THE 6TH WORKSHOP ON GHG INVENTORIES IN ASIA

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Uncertainty Assessment in GHG Inventories in Viet Nam

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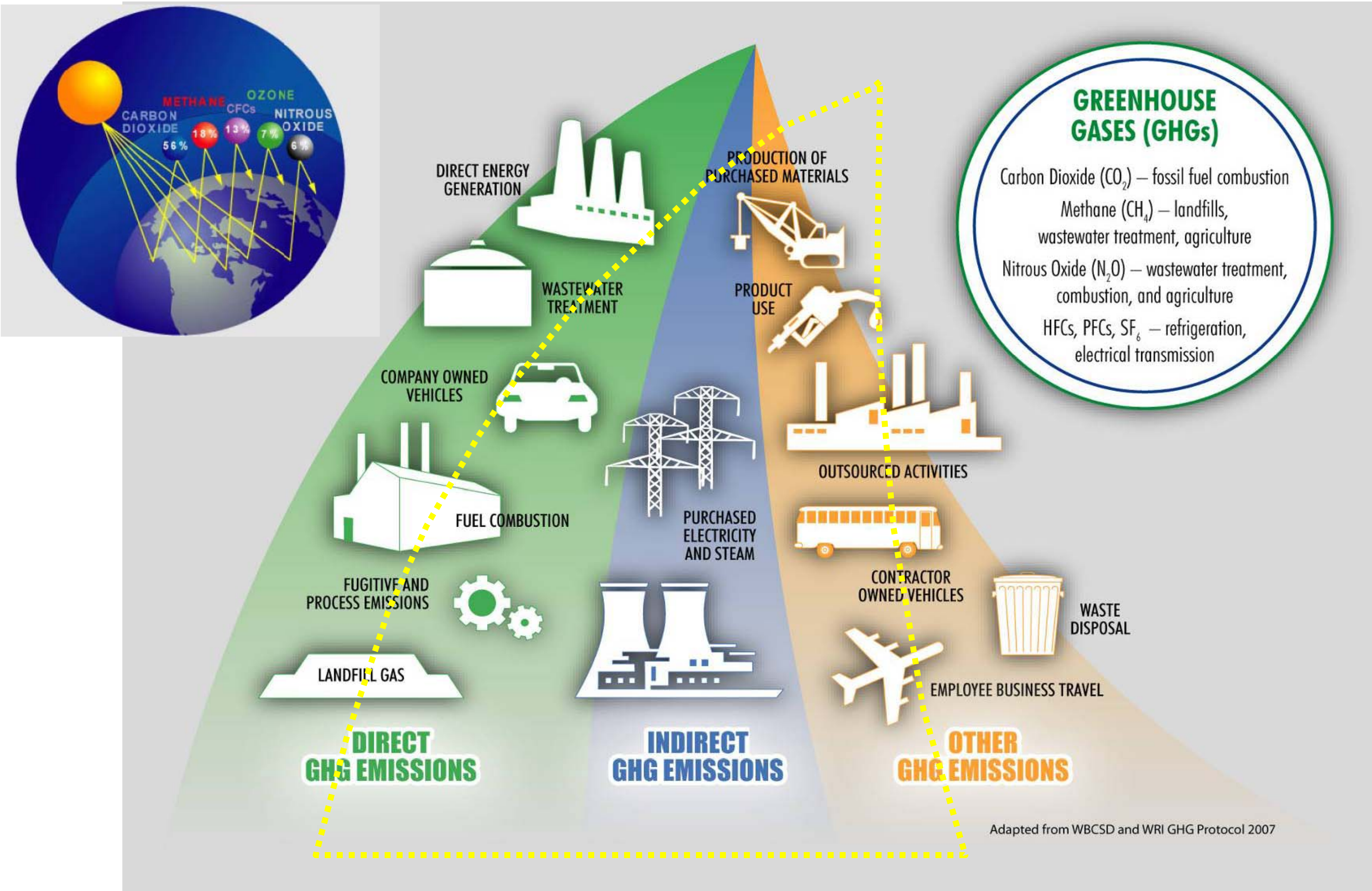
VINACOMIN - VIET NAM

Uncertainty in GHG Inventories

- A general and imprecise term which refers to the lack of certainty in emissionsrelated data resulting from any causal factor, such as the application of non-representative factors or methods, incomplete data on sources and sinks, lack of transparency etc. Reported uncertainty information typically specifies a quantitative estimates of the likely or perceived difference between a reported value and a qualitative description of the likely causes of the difference

- *Uncertainty investigations should be integrated within your QA/QC plan*!

Focus on Direct and Indirect GHG Emissions



Adapted from WBCSD and WRI GHG Protocol 2007

GHG Emissions Inventory Modeling

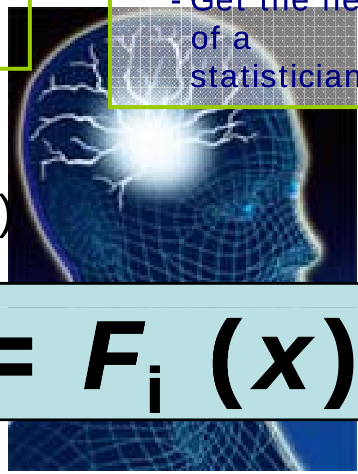
Guidance → **Data** → **Implement** → **Review**

Guidance
- Read the IPCC guidance
- Consider comments made by Expert Reviewers and in Peer Reviews

Data
- Country specific information on EFs and AD
- Use IPCC defaults only if sufficient information cannot be found

Implement
- Careful with uncertainty analysis – easy to produce poor quality work
- Get the help of a statistician

Review
- Ask for peer review
- Reflect on output of the uncertainty analysis – is it sensible?

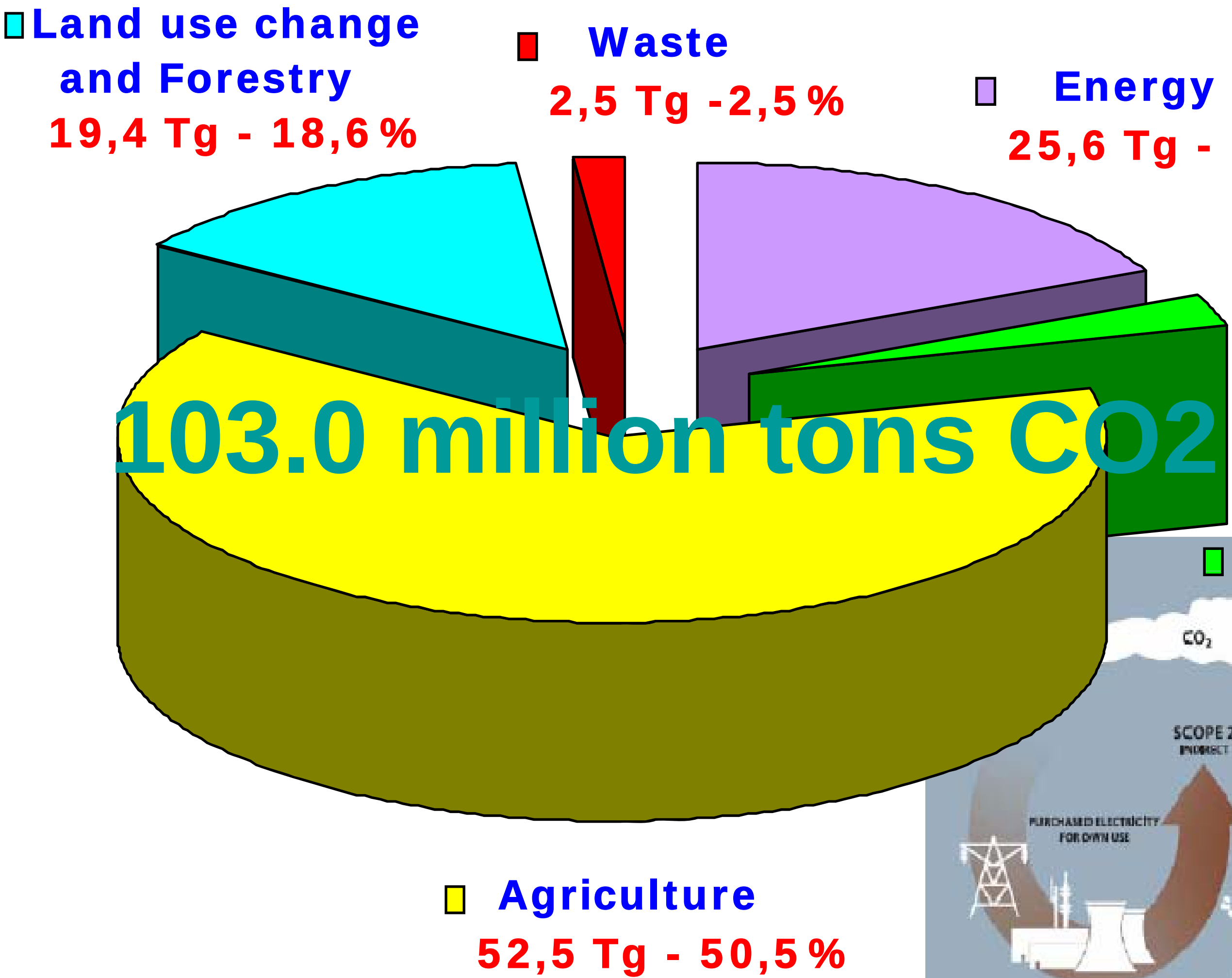


(Emission factors, Activity Data, etc.) → (GHG Inventory, Trend, etc.)

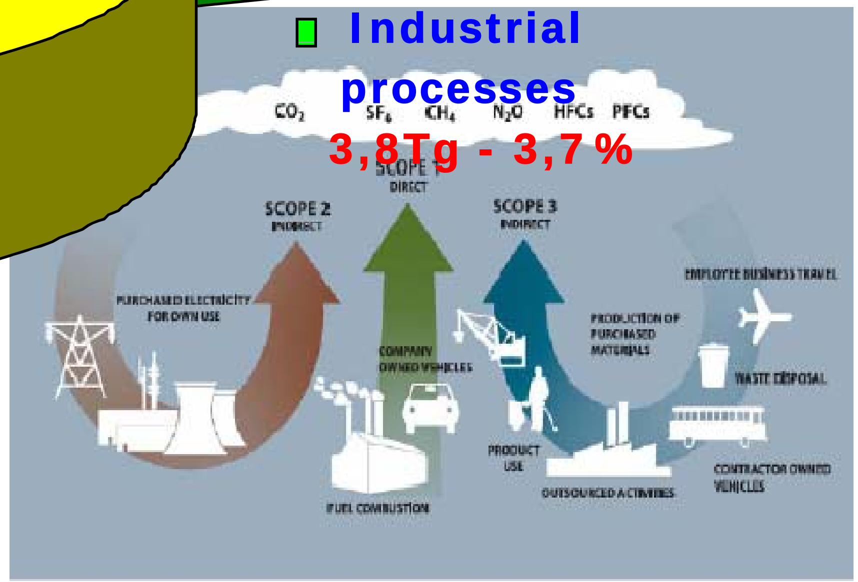
$x_1, x_2, \ldots, x_J$ → $$y = F_i(x)$$ → $y_1, y_2, \ldots, y_K$

Inventory Model: Spatial Database and Processing

The GHG inventory in 1994 in INC

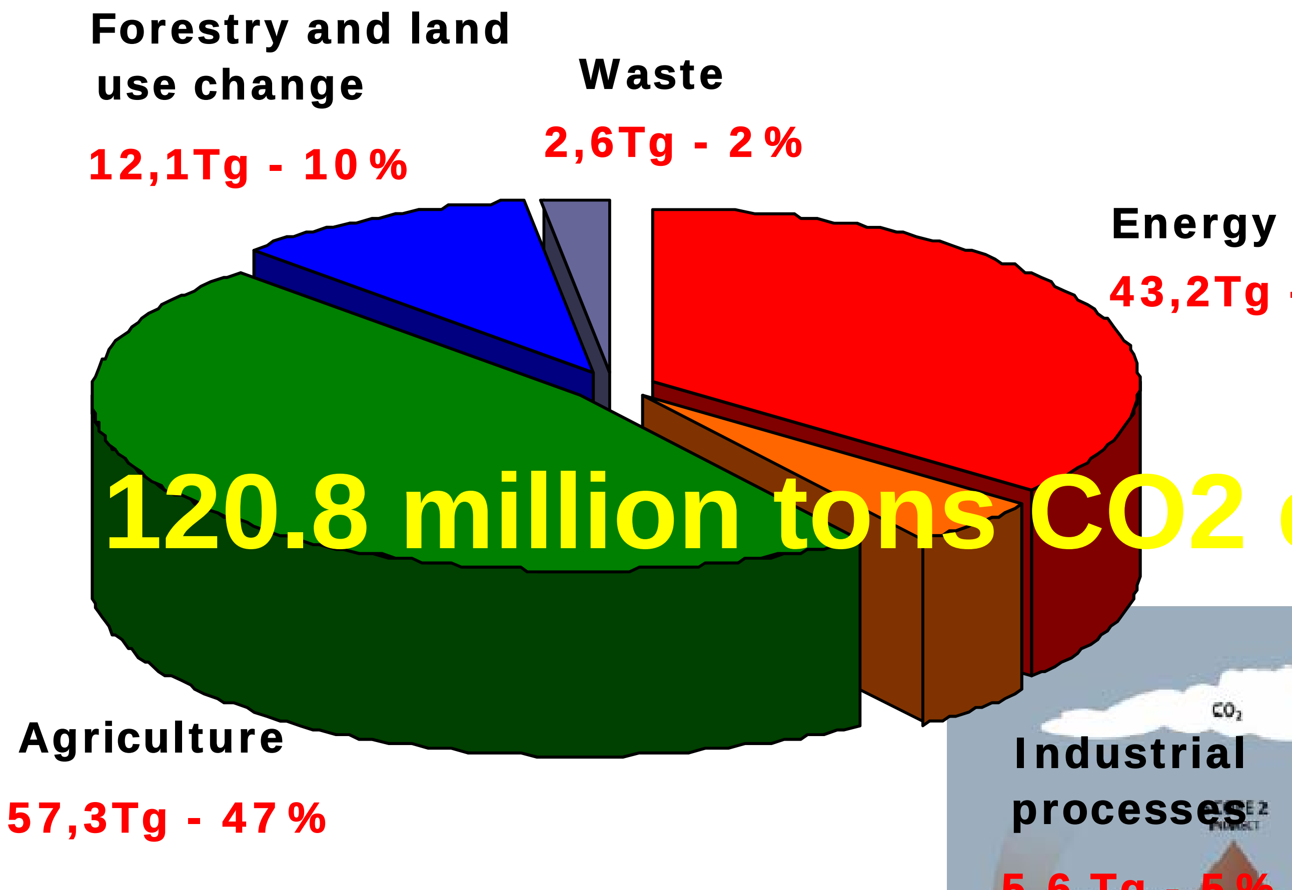


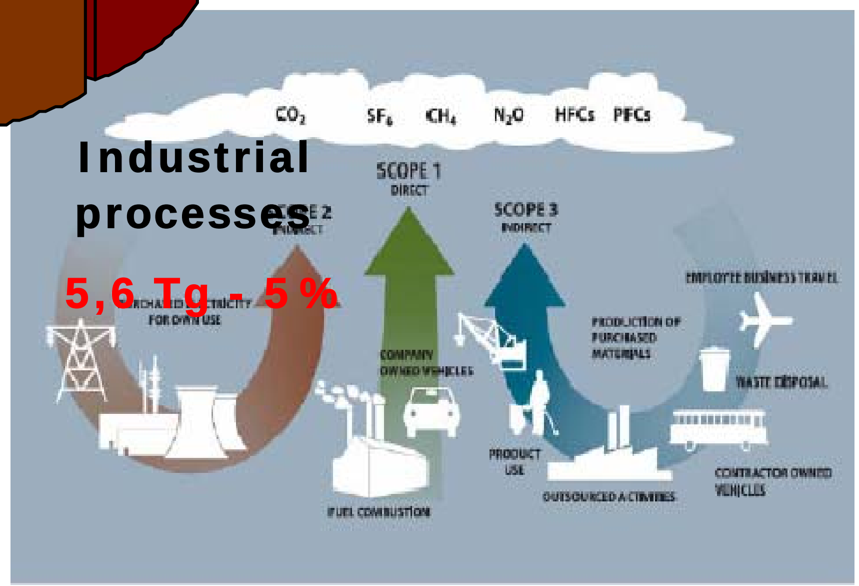
103.0 million tons CO2 equi.



(Source: MONRE 2000)

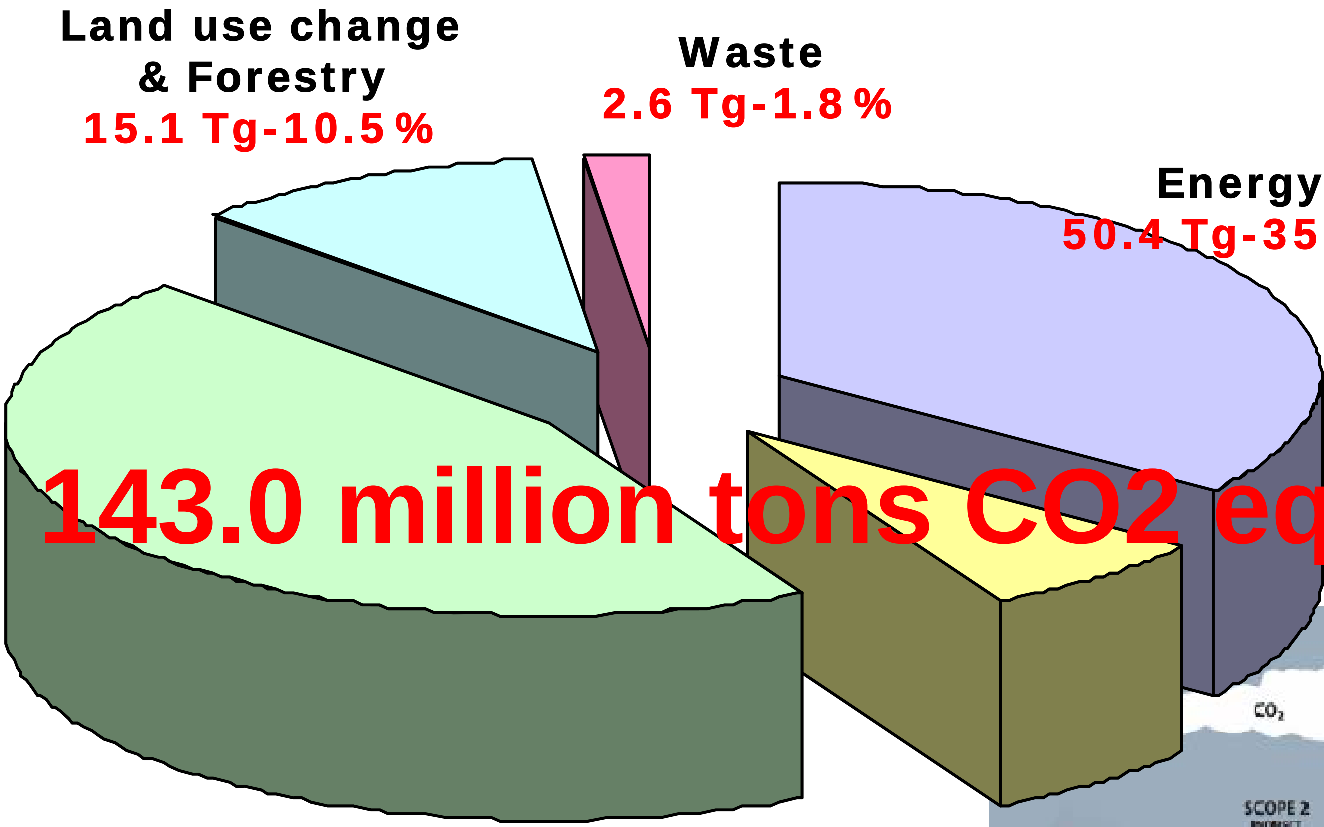
The National GHG inventory in 1998



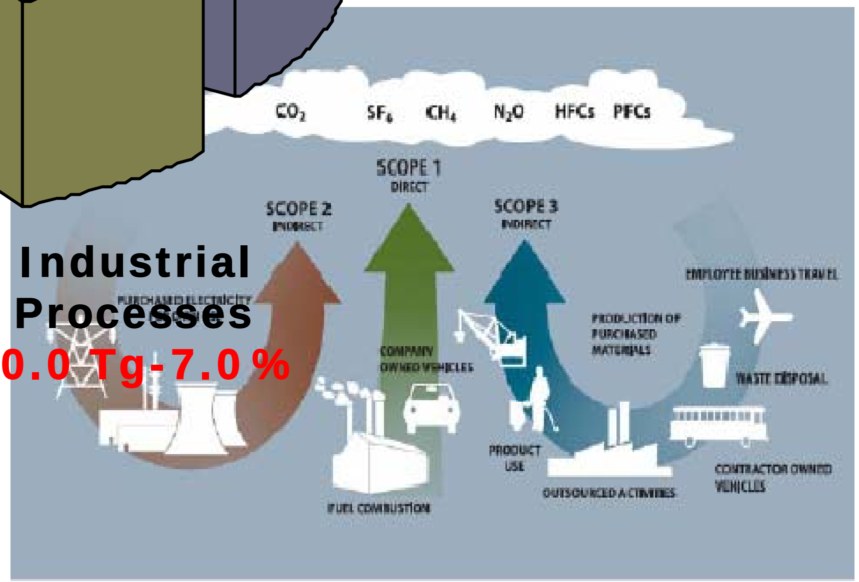


(Source: MONRE 2004)

The GHG inventory in 2000 in SNC



143.0 million tons CO2 equi.



(Source: MONRE 2008)

Strictly uncertainties in GHG inventories cannot be exactly quantified

1. **Activity data**

- Gaps in time series
  - Unknown sources
  - Gaps in understanding of existing sources
- Use of surrogate or proxy variables
- Lack of references (calculation or estimation methods, representativeness at local or national level)

2. **Emission Factors**

- Usually high uncertainty
  - Measurement for emission factors are inadequate to quantify uncertainties
  - Emission factors may be inappropriate for specific sources
- Scarcity of quantitative information (measurements, sample representativeness) as compared to qualitative information (experts judgement)

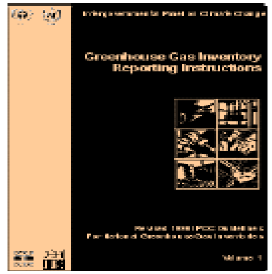
Uncertainty of the Knowledge that is Predicted

Variability and Uncertainty in GHG Inventories

Sources of Uncertainty:

- Random sampling error for a random sample of data
- Measurement errors
  - Systematic error (bias, lack of accuracy)
  - Random error (imprecision)
- Non-representativeness
  - Not a random sample, leading to bias in mean (e.g., only measured loads not typical of daily operations)
  - Direct monitoring versus infrequent sampling versus estimation, averaging time
  - Omissions
- Surrogate data (analogies with similar sources)
- Lack of relevant data, Lack of completeness
- Misreporting or misclassification
- Problem and scenario specification
- Bias and random errors from modeling

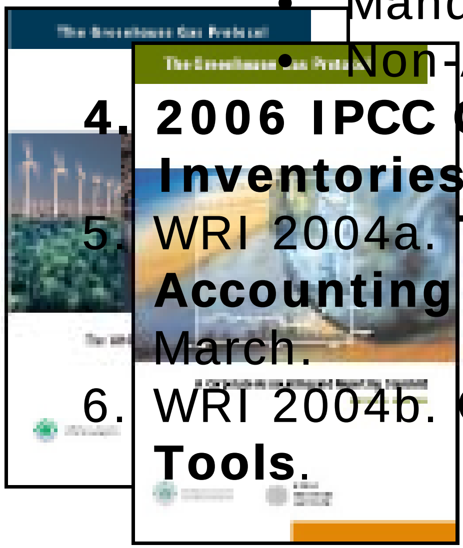
IPCC Guidelines and Guidance





Methods agreed by the COP

1. **Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 1996)**
   - Mandatory for **all** Parties
2. **IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000)**
   - Mandatory for Annex I Parties
   - Non-Annex I Parties encouraged to use
3. **IPCC Good Practice Guidance for land use, land-use change and forestry (2003)**
   - Mandatory for Annex I Parties
   - Non-Annex I Parties encouraged to use
4. **2006 IPCC Guidelines for National Greenhouse Gas Inventories**
5. WRI 2004a. **The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard**. Revised Edition. March.
6. WRI 2004b. **GHG Protocol Initiative – GHG Estimation Tools**.



Good practice inventories contain under or over estimates and uncertainties are reduced as far as is practicable

Reporting
(inventory,
uncertainties
and documentation)

Prioritization
methodological choice
(key category
Analysis,
reduce uncertainties)

Data collection
(QA/QC &
Uncertainty
assessment)

Estimation
(QA/QC &
Uncertainty
estimation)

Inventory compilation
(QA/QC,
time-series
consistency,
uncertainty compilation)

**Key category
Analysis**
(uncertainty input)

WORLD
RESOURCES
INSTITUTE

Overview of methods and guidance

- **Approach 1:**
  - emission sources aggregated up to level similar to IPCC Summary Table 7A
  - uncertainties then estimated for these categories
  - uncertainties calculated **based on error propagation equations**
  - Provides basis for Key Source analysis
- **Approach 2:**
  - corresponds to **Monte Carlo** approach
  - Can use software such as @RISK and MS excel spreadsheets
- Combine Monte Carlo and design-based methods to account for
  - sampling uncertainty
  - input uncertainty
  - model uncertainty
- Recommend reading the IPCC Guidelines – “Uncertainties”

Error propagation equations

Uncertainty of a product of several quantities

$$U_E = \frac{\sqrt{(U_1 \bullet E_1)^2 + (U_2 \bullet E_2)^2 + \cdots + (U_n \bullet E_n)^2}}{|E_1 + E_2 + \cdots E_n|}$$

where:

U_E : percentage uncertainty of the sum

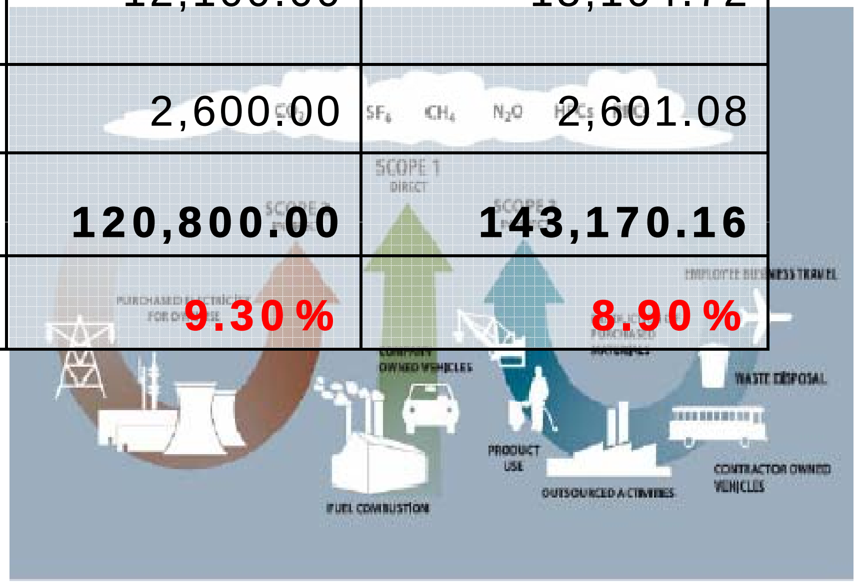
U_i : percentage uncertainty associated with source i

E_i : emission estimate for source I

(Equation 5.2.1, IPCC GPG 2004)

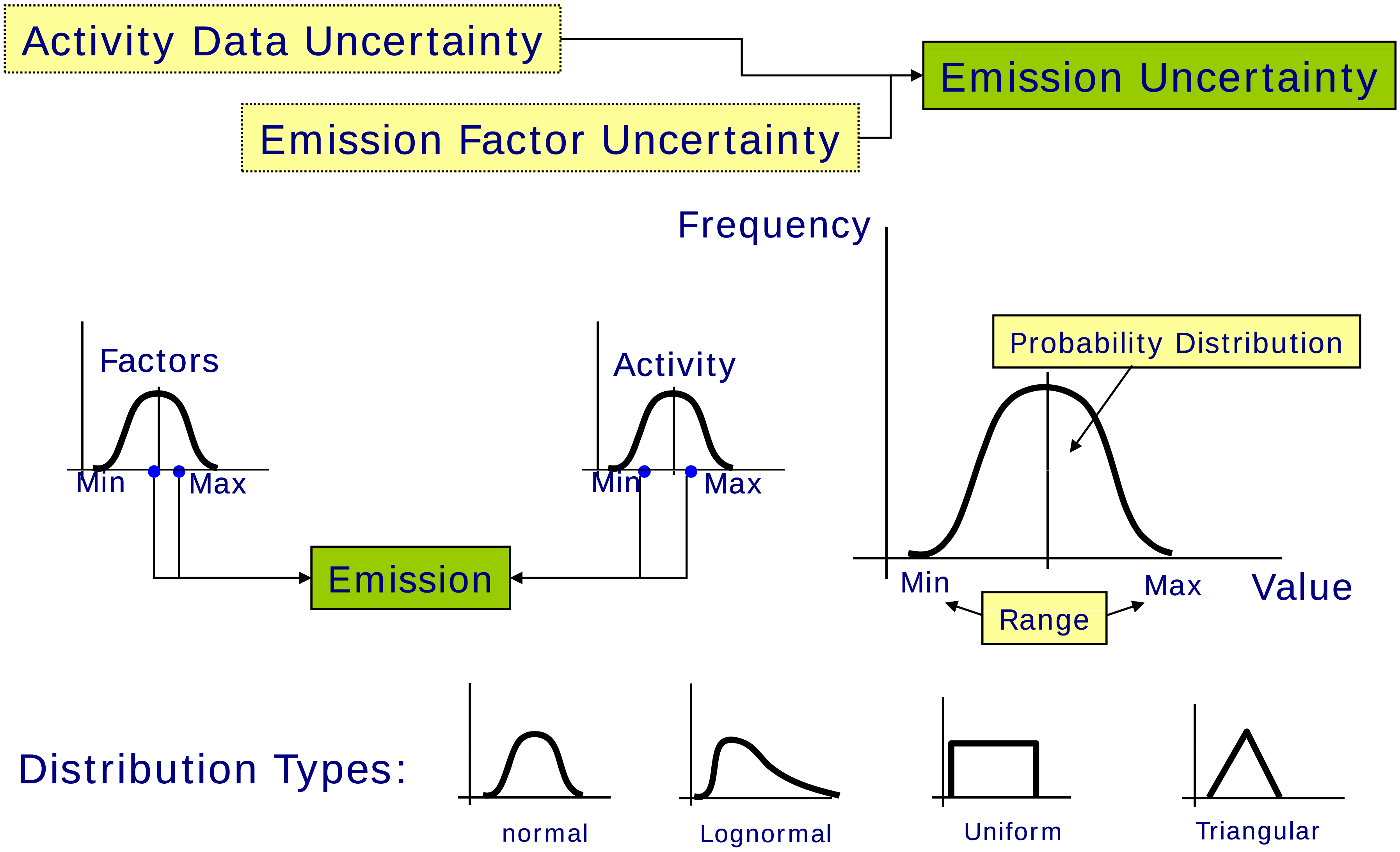
Uncertainty assessment of CO2 Emission by Error Propagation Equations

Emission Sources	GHG Emission (GT)		
	1994	**1998**	**2000**
Energy	25,600.00	43,200.00	50,368.03
Industrial Processes	3,800.00	5,600.00	10,005.72
Agriculture	52,450.00	57,300.00	65,090.61
Land use change and Forestry	19,380.00	12,100.00	15,104.72
Waste	2,560.00	2,600.00	2,601.08
Total	**103,790.00**	**120,800.00**	**143,170.16**
Cummulated Uncertainty	**9.10%**	**9.30%**	**8.90%**

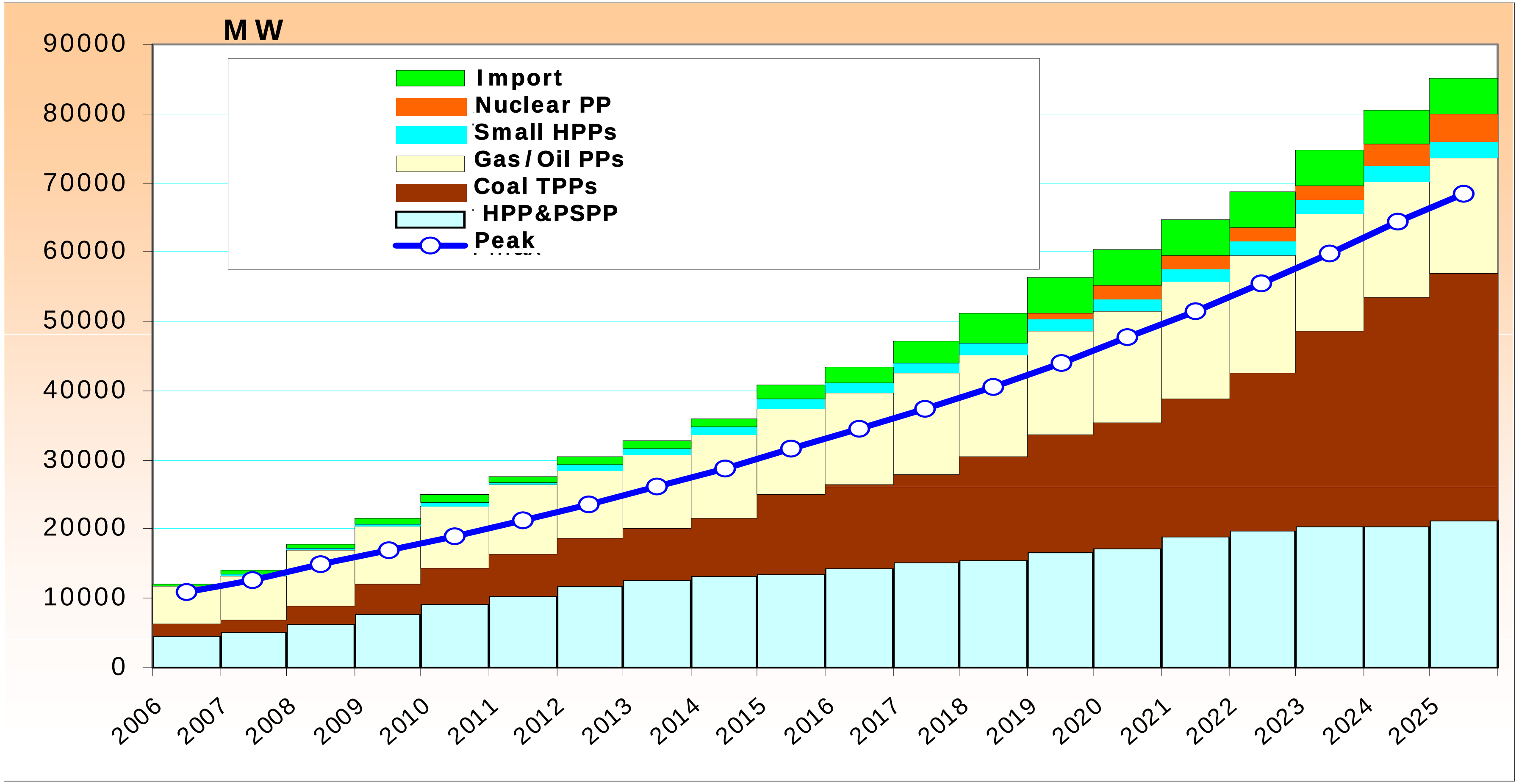


(Source: MONRE 2000,2004,2008)

Uncertainties Assessment: Monte Carlo Simulation

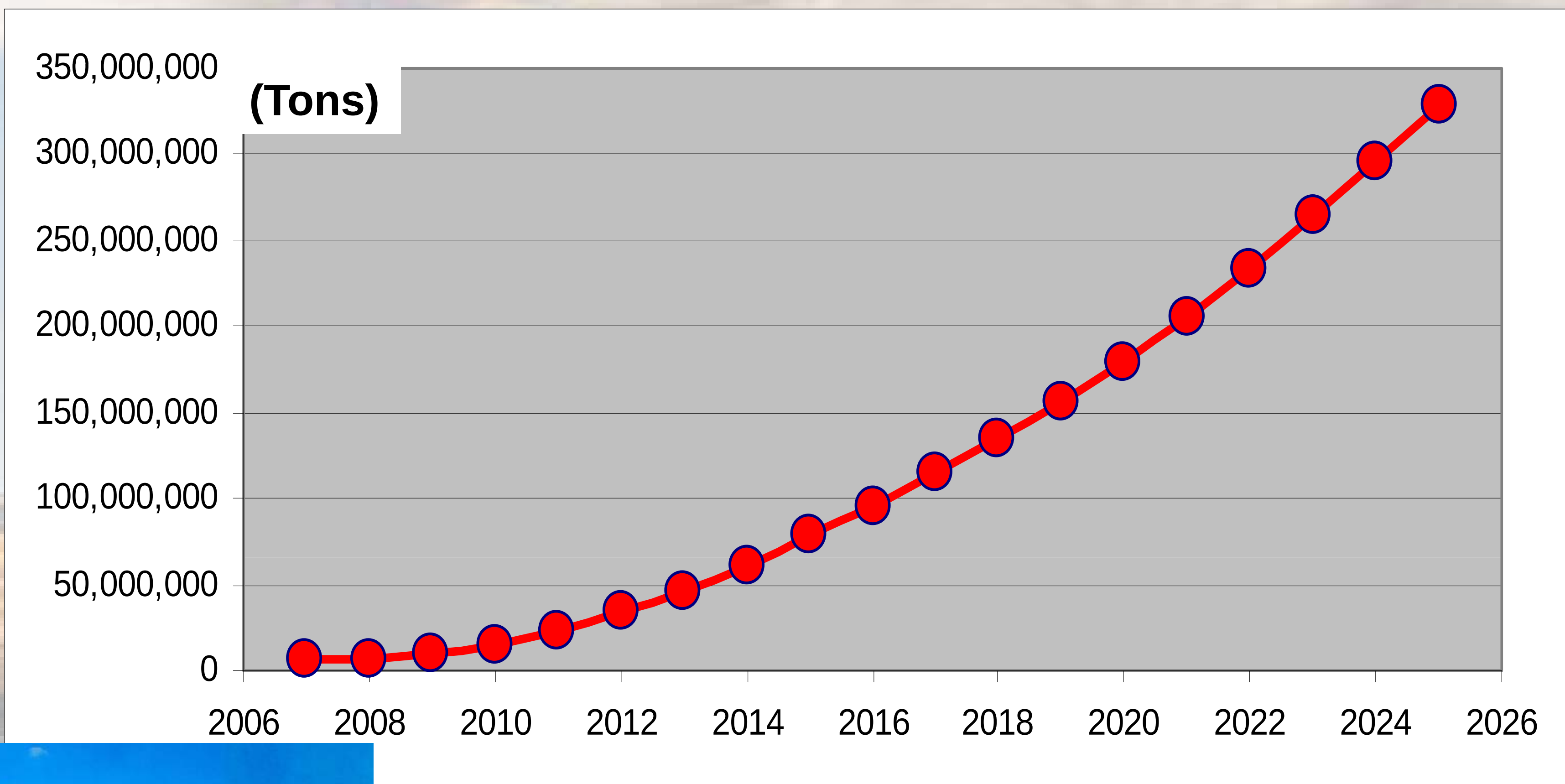


Electricity Demand and Resources Forecast to 2025

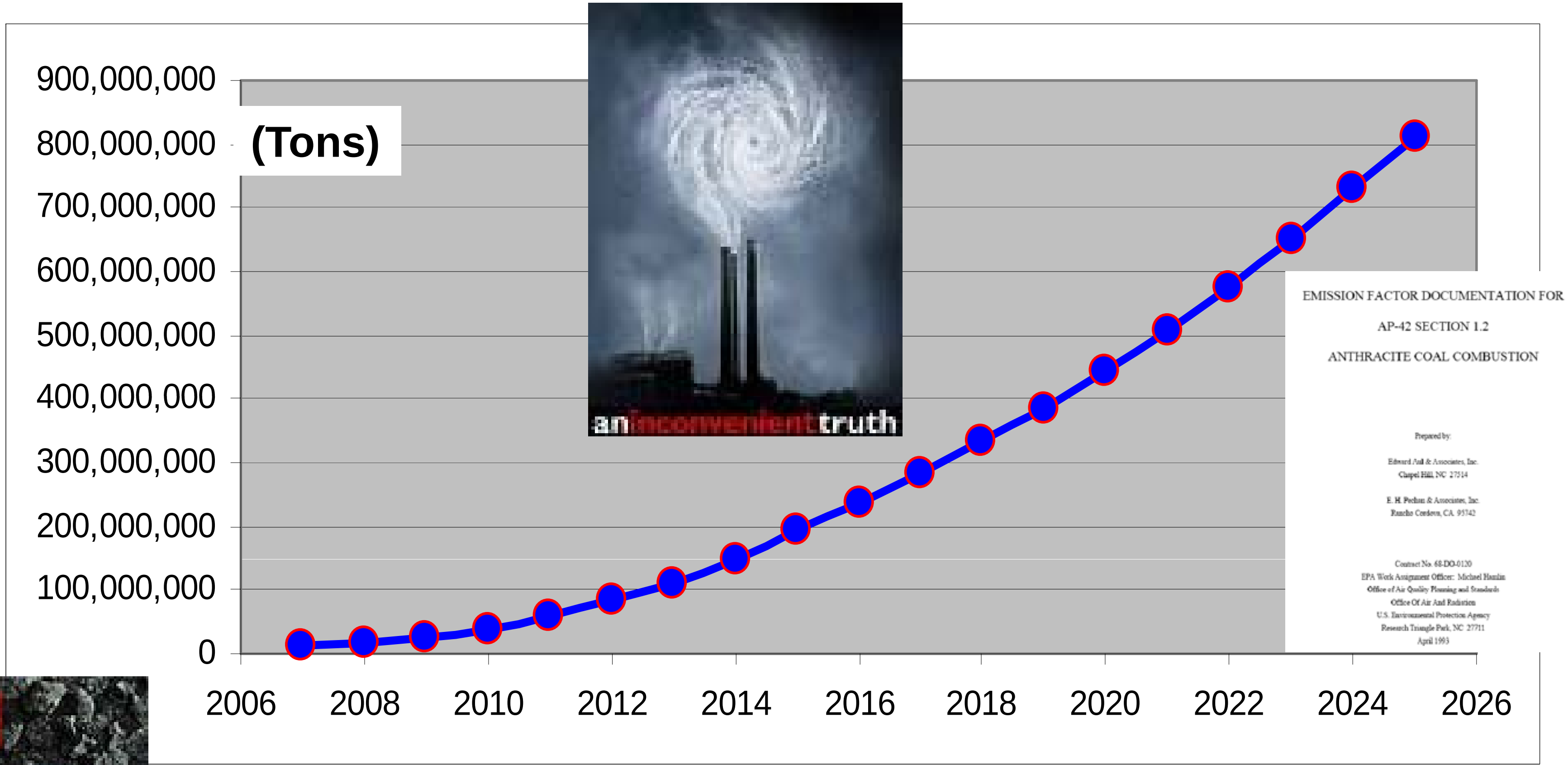


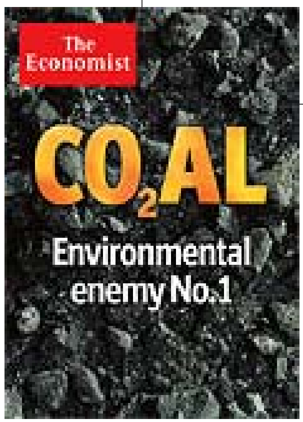
(Source: Sixth Master Plan – EVN, November 2007)

Coal Supply for Electicity Generation Forecast to 2025



CO2 Emission from Coal for Electricity Generation - Forecast to 2025

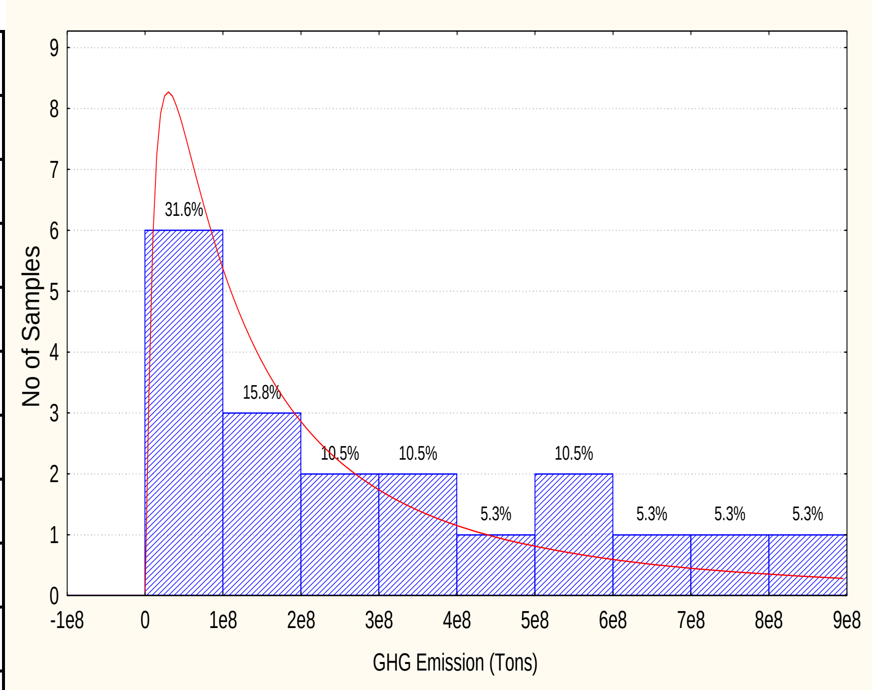


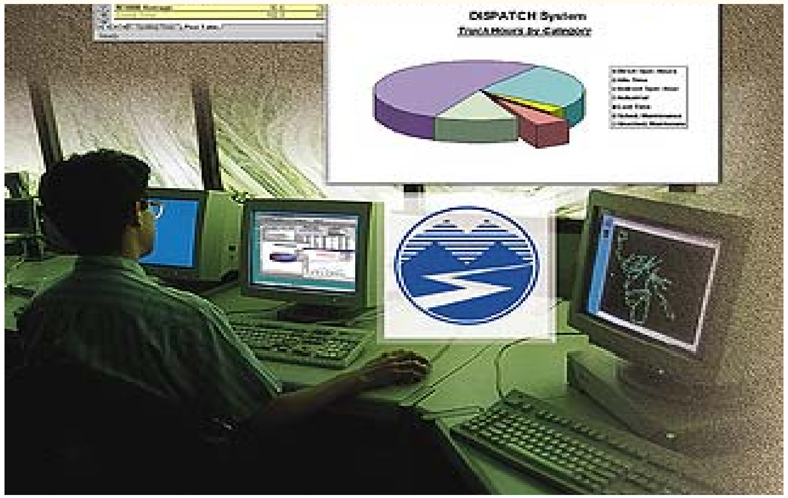


Given nearly identical human emissions, models project dramatically different futures. Carbon cycle feedbacks are among the largest sources of uncertainty for future climate.

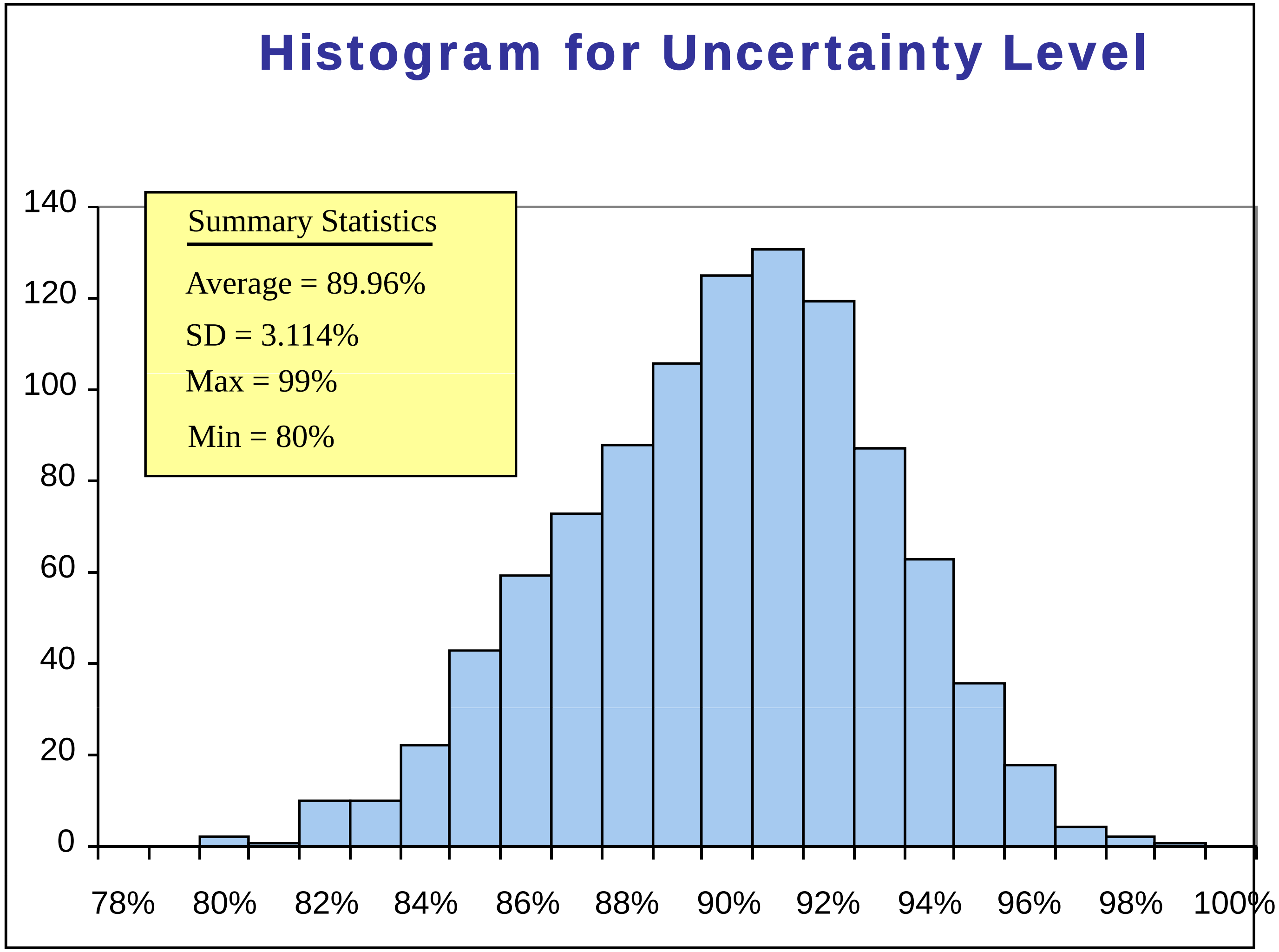
Uncertainty Assessment of CO_2 Emission by Statistical Analysis

Number of values	19.00
Sum	5,637,297,240.00
Minimum	14,439,970.00
Maximum	809,464,095.00
Range	795,024,125.00
Mean	296,699,854.70
Median	236,294,900.00
First quartile	64,859,080.00
Third quartile	489,206,981.30
Standard error	59,258,864.07
95% confidence interval	124,502,873.40
99% confidence interval	170,547,010.80
Variance	66,720,646,450,000,000.00
Average deviation	216,534,572.30
Standard deviation	258,303,400.00
Coefficient of variation	0.87





Uncertainty Assessment of CO_2 Emission by Monte Carlo Simulation



Sample Number	Sample Percentage
14,439,970	91%
16,187,655	88%
23,639,350	82%
37,975,790	94%
58,694,115	91%
83,353,975	97%
111,787,750	86%
149,041,295	95%
192,804,905	96%
236,294,900	94%
282,400,260	91%
332,373,205	91%
384,300,895	88%
441,681,165	90%
505,048,920	92%
575,616,940	92%
651,640,005	88%
730,552,050	89%
809,464,095	84%

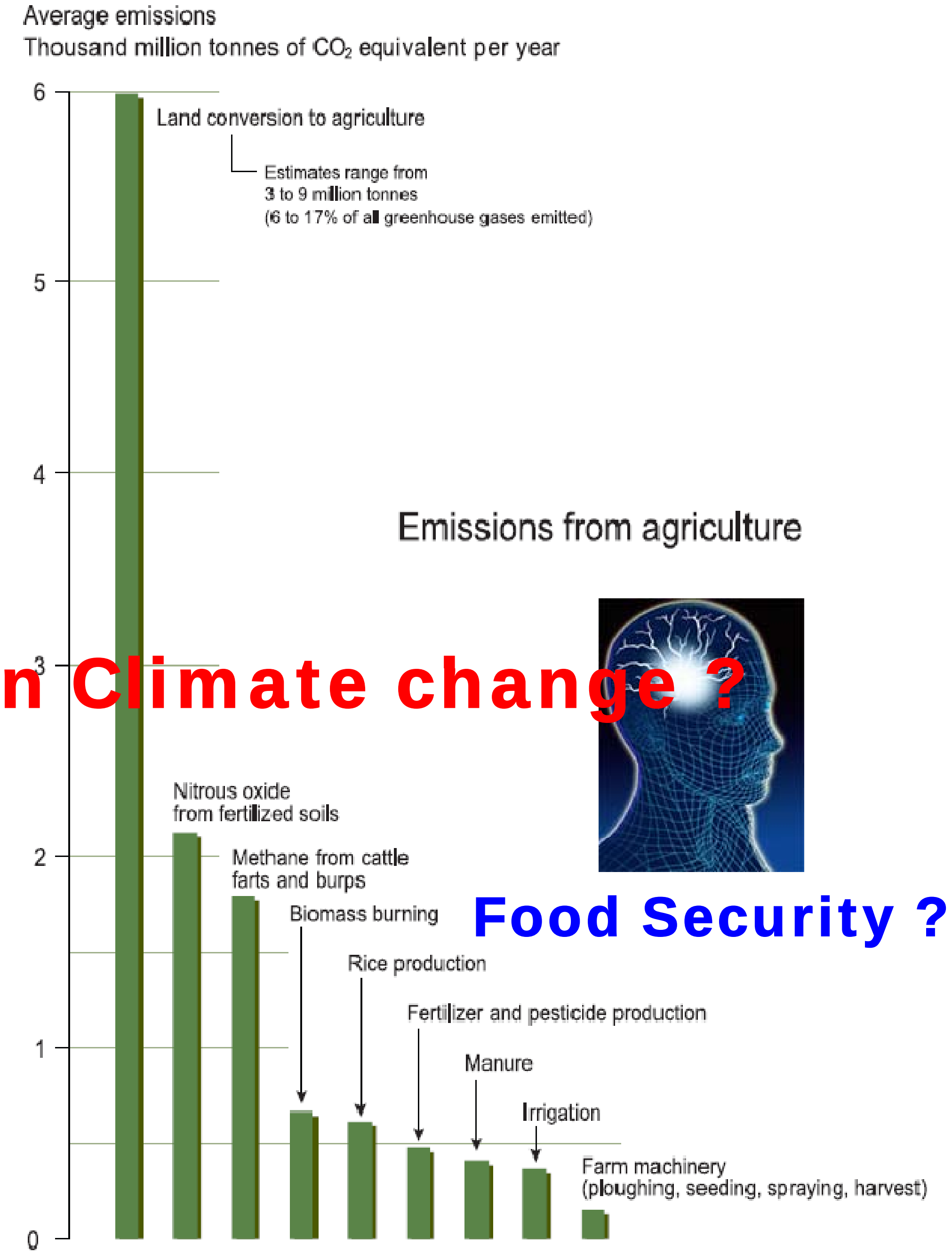
Conclusions and future prospects

- Uncertainties are not a good measure of inventory quality
- The subjectivity component in uncertainty estimates will probably be reduced through use of the 2006 IPCC Guidelines and better competence of inventory compilers
- Inventory quality needs to be measured using also other indicators (transparency and review reports)
- Uncertainties can be reduced and uncertainty estimates improved by addressing category-specific QA/QC and uncertainties at the data collection step
- Need to develop systematic methods for expert judgments addressing all errors
- Uncertainties are quantified for every submission; Sensitivity analysis is used to guide inventory improvement

Areas for co-operation proposal

- Exchange of information and experiences.
- Share of information, studies, more uncertainty data available within emission inventory guidebook.
- Clarify approaches for expert judgement to exclude subjective approaches and have influence on uncertainty estimates.
- Improve utilisation of analysis results by arranging a course in sensitivity analysis.
- It is possible to assess the uncertainty of national, sector and corporation GHG emission inventories.
- Scenario analysis and sensitivity runs allow to assess this influence and to understand/evaluate it.

Intuitive aspect gains weight when uncertainties are larger.



G8 Summit on Climate change ?

Food Security ?

Source: Greenpeace, *Cool farming: Climate impacts of agriculture and mitigation potential*, January 2008 (data for 2005).


This workshop is an important contribution!
Thank you