Advanced Methods for Estimating Uncertainties in National Greenhouse Gas Emission Inventories – the Case of Finland

Suvi Monni
VTT Processes
30 April 2003

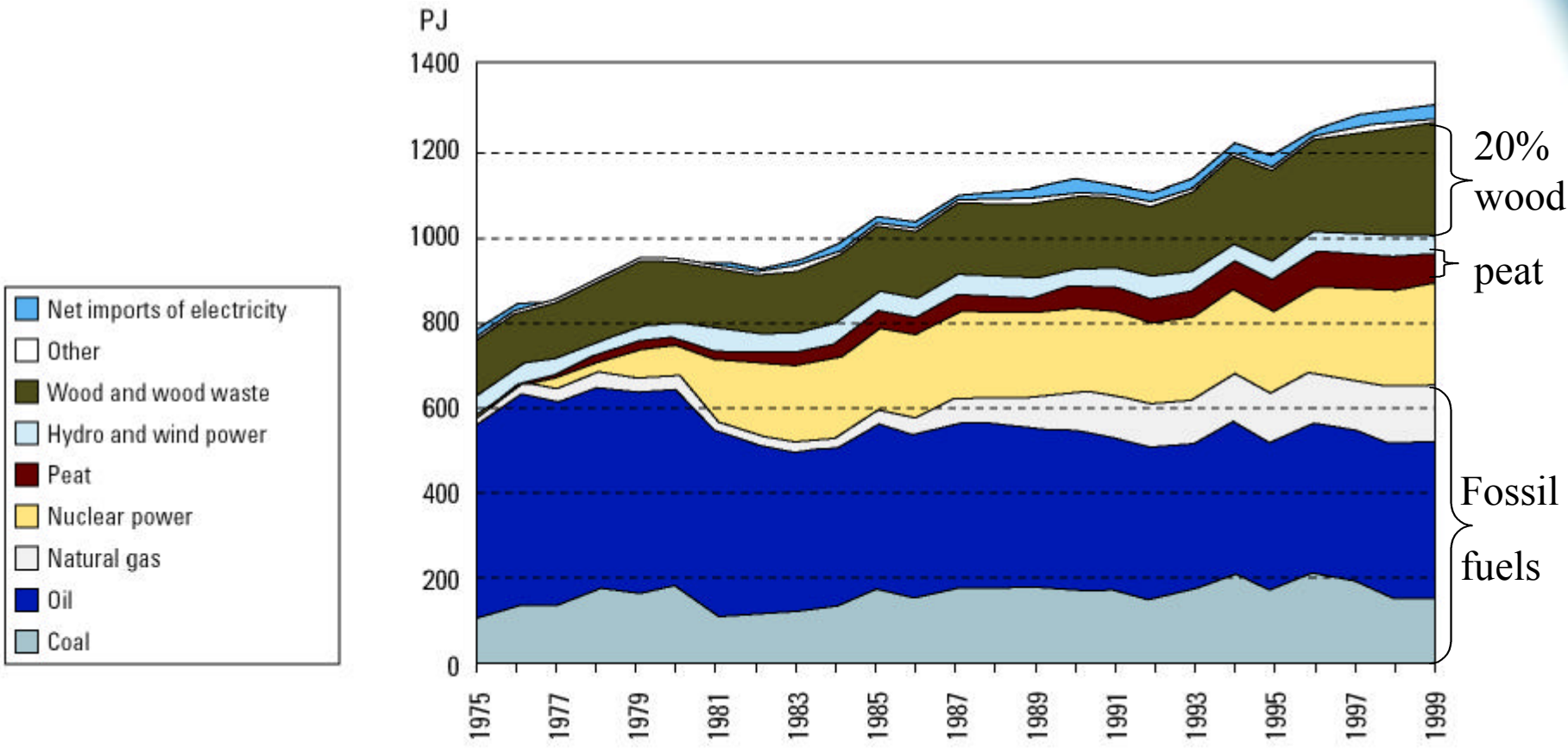
Structure of the presentation

- Greenhouse gas emissions in Finland
  - national circumstances
- General on uncertainty estimates
- Input parameter uncertainties
- Combining uncertainties
- Results
- Conclusions

Finland

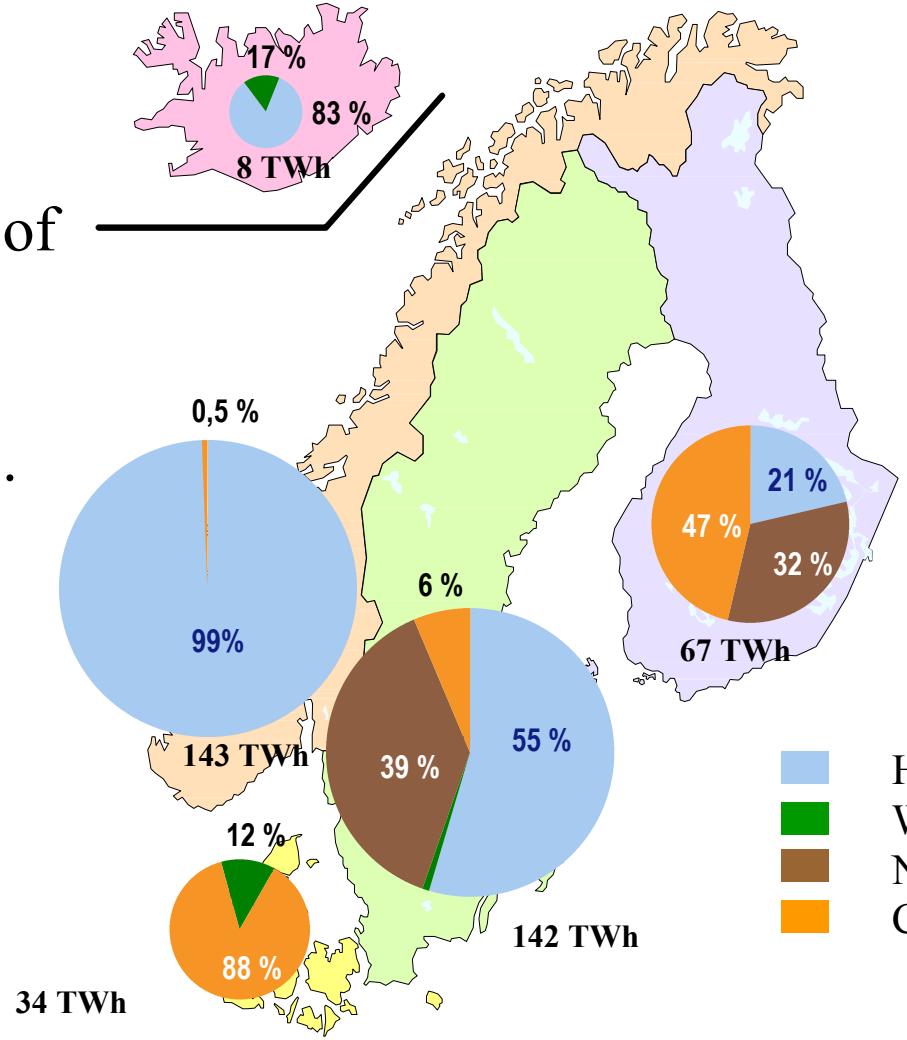
- Northerly located country
  - a quarter of the country lies north of the Arctic Circle
- Cold climate
  - annual mean temperature 6°C in south, less in north
  - 1/5 of final energy is used for space heating
- 2/3 of primary energy comes from imported sources

Primary energy production in Finland 1975-1999

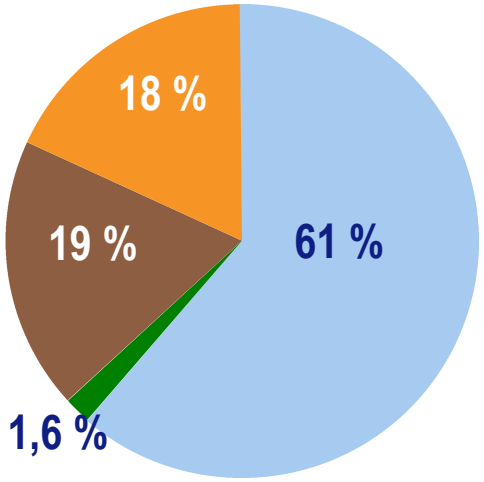


Electricity production in Nordic countries in 2000

Availability of hydropower depends on rainfall rates.



Nordel



394 TWh

Lots of energy used to produce export products (metals, pulp and paper)

Industry uses half of the final energy in Finland

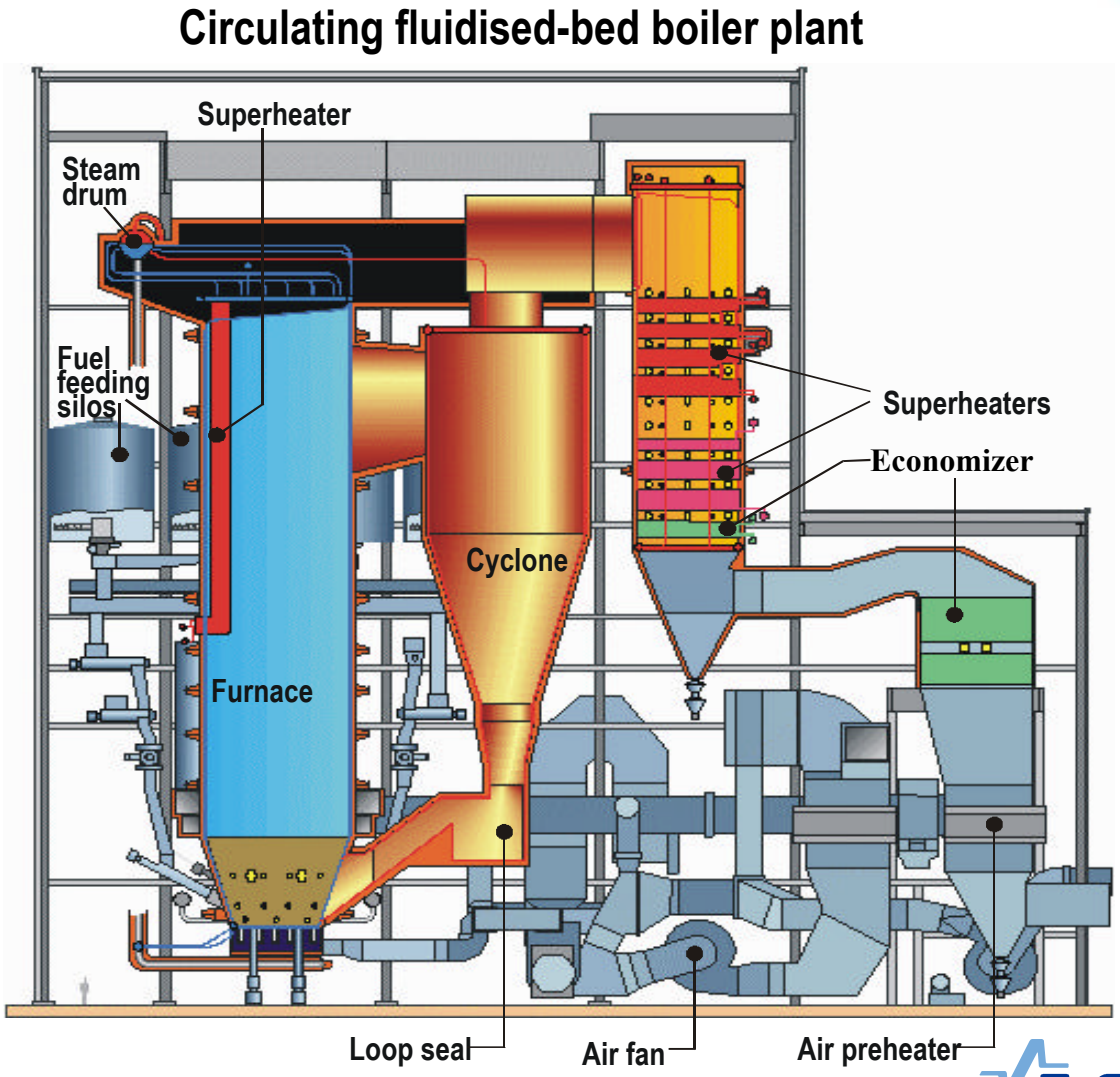
N_2O from Energy Sector: Fluidised Bed Combustion

Advantages of fluidised bed combustion:

- fuel flexibility (wet, low-grade fuels, different particle size etc)
- in-process capture of SOx
- low NOx emissions

Disadvantages:

- high N_2O emissions

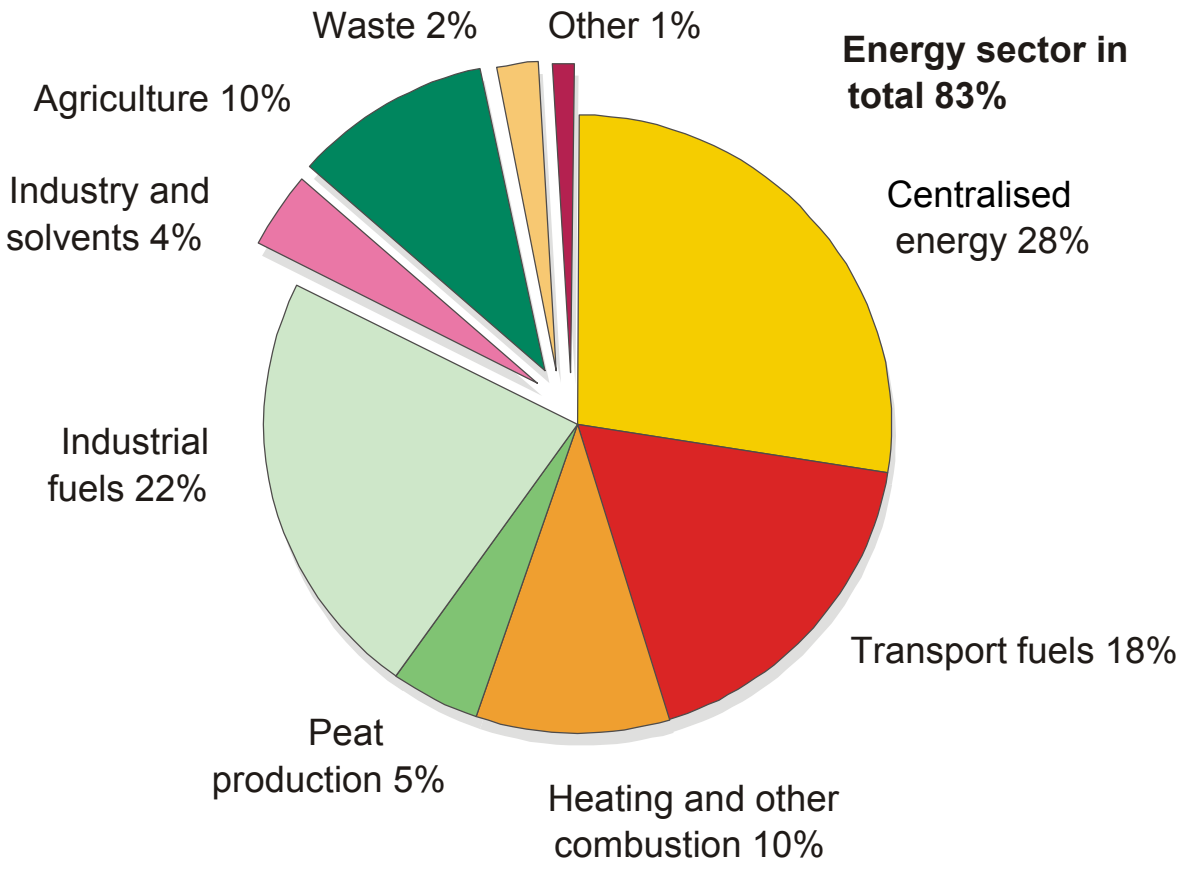


Peat Fuel Use

- 6% of Primary Energy in 2001
- Emissions from peat combustion (CO_2, CH_4, N_2O)
- Peat production area around 55 000 ha
  - emissions: CO_2 and CH_4
- Arable peatland area around 150 000 ha
  - emissions: CO_2
- Closely related to Land Use -sector

Picture: Heikki Kokkonen

Greenhouse gas emissions from Finland in 2000



Uncertainty estimates (1)

- Required for UNFCCC and Kyoto Protocol
- Essential for emission trading and other Kyoto mechanisms
- Give information on future research priorities
  - emission inventory improvements
- IPCC Good Practice gives two different “tiers” for combining uncertainties
  - Tier 1: error propagation equations (normal distributions, symmetrical, uncertainty cannot exceed 100%, handling of correlations problematic)
  - Tier 2: Monte Carlo simulation (distributions can have all possible shapes and widths, flexible handling of correlations)
    - used in this study

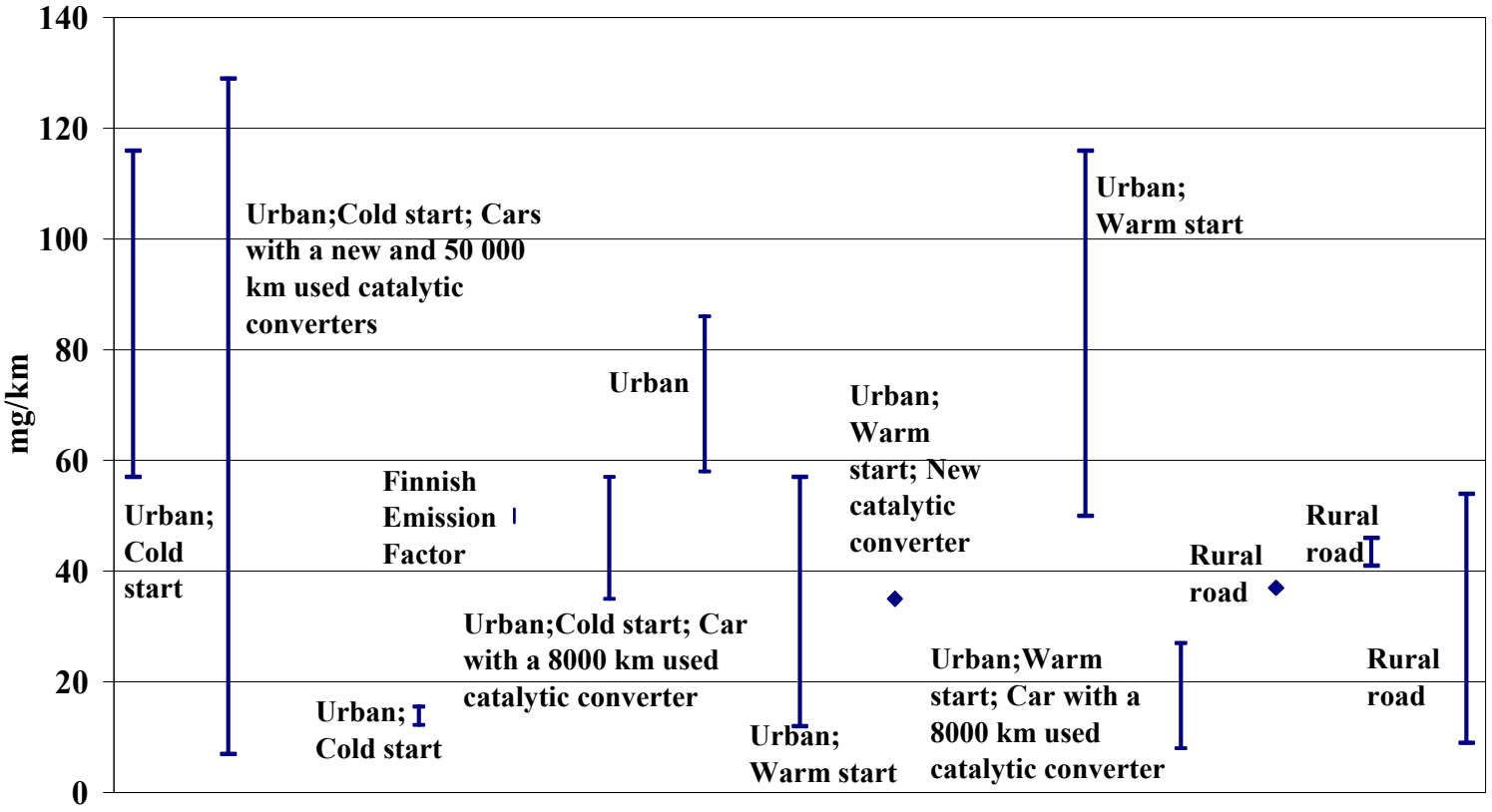
Uncertainty estimates (2)

- Uncertainties due to
  - measurement errors
  - natural variability of emission sources
  - bias in expert judgement
- Basis of uncertainty estimates
  - measurement data
  - domestic and international literature
  - expert judgement
  - IPCC default uncertainties

Uncertainty estimates (3)

- Fuel combustion often accurately known (IPCC 2000)
  - activity data uncertainty ±1-5% in large sources
  - emission factor uncertainty
    - CO_2: < ± 5%
    - CH_4: ± 50-150%
    - N_2O: order of magnitude
- Uncertainty in industrial processes depends of plant-specific data and process conditions
- Agriculture and Waste sectors contain many highly uncertain emission sources

Input Parameter Uncertainties, Case 1: N_2O Emissions from Cars with Catalytic Converters

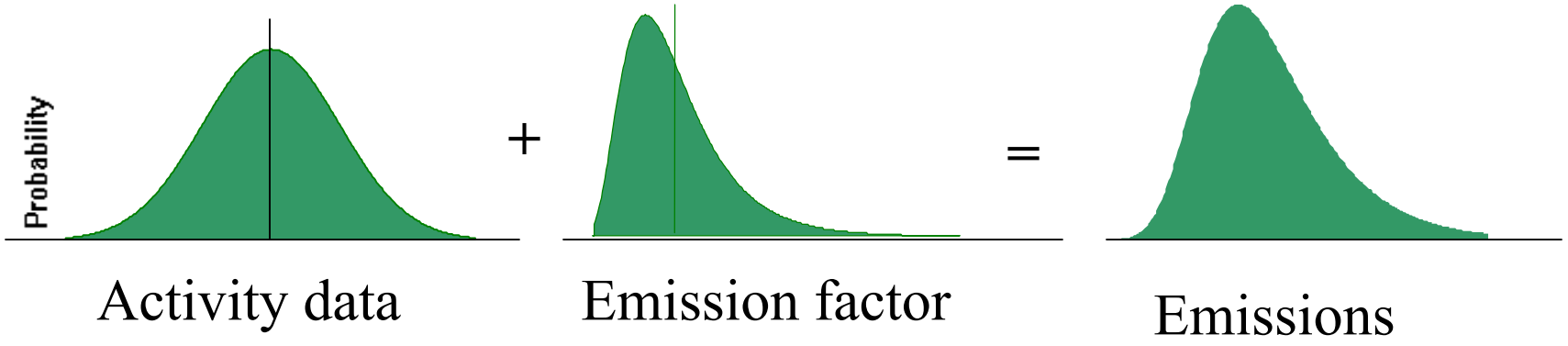


Input Parameter Uncertainties, Case 2: Solid Waste Disposal on Land

- Emissions from solid waste disposal on land are calculated with a First Order Decay Method (FOD)
  - takes the dynamic behaviour of waste degradation into account
  - emissions from waste disposed in landfills since year 1900 are calculated
- Uncertainties of each parameter are estimated
  - uncertainties in historical activity data are large (the waste amount in the beginning of 1900 was very small)
  - suitability of parameters in Finnish conditions (e.g. freezing and melting of land) has to be taken into account in uncertainty estimates
- Resulting uncertainty around ±30%

Monte Carlo Simulation

- Input parameters of emission calculation model are replaced with probability density functions (e.g. normal or lognormal distributions)
- Total uncertainty is obtained taking random numbers from each input distribution several thousands of times



Uncertainties by gas

Gas	Uncertainty
CO_2	-4...+6%
CH_4	–19...+20%
N_2O	-33...+40%
HFCs, PFCs and SF_6	–53...+32%

Uncertainties by sector

Sector	IPCC code	Uncertainty in 2001 (%)
Fuel Combustion	1A	±3%
Fugitive emissions from fuels	1B	-59...+106%
Industry	2	-27...+43%
Agriculture	4	-37...+47%
Waste	6	-28...+30%
Total		-5...+6%

Key sources

- Key sources identified with the Tier 2 method of IPCC Good Practice Guidance

5 most important key sources in 2001

Source category number	Gas	Key Sources
1B	CO_2	Arable peatlands
4D	N_2O	Agricultural soils
1B	CO_2	Peat production areas
1A4	CO_2	Other Sectors (commercial, institutional, residential, agriculture, forestry, fisheries,): Liquid Fuels
2B2	N_2O	Nitric Acid Production

Conclusions

- Total uncertainty in Finland is rather low (-5…+6%)
  - due to large share of CO_2 emissions from fossil fuel combustion, which are accurately known
- CO_2 emissions are accurately known, but other gases contain higher uncertainties
- CO_2 emissions from peat production and N_2O emissions from agricultural soils dominate the uncertainty
  - the reduction of these uncertainties would need lots of research both internationally and in Finland