HyWays
European Hydrogen Enery Roadmap

- First Results from Simulation, Stakeholder Discussion and Evaluation -

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Motivation

Project goals/ objectives

Partners

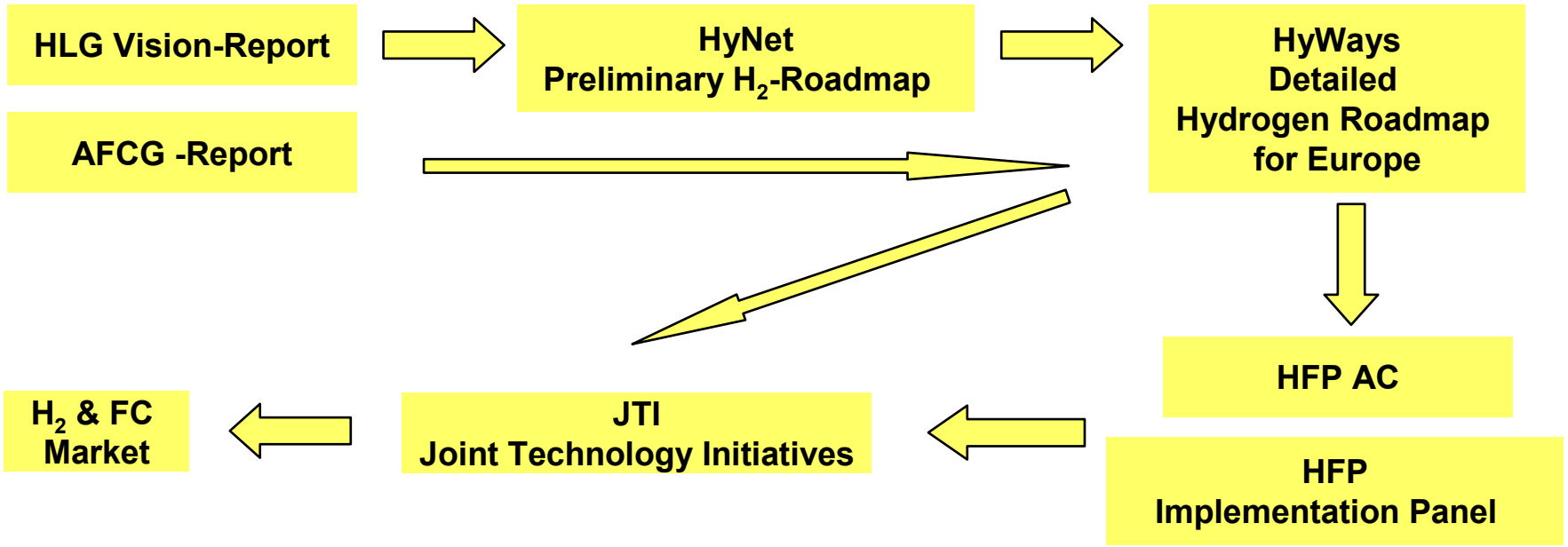
Methodology

First preliminary results

Acknowledgement

Motivation

Need for a European hydrogen energy roadmap as orientation and decision basis for industry, politics and society



Project goals

"If hydrogen has an X share in the future energy system…

- no prediction, no commitment, but plausible assumptions

… then what is the impact...

- on greenhouse gases and other emissions, economy, industry and society (competitiveness, employment)

… and how can we get there?"

- Scenarios for market introduction of hydrogen applications (vehicles, CHP, …), infrastructure build-up and energy diversification (hydrogen production)
- Recommendations to EC, Member States and industry

Objectives of the HyWays project

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A European Hydrogen Energy Roadmap

EU MS Hydrogen Energy Roadmaps

Pull

Why?

Long-term vision

Requirements

What? When?

Technical Roadmap

Socio-economic roadmap

Pull

Requirements

How? When?

EU Action Plan

Partners

Partners

HyWays

Industry

BMW Group

DaimlerChrysler

GM

Opel

Air Liquide

Air Products

Repsol YPF

Linde

Statkraft

GE Oil & Gas

Vattenfall

Total

EDF Electricité de France

Hydro

Hygear

infraserv höchst

DNV

acciona Biocombustibles

Hydrogenics Corporation

Member states

SenterNovem

dena Deutsche Energie-Agentur

dti

Hellenic Institute of Transport

VTT

Institutes

cea

INTA

gig Główny Instytut Górnictwa

ENEA

Bureau d'économie théorique et appliquée (BETA) UMR 7522

IDMEC Pólo Instituto Superior Técnico

Fraunhofer ISI Institute Systems and Innovation Research

L-B-Systemtechnik

ECN Energy research Centre of the Netherlands

ZEW Zentrum für Europäische Wirtschaftsforschung GmbH

APR 04 - MAR 07 in 2 phases of 18 months each; 7.9 M€ budget and 4 M€ EU funding

Methodology

Methodology (1) - Major Tasks and Their Cohesion

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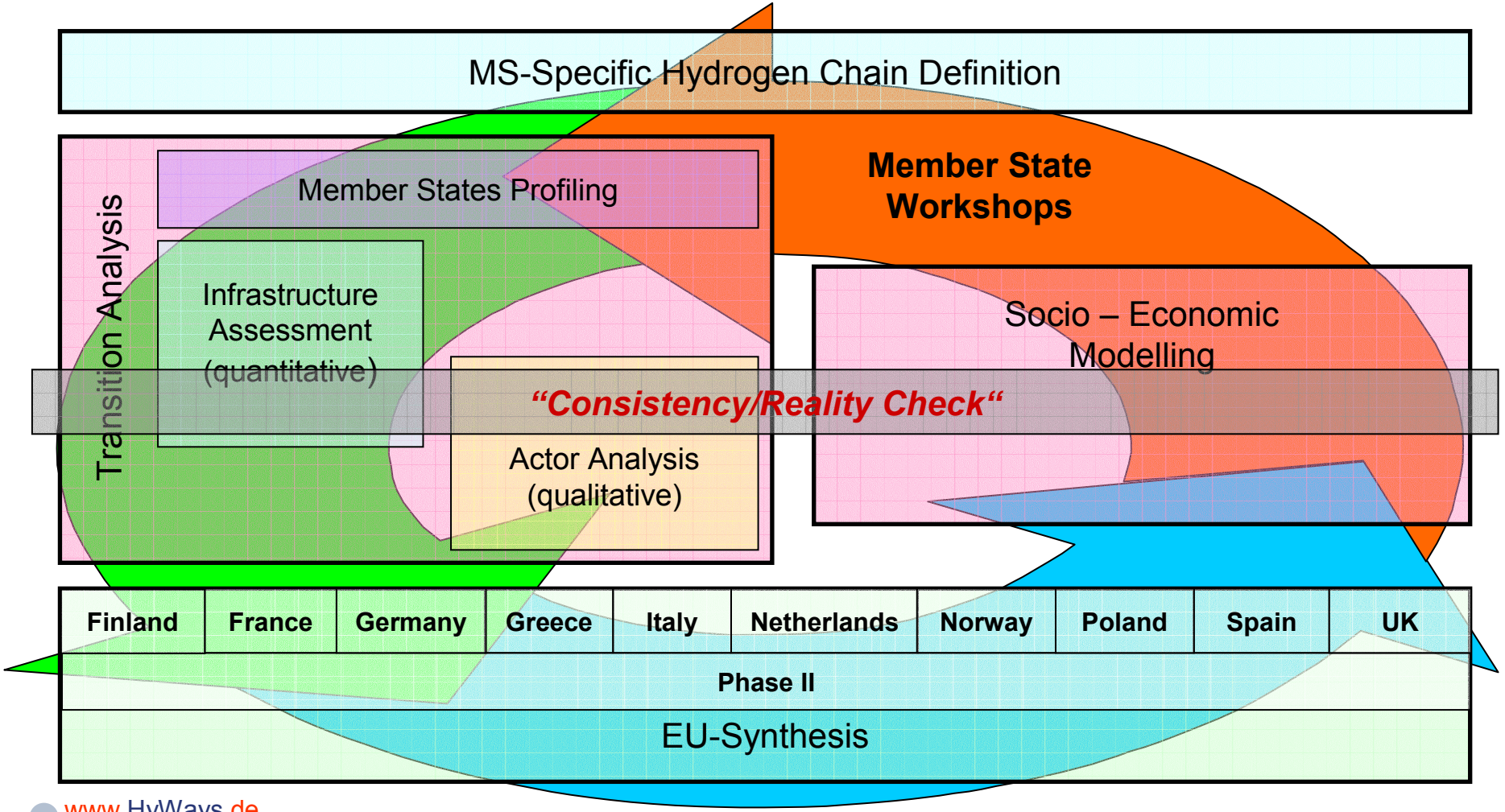
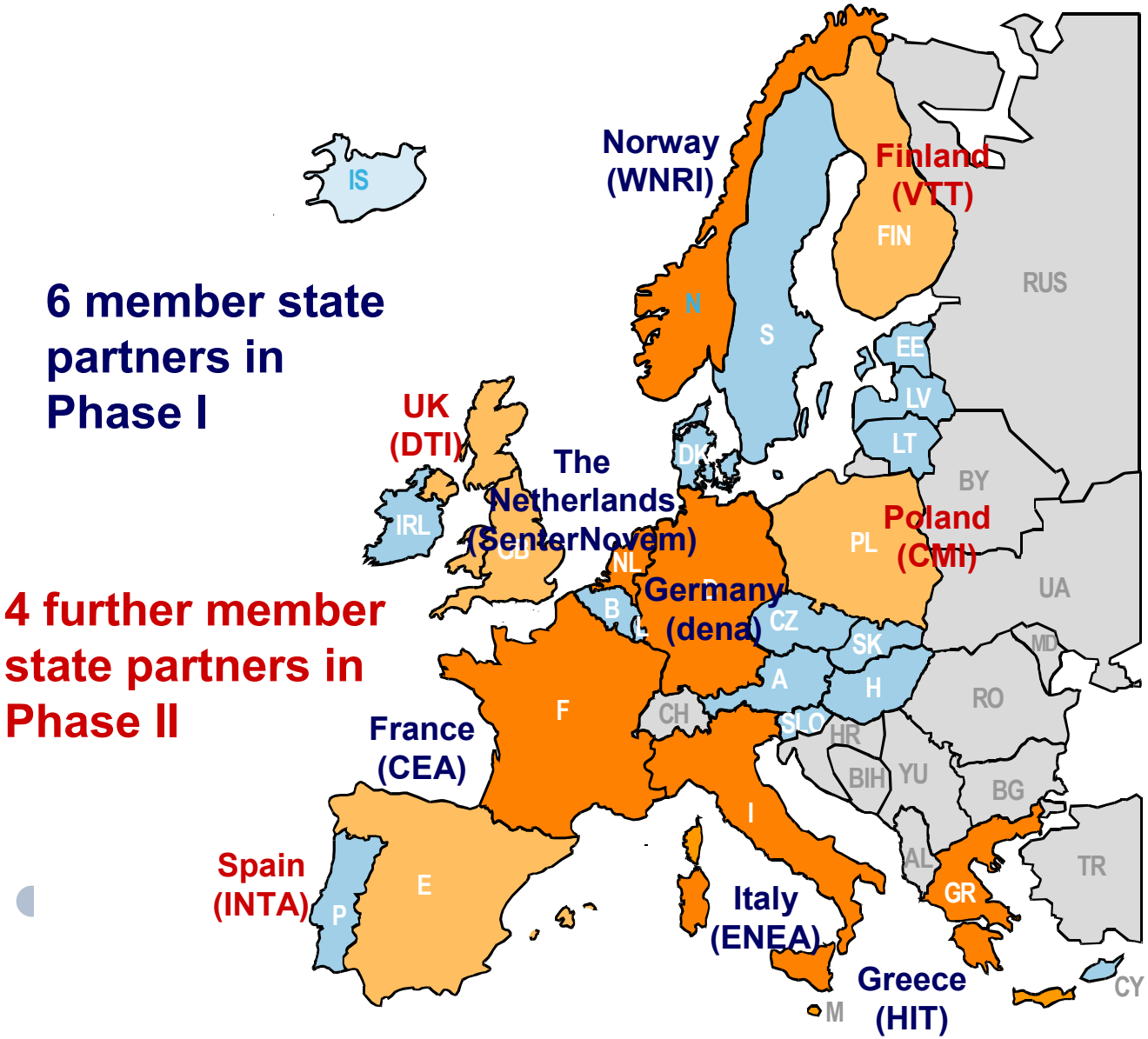


Methodology (2) - Geographical Representation of MS

HyWays

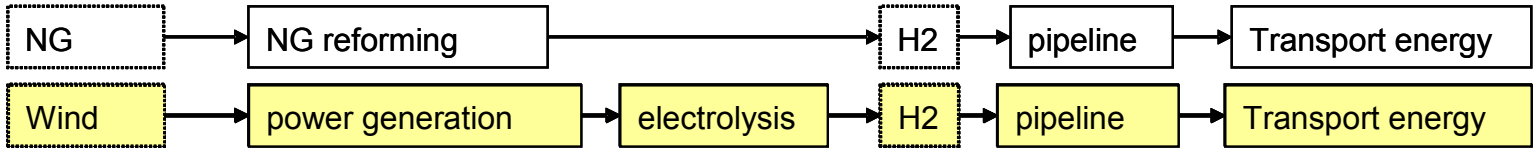


TIME HORIZON

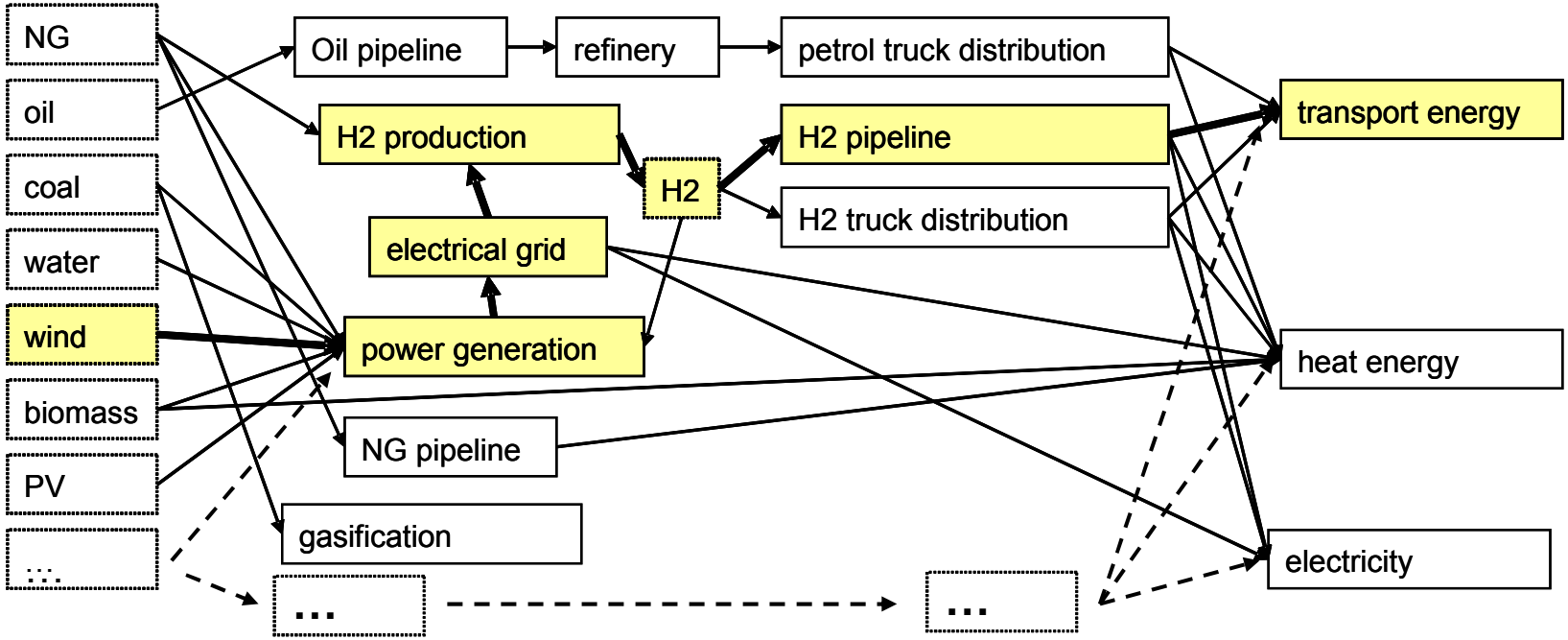
2010 / 2020 / 2030 / 2050

	Coverage [%] by	
	land area	population
Phase I	49,7	39,2
Phase I+II	80,5	71,4

1. *E3Database*: single energy chain evaluation (identify relevant chains)



2. *Markal*: energy system, integrated chain evaluation* (build energy model)



* The energy market structure shown is only for illustration purposes

Results of MARKAL:
Energy and
H_2 system

Optimum energy system,
e.g.:
25 GW Wind
12 GW NGCC
36 GW …

3. *COPERT*: Environment

Activity level X Emission-factor

Emission forecast

4. *ISIS and PACE-T*: Economy

Industry branches **Consumers** **Trade**

Sectoral GDP effects

Sectoral employment effects

Welfare effects

Price effects

First preliminary results

- HyWays – A European Roadmap – Assumptions and robust results from Phase I
- Phase I flyer and glossy external publication on the public website (http://www.hyways.de/docs/main1.html)
- Kick-Off Workshop incorporating further 4 member states in Phase II held in Frankfurt on 20 March 2006
- 6 Phase I modelling reports and one Background Document submitted to EC by 13 January 2006
- EU HFP AC recognition as "Special Initiative Group" for Roadmapping (now handled by one of the HFP IP Vice Chairs)
- IPHE project recognition achieved
- The infrastructure analysis is on its way to finalize *Supply* and *Demand* figures by summer 2006 and will work on *Cashflow analysis* and *EU synthesis* in fall 2006

Different Preferences by Phase I EU Member States and Associate States

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D: Lacking primary energy potentials require high degree of diversification

F: Vision of CO2-free hydrogen production from nuclear energy (electrolysis) and from renewable energy (biomass, wind)

GR: Large demand in distributed solutions for islands, CHP

I: Strong political interest in CCS for combined CO_2-free production of electricity and of hydrogen as vehicle fuel

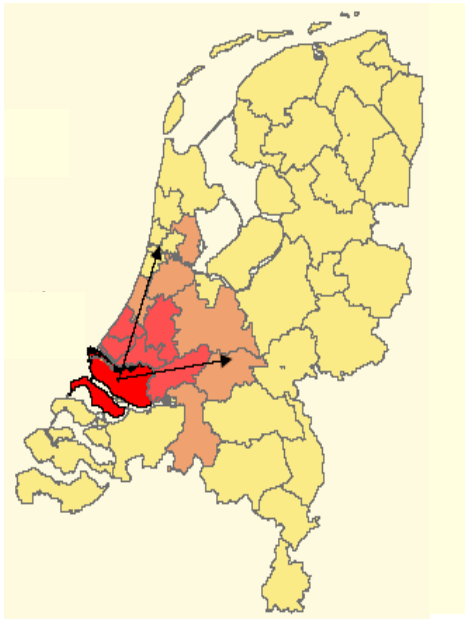
N: Renewable energies and potentials for carbon sequestration

NL: Focus in transition on natural gas and pipeline-based solutions

Challenge to synthesise different strategies,
arising from fertile European diversity,
into one harmonised European Hydrogen Energy Roadmap

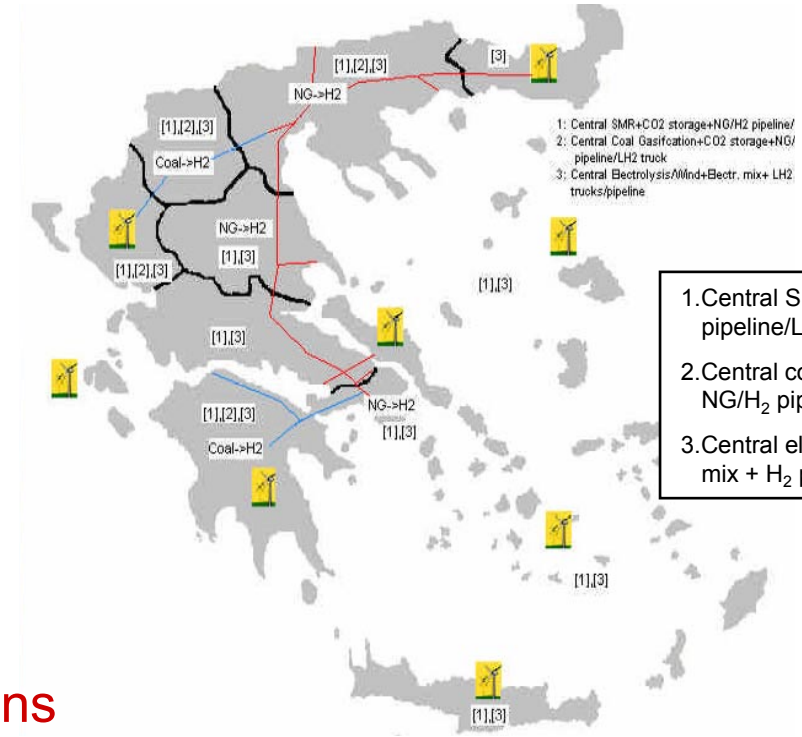
Member and Associate States Visions

The Netherlands H_2 Vision



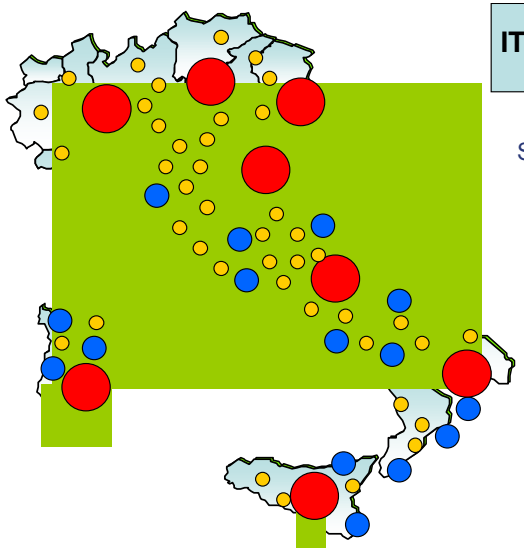
Pipeline grid:
Central hydrogen production capacity located e.g. in Rijnmond area. Infrastructure can grow to neighbouring regions.

Greece H_2 Vision



1. Central SMR + CCS + NG/H_2 pipeline/LH_2 truck
2. Central coal gasification + CCS + NG/H_2 pipeline/LH_2 truck
3. Central electrolysis/wind + EL mix + H_2 pipeline/LH_2 trucks

ITALY H_2 Vision



Source: Italian Ministry for the Environment, 2004

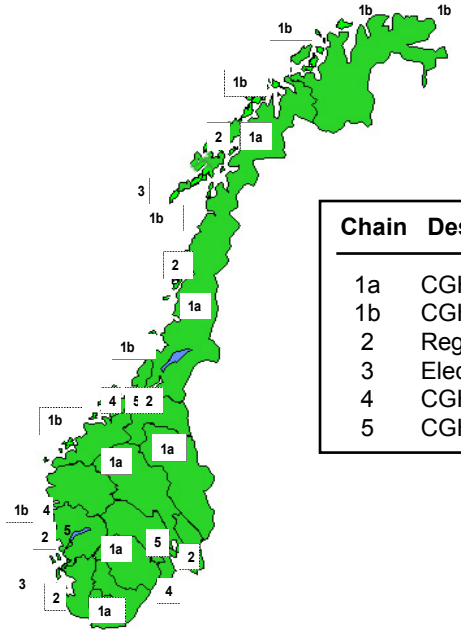
Possible sites for CO_2 geological sequestration

Hydrogen Hub Fossil Fuel based

Hydrogen Hub Solar Energy based

Hydrogen Hub Biomass based

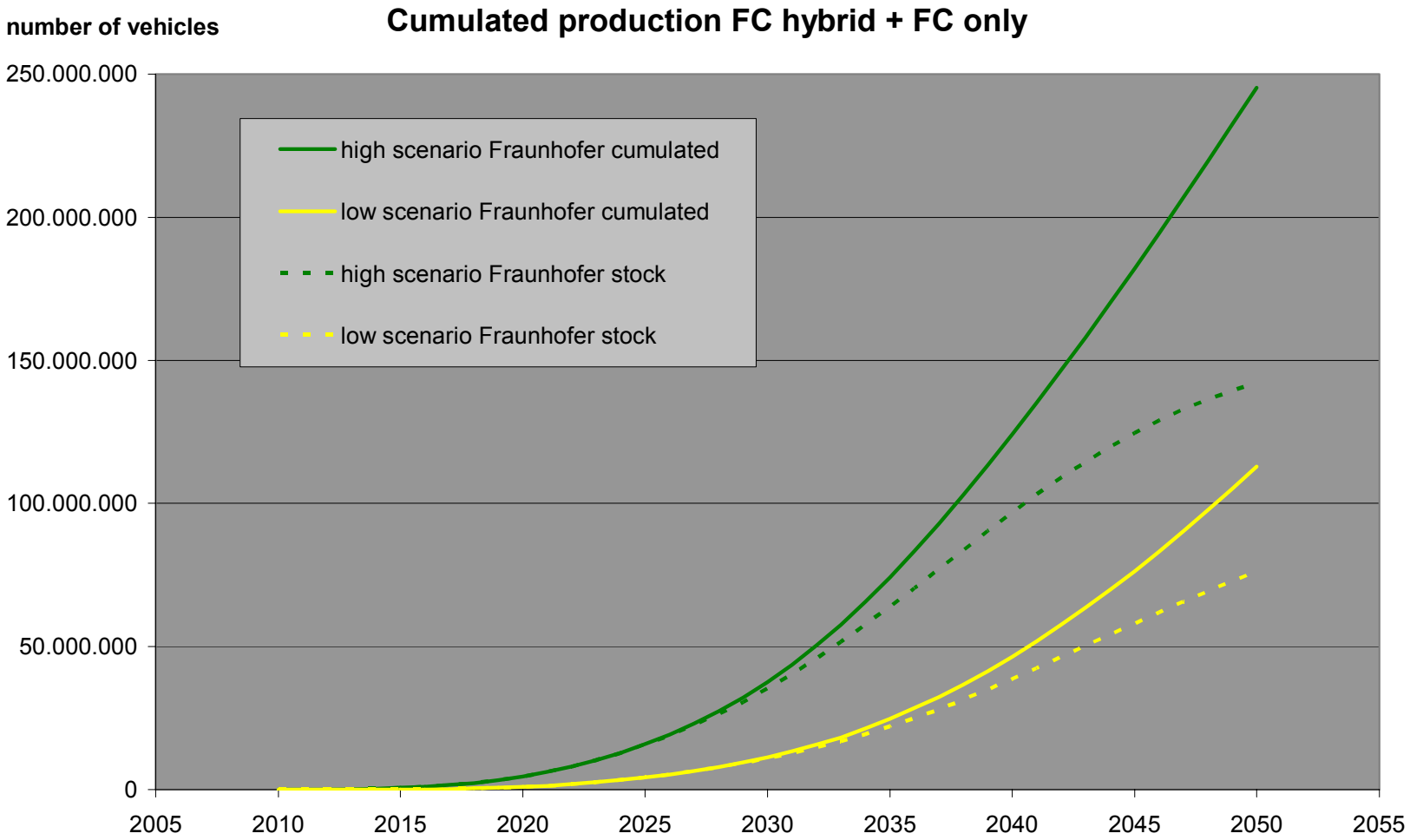
Norway H_2 Vision



Chain	Description
1a	CGH_2 local electrolysis „NordPool electricity“
1b	CGH_2 local electrolysis „new renewables“
2	Regional SMR
3	Electrolysis from remote wind („Utsira“)
4	CGH_2 by-product hydrogen (NG for substitution)
5	CGH_2 biomass (e.g. wastewood)

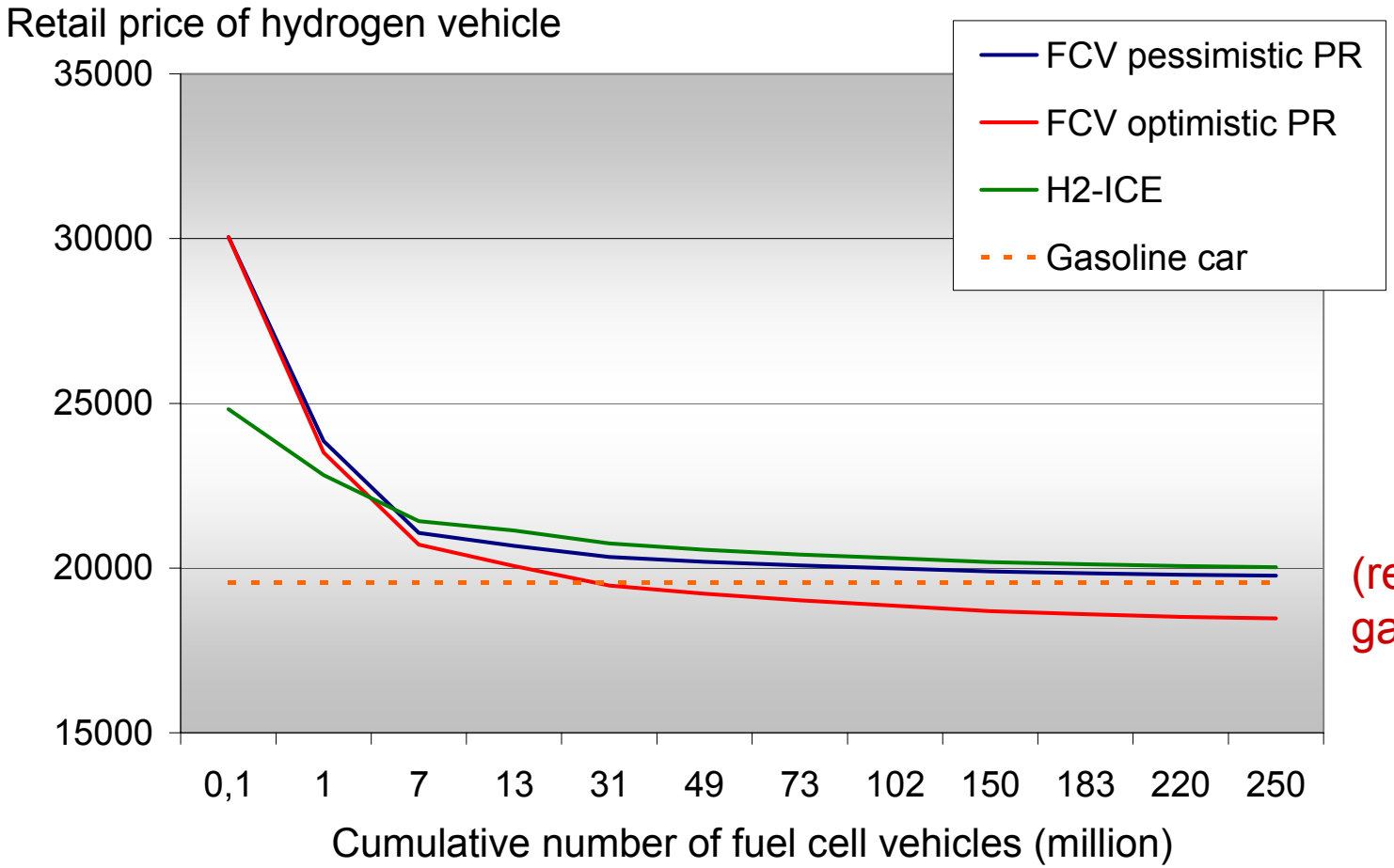
Production curve of FC cars

HyWays



Cost reduction of hydrogen cars (only medium class cars) shown for two progress ratio scenarios

HyWays



(reference is 2010 gasoline car)

Accumulated investments in hydrogen vehicles and number of cars until cost-competitiveness of FCV is reached

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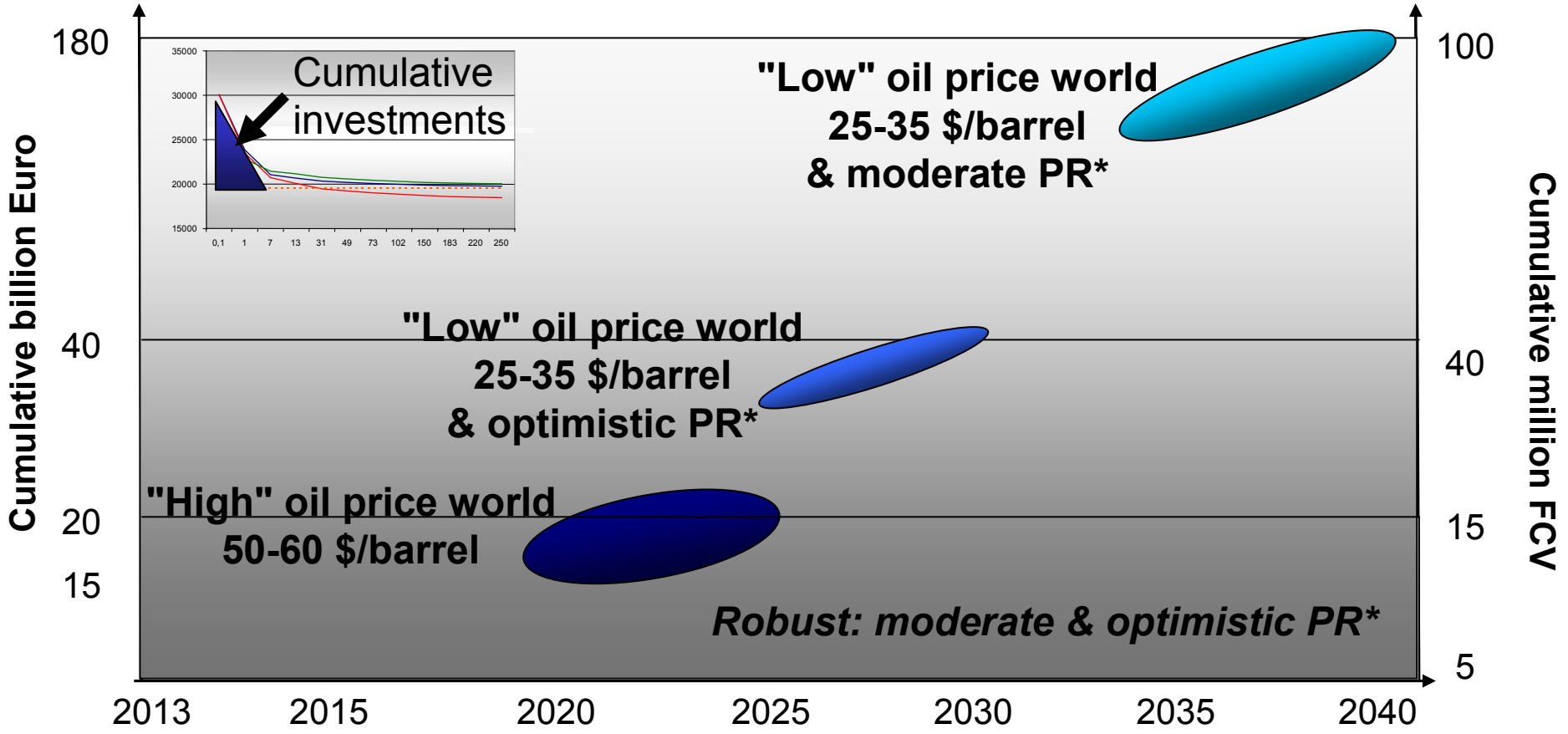
Cumulative investments and car numbers to reach competitiveness of FCVs (global, assuming mass production)



* **PR** = **P**rogress **R**atio describes the speed of cost reduction over the cumulative output (without externalities and interest rate, from the beginning of mass production {€ 10,000 more for a fuel cell car}, worldwide)

Specific additional cost and savings of a FCV compared with a conventional vehicle

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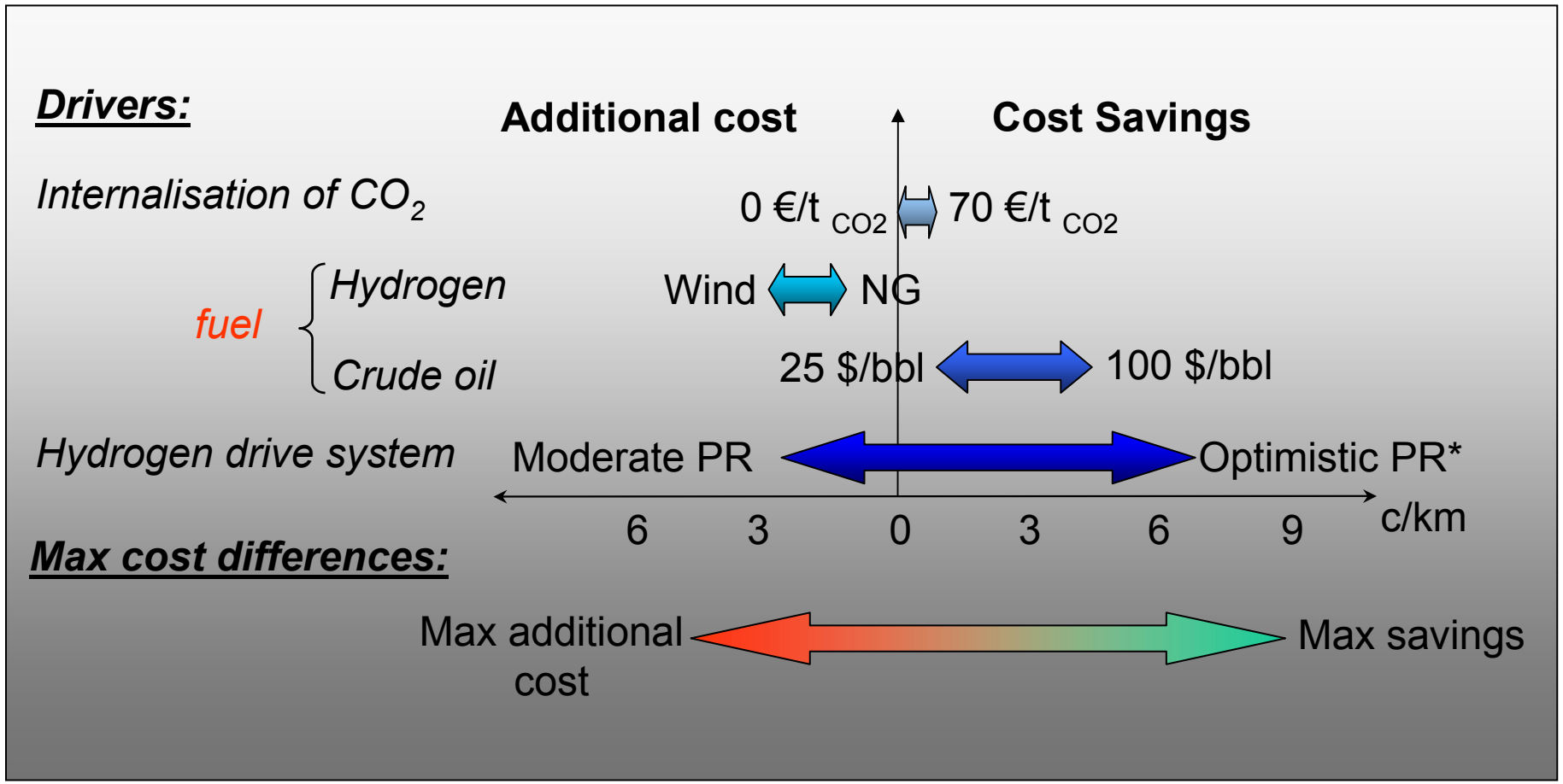
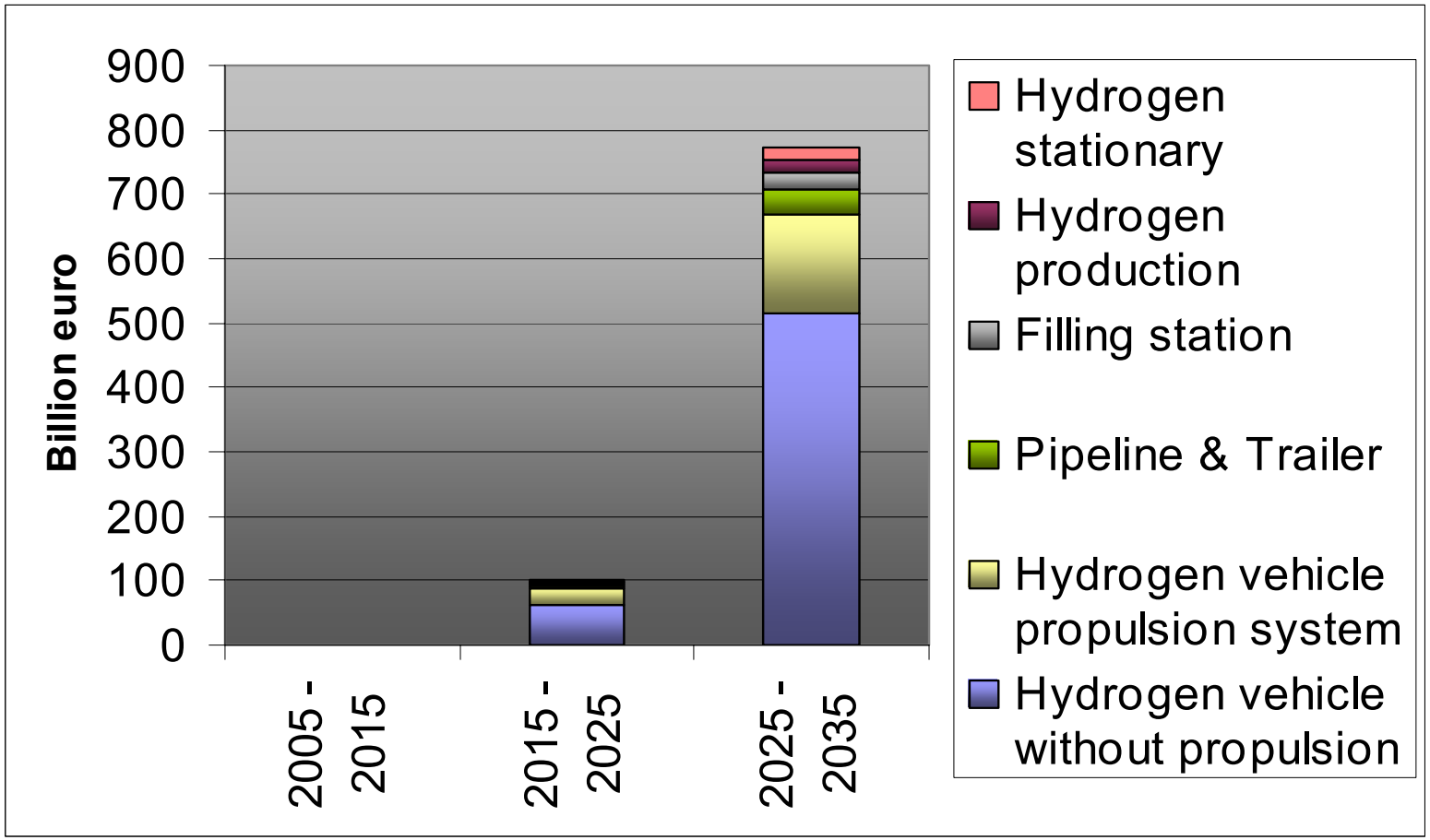
Spec. additional costs/savings of FCVs compared with conventional cars without tax



* **PR** = **P**rogress **R**atio describes the speed of cost reduction over the cumulative output

Structure of the investments in a hydrogen economy of the six HyWays countries

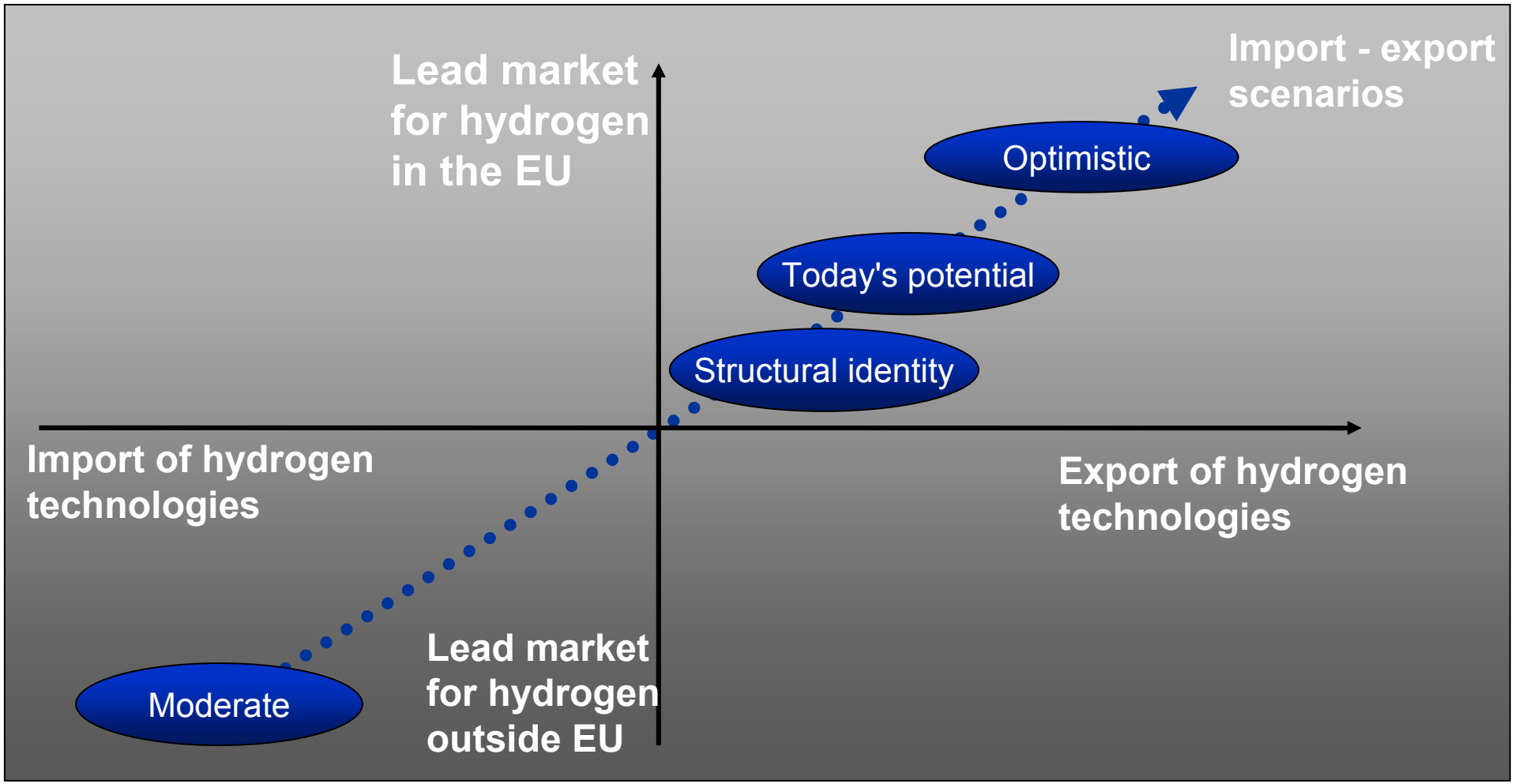
HyWays



(cumulative investments for a ten-year period, hydrogen high penetration scenario)

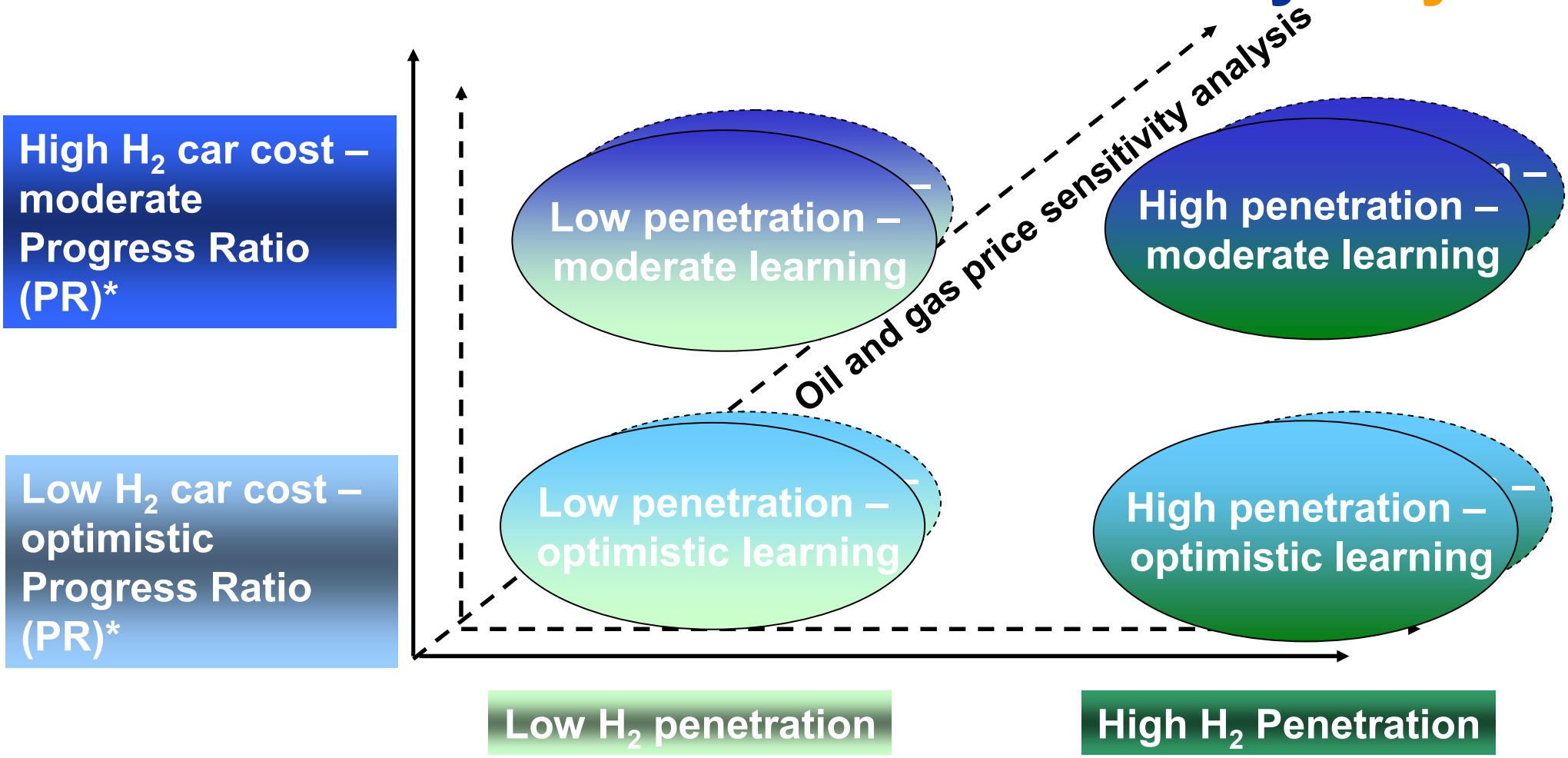
The classification of the four hydrogen import/export scenarios for the economic analysis

HyWays



The classification of the four hydrogen import/export scenarios for the economic analysis

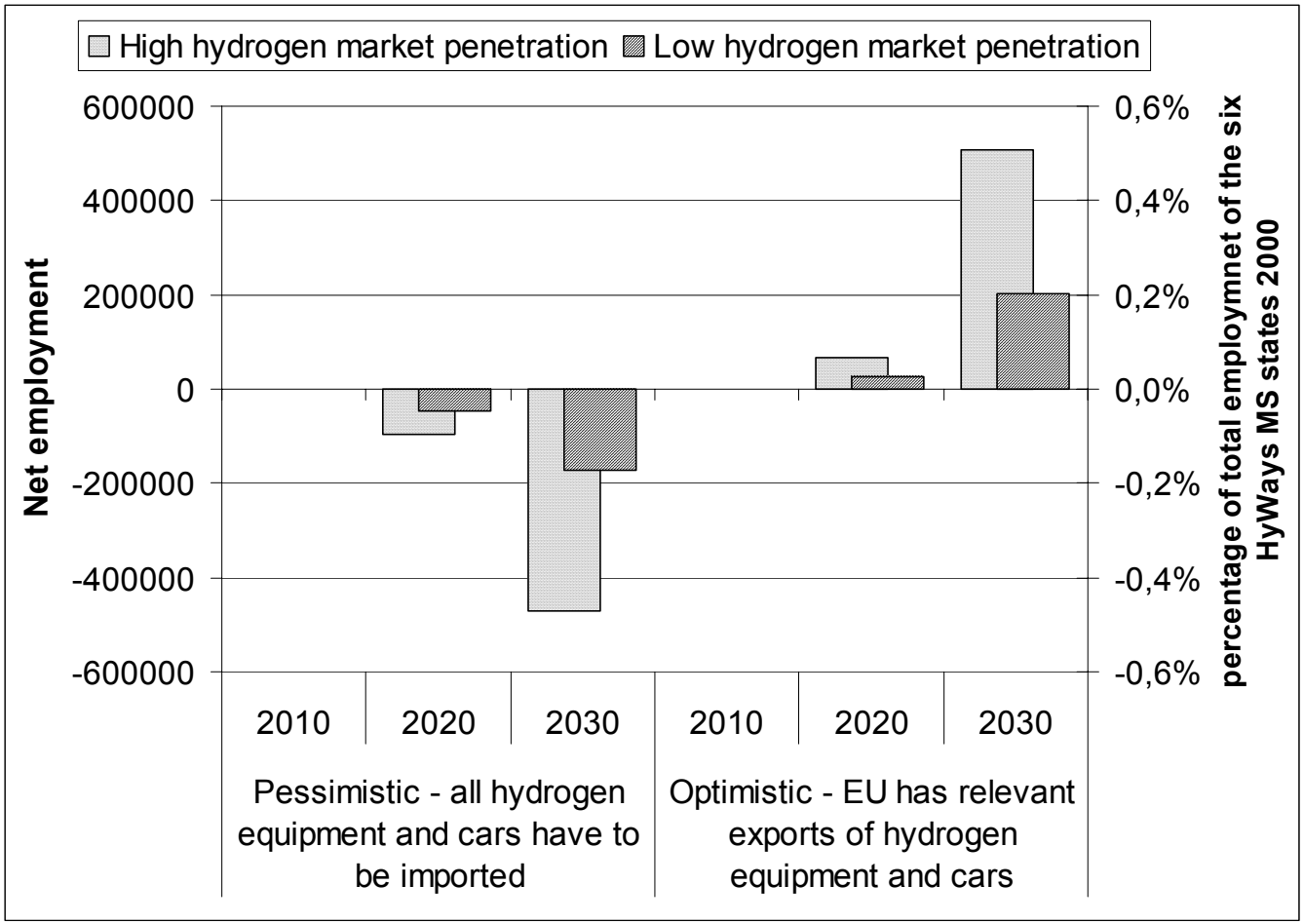
HyWays



* **PR** = **P**rogress **R**atio describes the speed of cost reduction over the cumulative output

Net employment effects for two penetration scenarios (low and high) for 2010 - 2030

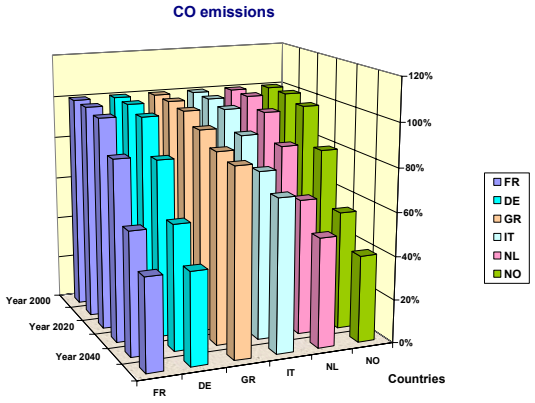
HyWays



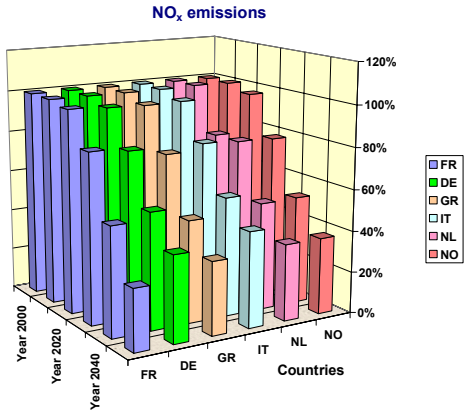
Net employment effects for the "hydrogen high penetration" and "hydrogen low penetration" scenarios with high learning rates for hydrogen passenger cars for the years 2010-2030. Shown are the net employment effects for the six HyWays Phase I countries in two import/export scenarios (HyWays calculations)

Development of CO, NO_x and PM emissions 2000-2005

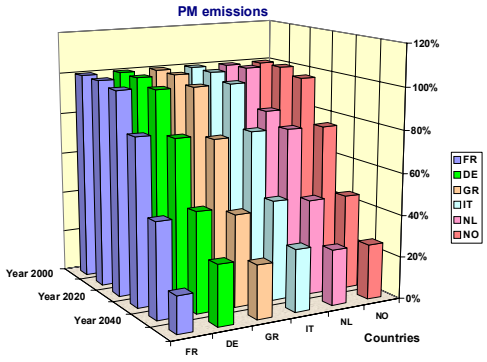
HyWays



Development of CO emissions normalised to reference scenario for the period 2000 - 2050



Development of NO_x emissions normalised to reference scenario for the period 2000 - 2050



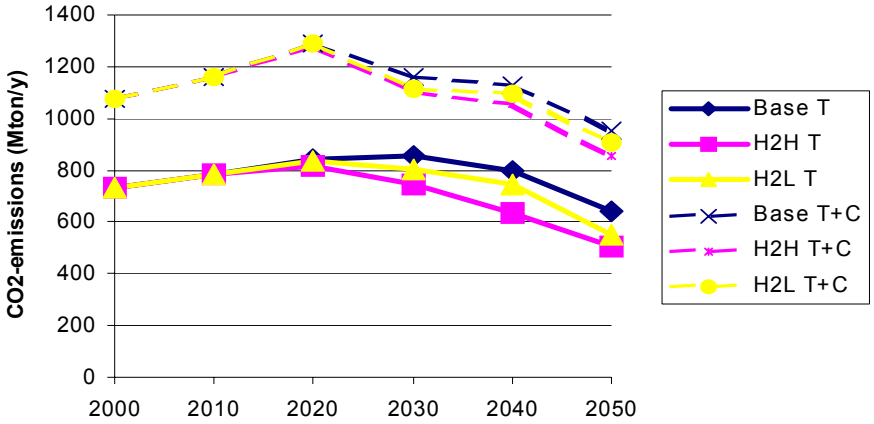
Development of the PM emissions normalised to reference scenario for the period 2000 - 2050

GHG-emissions from road transport WTW

HyWays

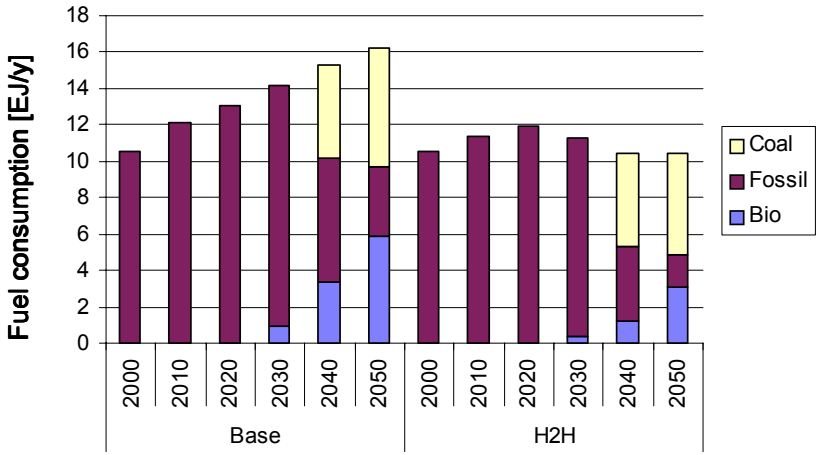
(Sum of all greenhouse gas emissions in CO_2-equivalent)
[Preliminary HyWays Results of Phase I for 6 European Countries: D, F, I, GR, N, NL]

Results from HyWays (MARKAL): CO_2-emissions



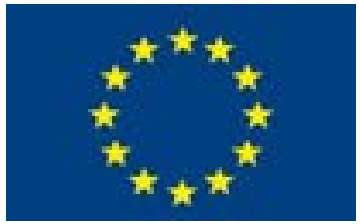
Base = scenario with high biofuel share
H2H = scenario with high hydrogen share
H2L = scenario with low hydrogen share
T = TTW only
T+C = TTW + fuel production

Results from HyWays (MARKAL): Use of fuels in transport sector



Use of fuels in the transport sector in EU15 in the baseline (left) and H2H high hydrogen penetration scenario. Share of primary energy contribution to total road transport fuel use shown. The contribution of single fuels like gasoline, diesel or H2 in the fuel consumption is <u>not</u> shown

This project is financed by the HyWays partners and by funds from the European Commission under FP6 Priority [1.6] contract number SES6-CT-2004-502596.



We would like to thank the EC that the European Hydrogen and Fuel Cell Platform provides the appropriate framework for the discussion process, and the HyWays partners for their continued support and inspiration.