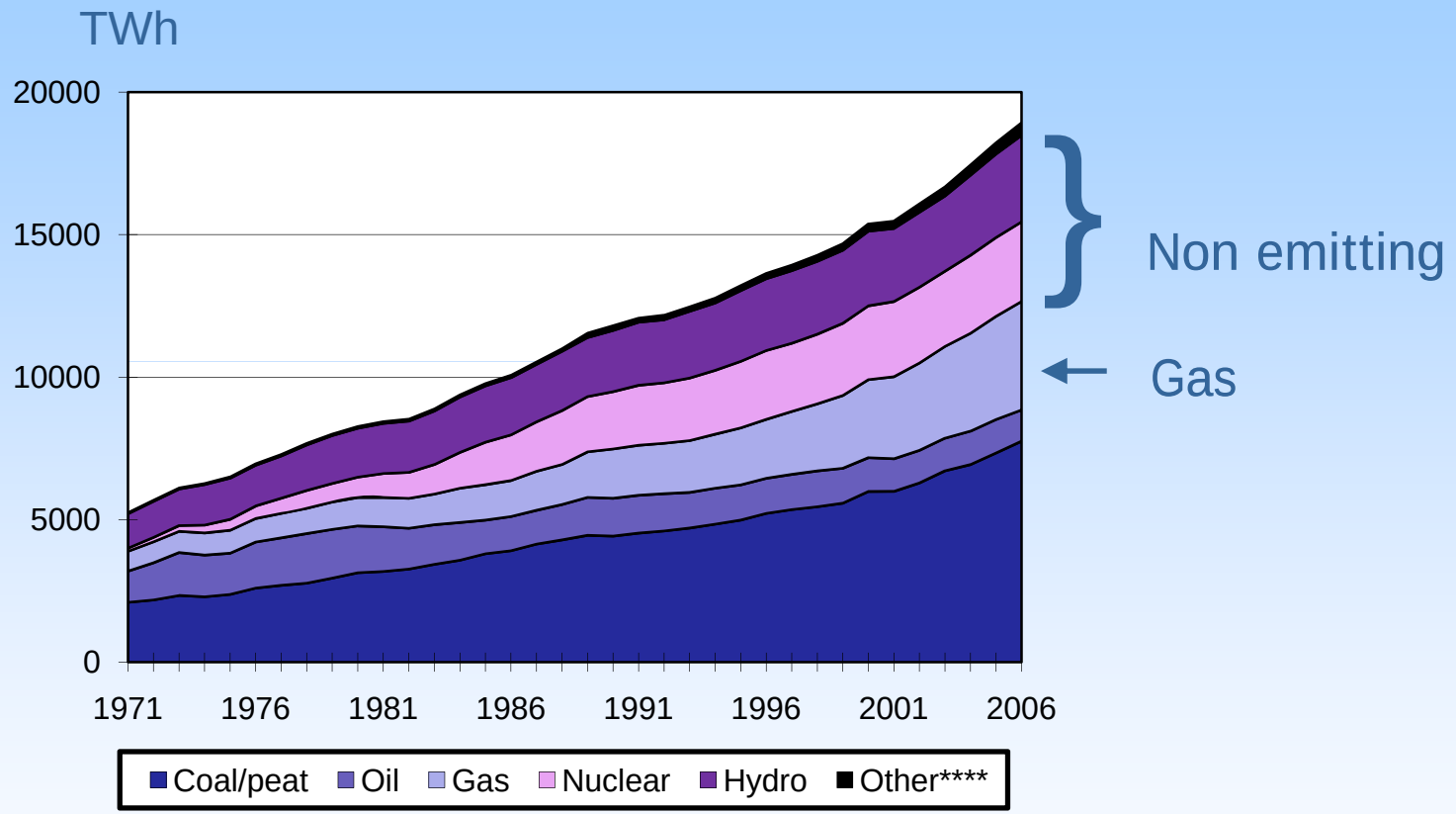

*Key point: Accounting for the largest share of global GHG emissions, energy emissions are predominantly $CO_2$.*

# World primary energy supply



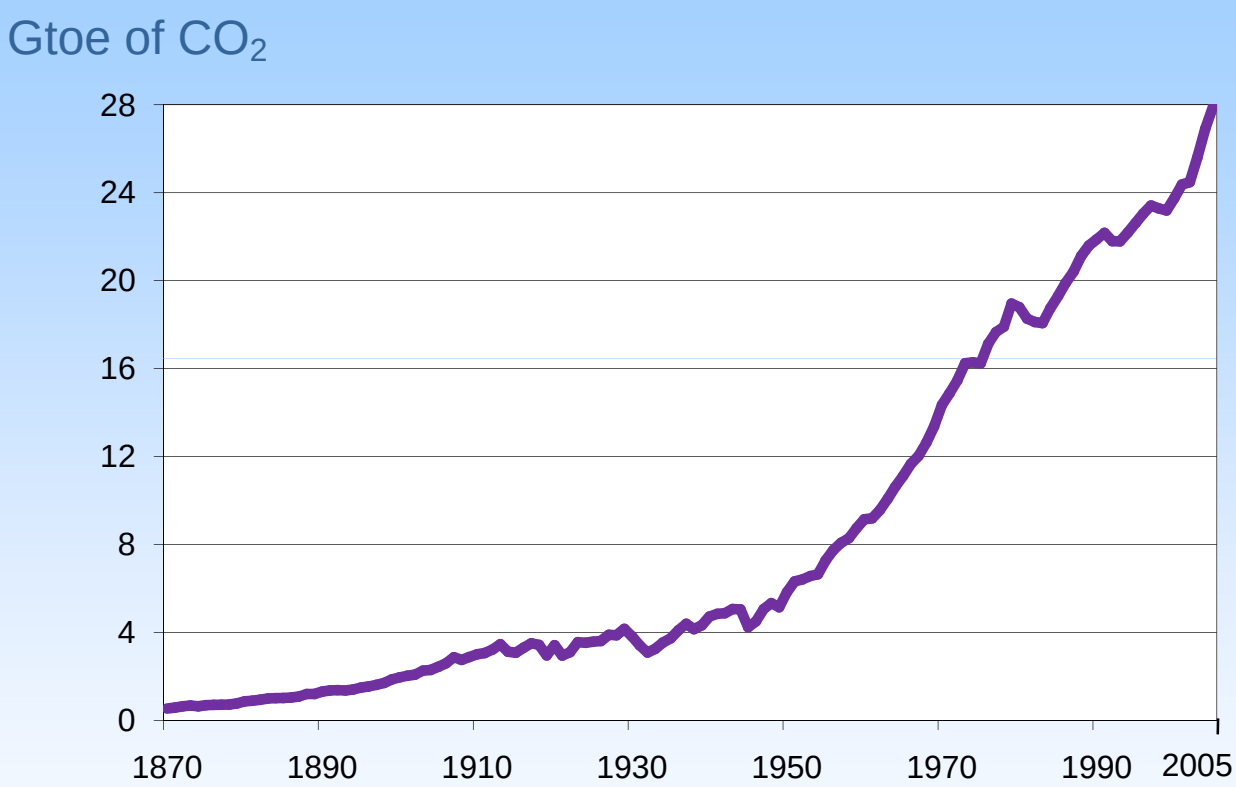

*Key point: Fossil fuels still satisfy most of the world energy supply.*

# 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.*

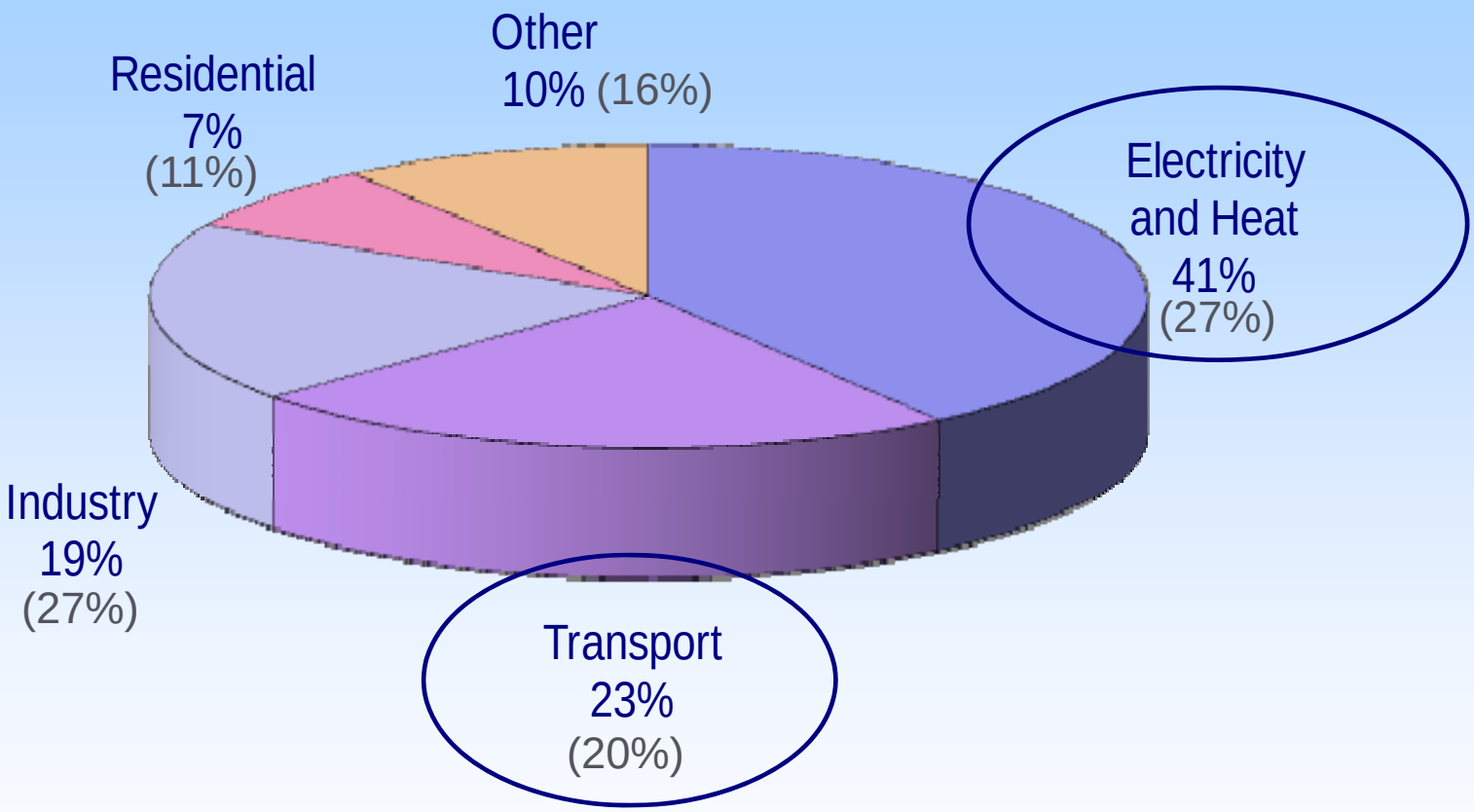
# Trend in $CO_2$ emissions from fuel combustion




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

# World $CO_2$ emissions by sector in 2006

Total emissions: 28.0 Gt $CO_2$

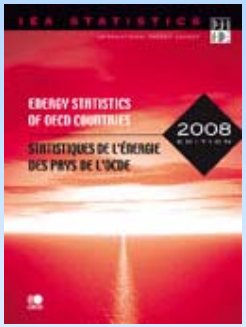


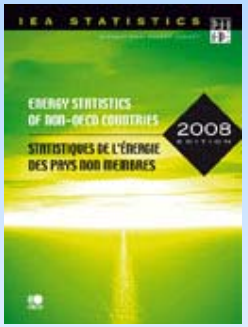

*Key point: Between 1971 and 2006, the combined share of electricity and heat generation and transport shifted from 1/2 to 2/3 of global emissions.*

# How IEA estimates $CO_2$ emissions from fuel combustion

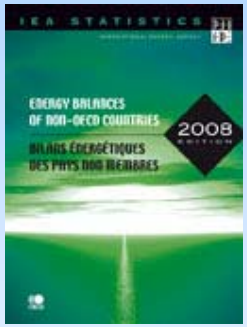
Energy Statistics

Energy Balances










IPCC Methodologies

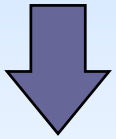
$CO_2$ Emissions

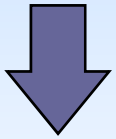
# IPCC Methodologies

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:**

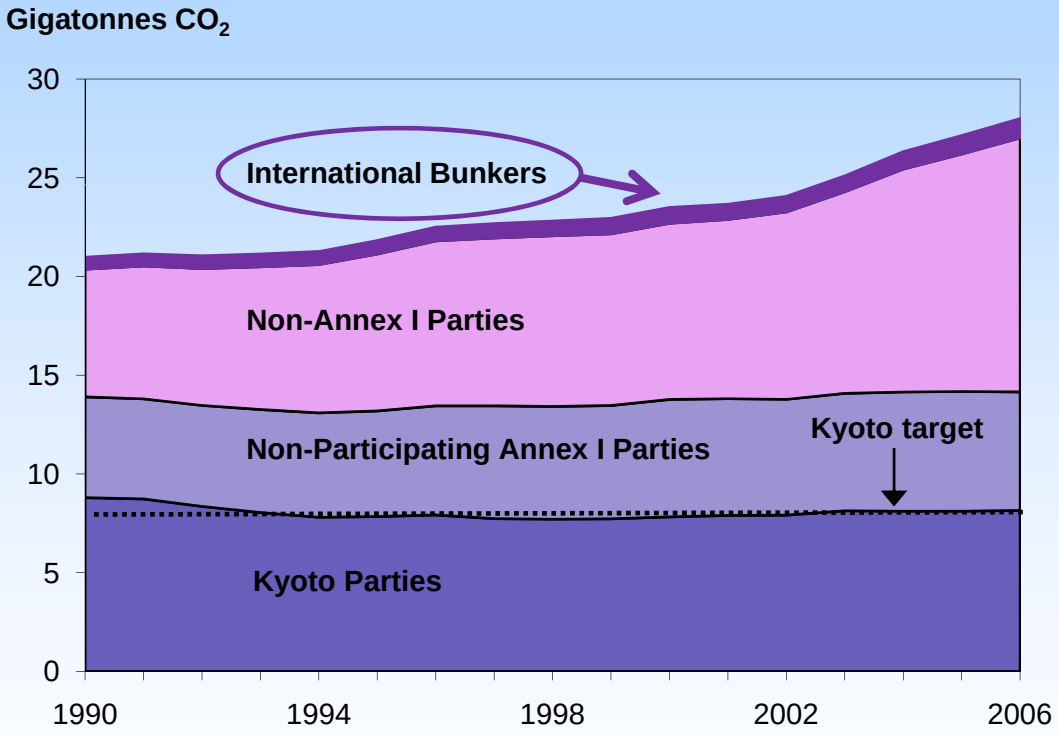




| **Supply** of fuels to the country | **Consumption** by end-use sectors |
|---|---|
| **Reference Approach** | **Sectoral Approach** |

# Note on International Bunkers

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




*Key point: The Kyoto Protocol is limited in its potential to reduce emissions as not all major emitters are included.*

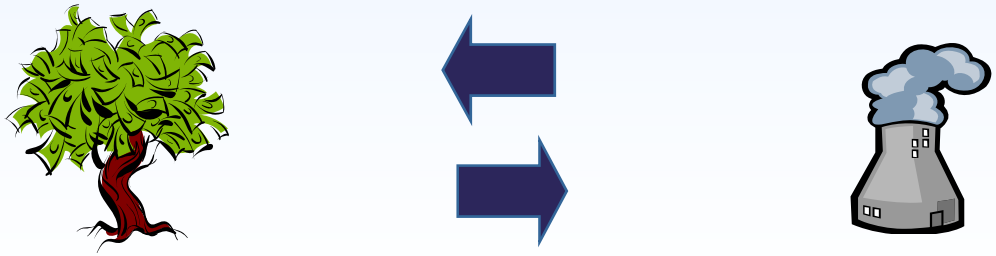
# Note on Biomass

***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 SECTORA** |
| **WORKSHEET** | **STEP BY STEP CALCULATIONS** |
| **SHEET** | **MANUFACTURING INDUSTRIES AND CONSTRUCTI** |

| | 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** | |
|---|---|
| | *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 |
|---|---|
| SUBMODULE | $CO_2$ FROM FUEL COMBUSTION (TIER I SECTORAL APPROACH) |
| WORK | |

| | | | | | |
|---|---|---|---|---|---|
| **Manufacturing Ind and Construction** | | | | | |
| 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**

| | |
|---|---|
| Gas/Diesel Oil | 0.5 |
| LPG | 0.8 |
| Ethane | 0.8 |
| Naphtha | 0.8 |
| Natural Gas | 0.33 |
| Other Fuels | ? |

# Step 5: Correcting for Carbon Onoxidised

| | | | | | | |
|---|---|---|---|---|---|---|
| **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)

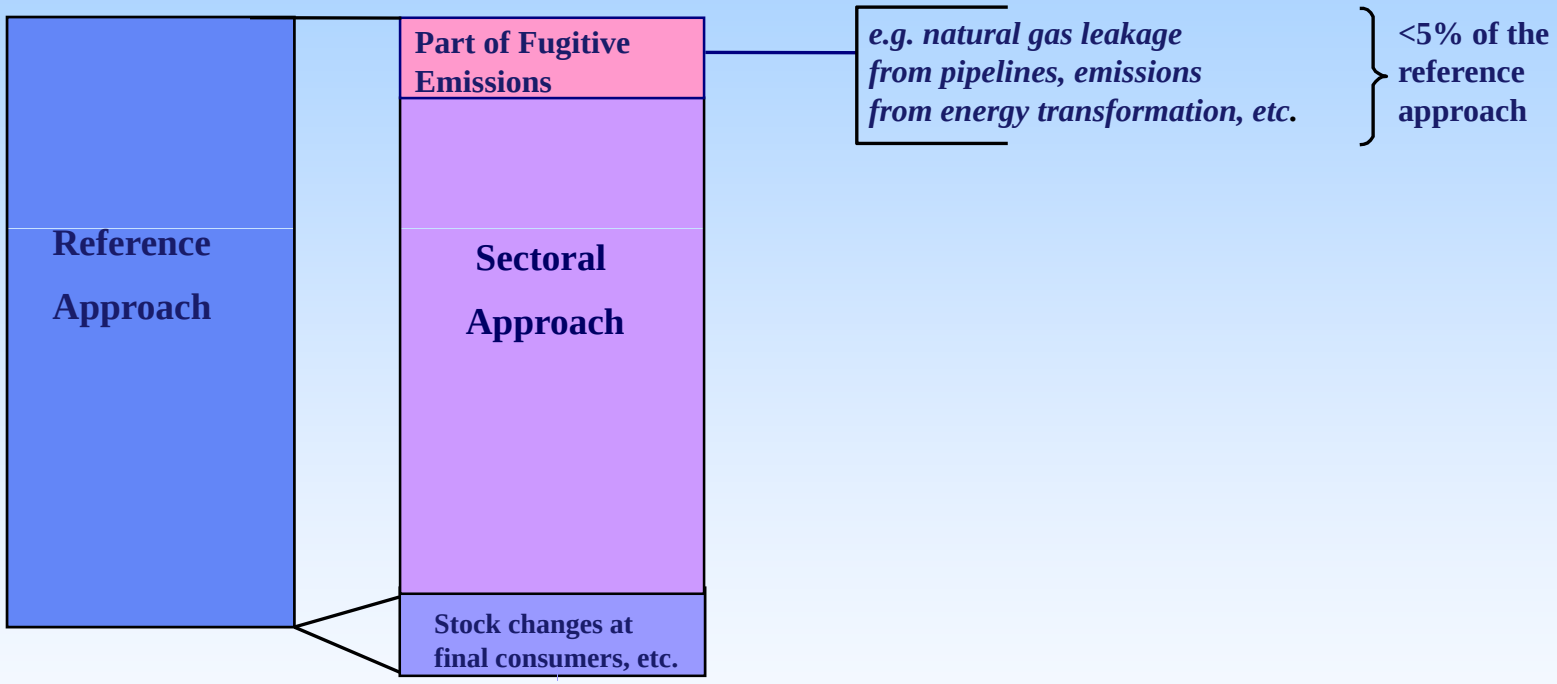
# 2006 World $CO_2$ Emissions

| *million tonnes of CO2* | Coal/peat | Oil | Gas | Other * | Total | % change 90-06 |
|---|---|---|---|---|---|---|
| **Sectoral Approach** | **11 686.3** | **10 768.3** | **5 444.7** | **103.4** | **28 002.7** | **33.4%** |
| Main activity producer elec. and heat | 7 842.0 | 711.9 | 1 816.2 | 29.7 | 10 399.7 | 49.8% |
| Unallocated autoproducers | 501.3 | 170.3 | 400.8 | 36.7 | 1 109.1 | 93.1% |
| Other energy industries | 207.6 | 665.6 | 463.5 | 1.6 | 1 338.3 | 32.2% |
| Manufacturing industries and construction | 2 670.6 | 1 554.0 | 1 220.3 | 32.1 | 5 477.1 | 20.8% |
| Transport | 14.7 | 6 271.5 | 166.6 | - | 6 452.8 | 40.9% |
| *of which: road* | - | *4 691.9* | *20.3* | - | *4 712.2* | *43.6%* |
| Other sectors | 450.2 | 1 394.9 | 1 377.4 | 3.3 | 3 225.8 | -3.5% |
| *of which: residential* | *279.2* | *650.4* | *930.0* | *0.0* | *1 859.5* | *2.3%* |
| **Reference Approach** | **11 892.1** | **10 886.7** | **5 525.1** | **104.3** | **28 408.2** | **32.3%** |
| Diff. due to losses and/or transformation | 218.8 | 100.2 | 89.0 | 0.9 | 408.9 | |
| Statistical differences | - 13.0 | 18.2 | - 8.6 | 0.0 | - 3.4 | |

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

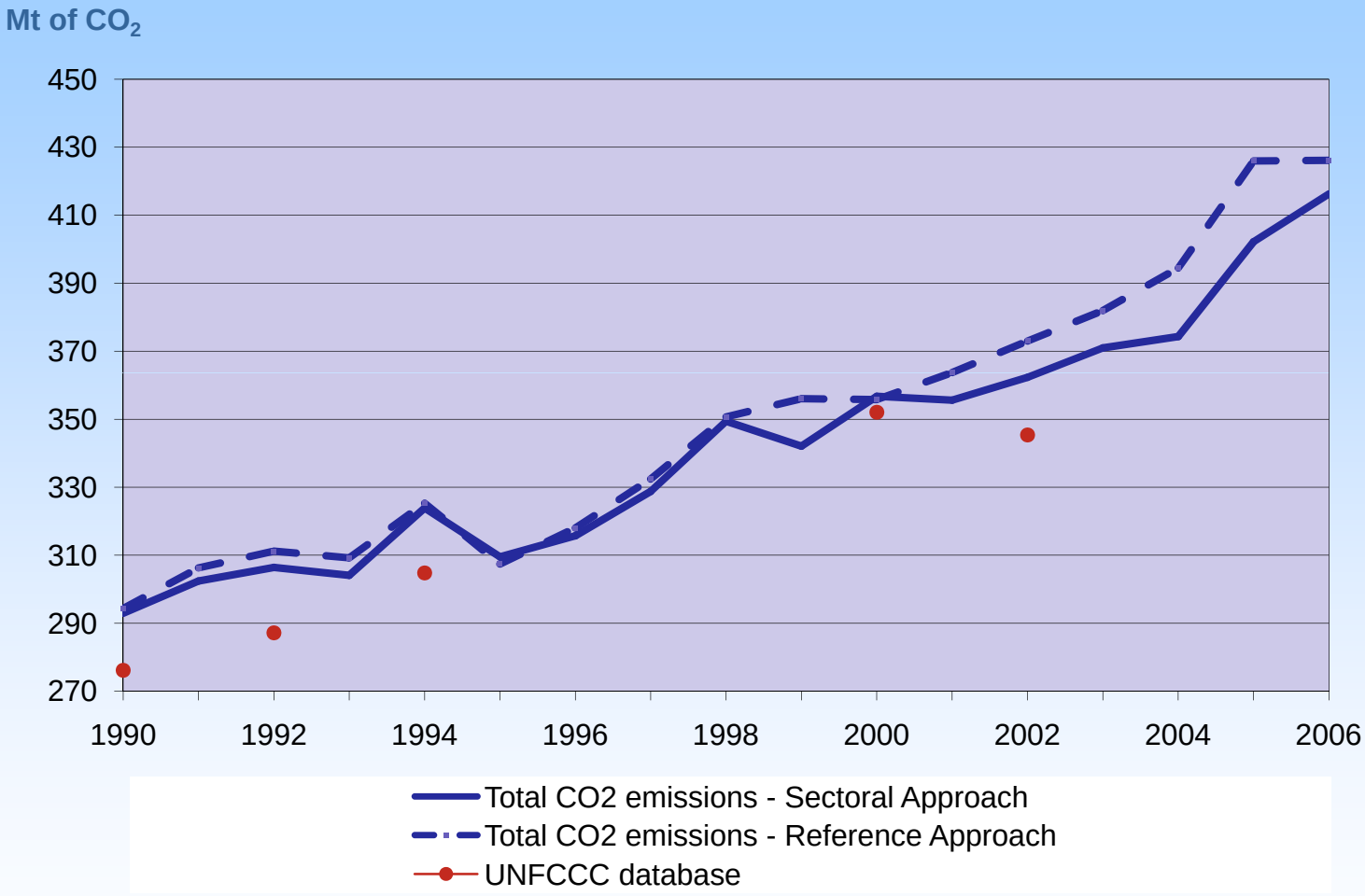
# Data Quality: Reference vs. Sectoral Approach

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




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

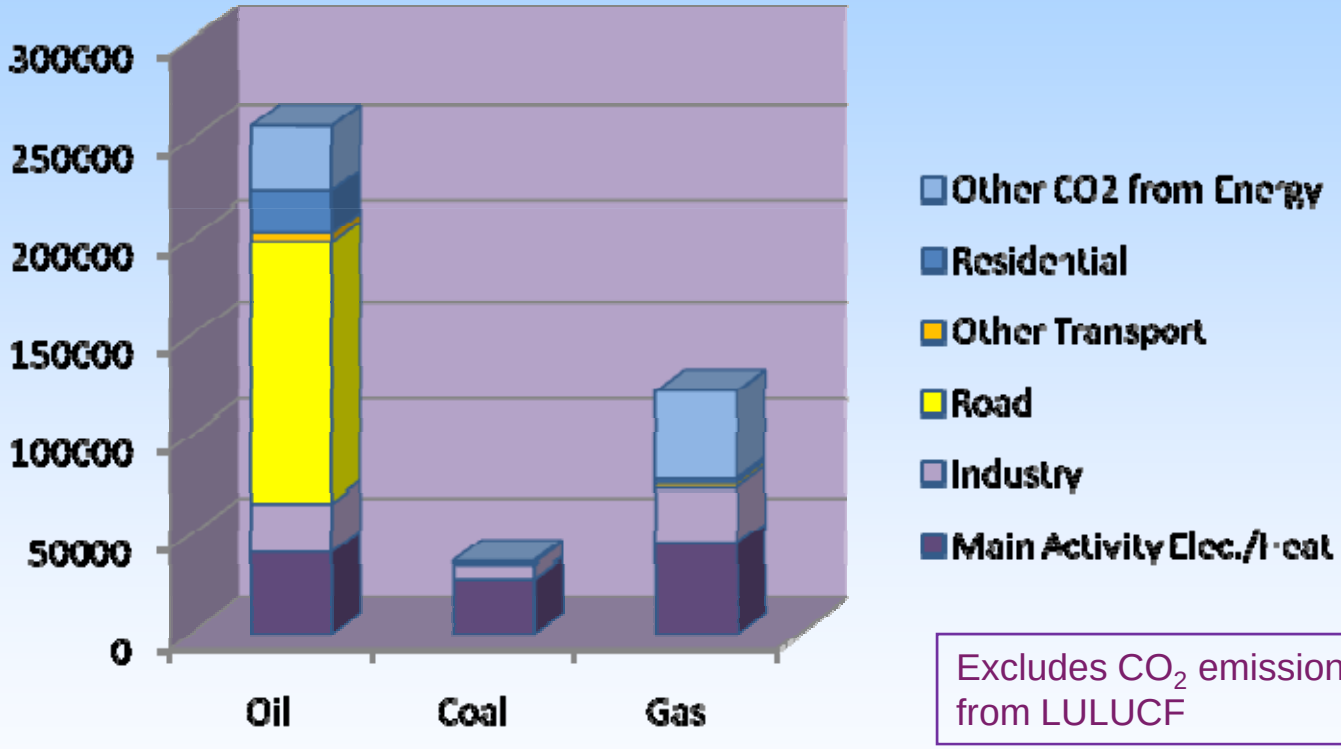
# Reference vs. Sectoral Approach: Mexico




*Key point: The IEA estimates of $CO_2$ from fuel combustion are very similar to the Mexican submission to the UNFCCC.*

# Key Sources for $CO_2$ Emissions from Fuel Combustion: Mexico

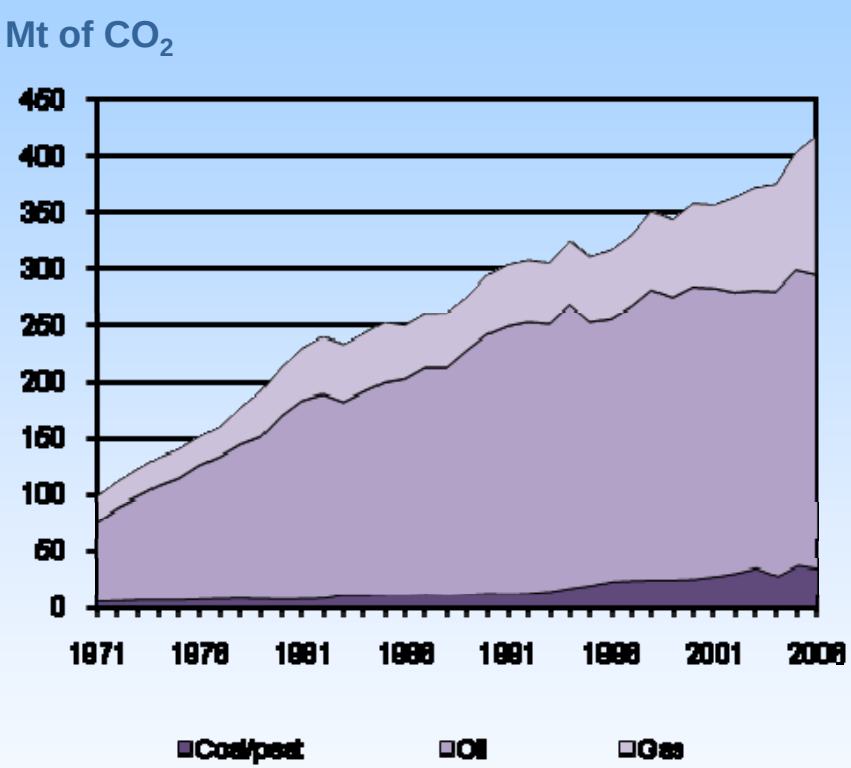
**Level Assessment (%)**




Excludes $CO_2$ emissions/removals from LULUCF

*Key point: Key source analysis can help identify which sectors would benefit from better quality data, NCVs and emission factors.*

# $CO_2$ Emissions by Fuel: Mexico




*IEA estimates*

- Between 1990 and 2006, $CO_2$ emissions increased by 42%.
- In 2006, oil contributed 62%, gas contributed 29% and coal only 9% of $CO_2$ emissions from fuel combustion.
- Road represented 28% and main activity producer electricity and heat represented 18% of total $CO_2$ emissions.

# Dealing with Climate Change: National Policy Options

- Emit less (be more efficient)
- 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 as well as to verify and validate the Kyoto targets.