Can HFC in automotive use contribute to EU goals?

Societal priorities and goals in the EU
Quantifying the reasons for supporting HFC

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Zero Regio
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Societal priorities and goals

- Energy efficiency
- Cost effectiveness
- Eco-efficiency
- Supply security

- Can HFC in transport contribute to EU goals?
- Focus on 2015-2025

Which competing technology?
TtW energy efficiency advantage

JRC EUCAR and CONCAVE (2006):	
Direct hydrogen	**0%**
Direct hydrogen hybrid	**-11%**
Gasoline PISI hybrid	**72%**
Gasoline/ethanol DISI hybrid	**73%**
Diesel/biodiesel DICI+DPF hybrid	**55%**
CNG PISI	**48%**
LH2 PISI	**40%**
Argonne National Laboratory (2007):	
CIDI Vehicle (CD, BD, FTD, DME,RFG)	**71%**
Gasoline etc. hybrids (EtOH, MeOH, NG, RFG)	**53%**
Diesel etc. hybrids (BD, FTD, or CD)	**33%**
Hydrogen Fuel-Cell Vehicles	**0%**
Battery Electric Vehicles	**-34%**

Eaten up by WtT conversion loss?

	Worst	Best
TtW efficiency advantage	**50%**	**50%**
WtT ("system") efficiency	**62%**	**70%**
WtW efficiency gain	**1%**	**14%**

Will NG based H2 be delinked from the oil price?

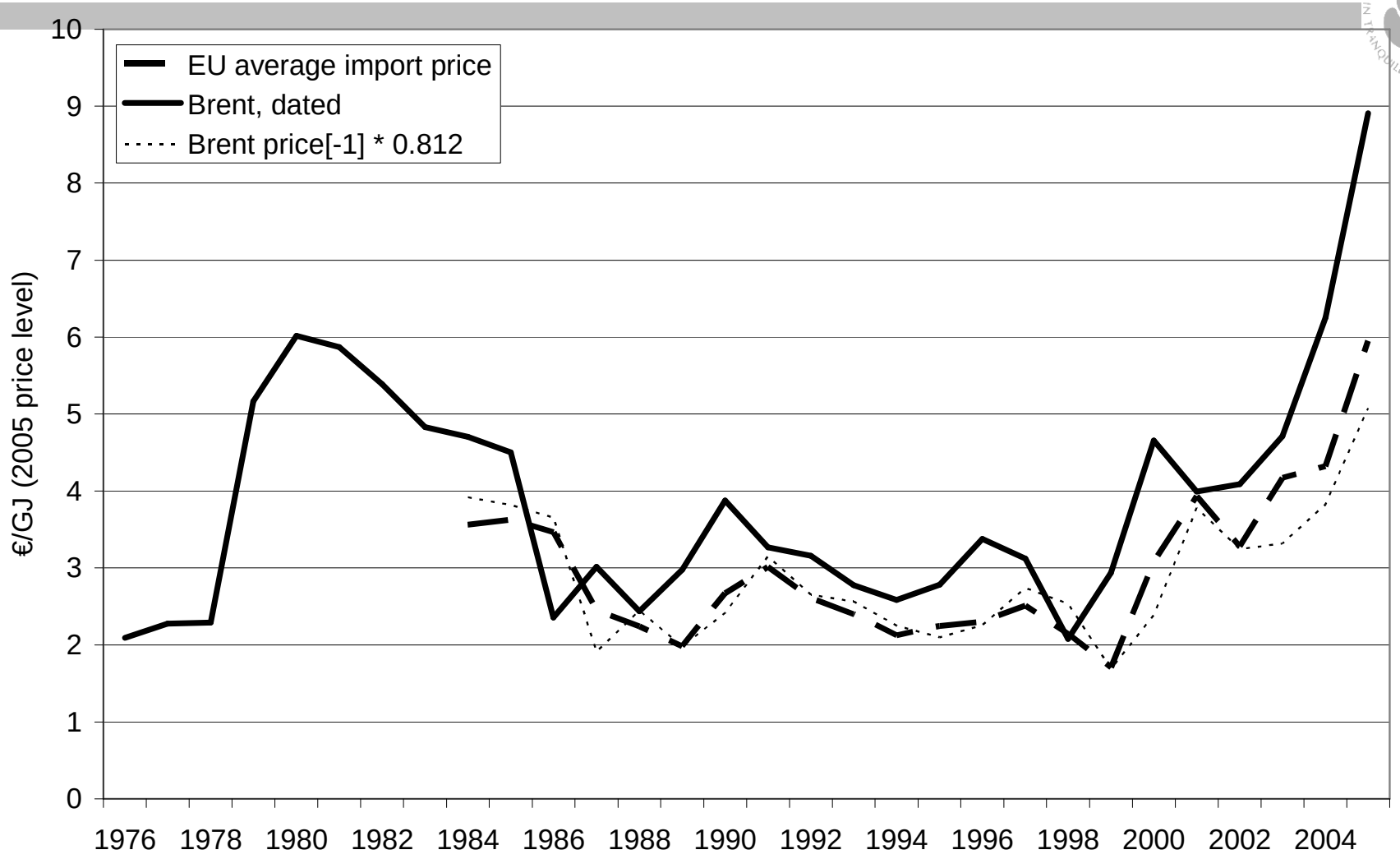


Figure 1. Natural Gas and Oi Prices 1976-2005.

Coal price and oil price

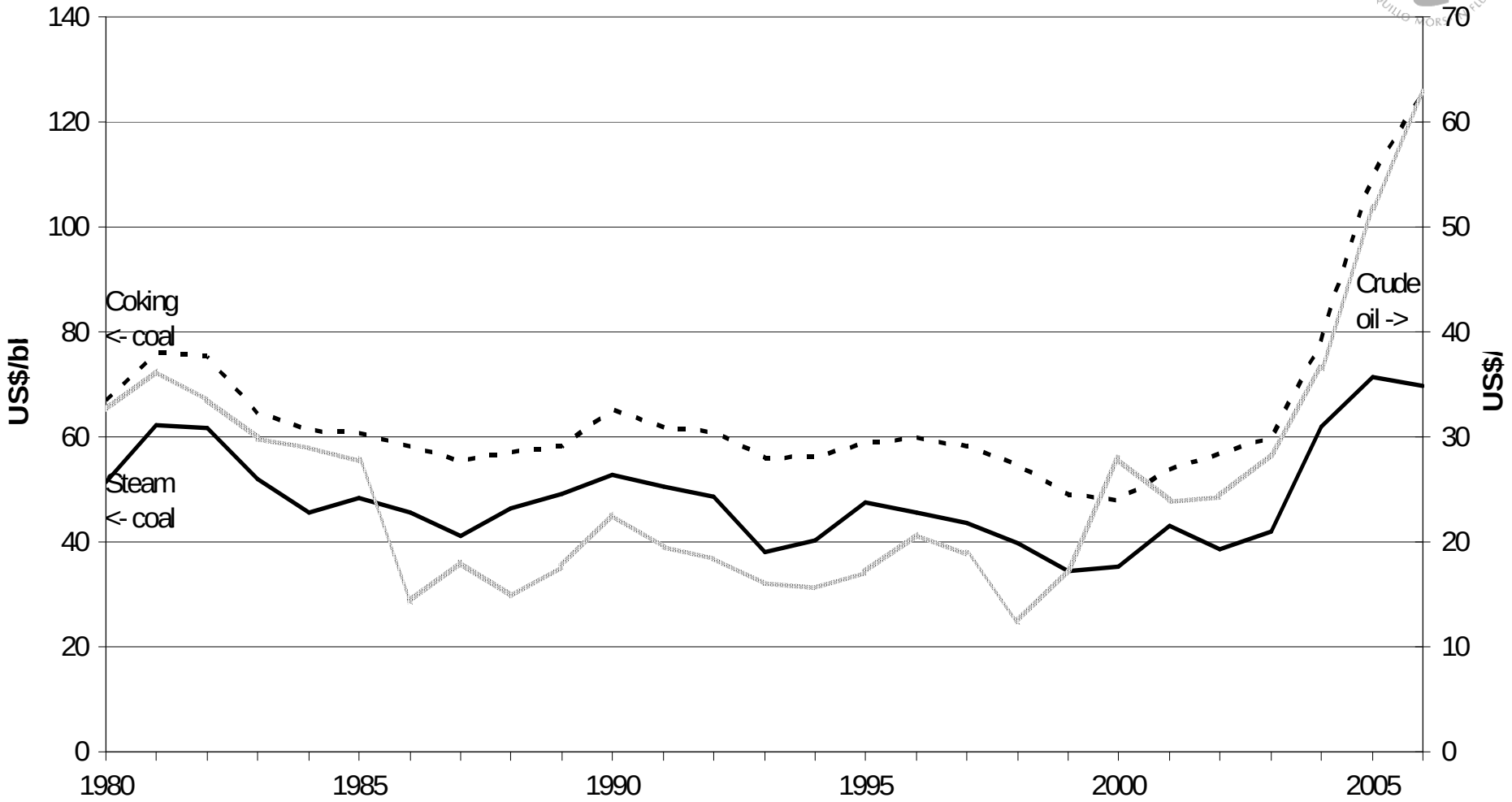


Figure 2. European Coal and Oil Prices 1980-2006.
Source: International Energy Agency (IEA): Energy prices and taxes. Database. http://www.oecd.org, 12.11.07.

Competitiveness threshold for fuel cost per km

Diesel and petrol (€/GJ)	0		10		10		10		20	
Hydrogen (€/GJ)	0		10		0		0		0	
Natural gas (€/GJ)	0		0		10		8		16	
	NG	Win	NG	Win	NG	Win	NG	Win	NG	Win
Best case ($/bbl)	188	105	86	85	174	45	115	45	42	-16
Worst case ($/bbl)	542	170	327	150	590	110	452	110	362	49

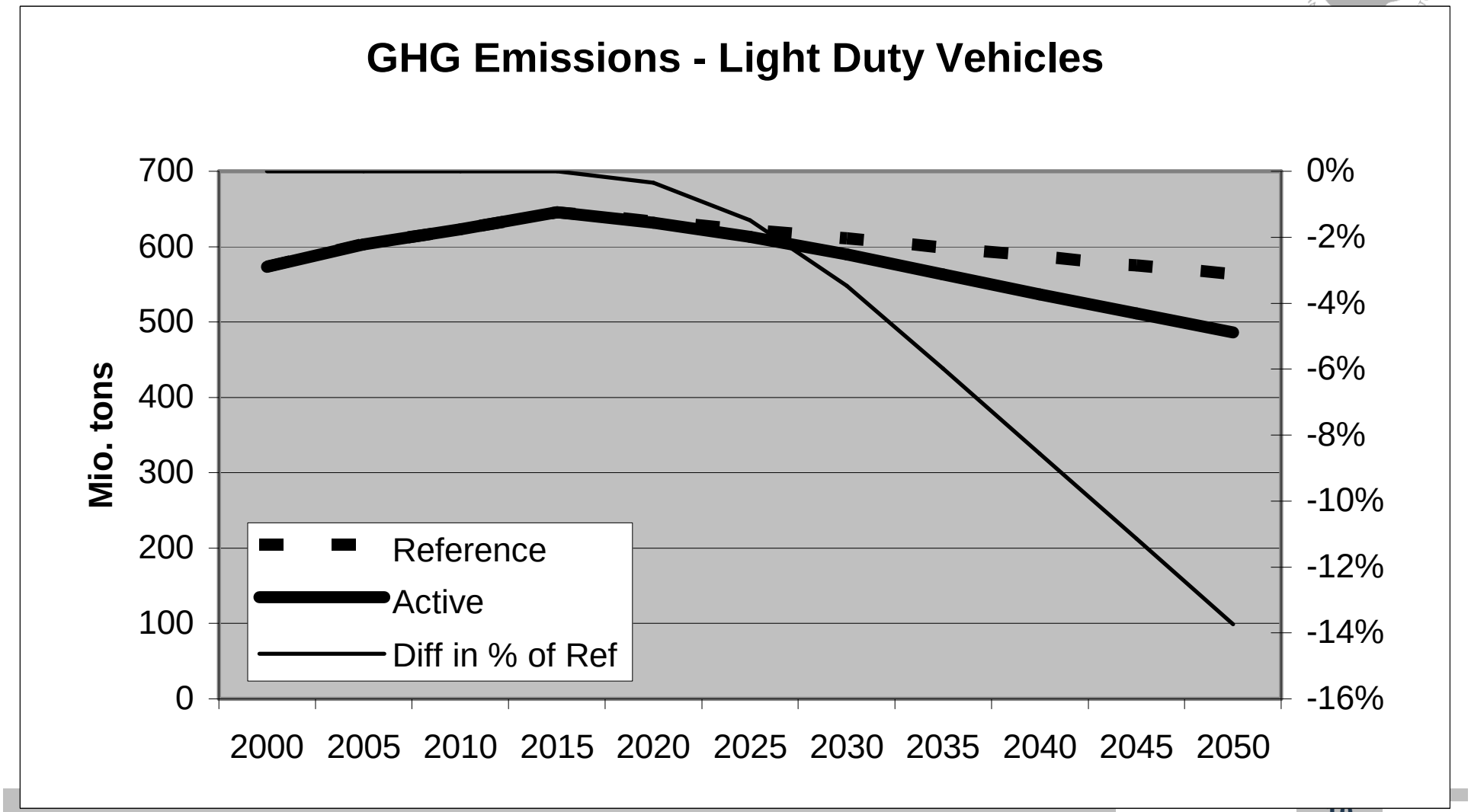
Model

- Model
  - from Sustainable Mobility Project
  - WBCSD and IEA
- Only passenger cars in Europe
- Levels are debatable since assumptions would probably be different today
  - But we only look for changes

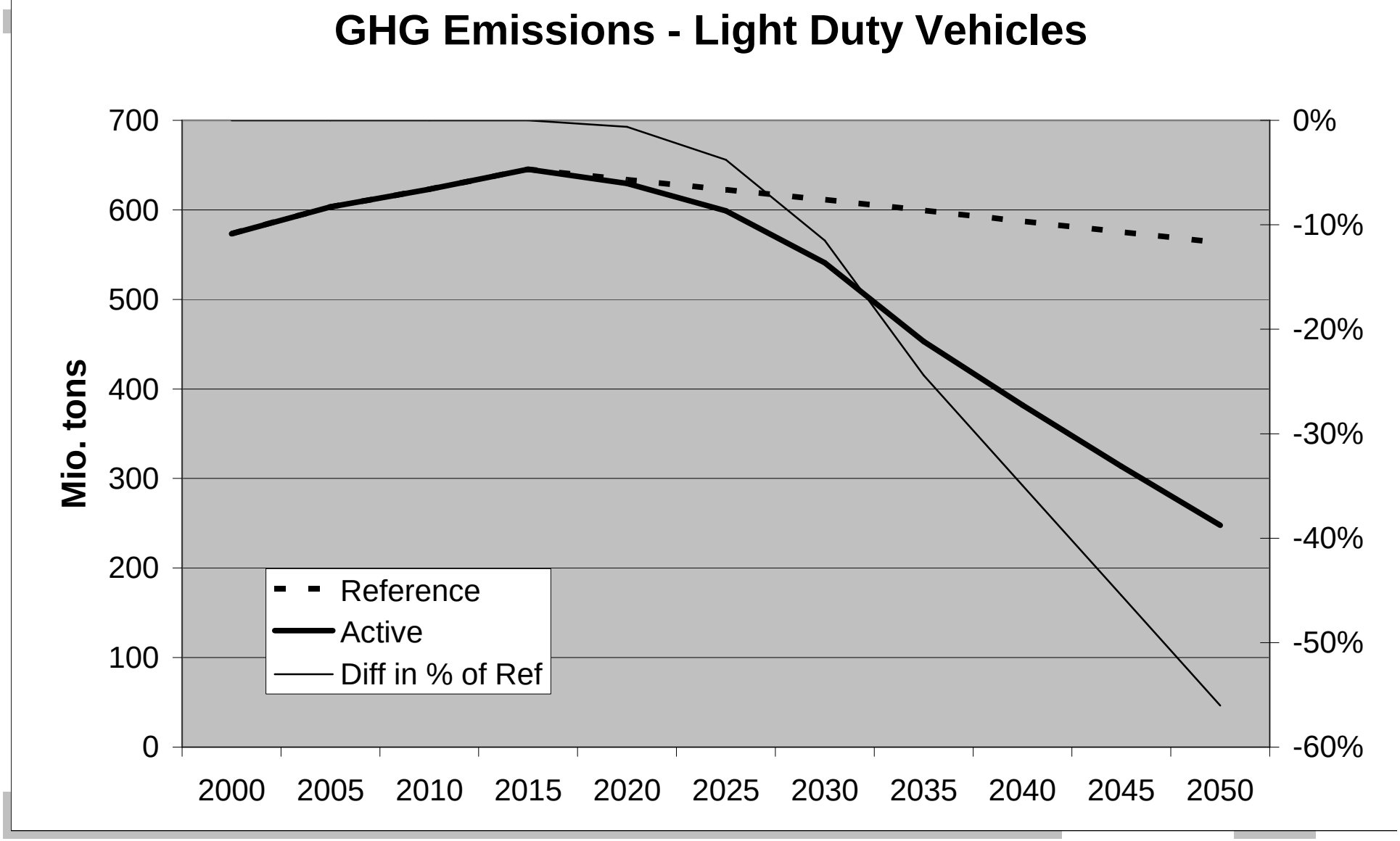
Scenarios

1) A reference scenario
   - Almost only gasoline and diesel
   - Market shares of hybrids, LPG/CNG, and EV negligible
2) NG based HFC scenario
   - Introduction of HFC in passenger car market is advanced
   - 41% of passenger car sales in 2050
   - hydrogen is based on natural gas
3) Low carbon HFC scenario
   - Like NG based scenario, but
   - H_2 is produced with GHG emission free or light methods
   - Low carbon H_2 99% market share in 2025

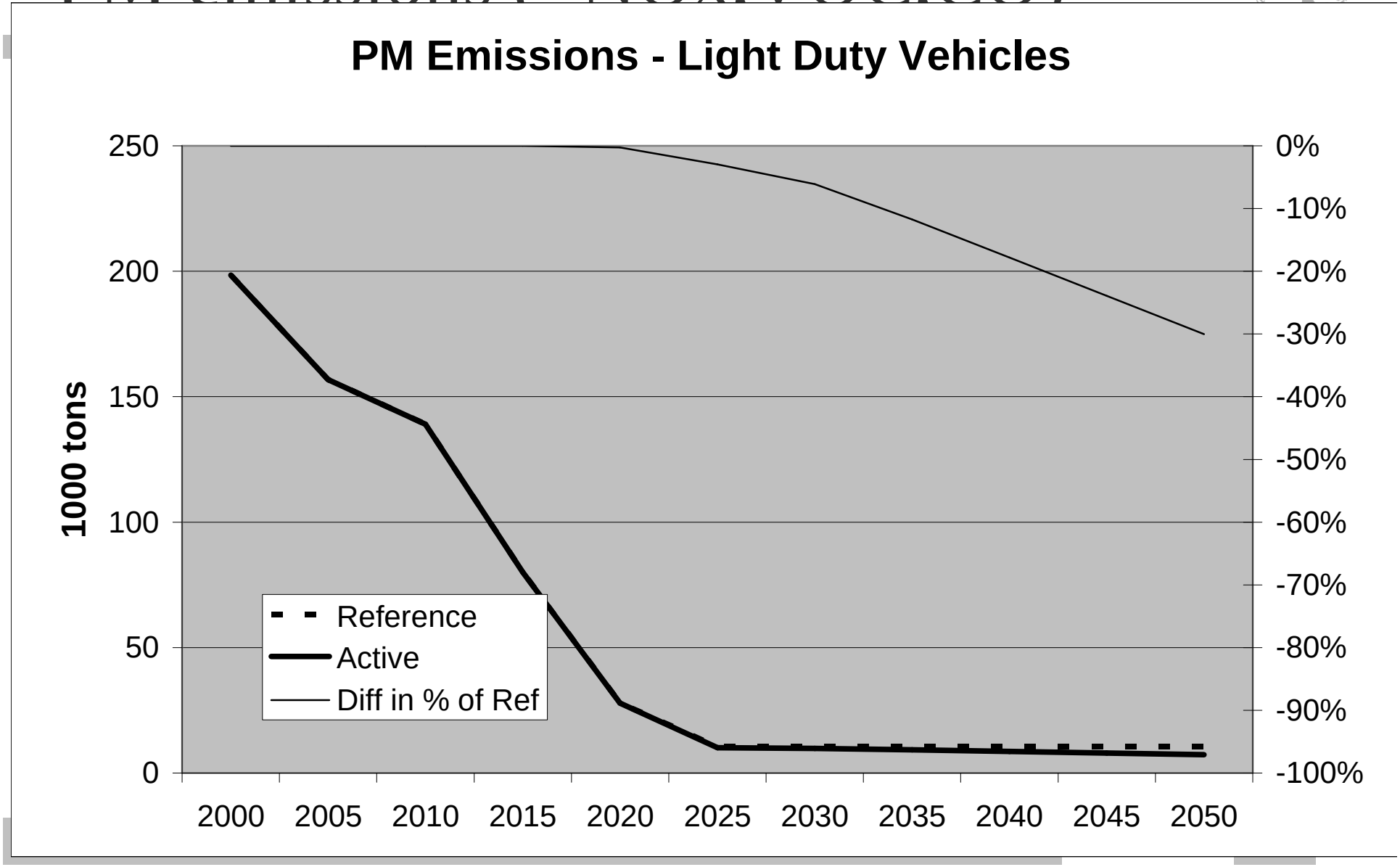
NG based HFC scenario
GHG emissions



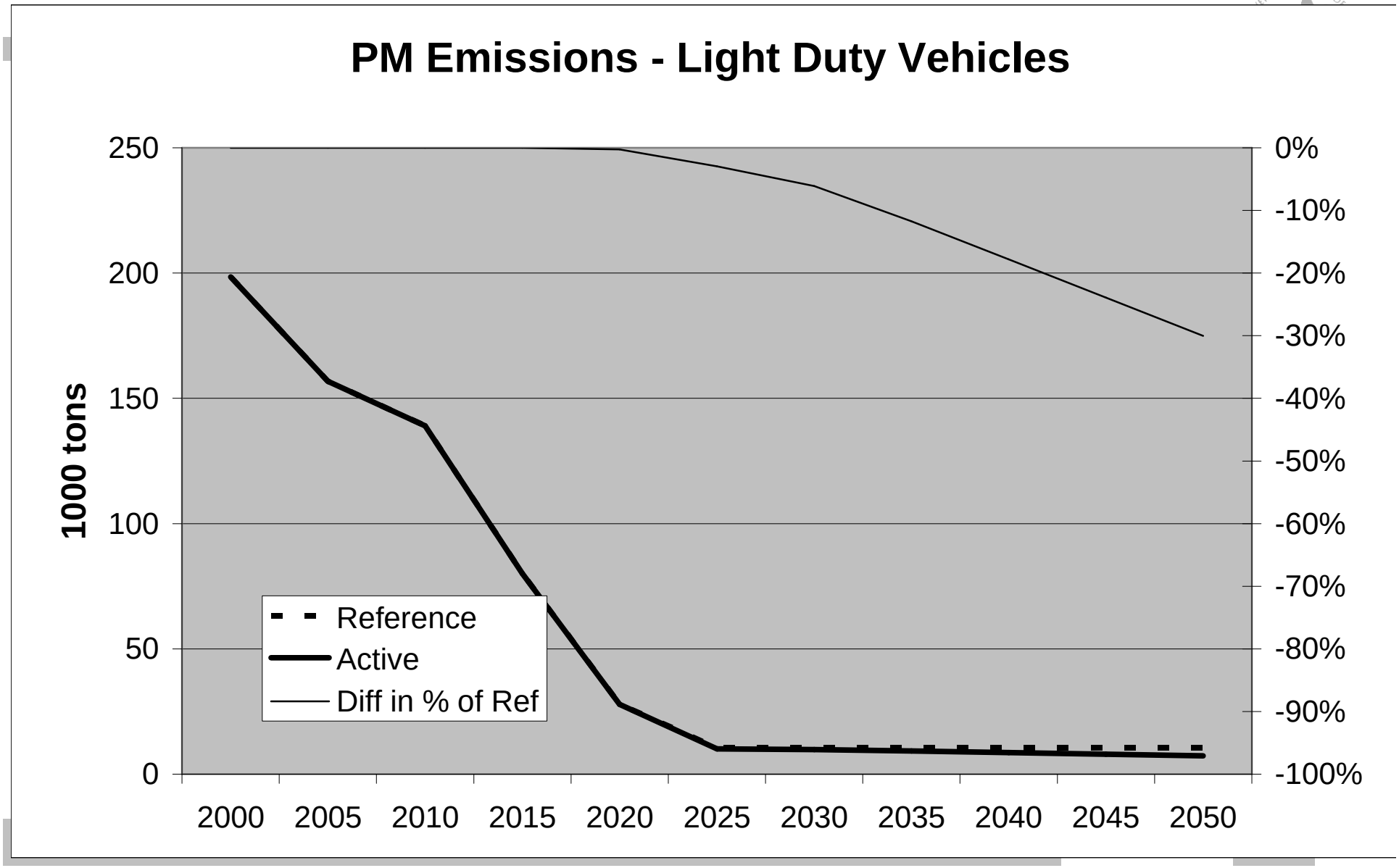
Low carbon HFC scenario
GHG emissions



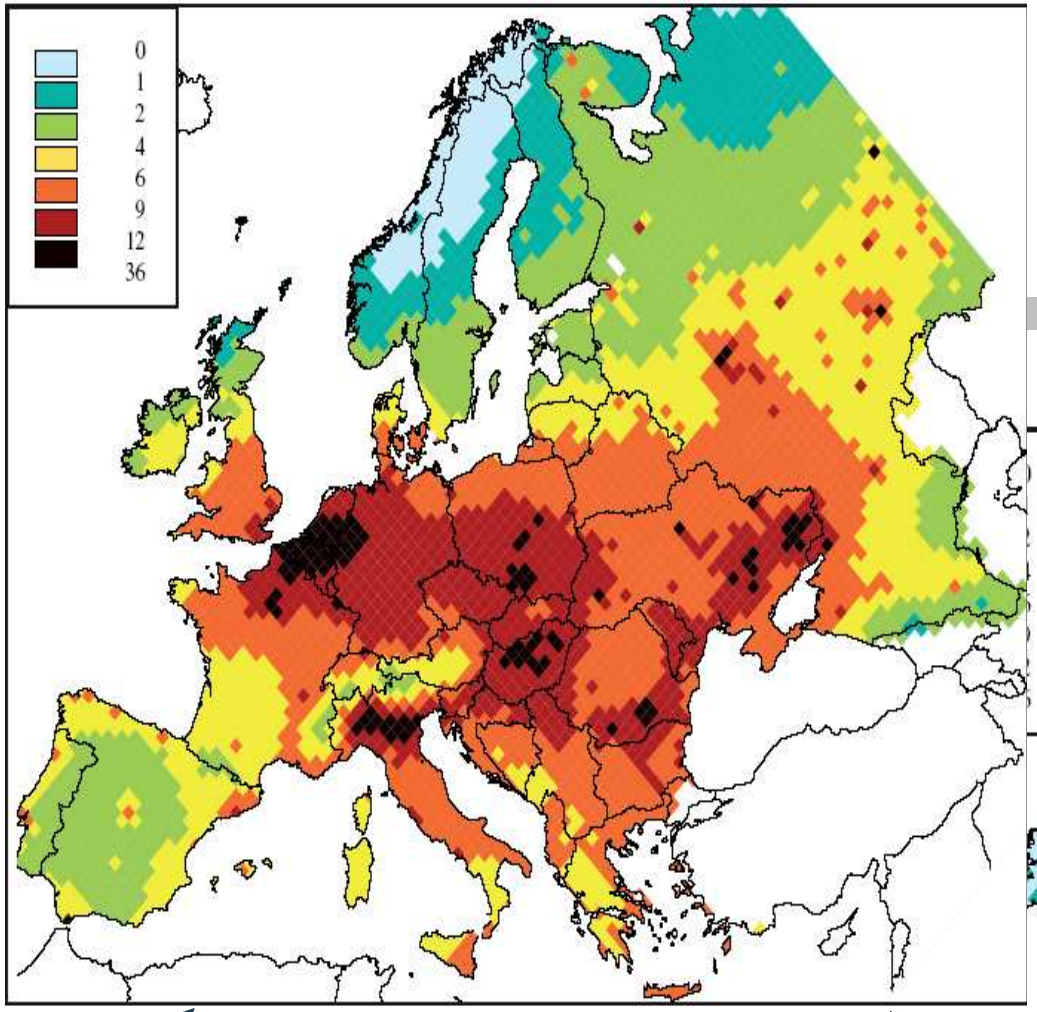
NG based HFC scenario
PM emissions (≈NOx,VOC,CO)



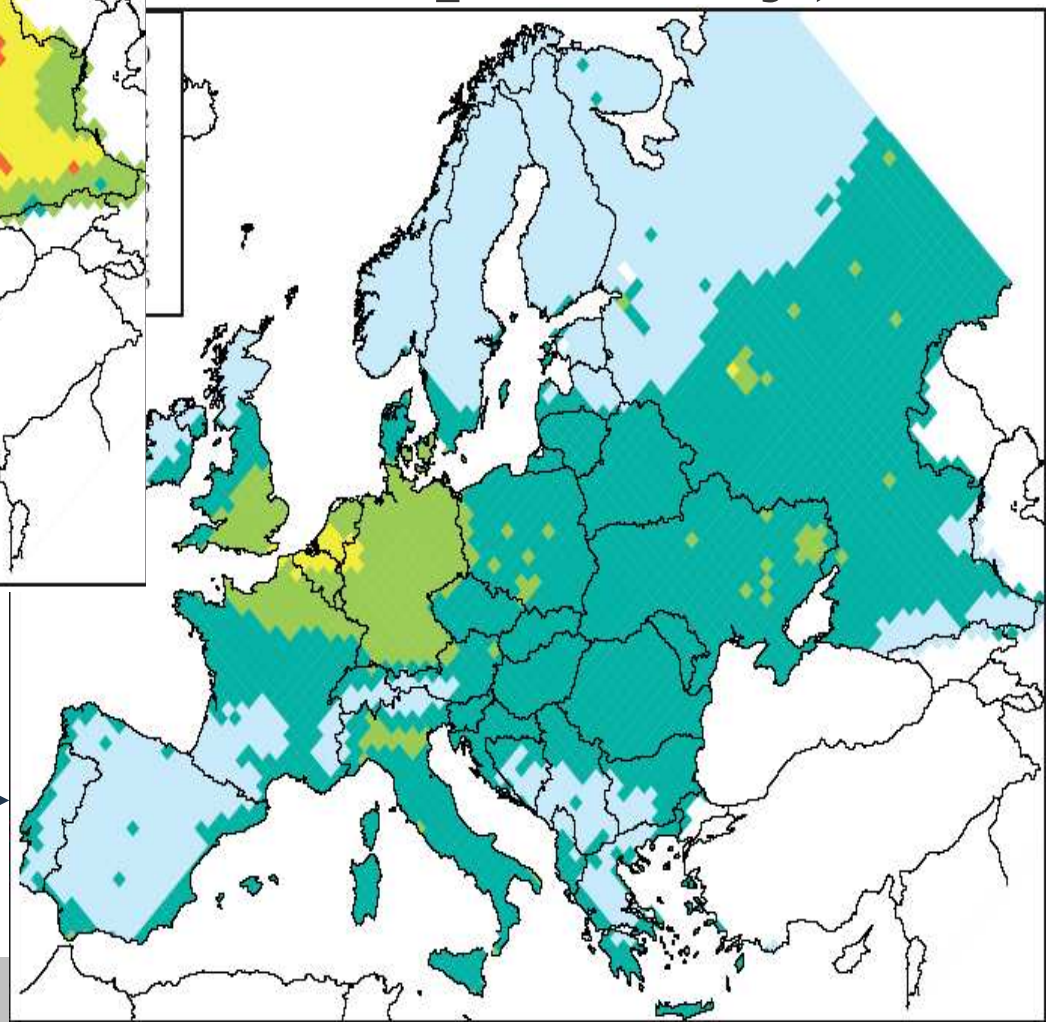
Low carbon HFC scenario
PM emissions (≈NOx,VOC,CO)



PM 2.5 deaths (loss of statistical life expectancy)



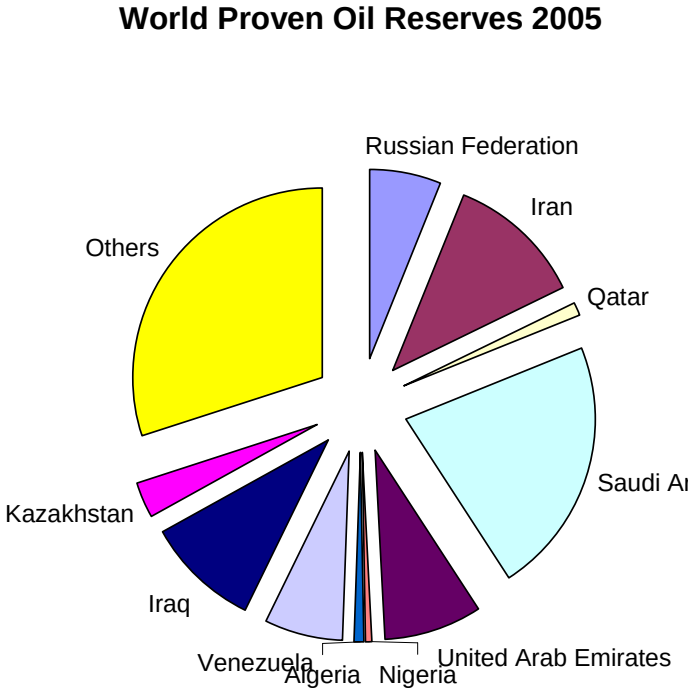
2000

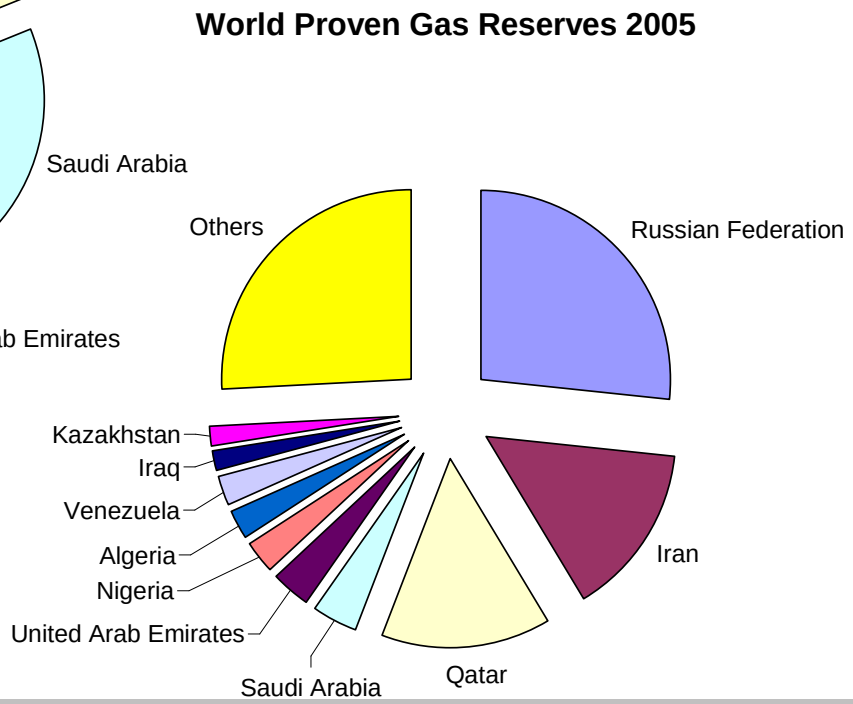


2020 after EU Air Strategy and Maximum Climate Action

Source: EEA (2006)

Concentration of remaining reserves





Cost effectiveness in a dynamic perspective

- Dynamic effects throughout the fuel chain (and commodity chain for equipment)
  - Pull forces
  - User-producer interaction
  - Economies of scope
  - External economies of scale (cluster effects)
  - ….

Summary

- Why advance the introduction of HFC prior to the competitiveness threshold?
  - Energy efficiency
    - System efficiency >> 62%
  - Eco-efficiency
    - Renewables, nuclear, CCS and filters on fossil fuels
    - Hotspot areas
  - Cost efficiency
    - Oil price independent primary energy
    - Fuel and commodity chain innovation effects
  - Supply security: Less dependence of oil & gas
    - Renewables, nuclear, coal

Recent EECG Research Papers on HFC in automotive use from Department of Environmental, Social and Spatial Change (ENSPAC) at Roskilde University

Hansen, A. C. (2007) Where in Europe Will Hydrogen Become Competitive First? http://hdl.handle.net/1800/3012

Hansen, A. C. (2007) When Will Hydrogen Become a Competitive Transport Fuel? http://hdl.handle.net/1800/3011

Hansen, A. C. (2007) Hydrogen and Fuel Taxation. http://hdl.handle.net/1800/2991

Hansen, A. C. (2007) The Potential Contibution of Hydrogen to Societal Goals. http://hdl.handle.net/1800/2979

Hansen, A. C. (2007) The Supply Security of Hydrogen as Transport Fuel.http://hdl.handle.net/1800/2978

Hansen, A. C. (2007) Hydrogen and Fuel Cell Technology in EU LDV Transport: Potential Contribution to Environmental Goals. http://rudar.ruc.dk/handle/1800/2434

Hansen, A. C. (2007) The International Oil Price and Hydrogen Competitiveness. http://rudar.ruc.dk/handle/1800/2433