

# **Life Cycle Assessment and Carbon Footprinting**

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# Overview

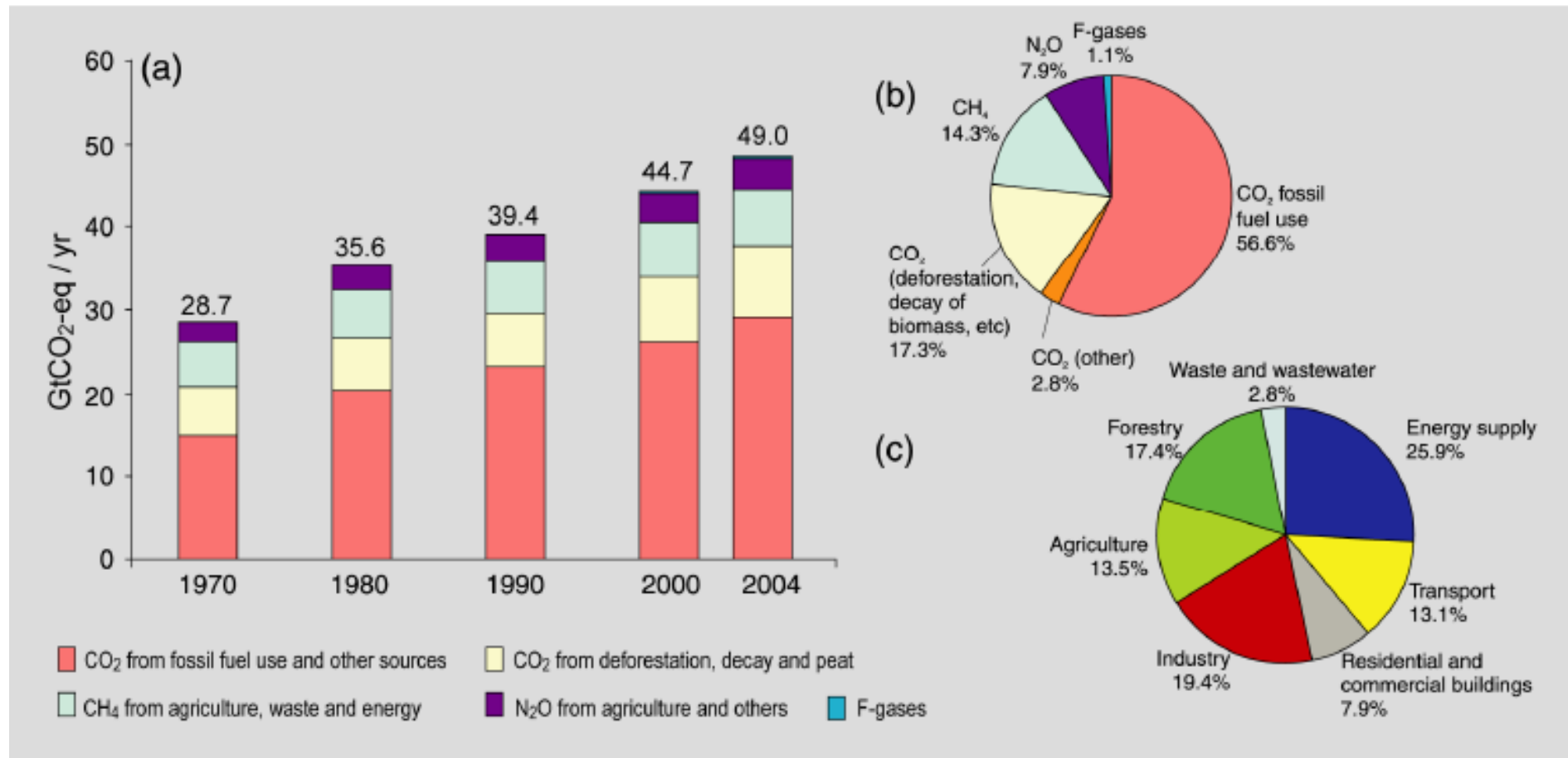
- Introduction
- Carbon footprinting
  - Energy
  - Industry
  - Transport
  - Food
- Conclusions

# Carbon footprinting

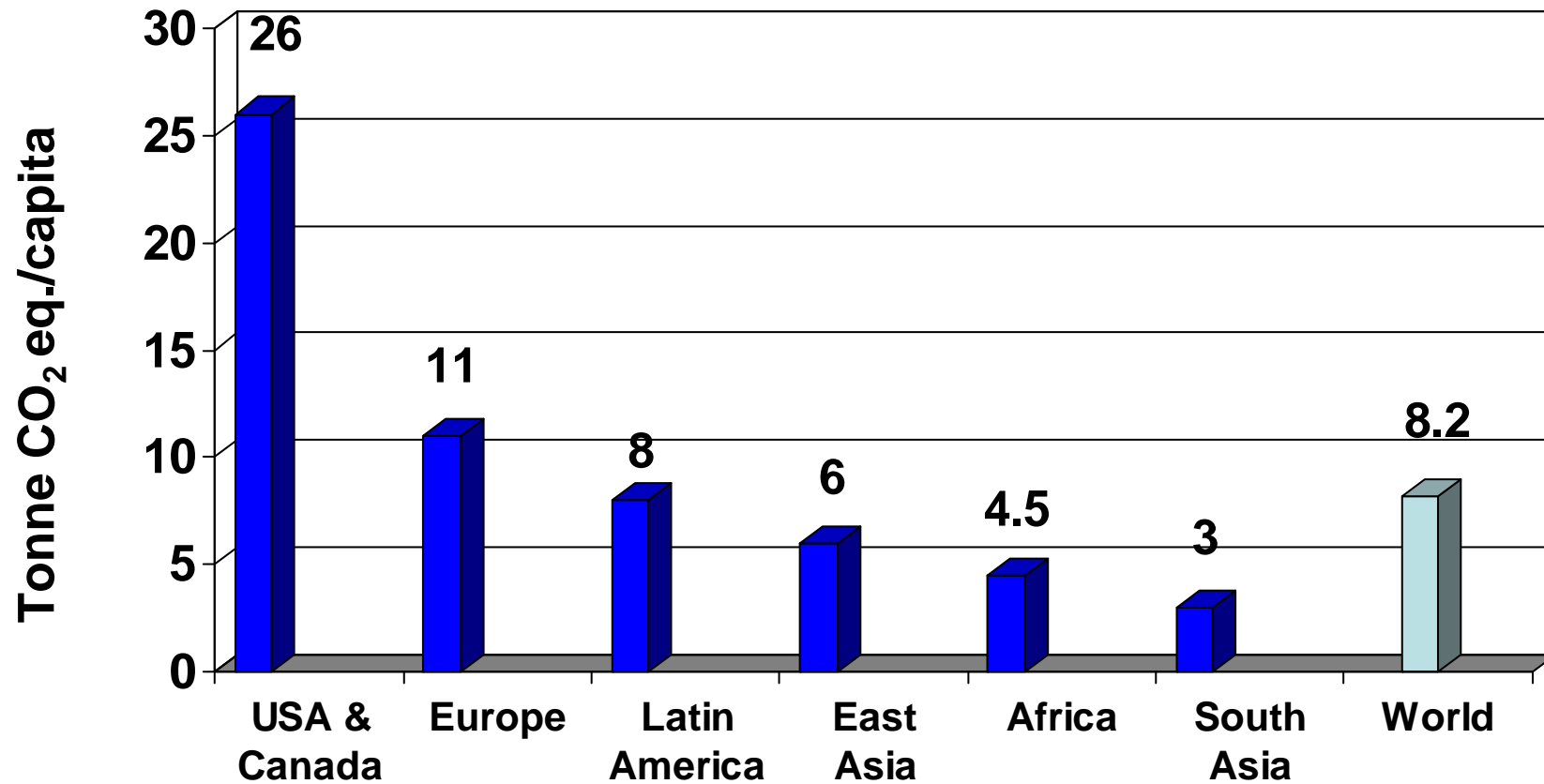
- Estimating emissions of GHG from different human activities
- Expressed as CO<sub>2</sub> eq.
  - The amount of carbon dioxide emission that would cause the same integrated radiative forcing, over a given time horizon, as an emitted amount of a GHG or their mixture
- Also known as Global Warming Potential (GWP)



# Global anthropogenic GHG emissions



# GHG emissions per capita

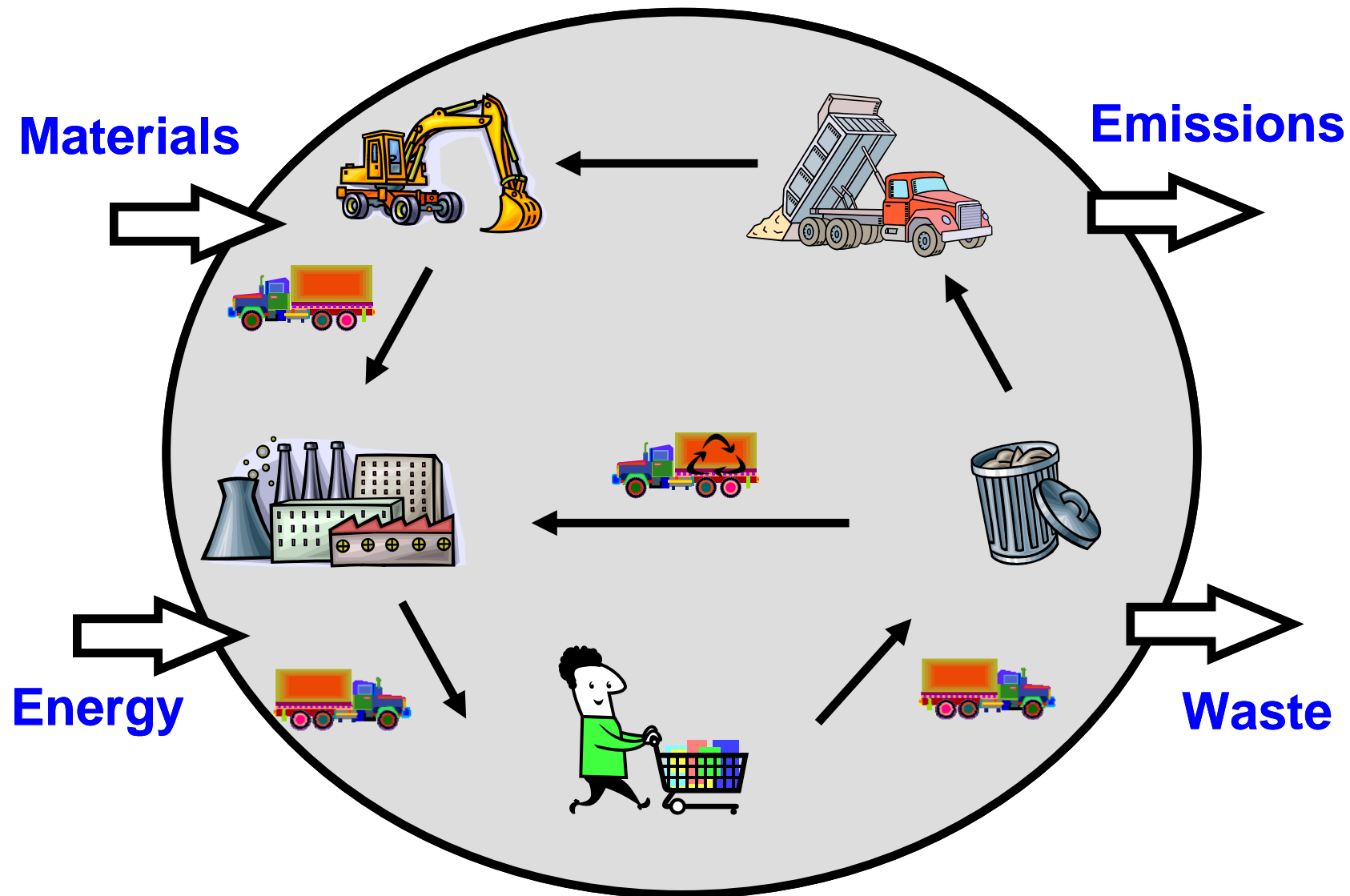


IPCC (2007). Fourth Assessment Report: Climate Change 2007

# Carbon footprinting

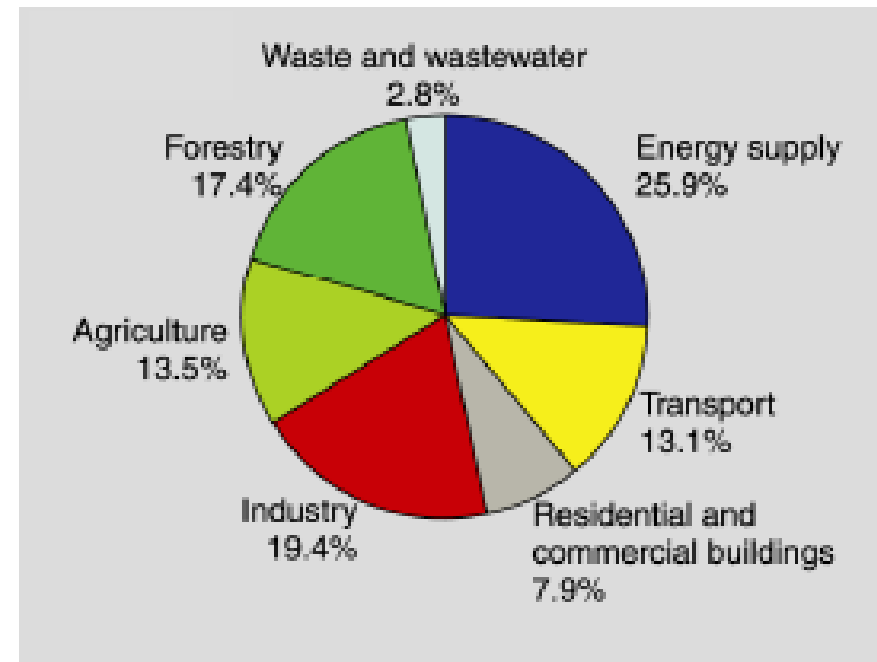
- Carbon footprint can include
  - Direct and
  - Indirect emissions
- Often comprises direct emissions only
  - e.g. Kyoto reporting of GHG is based on direct emissions only
- In many cases indirect emissions contribute much more than the direct emissions
- Life cycle approach essential for measuring the true GHG emissions of human activities

# Life cycle approach to carbon footprinting



# Carbon footprinting of different human activities and sectors

- Energy
- Industry
- Transport
- Agriculture/Food

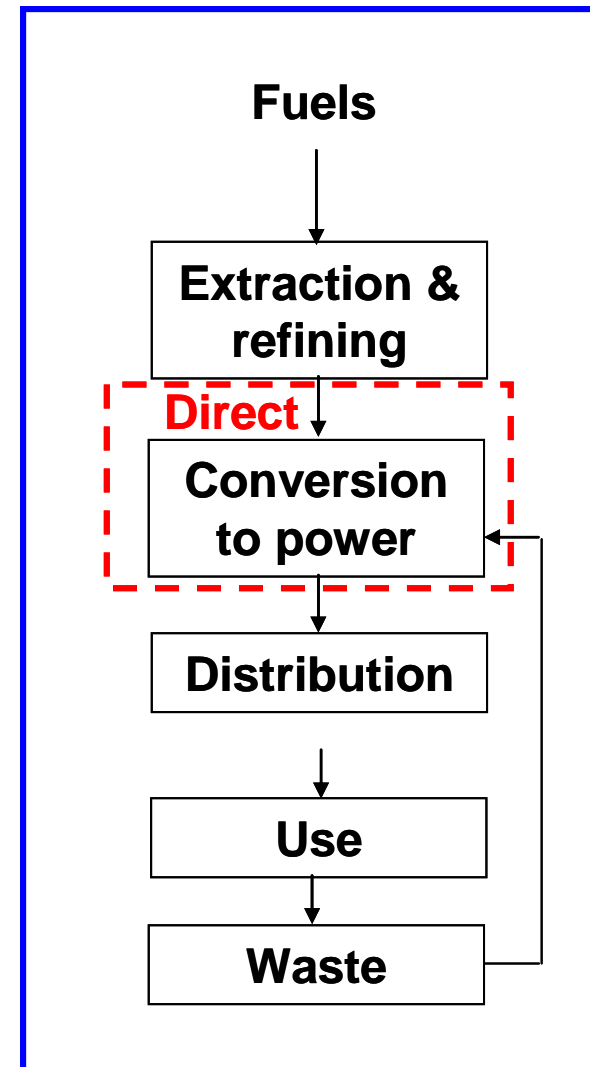




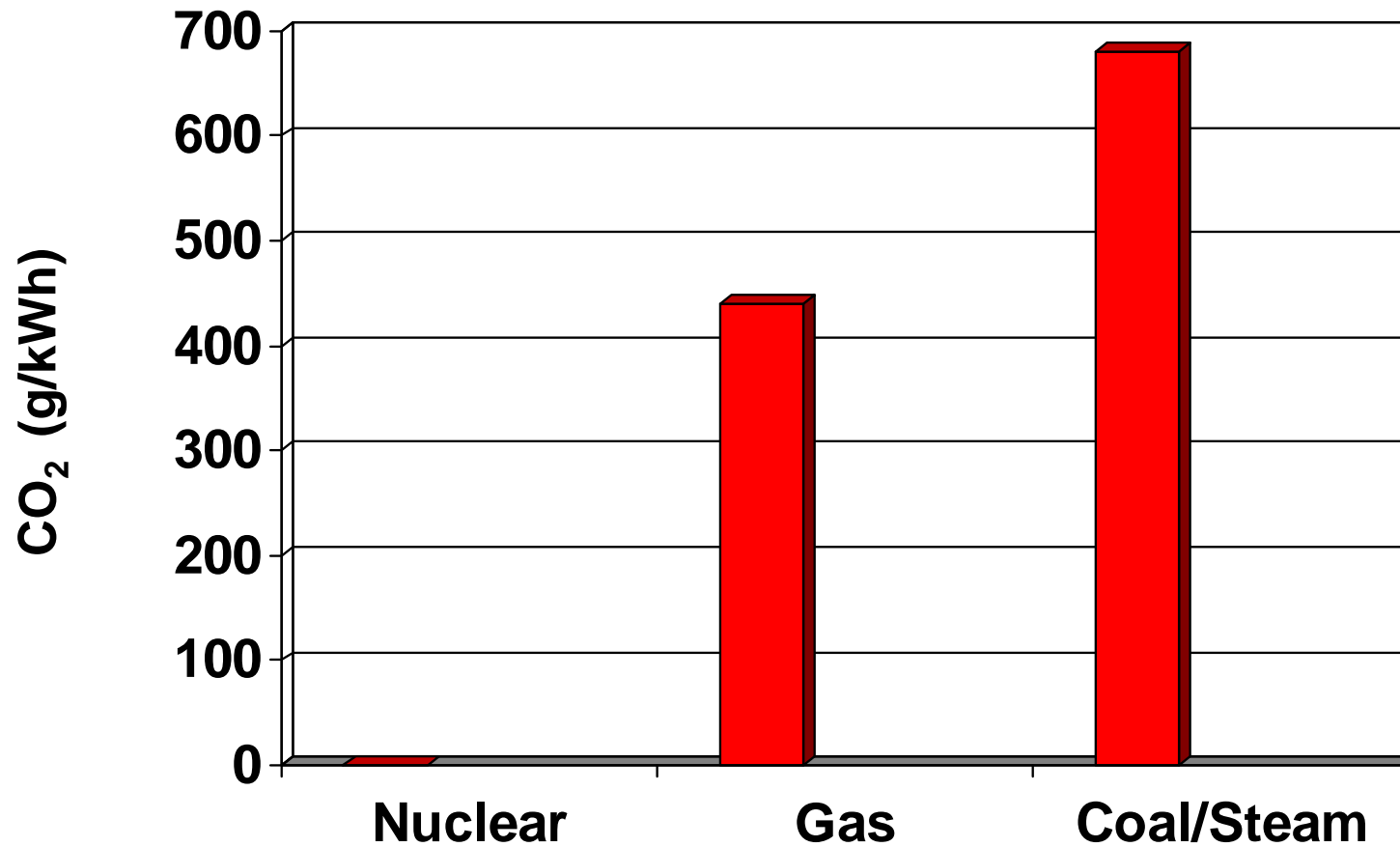
# Carbon footprinting the energy sector

- Normally done for direct emissions, i.e. from combustion (use phase)
- Other life cycle stages can contribute to the total footprint

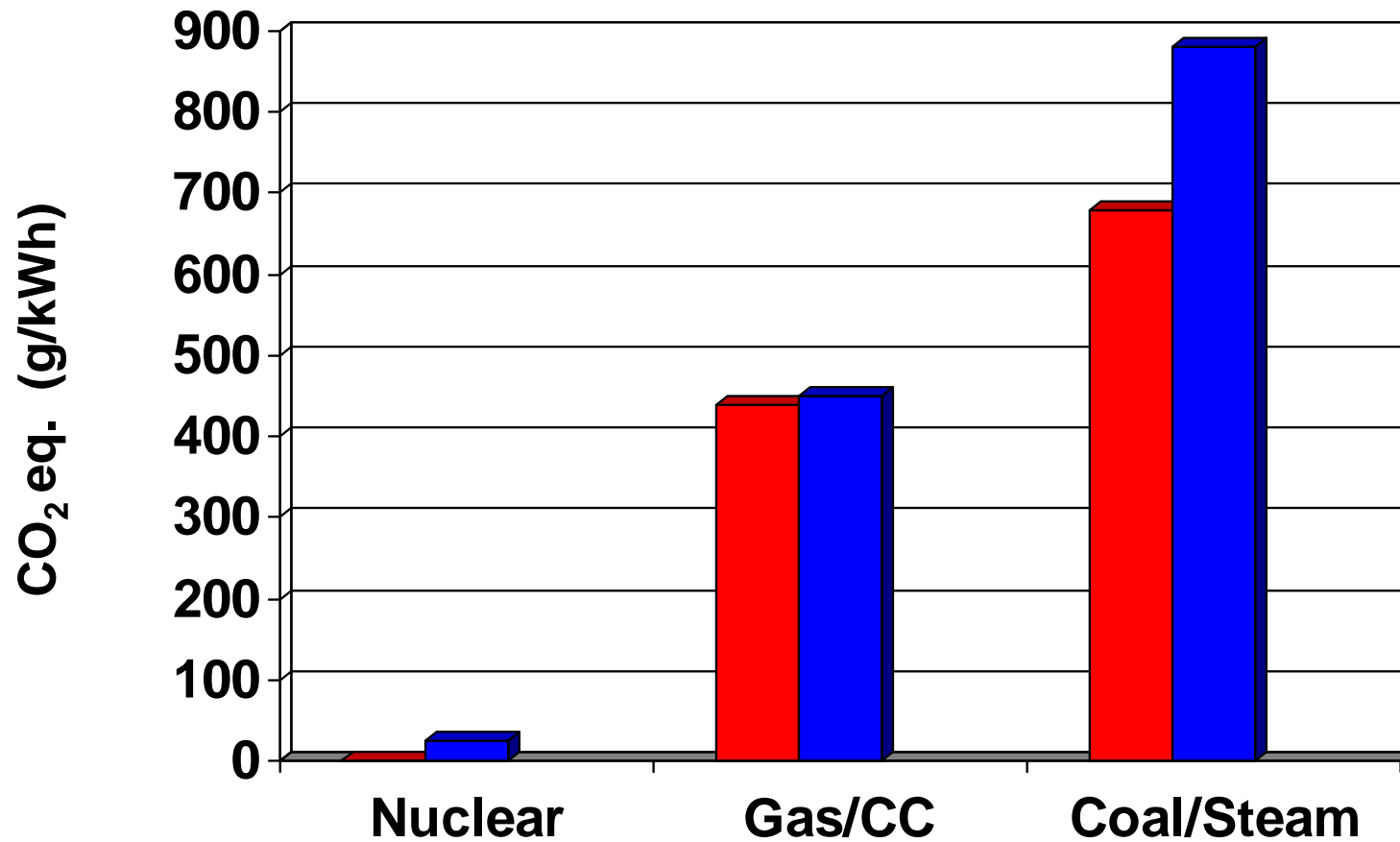
## Life cycle



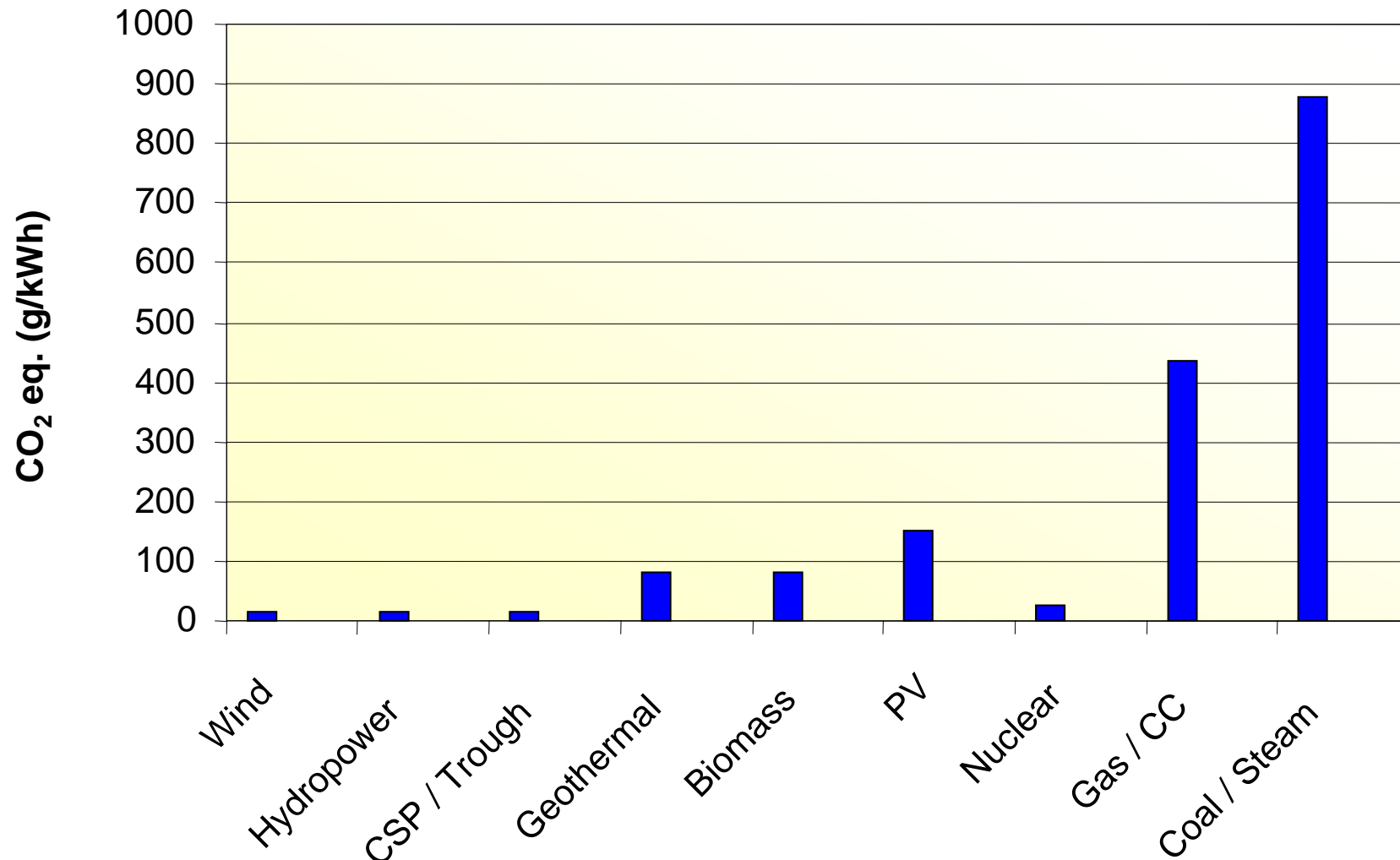
# Carbon footprinting energy technologies: Direct CO<sub>2</sub> emissions



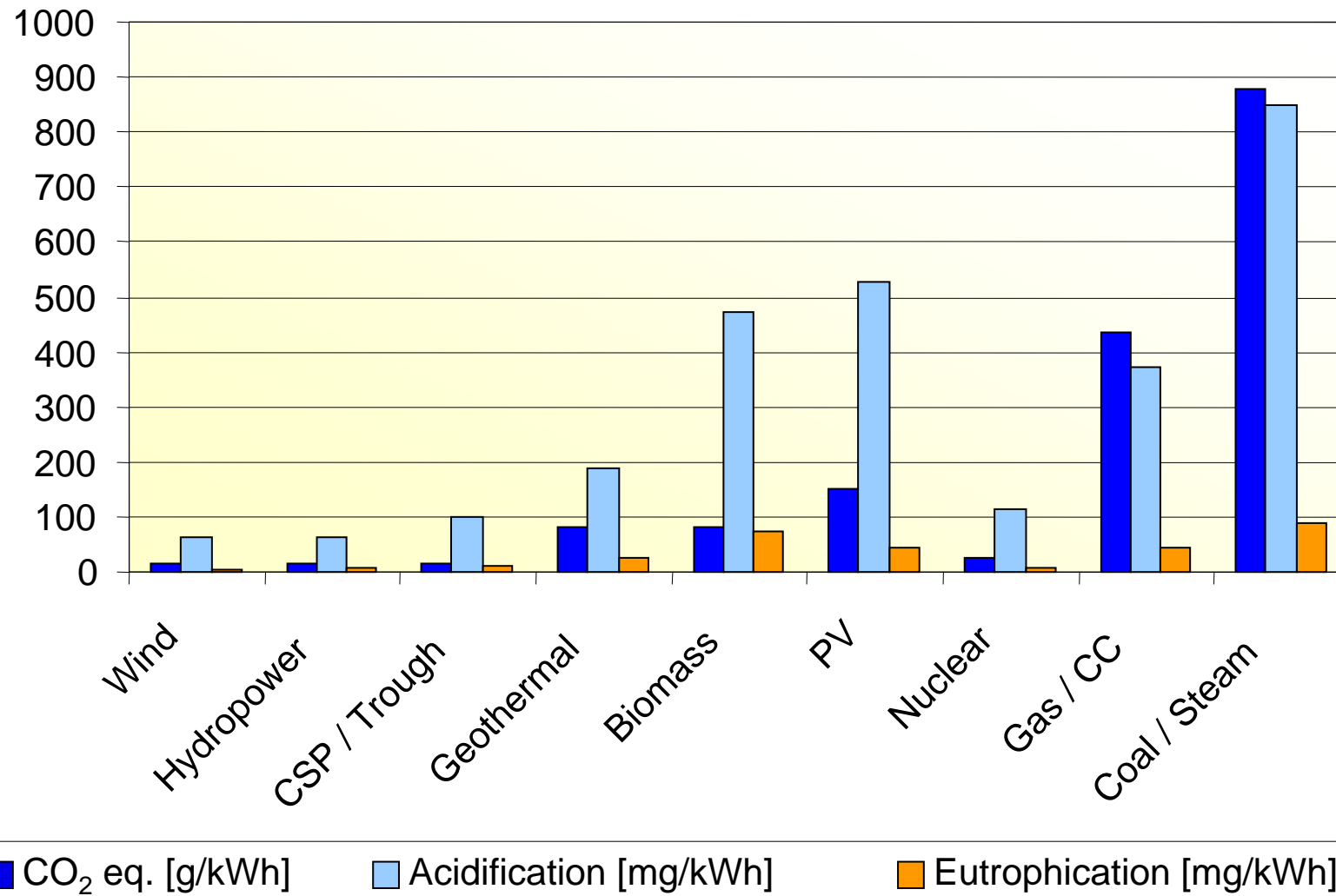
# Carbon footprinting energy technologies: Life cycle CO<sub>2</sub> eq. emissions



# Carbon footprinting energy technologies: Life cycle CO<sub>2</sub> eq. emissions



# Carbon footprinting energy technologies: Carbon footprint vs other life cycle impacts

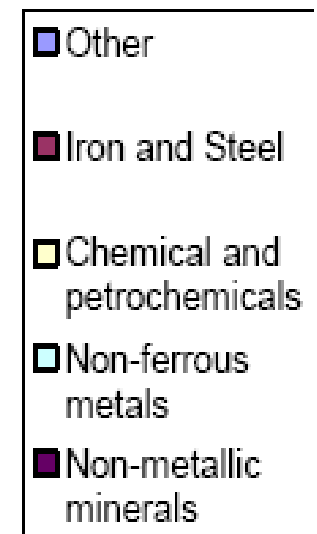
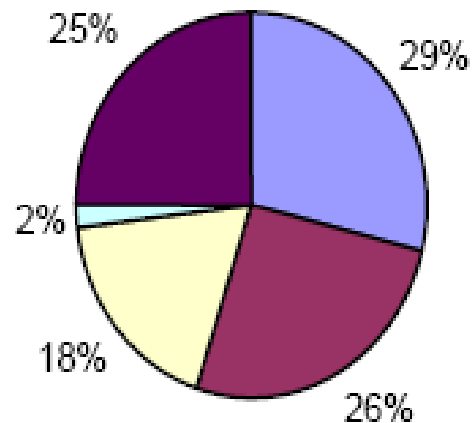


# Carbon footprinting industry: Direct CO<sub>2</sub> emissions

- Industry is directly responsible for 14% of GHG emissions
  - 20% if emissions from the power sector are included

- Two thirds of direct CO<sub>2</sub> emissions are from three sectors:

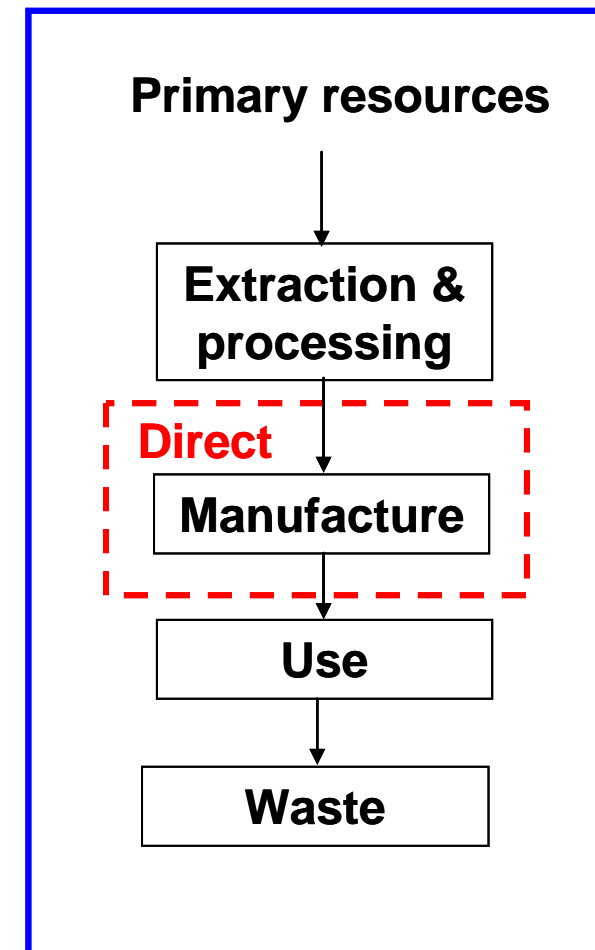
- Iron and steel
- Non-metallic minerals and
- Chemicals and petrochemicals



## An example: Carbon footprinting the UK Chemicals industry

- 50,000 products
- 4000 sites
- UK's top manufacturing export earner
  - £33 billion sales
  - £29 billion exports
- But how big is the industry's carbon footprint?

### Life cycle



## Direct emissions (as reported under the Kyoto)

<b>Gas</b>	<b>Emissions (kt)</b>	<b>GWP (kt CO<sub>2</sub> eq.)</b>
<b>CO<sub>2</sub></b>	1120	1120
<b>CH<sub>4</sub></b>	2	42
<b>N<sub>2</sub>O</b>	9	2796
<b>Total</b>		<b>3958</b>

(2005)

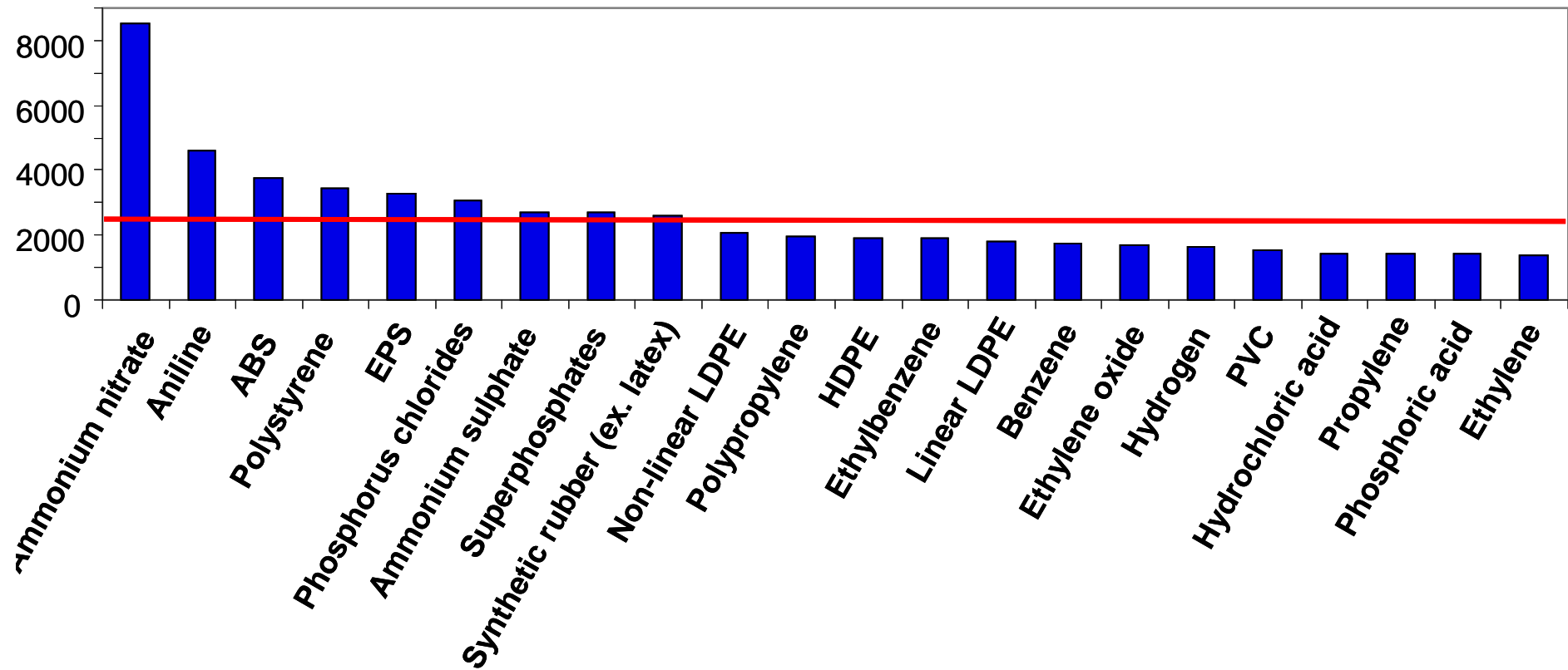


## And how much it would be on a life-cycle basis

<b>Gas</b>	<b>Emissions (kt)</b>	<b>GWP (kt CO<sub>2</sub> eq.)</b>
<b>CO<sub>2</sub></b>	1120	1120
<b>CH<sub>4</sub></b>	2	42
<b>N<sub>2</sub>O</b>	9	2796
<b>Total</b>		<b>3958</b>
<b>Life cycle emissions</b>		<b>12,050</b>

# Carbon footprint of some chemicals

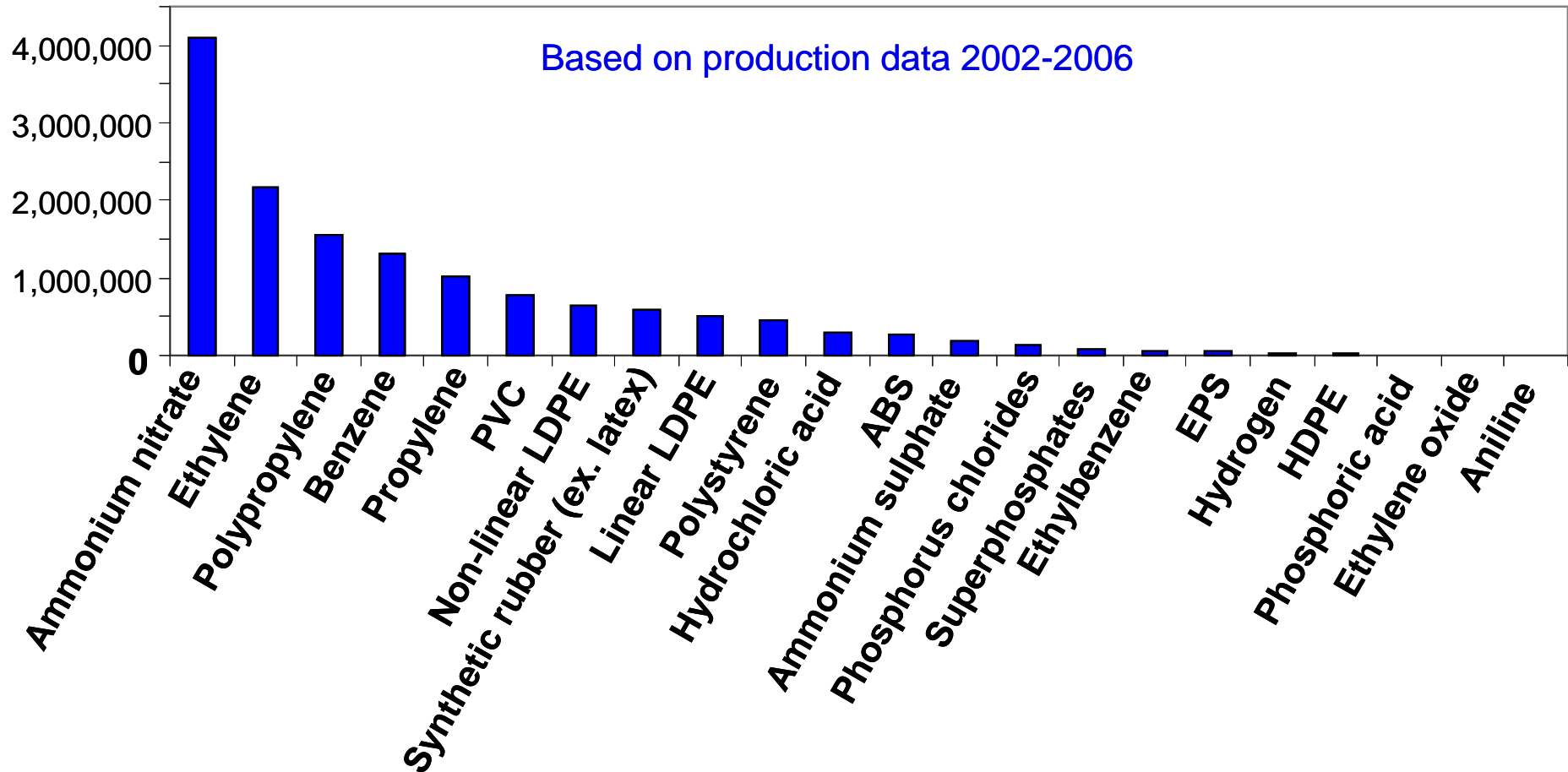
GWP (kg CO<sub>2</sub> eq./t)



# Carbon footprint of some chemicals

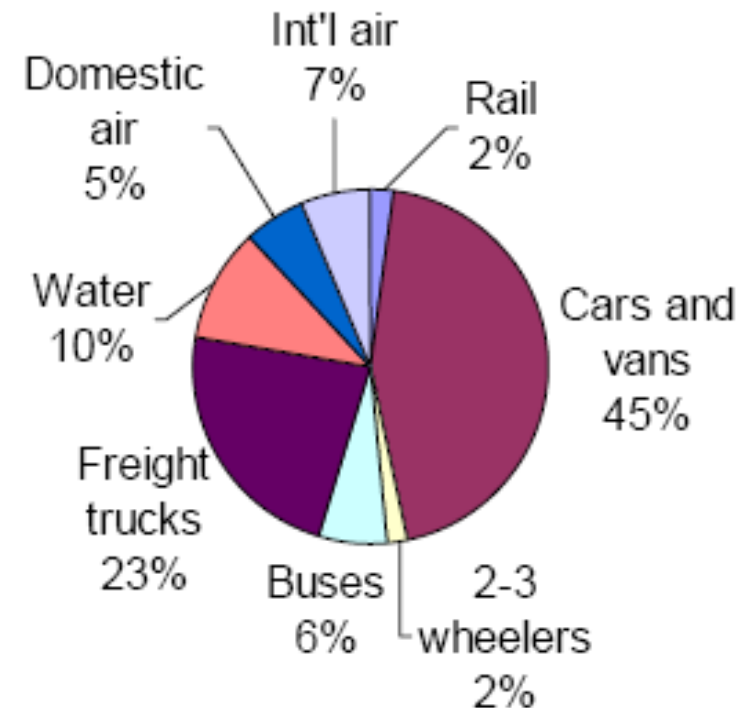
Total: 12.05 Mt CO<sub>2 eq</sub>/yr

GWP (kt CO<sub>2 eq</sub>/yr)



# Carbon footprinting the transport sector: Direct CO<sub>2</sub> emissions

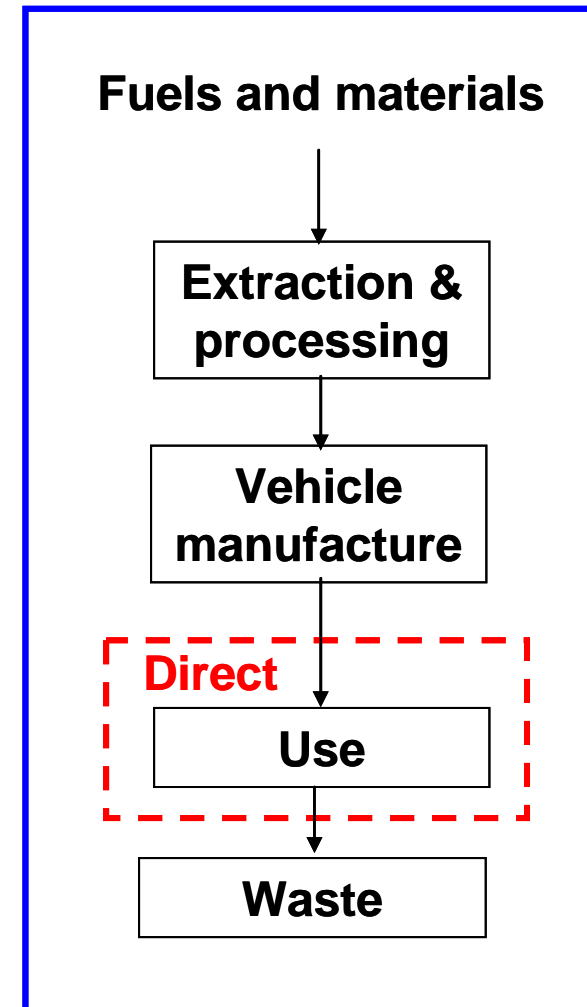
- Transport is responsible for 13% of direct GHG emissions
  - The majority of emissions are from road transport (76%) and aviation (12%)
  - Aviation accounts for 1.6% of global GHG emissions



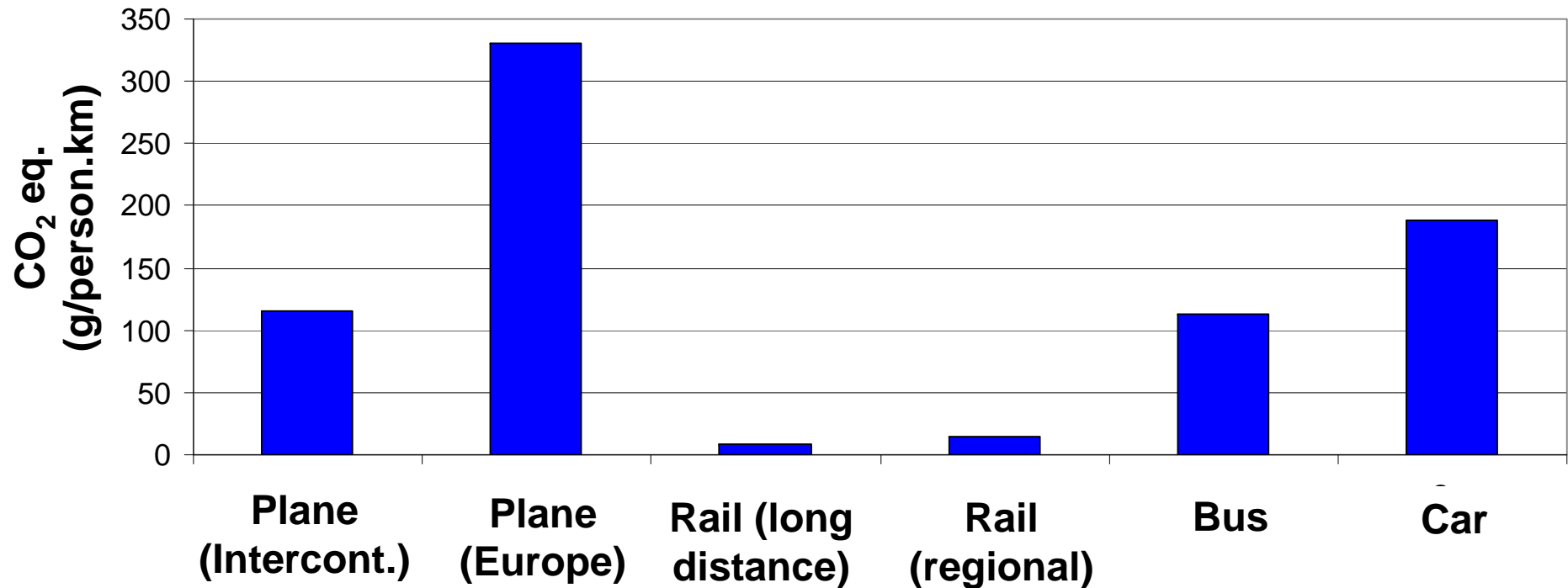
# Carbon footprinting the transport sector: Life cycle emissions

- Indirect emissions are from:
  - Non-CO<sub>2</sub> effects of aviation (water vapour)
    - currently excluded from emission estimates
    - If included, aviation could account 5% of global GWP in 2050
  - Fuel refining and electricity generation

## Life cycle

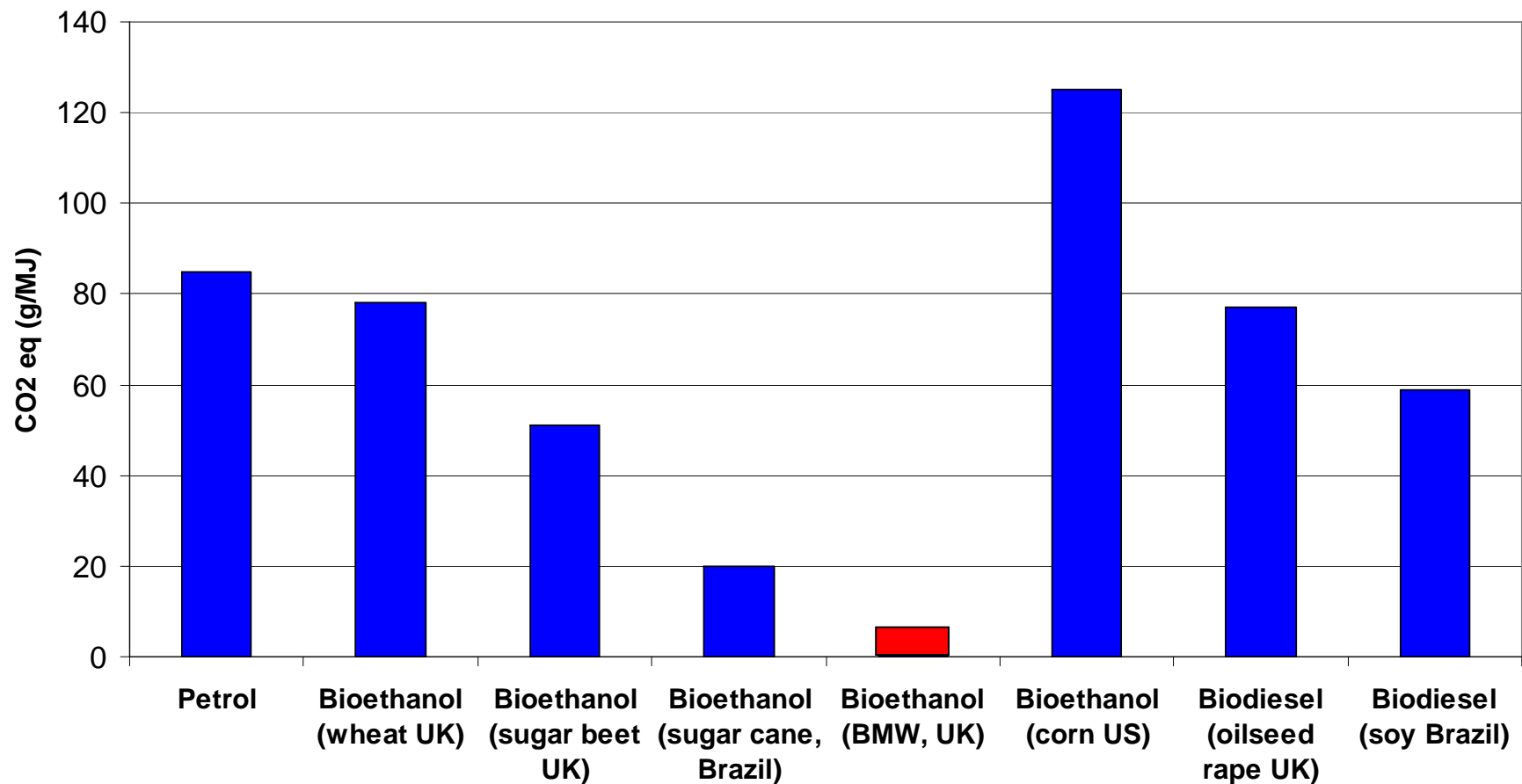


# Carbon footprinting the transport sector: Life cycle comparison of different transport modes



Source: Ecoinvent Database, v1.3

# Carbon footprinting transport: Life cycle comparison of different fuels



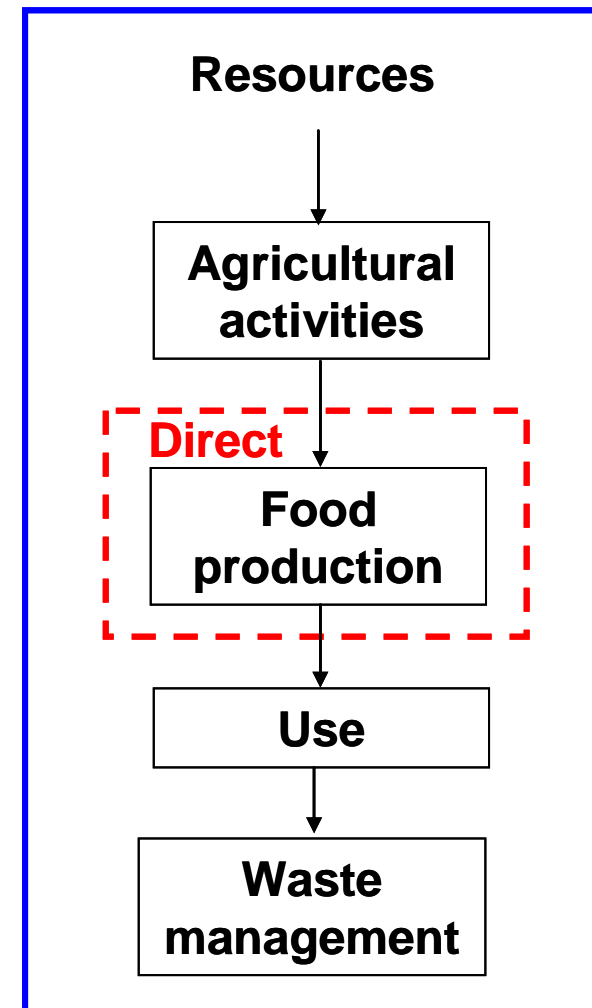
 Stichnothe, H., J. Hau and A. Azapagic (2008). Bioethanol from Waste: Estimation of Greenhouse Saving Potential on a Life Cycle Basis. Waste Management 2008, Granada, 2-4 June 2008.

 Carbon and Sustainability Reporting within the Renewable Transport Fuel Obligation. Government Recommendation to RTFO Administrator. Department of Transport (DFT), June 2007

# Manufacture of food and drink: Main GHG and sources

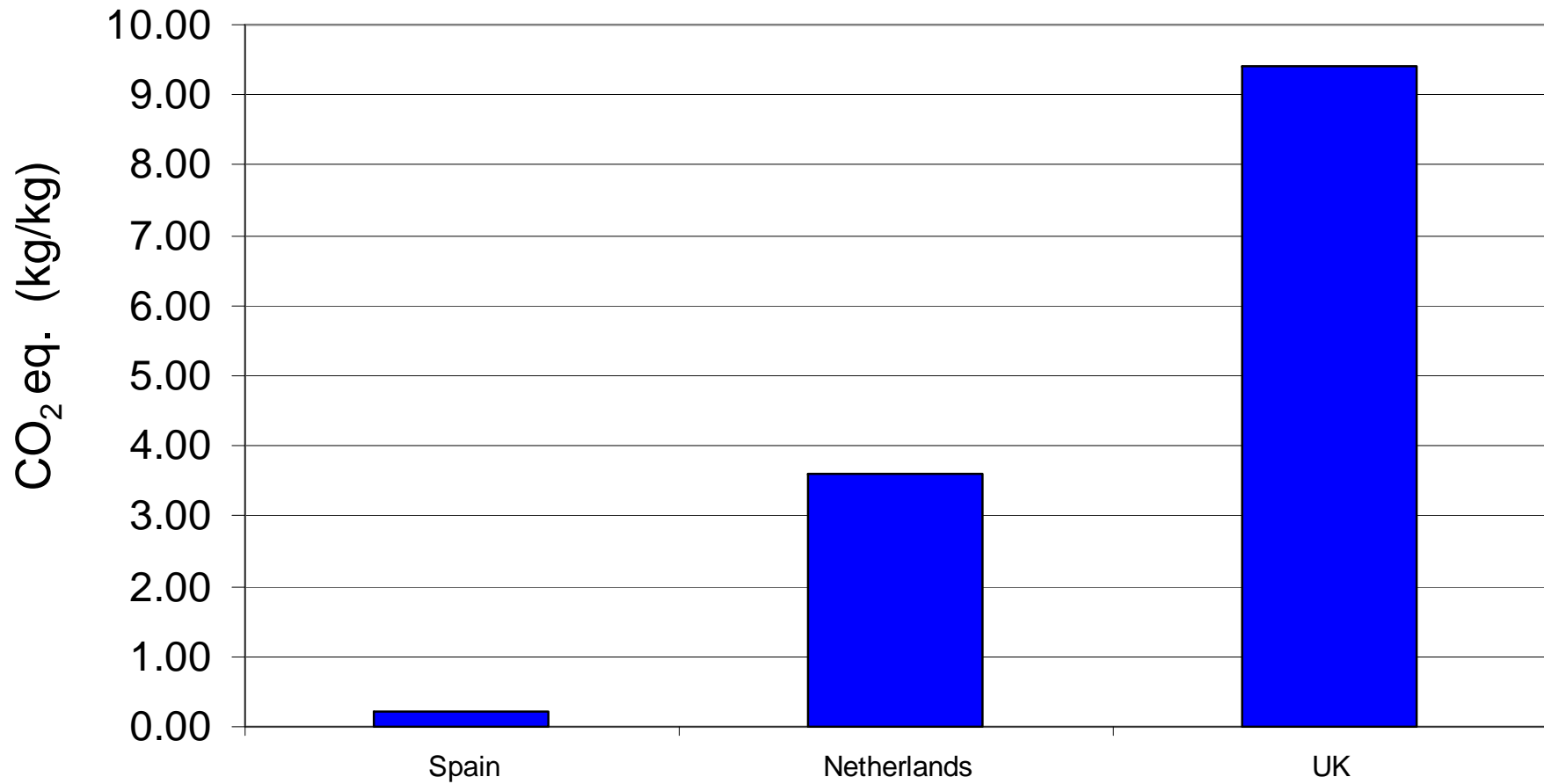
- CO<sub>2</sub>
  - Energy use (processing and refrigeration)
  - Transport
  
- Non-methane VOCs
  - Whisky maturation
  - Bread making
  - Heating of food
  - Processing of oils and fats
  
- HFCs
  - Refrigeration

## Life cycle



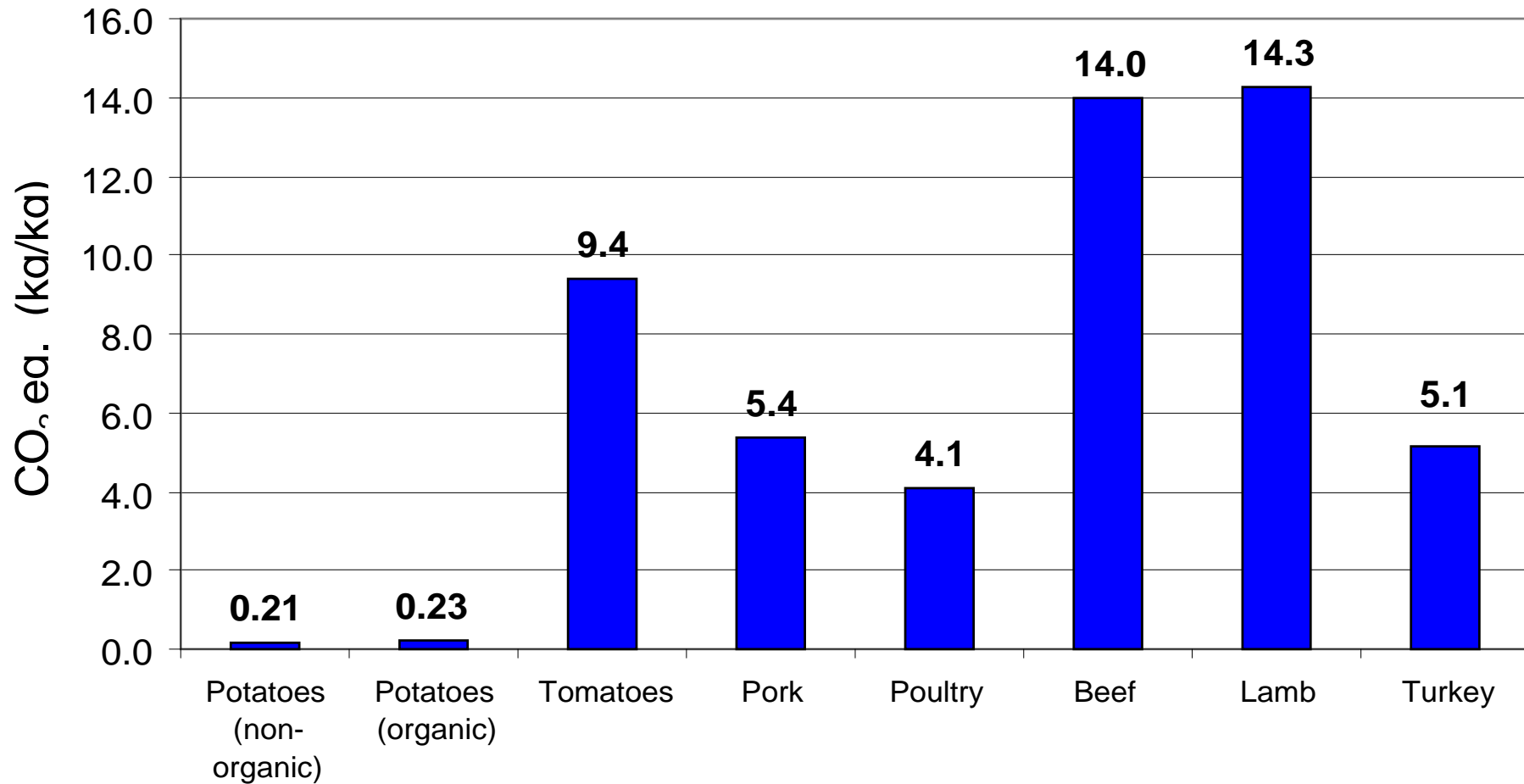


# Carbon footprinting the food sector: Tomatoes in different countries



Comparison on a life cycle basis

# Carbon footprinting the food sector: Meat vs vegetables



Comparison on a life cycle basis, at farm, UK

# Conclusions

- Climate change is probably one of the greatest threats to society today
- Successful adaptation and mitigation depend on better understanding of GHG emissions from different activities
- Life-cycle based carbon footprinting can contribute towards this
- It can also contribute towards sustainable production and consumption

# Acknowledgments

- Dr Heinz Stichnothe
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  - EPSRC
  - NERC