INNOVATION AND EFFICIENCY

PE CONSULTING GROUP
Life Cycle Engineering

Alternative fuels conference 2006

Perth, September 12th, 2006

Life Cycle Assessment – the silver bullet to evaluate current and future transport fuel options ?

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PE Consulting Group

Content

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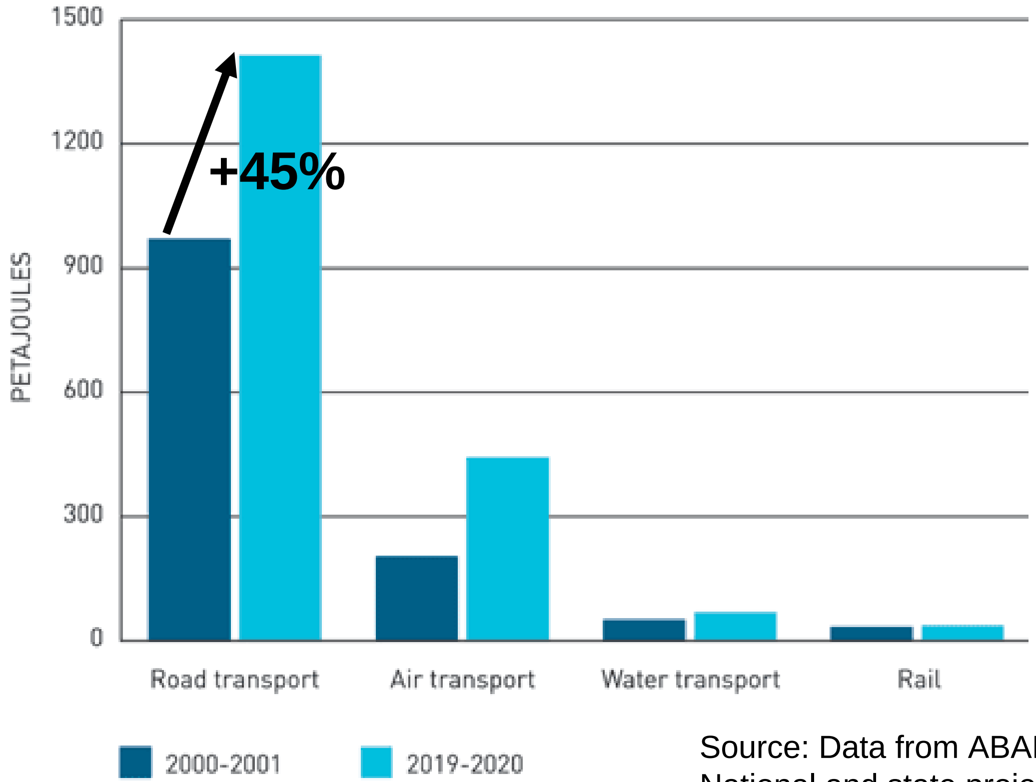
Introduction

Developments in the Transport sector (I)

- Increase of energy demand in Australia to 2020

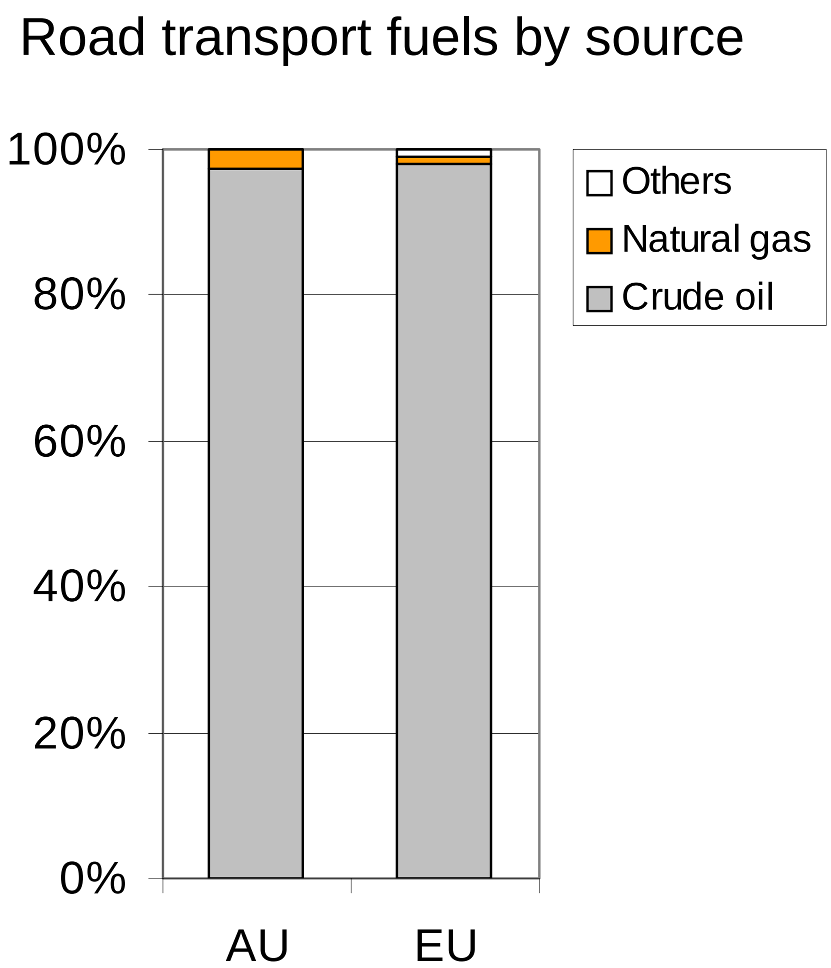


Source: Data from ABARE, Australian energy: National and state projections to 2019-20

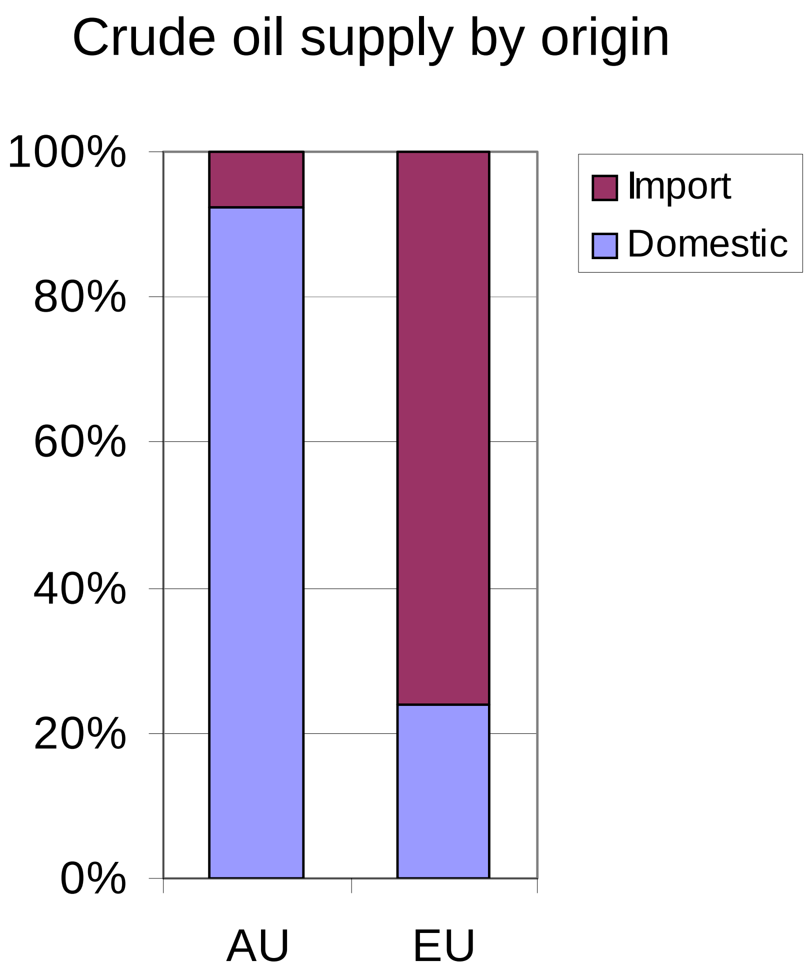
- Increase in OECD: + 30% (Source: IEA - World energy outlook 2004)

Introduction

Development in transport sector (II)



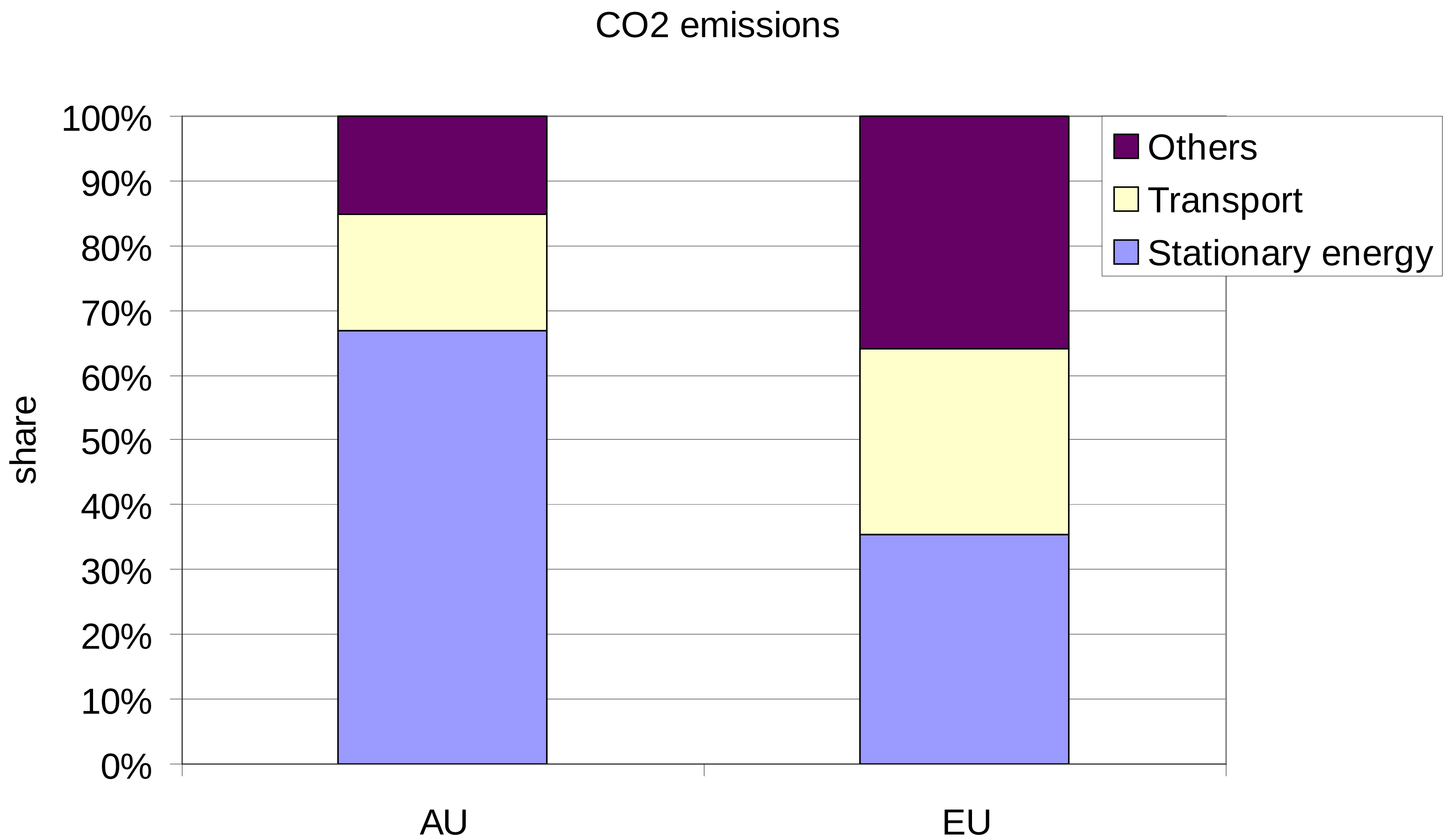
Source: AU: Commonwealth Fuel taxation Inquiry, 2003
Assumption: 60% of LPG Crude Oil based
EU: DG TREN, 2005



Source: IEA: Oil information 2004

Introduction

Transport sector – share or emissions



Introduction

Need for alternatives

Alternatives need to address the following aspects

- Broadening the used energy carrier mix
- Reduce import dependency
- Reduce usage of non renewable resources
- Reduce environmental burdens connected to their use

→ What is the “best” solution?

Evaluation methodology

Requirements

- Consideration of the complete system transport, not only use of fuel, but also fuel supply + vehicle manufacturing + vehicle EoL

- Consider not only primary energy demand and GHG emissions but also other harmful emissions and environmental impacts from traffic

- Consider regional boundary conditions (origin of resources, operation of transport system)

Life Cycle Assessment

From Cradle-to-Grave

Life Cycle Assessment is a very suitable approach to provide decision support

✓ Based on the life cycle approach for evaluating a system, product or service

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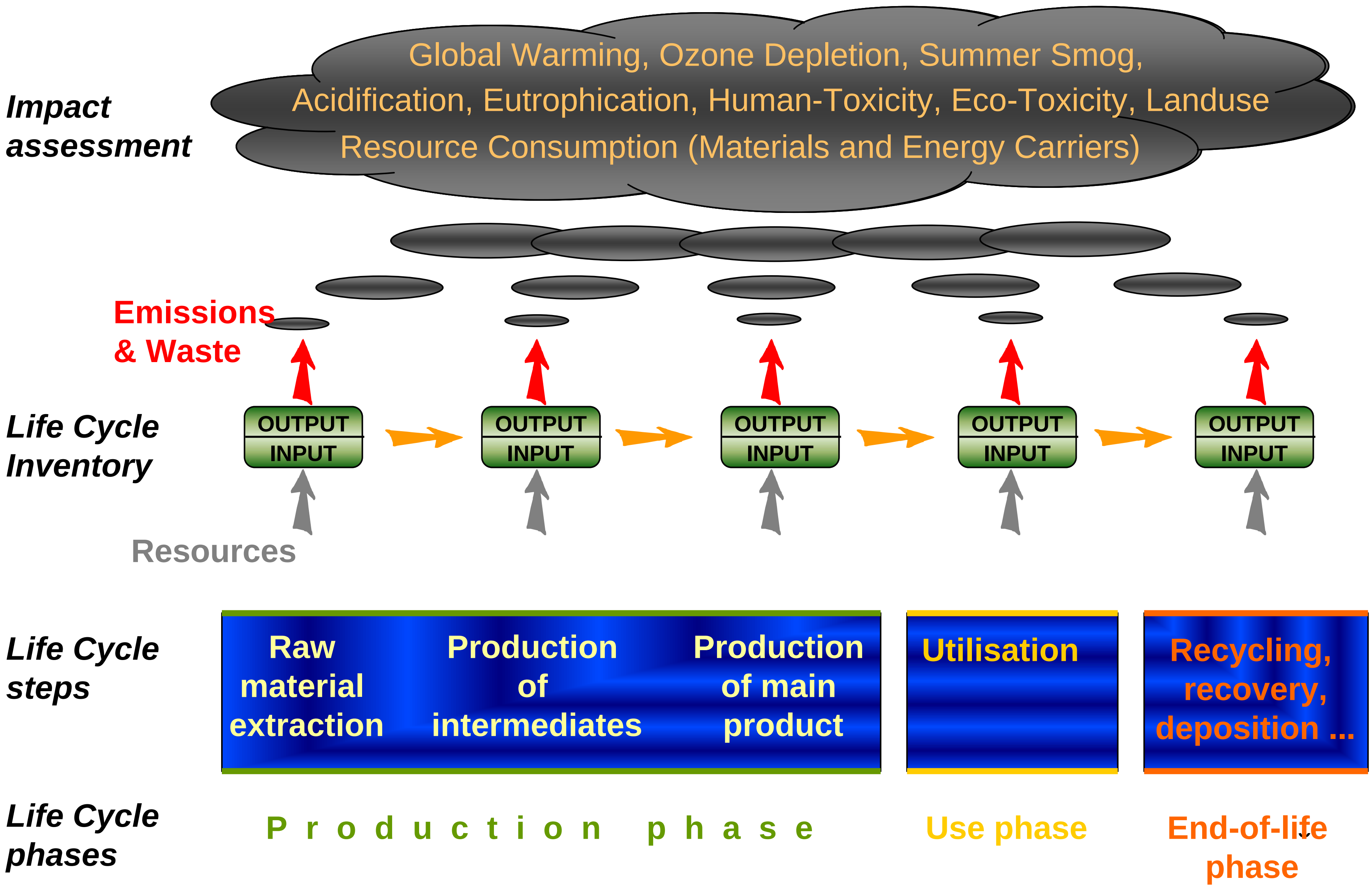
Life Cycle Assessment

Tool for determination of material flows and their impact on the environment



Life Cycle Assessment

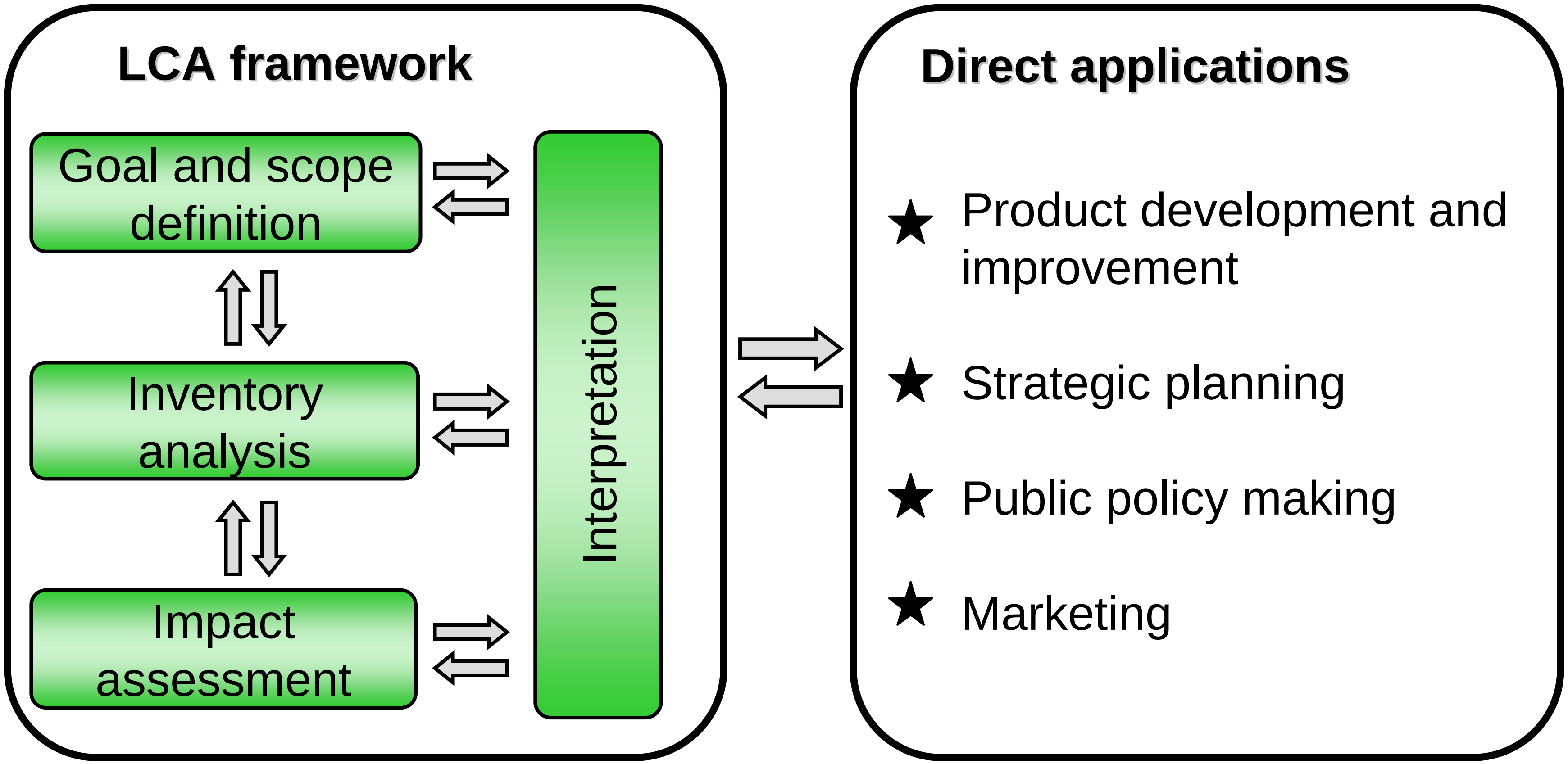
From Cradle-to-Grave

Life Cycle Assessment is a very suitable approach to provide decision support

- ✓ Based on the life cycle approach for evaluating a system, product or service
- ✓ Standardised methodology (DIN ISO 14044)

Life Cycle Assessment

Methodology - ISO 14044



Life Cycle Assessment

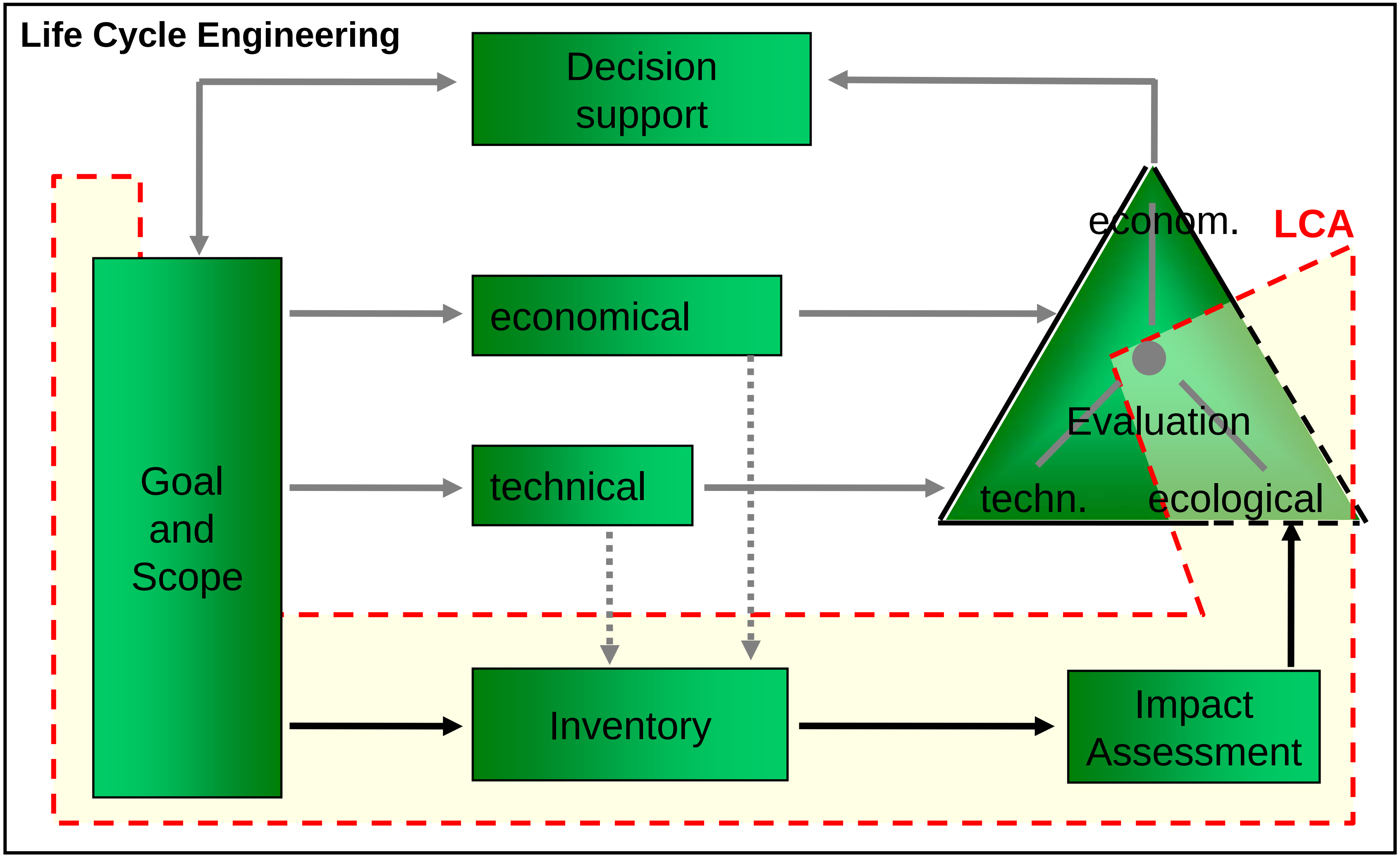
From Cradle-to-Grave

Life Cycle Assessment is a very suitable approach to provide decision support

- ✓ Based on the life cycle approach for evaluating a system, product or service
- ✓ Standardised methodology (DIN ISO 14044)
- ✓ allows consideration of a multitude of emissions/ environmental effects

Life Cycle Engineering

Life Cycle Assessment as part of Life Cycle Engineering



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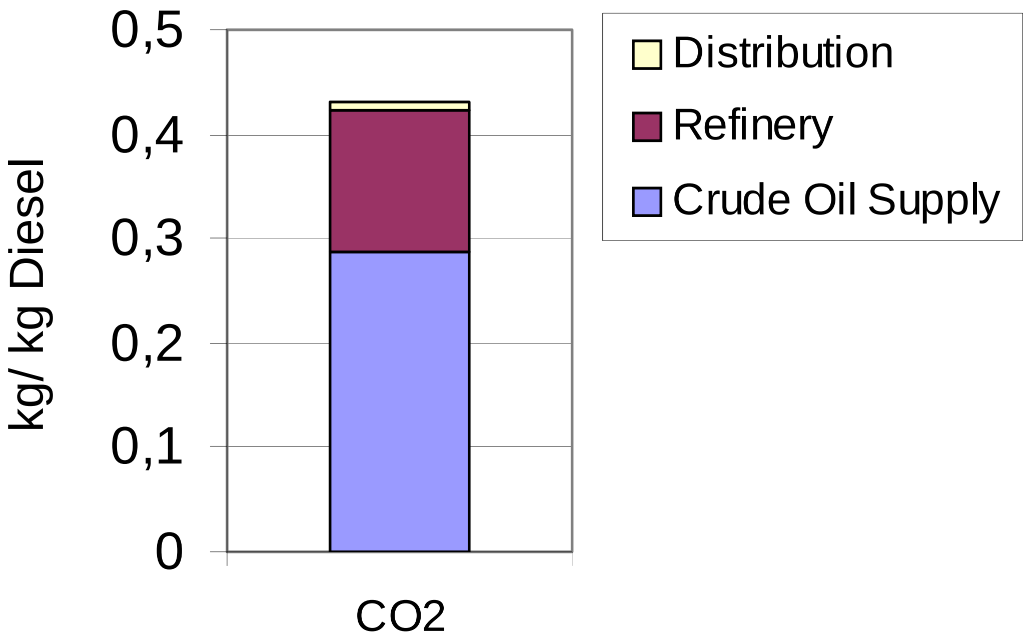
Exemplary LCA results

Quantification of the environmental inventory of a fuel

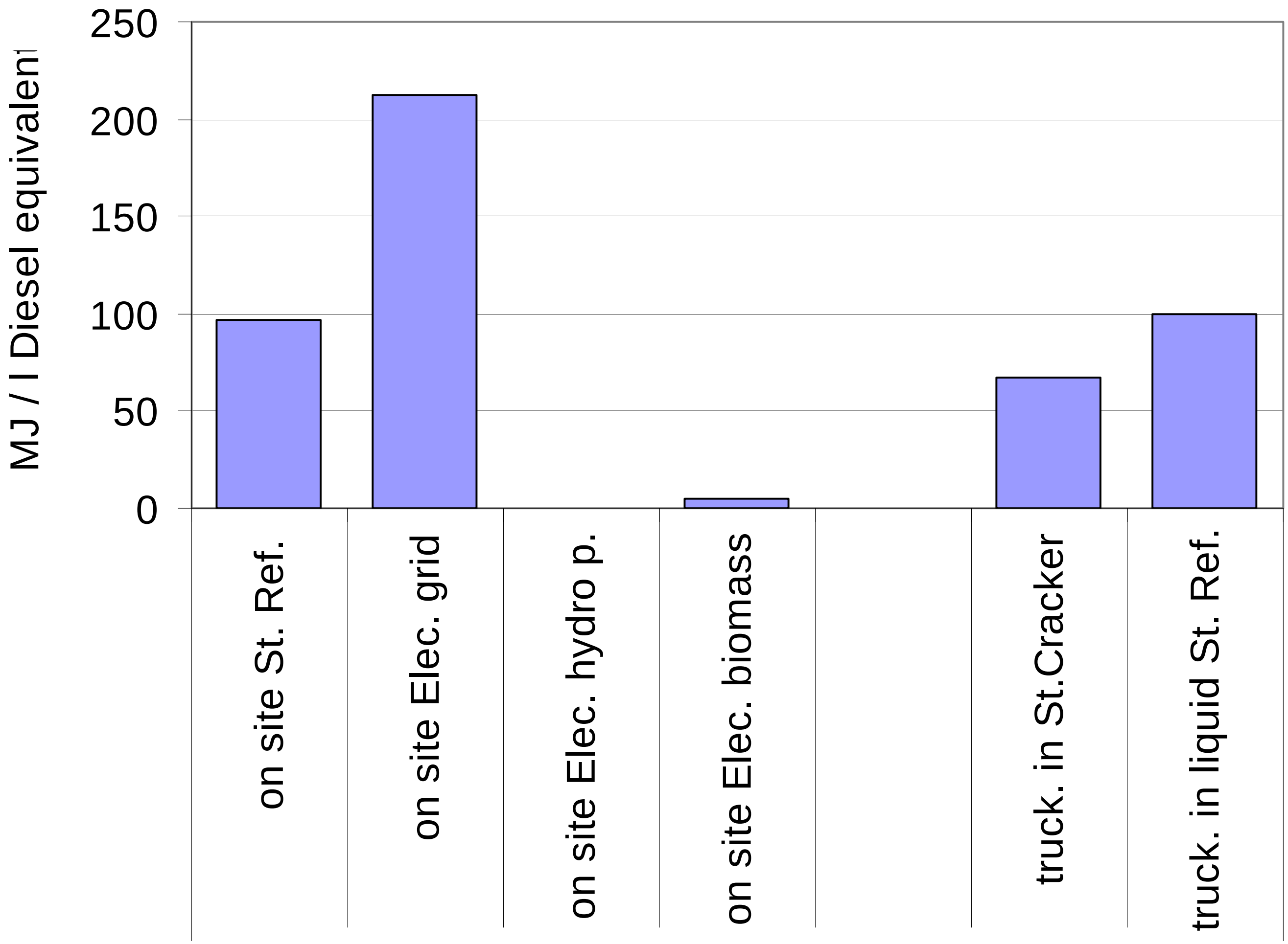
Diesel supply (crude oil based, European boundary conditions)



- Analysis of quantitative contribution of different processes
- Determination of environmental burdens in absolute terms

Exemplary LCA results

Producing a fuel (hydrogen) using different production routes

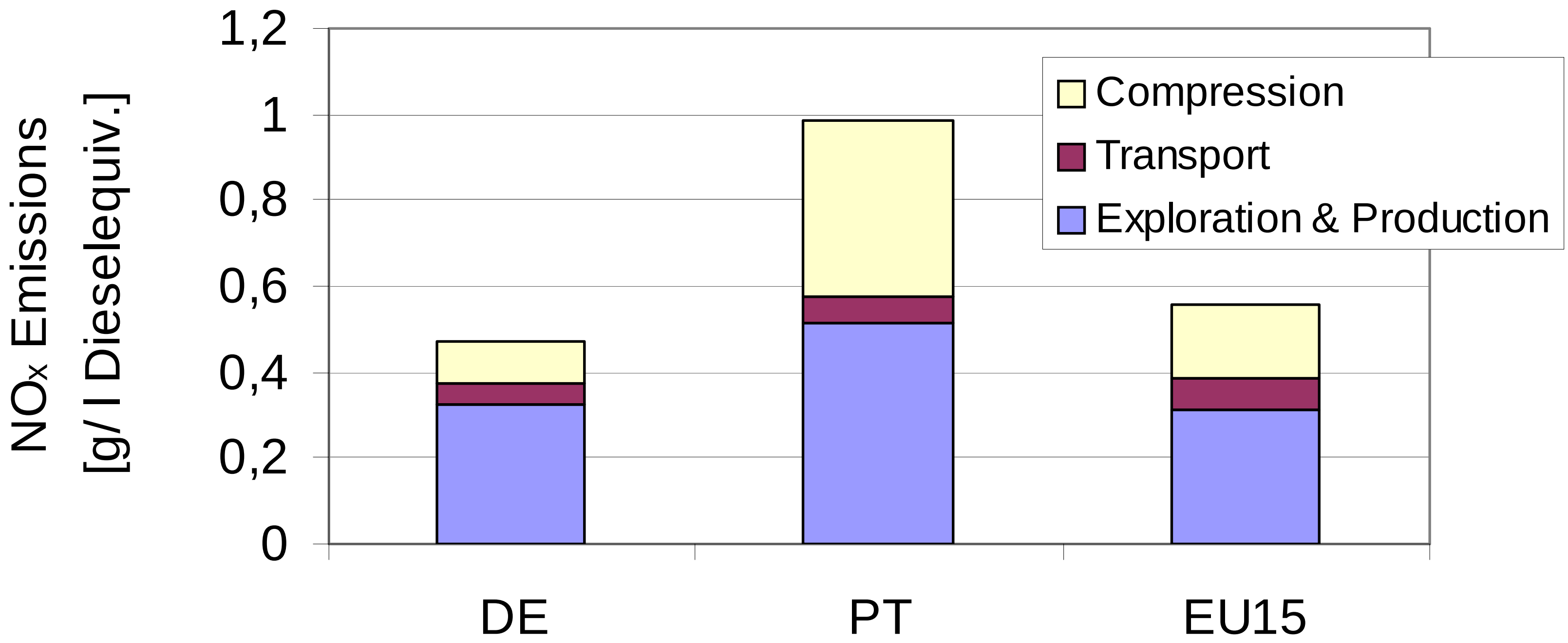


Primary energy demand (non renew. resources)

- Benefit of using renewable resources
- Higher efficiency of centralised large scale production facilities

Exemplary LCA results

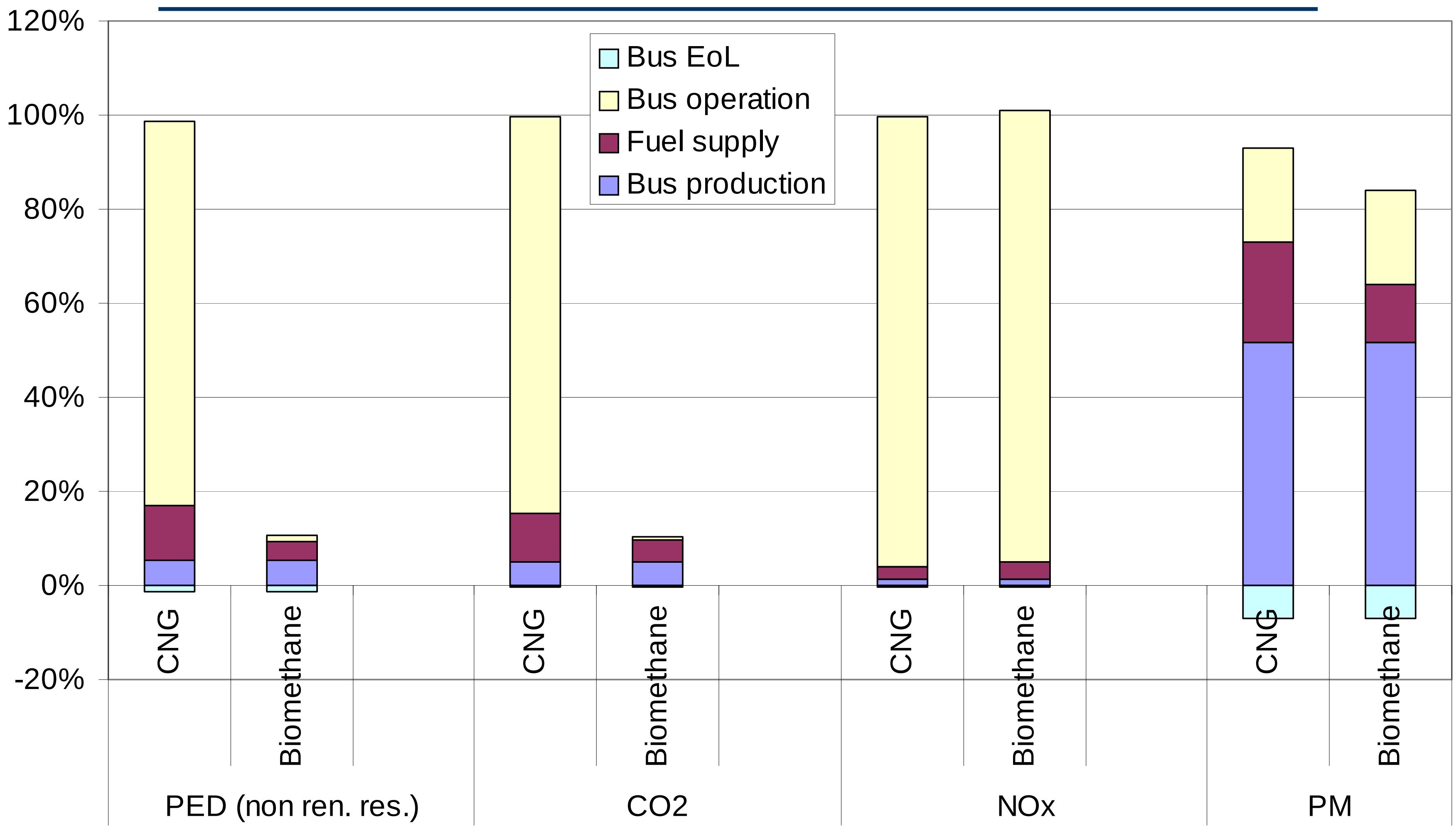
Regional impact of supplying a fuel (CNG)



- Significant differences due to
  - natural gas supply from different regions
  - supply of electricity
- Consideration of varying fuel properties
  → results normalised to the energy content of 1 litre of diesel

Exemplary LCA results

Usage of different fuels in a transport system (CNG Euro 3 bus on Line 42 in Stuttgart)



- Advantage of Biomethane for Primary Energy Demand and CO_2
- Higher NO_x emissions for Biomethane supply
- High relevancy of Bus production and EoL for PM emissions

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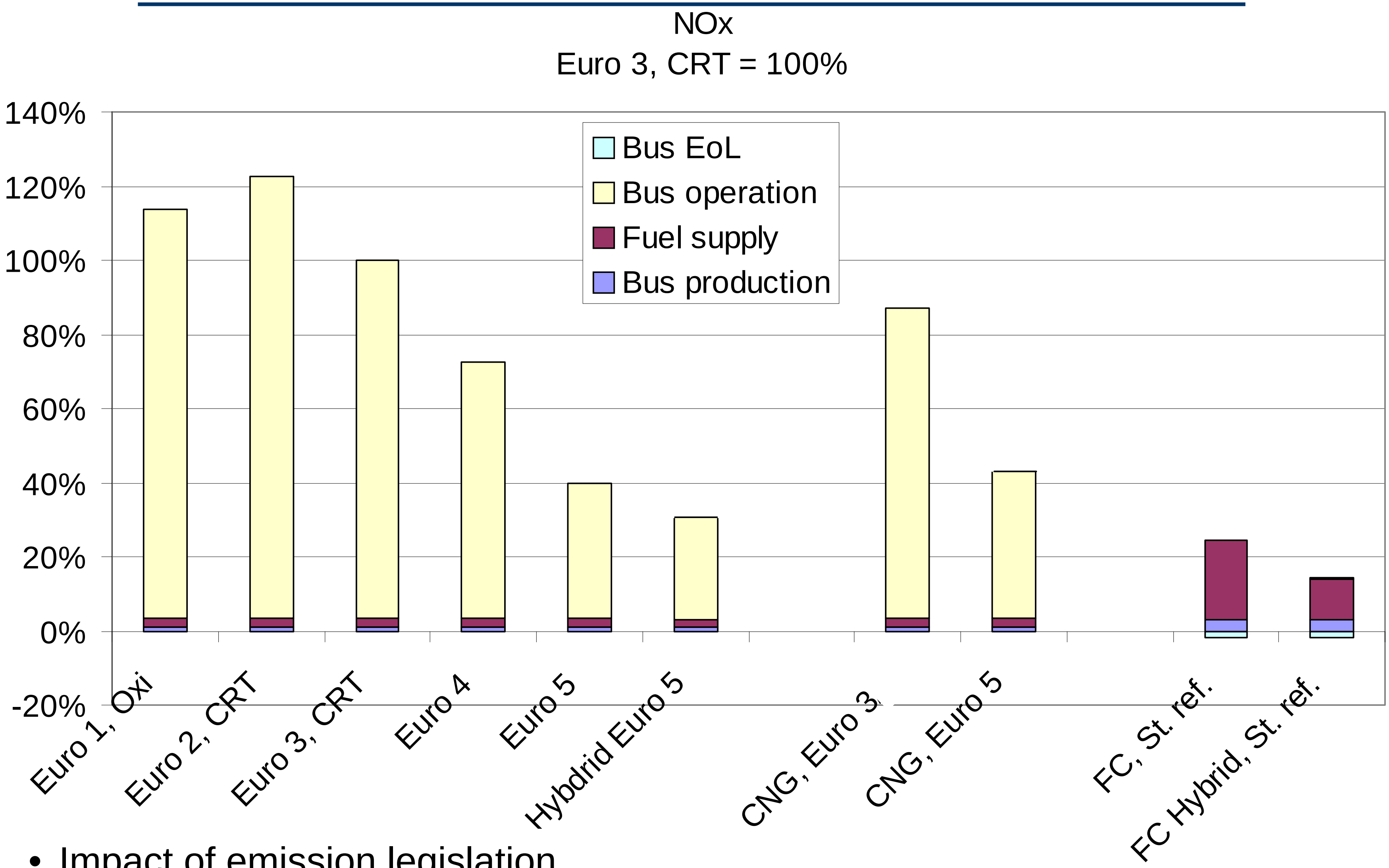
Exemplary LCA results

Various propulsion technologies used on Line 42 in Stuttgart



- Impact of emission legislation
- Advantage for FC bus system

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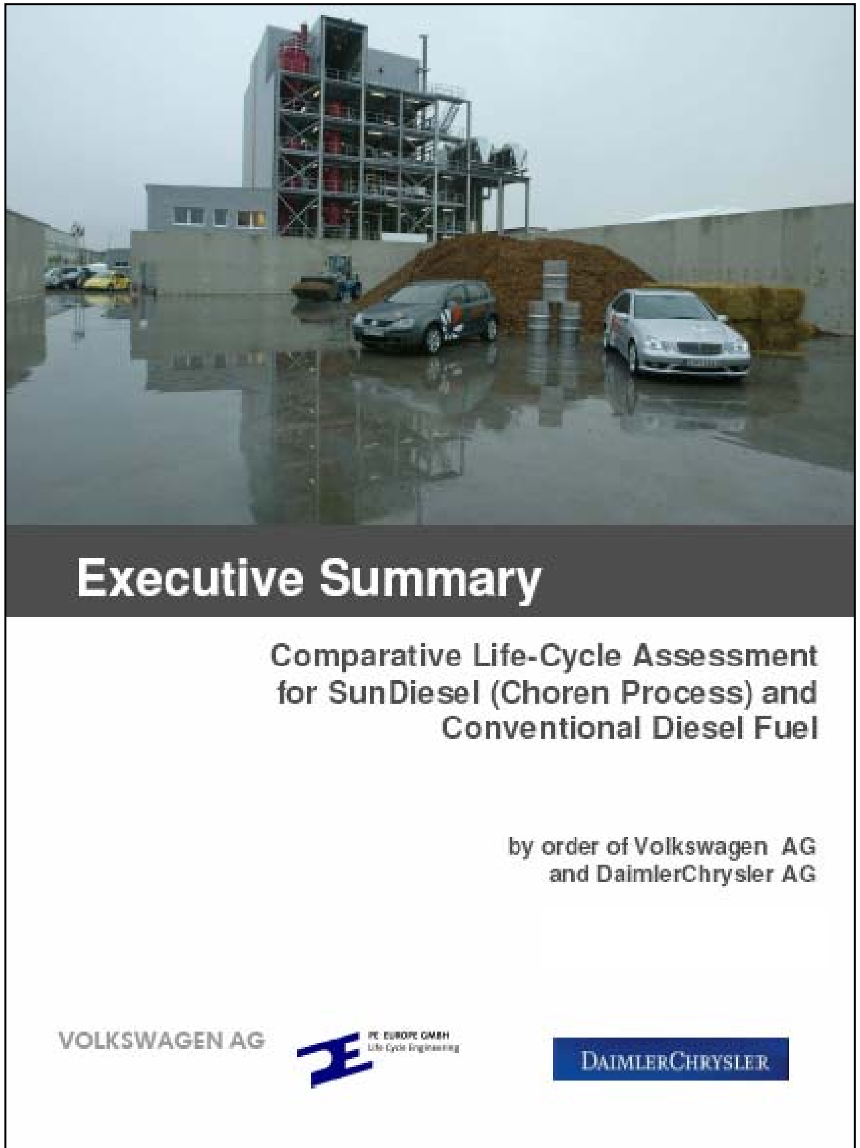
Exemplary LCA results

Comparison of Synthetic Diesel from biomass and conventional diesel


Executive Summary

Comparative Life-Cycle Assessment
for SunDiesel (Choren Process) and
Conventional Diesel Fuel

by order of Volkswagen AG
and DaimlerChrysler AG

VOLKSWAGEN AG
PE EUROPE GMBH Life Cycle Engineering
DAIMLERCHRYSLER

- Fischer Tropsch Diesel via gasification of biomass (wood) using the CarboV process
- Handed over to the German Federal minister of food and agriculture by the heads of R&D of DaimlerChrysler and Volkswagen AG

Exemplary LCA Results – BtL vs. conv. Diesel

Approach

- Complete LCA study of the Choren CarboV process (gasification of wood wastes followed by Fischer Tropsch synthesis) to produce Biomass to Liquid (BtL) Diesel
- Conducted with the fuel producer (Choren) and the fuel user (DaimlerChrysler and Volkswagen)
- fuel producer supplied based on questionnaires:
  - general process data
  - detailed process data (mass and energy flows) for a 43 MW plant
- car manufacturers supplied:
  - test bench data on the use of BtL in their vehicles

Exemplary LCA Results – BtL vs. conv. Diesel

Development of scenarios

- 3 different scenarios were developed for the large scale BtL production (43 MW plant)

  - self sufficiency (on site production of electricity, hydrogen, oxygen and nitrogen based on biomass)

  - partial self sufficiency (on site production of hydrogen (biomass based), external supply of electricity, oxygen and nitrogen from conventional production)

  - future (electricity, hydrogen, oxygen and nitrogen are produced externally based on renewable resources and delivered to the site)

Exemplary LCA Results – BtL vs. conv. Diesel

General conditions and results of the 3 scenarios

	Scenario		
	Future	**Self-sufficiency basis**	**Partial self-sufficiency**
Transportation of wood Forest > Choren Plant	50 km		
Fuel transportation Choren Plant > petrol station	50 km		
Sensitivity analyses	100% standing timber as biomass input Transportation distance, forest-Choren Plant 200 km Transportation distance Choren Plant – petrol station 100 km		
Mass ratio Biomass [kg] to diesel [kg]	≈ 3.4 : 1 (35 % H_2O) ≈ 2.2 : 1 (atro)	≈ 9.3 : 1 (35 %H_2O) ≈ 6 : 1 (atro)	≈ 7.5 : 1 (35 % H_2O) ≈ 4.9 : 1 (atro)
Efficiency Choren Process [%] (Hu Output / Hu Input)	≈ 64 %	≈ 45 %	≈ 55 %
Global warming potential compared with conv. diesel	-91 %	-87 %	-61 %

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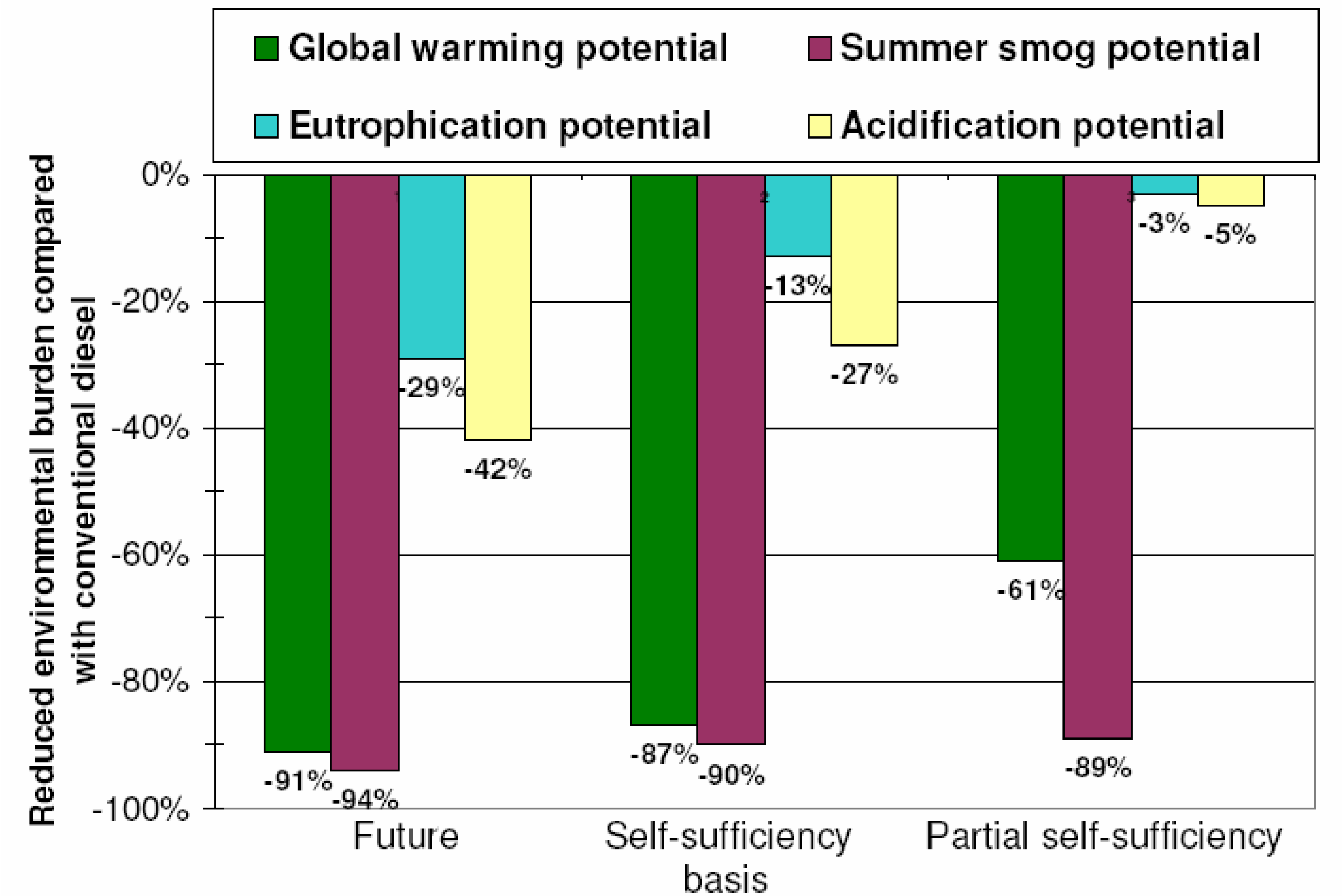
LCA Results – Comparison of BtL and conv. Diesel

Reduction potential of BtL vs conv. Diesel in the 3 scenarios



- Substantial savings for GWP and POCP
- Savings for AP and EP depending on boundary conditions less clear

LCA Results – Comparison of BtL and conv. Diesel

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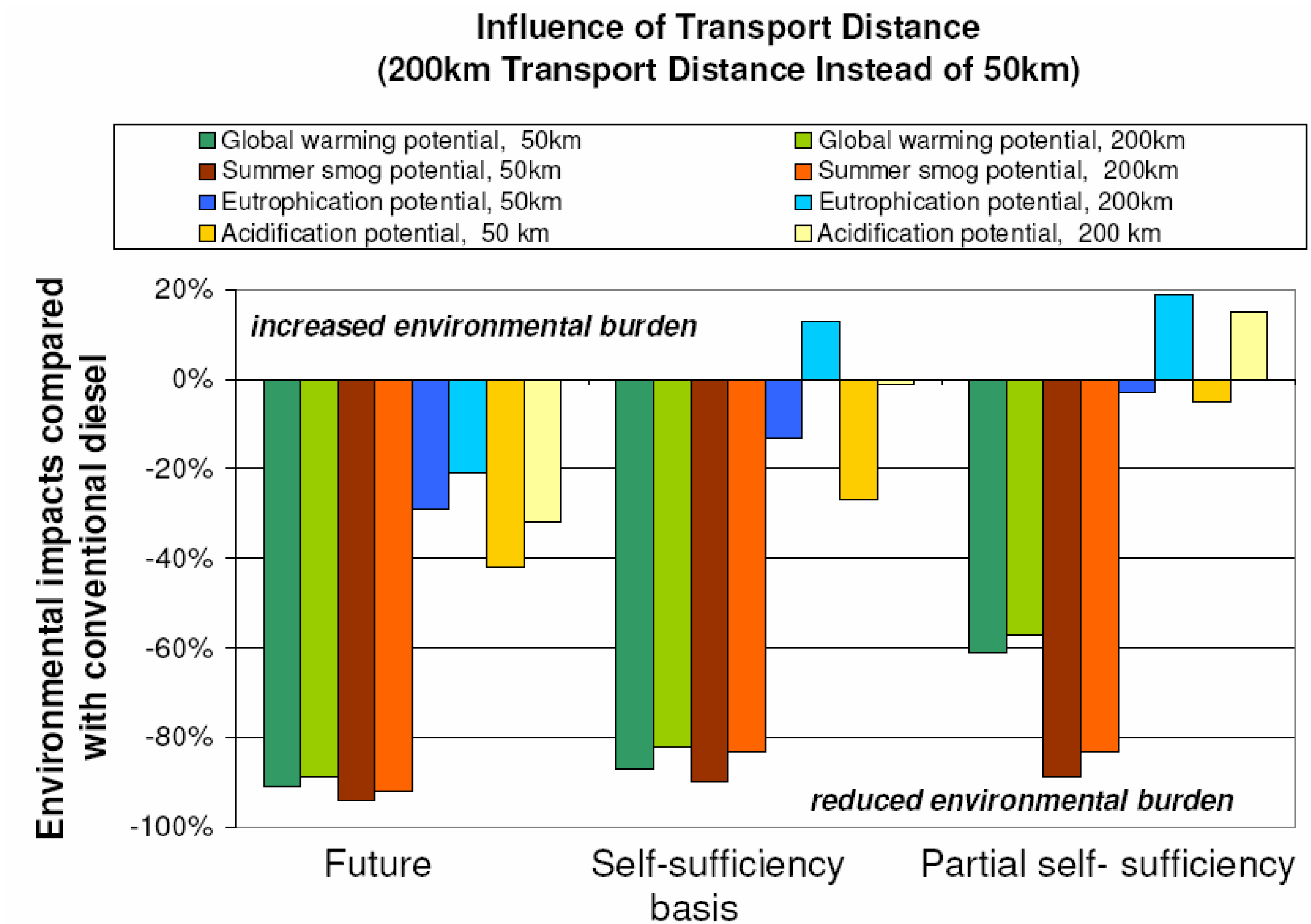
Variation of transport distance



- Break even points for AP: self sufficiency 120 km
  partial self sufficiency 70 km

Conclusions

- **Alternative fuels/propulsion systems required** to avoid increasing dependency from energy imports and increasing environmental pollution
- Need for **quantitative assessment** of the environmental impact of alternative fuels and propulsion systems in the transport sector
- Essential to **consider the whole life cycle** of a transportation system and not only the operation phase
- **Life Cycle Assessment** appropriate methodology for decision support (quantitative, standardised, transparent, R&D accompanying)
- To ensure that there is no **shift of environmental burdens** between impact categories, it is essential to consider various impact categories
- For fuel supply the **regional boundary conditions**/ the used **primary energy carrier (mix)** and the used conversion technologies are decisive
- **Renewable primary energy carriers** will address the Kyoto commitment, locally relevant emissions (e.g. NO_x, PM) have to monitored
- **Production of transport carriers** becomes more relevant

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Thank you for your attention!

New subsidiary opened in Australia

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