L-B-Systemtechnik

HyNet and HyWays
- Projects towards a European Hydrogen Roadmap -

Dr. Ulrich Bünger

on behalf of the project partners

International Partnership for the Hydrogen Economy

4th IPHE Steering Committee Meeting
The Westin Miyako. Kyoto, 14-15 September 2005

Outline

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HyNet – Identifying key parameters and setting the scene

- A “Thematic Network” under the 5th Framework Programme
- Goals, duration and partners
- Methods and results

HyWays – Infrastucture analysis embedded in socio-conomic modelling

- An Integrated Project under the 6th Framework Programme
- Budget, duration and partners
- Methods, tools and tentative results

Conclusions

Infrastructure Analysis as part of Hydrogen Roadmap Evolution

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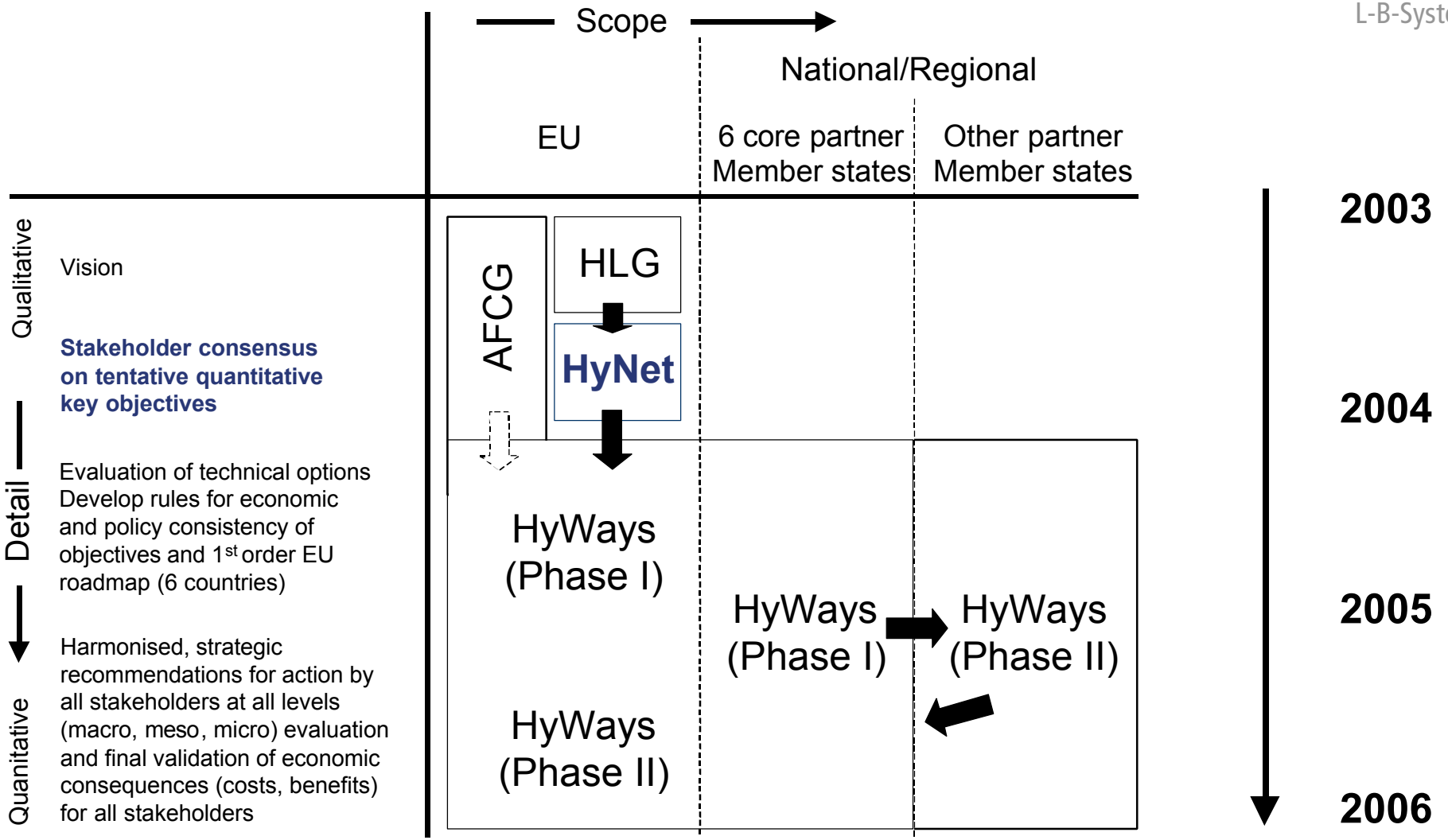


HyNet Goals, Duration and Partners

- Carry the HLG Vision Statement one step further
- Build European *Thematic Network** on Hydrogen Energy (1/02 - 12/04)
- Quantify major hydrogen development goals (infrastructure, cars)
- Preparation of HyWays European Hydrogen Roadmap
- **Hydrogen refueling infrastructure build-up**

BMW Group, bp, HYDRO, Shell Hydrogen, Linde, MESSER, Raufoss, VANDENBORRE TECHNOLOGIES N. V., TÜV NORD, TÜV SÜDDEUTSCHLAND, CSIC

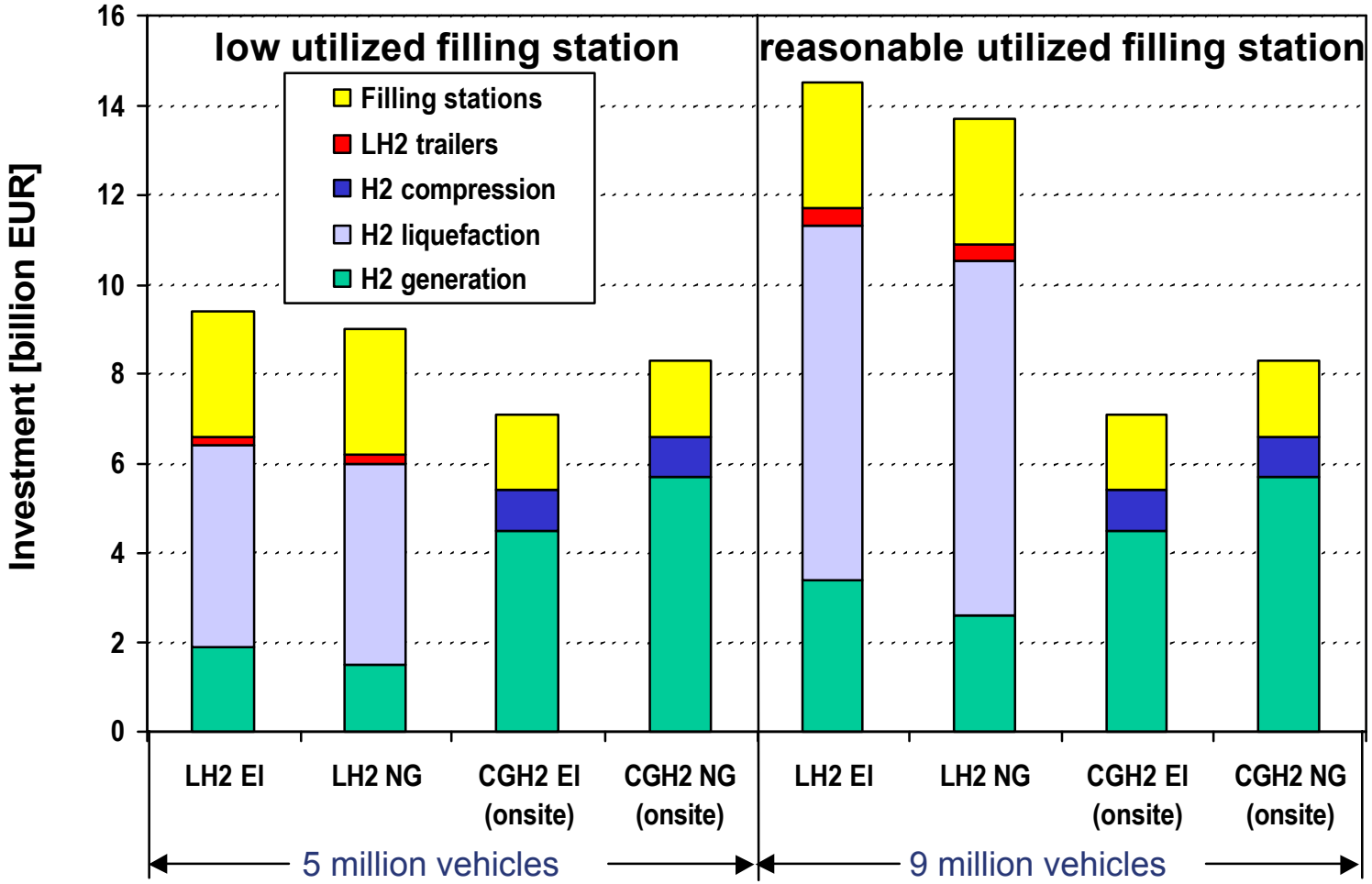
Active Supporters:

Air Products
Air Liquide
DC
EdF
GE
GM/Opel
Repsol
TFE
Vattenfall Europe

* A *Thematic Network* is a specific funding instrument in EC's 5th Framework Program (1998 – 2002)

HyNet Preliminary Infrastructure Analysis (Input to AFCG*)

Investment for H_2 Infrastructure (10,000 filling stations):



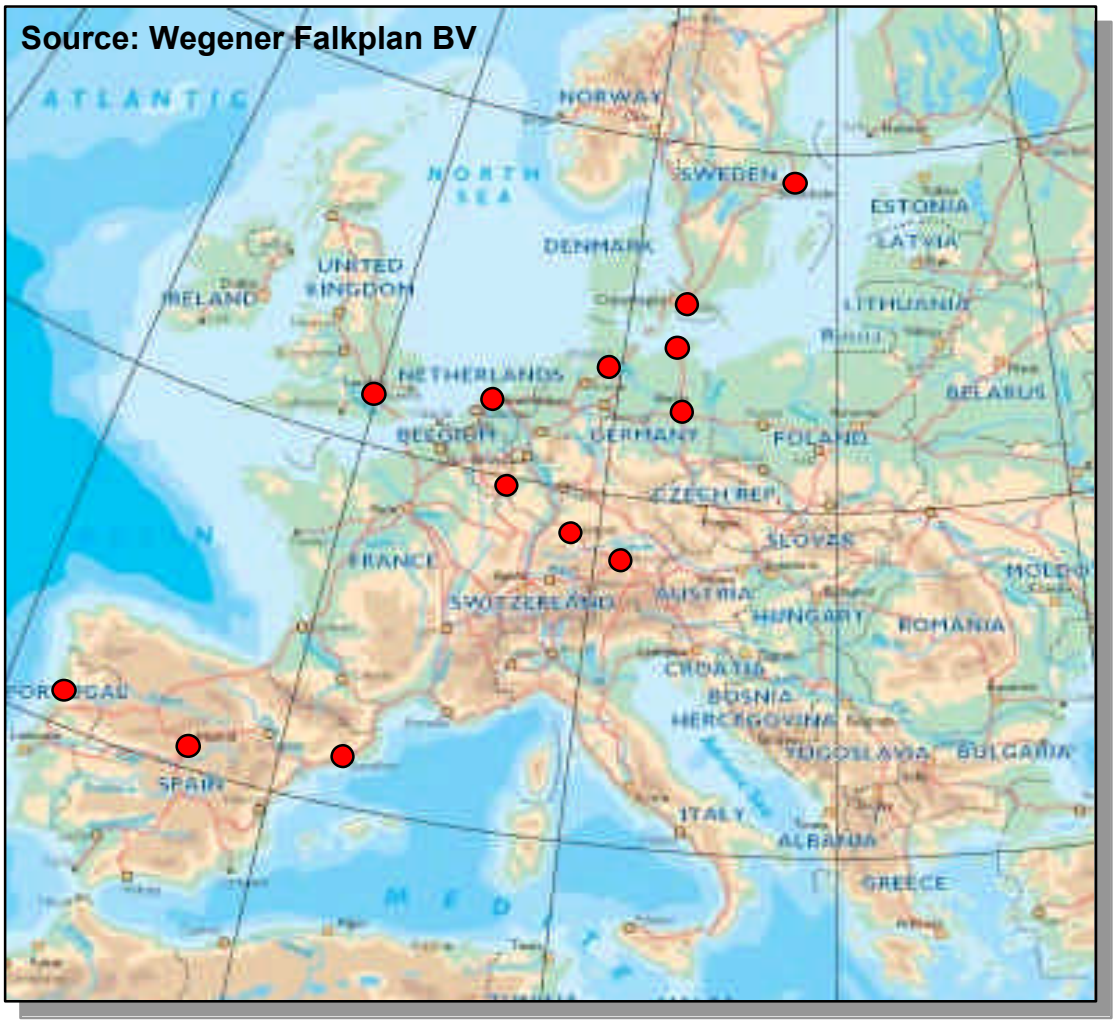
Source:
AFCG, September 2003

AFCG – Alternative Fuels Contact Group, Subgroup on Hydrogen, on behalf of DG TREN
(Air Products, BMW, DaimlerChrysler, LBST, Opel and TOTAL; also representing TES and CONCAWE)

HyNet Steps for the Infrastructure Build-up Analysis

- Analysis of the European
  - population structure (distribution to population centres and rural areas) member state by member state,
  - road structures (major trunk roads) and
  - existing gasoline refuelling network,
- Discussion of fuelling station build-up strategy in phases,
- Quantification/validation of the required fuelling station numbers (cities and trunk roads),
- Definition of the basic layout/sizing of the individual fuelling stations,
- Calculation of the fuelling station utilisation and reach of population,
- Assessment/validation of refuelling infrastructure investment costs and
- Scoping of the results.

HyNet Infrastructure Build-up Analysis (Phase I)



Phase I:
- **existing demonstration sites**

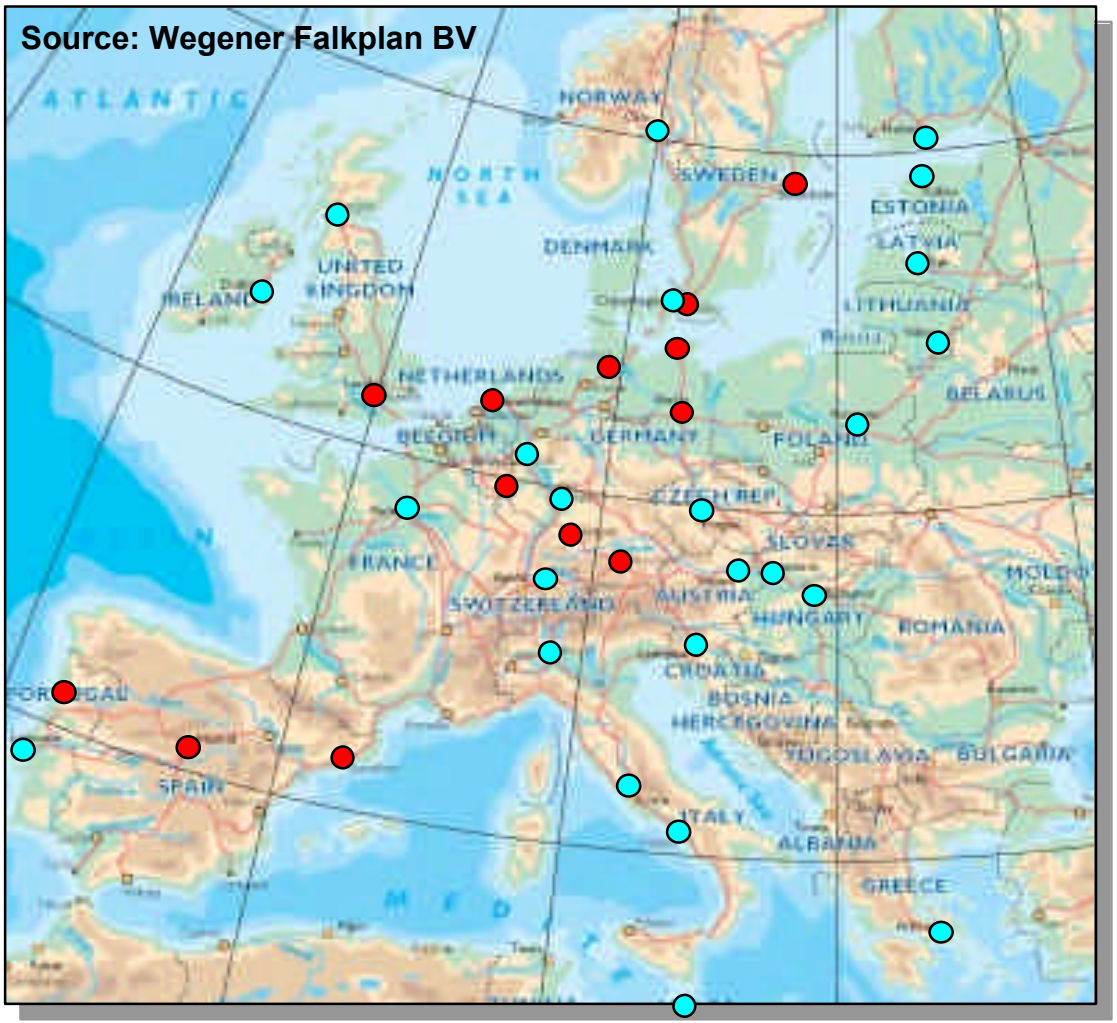
Phase II:
- **extension to population centres** (> 1 million) **and EU capitals**

Phase III:
- **growth in population centres**
- **extension to further population centres**

Phase IV:
HyNet roadmap analysis (not graphical)

Source: HyNet, 2004

HyNet Infrastructure Build-up Analysis (Phase II)



Source: HyNet, 2004

Phase I:
- existing demonstration sites

Phase II:
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Phase III:
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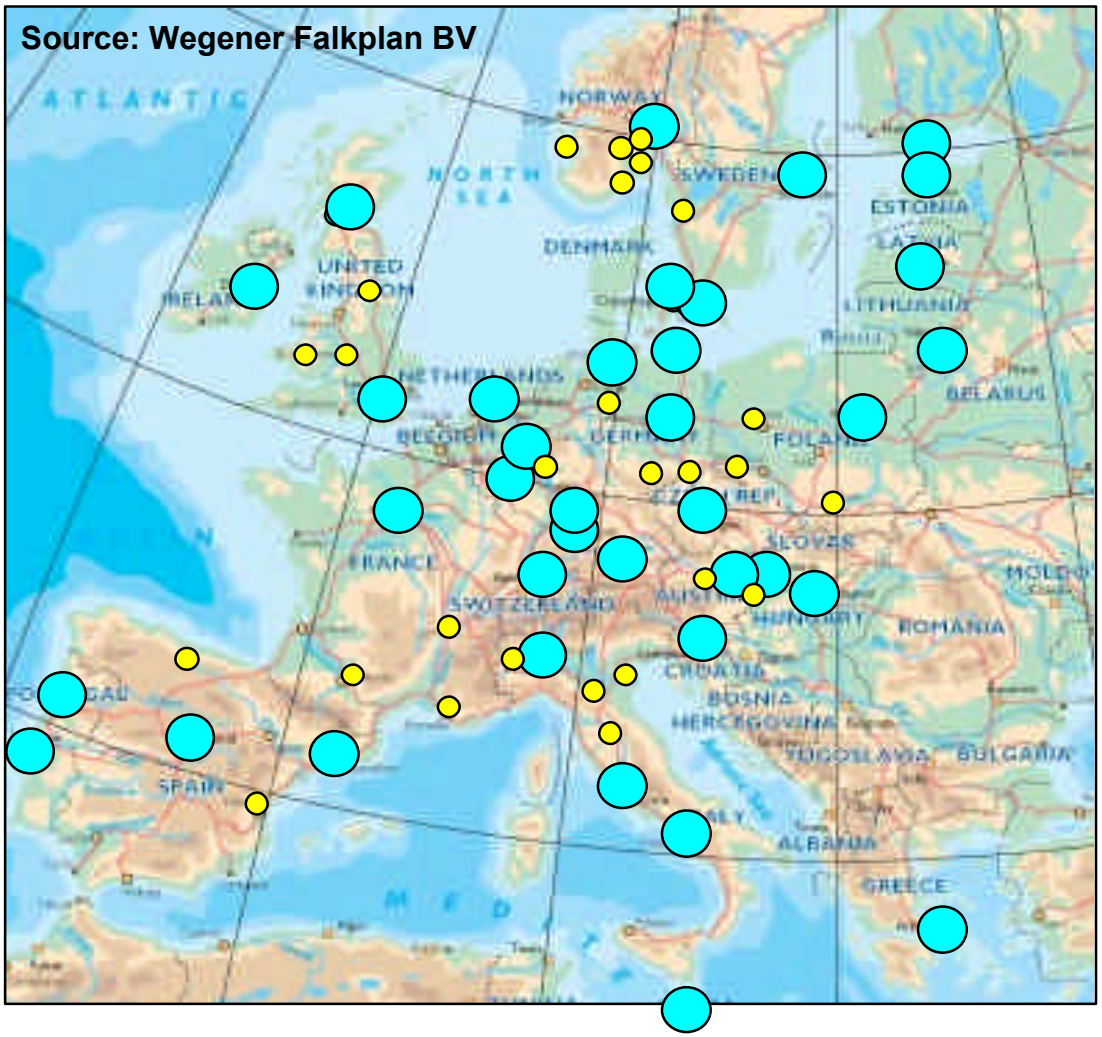
HyNet roadmap analysis (not graphical)

HyNet Infrastructure Build-up Analysis (Phase III)



Source: HyNet, 2004

Phase I:
existing demonstration sites

Phase II:
extension to population centres (> 1 million) and EU capitals

Phase III:
growth in population centres

extension to further population centres

Phase IV:
HyNet roadmap analysis (not graphical)

HyNet

Conclusions for „Phase IV“

- A four phase infrastructure build-up is assumed. Its last phase corresponds with the HyNet Roadmap analysis.
- Two fuelling station scenarios were analysed for bandwidth*:
  - ~ **5,000** (**4,029** in cities with >50,000 inhabitants **+ 1,166** each 100 km along trunk roads)
  - ~ **10,000** (**7,056** in cities with >20,000 inhabitants **+ 2,331** each 50 km along trunk roads)
- 5,000 - 10,000 fuelling stations for EU 25 + CH + N, resulting from the HyNet Roadmap, are validated. The total investments amount to 7 - 15 billion EUR.
- Thereby, up to 40 - 55% of the population could gain access to hydrogen as a vehicle fuel. The fuelling capacity is adequate to supply up to 3.5 - 6 million vehicles or 1.8 - 3% of all passenger cars.
- The results stand for a 0^{th} order approach, to be validated by the HyWays Roadmap Project.

* Currently ~135,000 gasoline fuelling stations in Europe

HyWays Budget, Duration and Partners

HyWays

Initiation by HyNet:	May 2002
Start of HyWays:	01 April 2004
Duration:	3 years (in 2 phases of 18 months)
Total Budget:	7.9 M€
Funding:	4.0 M€

Industry

BMW Group, DaimlerChrysler, GM, Opel, GE Power Systems, Air Products, Air Liquide, stuartenergy, Linde, DNV, bp, Repsol YPF, Statkraft, EHN, Total, Hydro, Vattenfall, EDF, Hexion, infraserv höchst

Member states

SenterNovem, dena, cea, ENEA, Hellenic Institute of Transport

Institutes

ZEW Zentrum für Europäische Wirtschaftsforschung GmbH, Imperial College London, ECN, IDMEC, Fraunhofer Institute Systems and Innovation Research ISI, Bureau d'économie théorique et appliquée (BETA) UMR 7522

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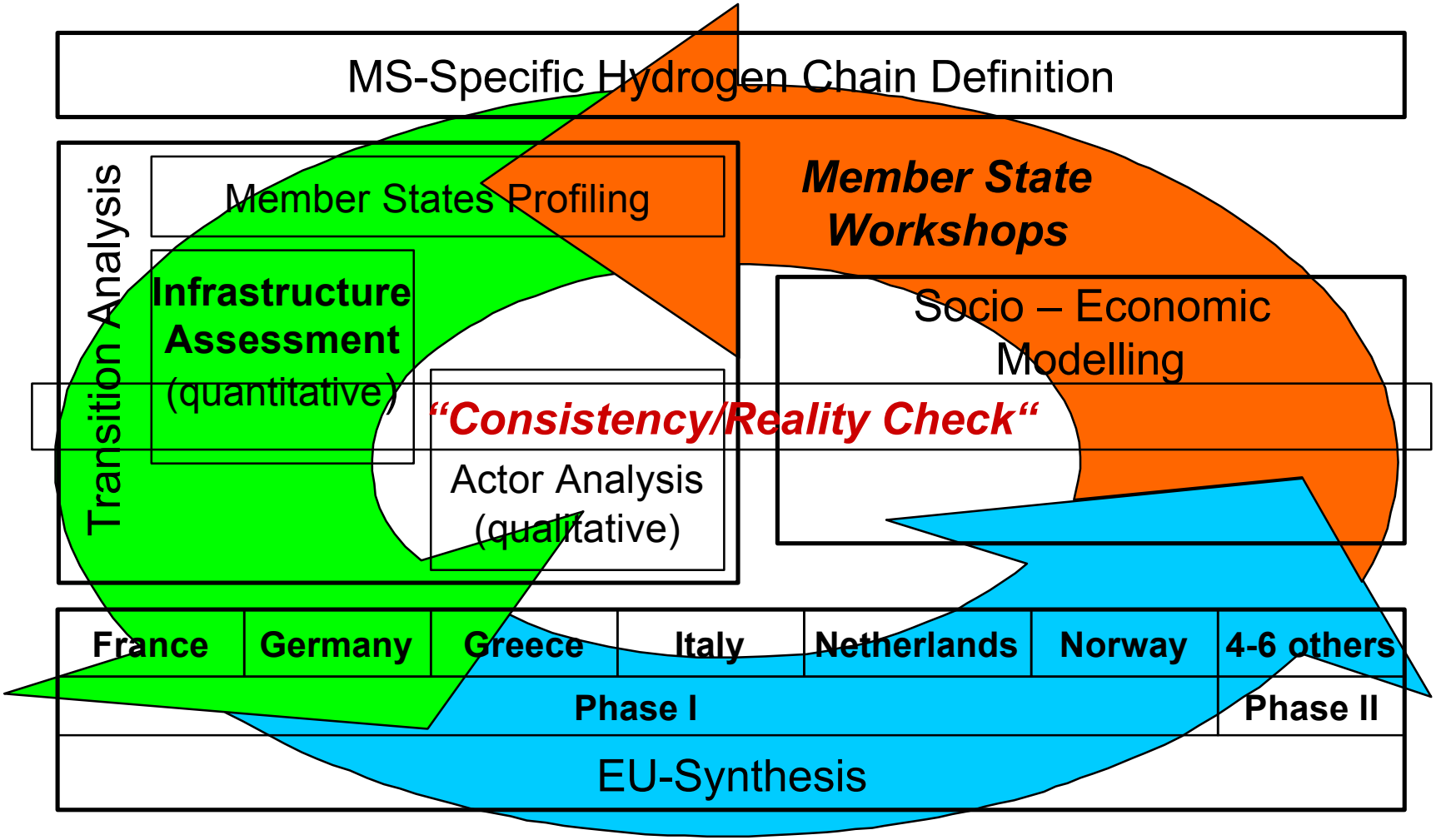
www.lbst.de

HyWays Methodology – A Multi-Dimensional Approach

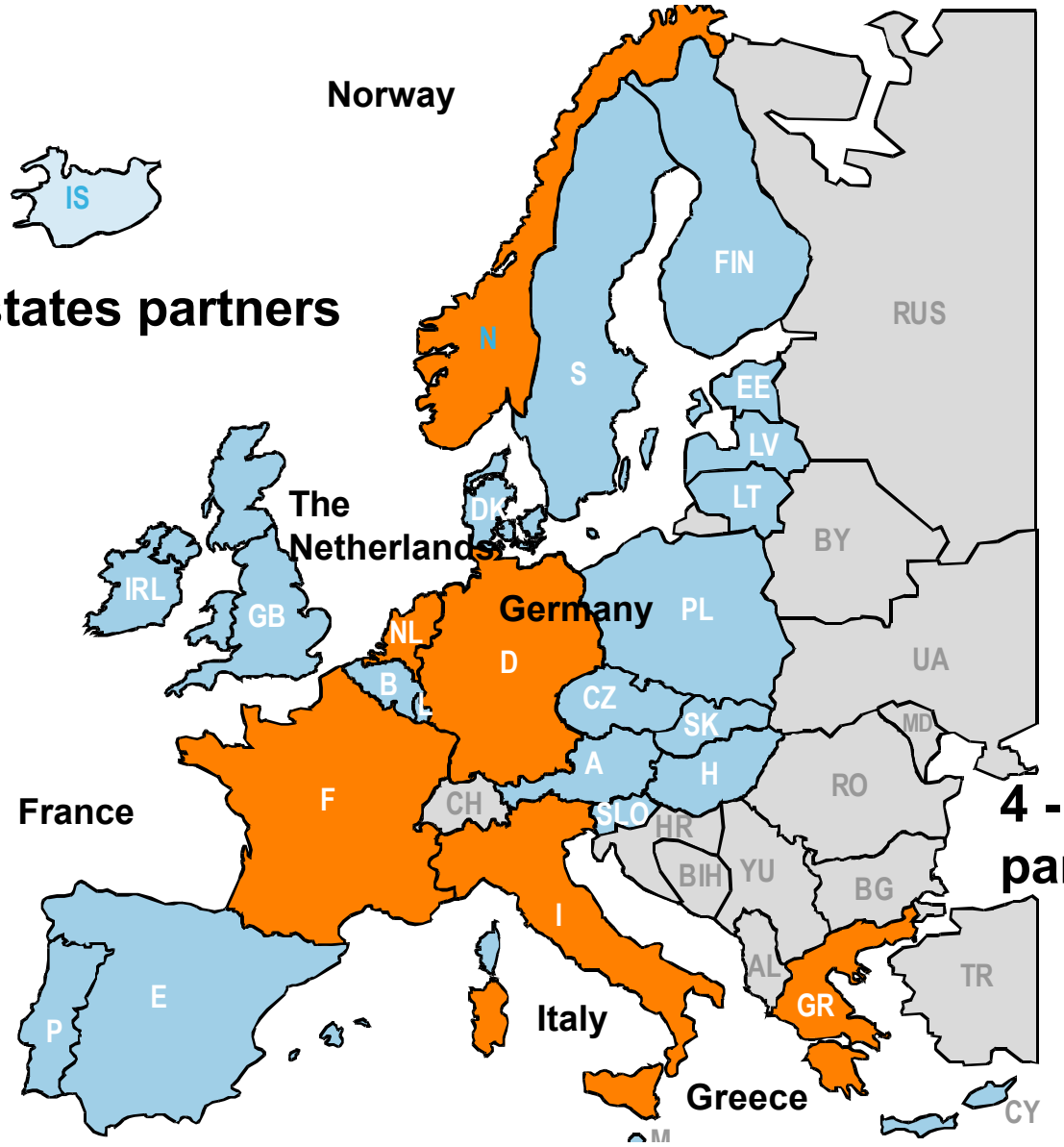
HyWays



Geographical Representation of MS Partners (Phase I)

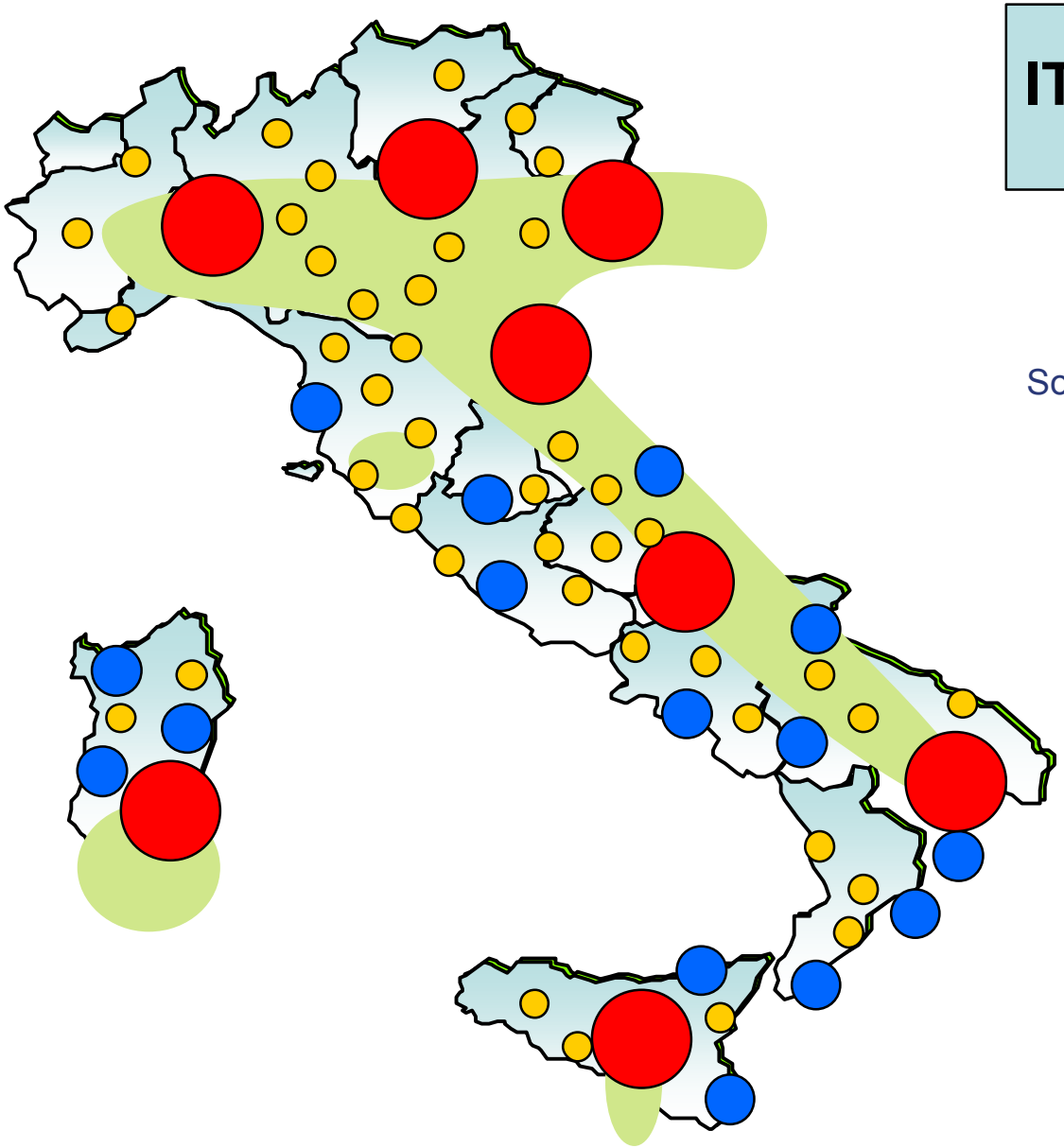
HyWays

6 member states partners in Phase I



4 - 6 further member state partners in Phase II

ITALY H_2 Vision



Source: Italian Ministry for the Environment, 2004

Possible sites for CO_2 geological sequestration

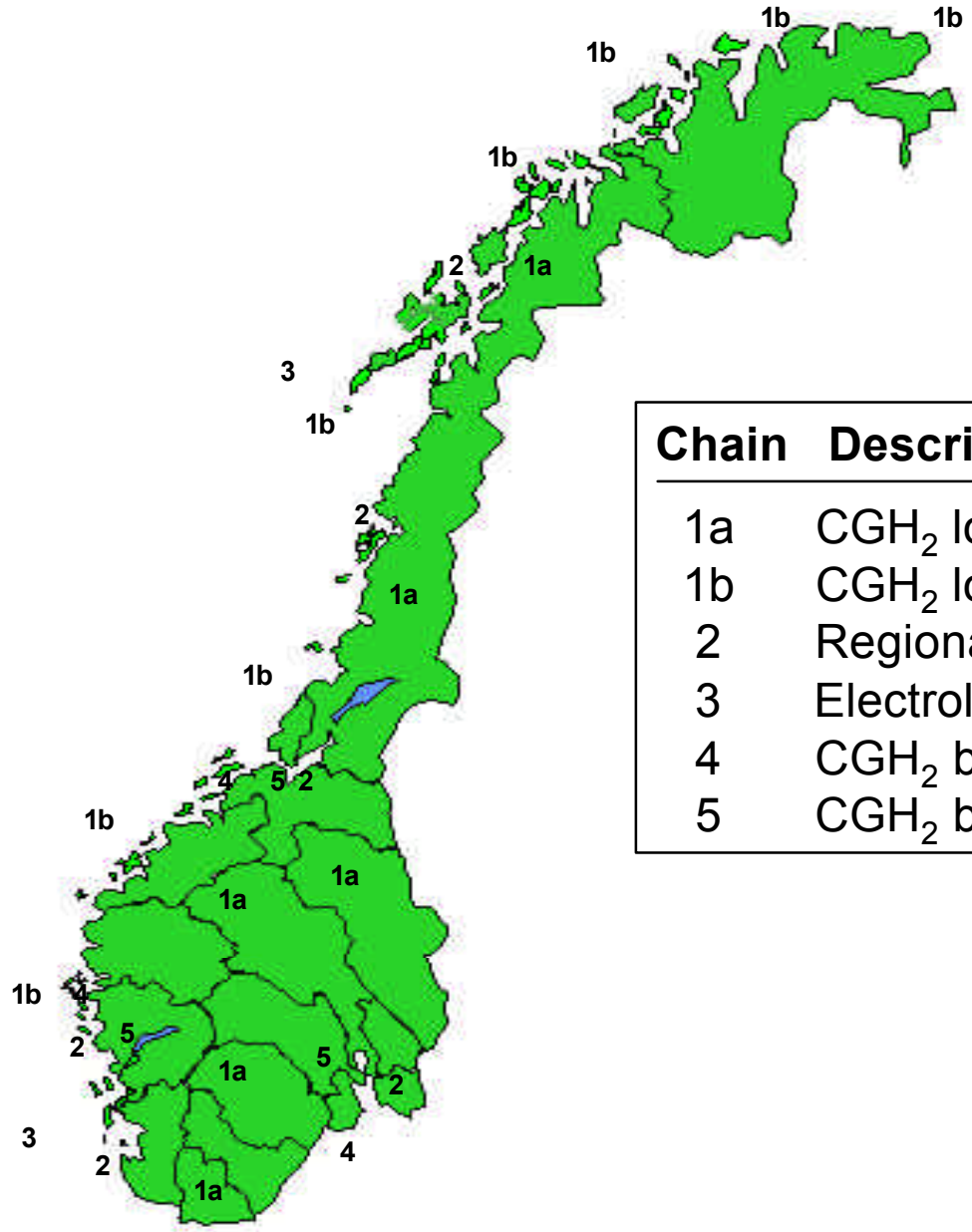
Hydrogen Hub Fossil Fuel based

Hydrogen Hub Solar Energy based

Hydrogen Hub Biomass based

HyWays Infrastructure Analysis – Regionalisation for Norway

HyWays



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)

Source: HyWays, 2005

HyWays Infrastructure Analysis – Build-up The Netherlands (III)

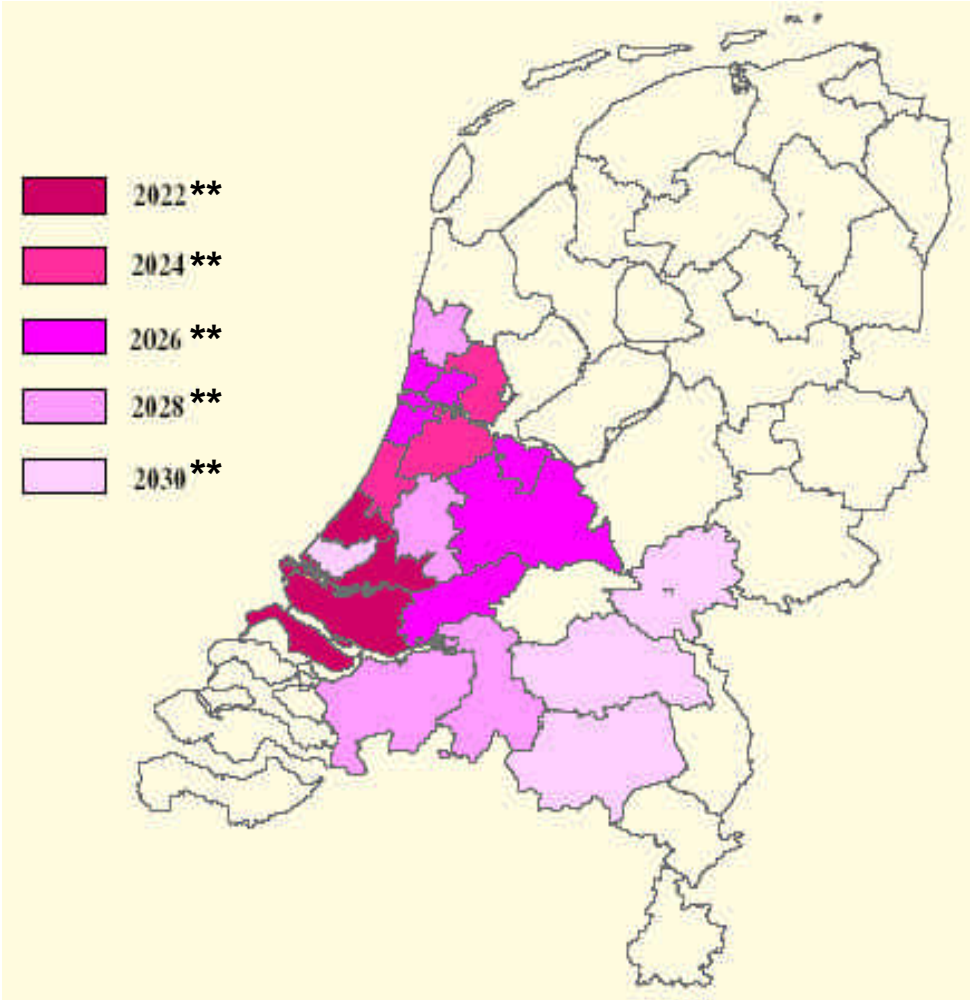
HyWays

Method:

1.) identify regional nodes

2.) Rotterdam mainly merchant hydrogen as starting point*

3.) Use dedicated H_2-pipeline grid for hydrogen transport and distribution (based on data from NG grid)



Scenario:

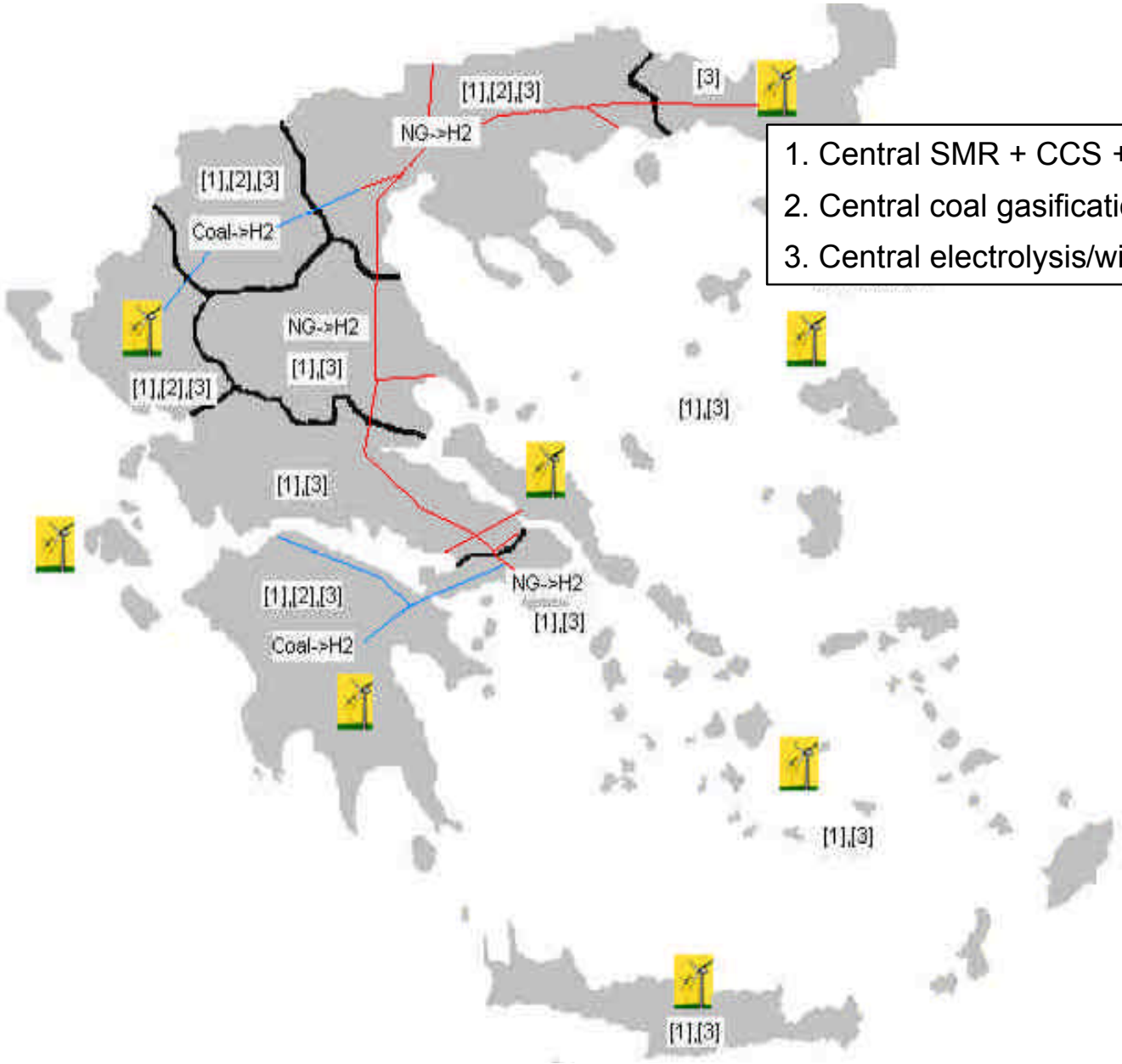
„High hydrogen penetration rates“

* See previous slide

** Tentative indicative point in time for profitability to shift from local production to pipelines

HyWays Infrastructure Analysis – Regionalisation for Greece

HyWays



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

Conclusions (as input to IPHE considerations)

HyWays

- Europe-wide hydrogen infrastructure build-up studies are complex considering technical, policy, economic and emission issues (culture, approach, role of stakeholders, geography, climate, infrastructures, energy strategies)

➡ *A European Roadmap requires individual roadmaps of major member states*

➡ *Working level co-operation is a key success factor to support strategic decisions*

- Hydrogen awareness varies from member state to member state and at various stakeholder levels, methodology/tools harmonisation

➡ *Europe's short term weakness (complexity) may prove to become its long-term strength (diversity)*

- Hydrogen's universality turns out to be in favor of a wide interest by industrial stakeholders, but only in the medium- to long-run

➡ *A powerful stakeholder group can develop but needs experienced moderating structures and exchange of expertise at European/global level for decisions*

- Infrastructure modelling is <u>important</u>, but <u>only one</u> element of the process

➡ *A new "culture" to apply simulation instruments facilitating a coherence between political and industrial strategies needs to be developed*

Acknowledgement

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HyNet and HyWays were/are funded by the project partners and by funds from the European Commission under ***FP5 Contract ENK6-CT-2001-20537*** and ***FP6 Contract SES6-2004-502596***.
HyWays is closely linked with the projects under negotiation ***HyLights*** and ***Roads-to-Hycom***, all of which are an intrinsic part of the European strategy to deploy fuel cells and hydrogen as an energy carrier.

The co-ordination of HyNet and HyWays were/are a rewarding and satisfying tasks due to the innovation potential and creativity of the project partners.

We would like to thank the EC that the European Hydrogen and Fuel Cell Platform provides the right framework for the discussion process, and the HyWays partners for their support and patience during the long and exhausting proposal and contract preparation phases.

Internet Sites

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www.HyNet.info

HyWays *www.HyWays.de*

Results of the HyNet Infrastructure Build-up Analysis

http://www.hynet.info/hyactiv/docs/presentation_long.pdf

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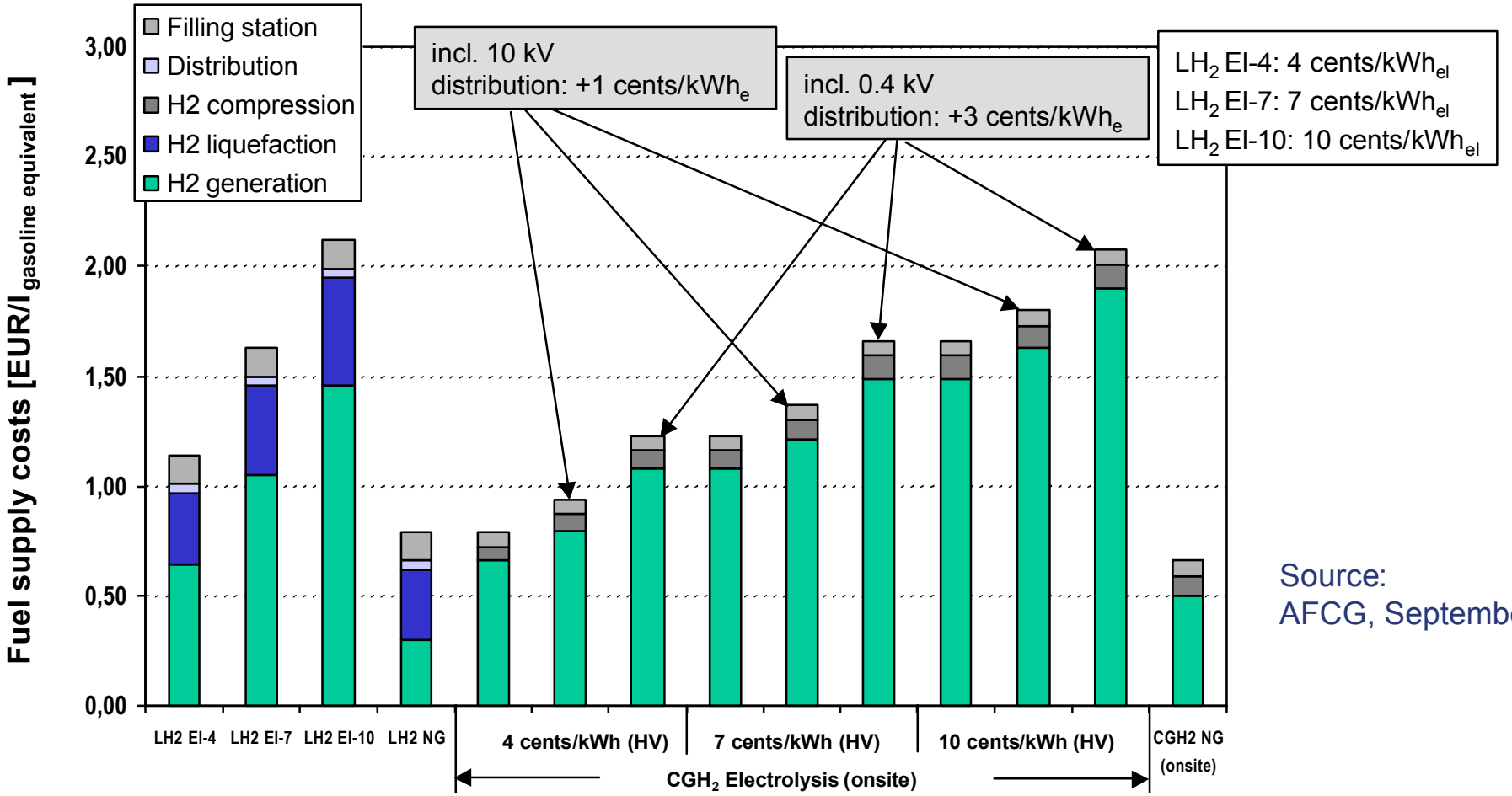
Back-up Material

HyNet Preliminary Infrastructure Analysis (Input to AFCG*)

Fuel supply cost per liter gasoline equivalent:



Source:
AFCG, September 2003

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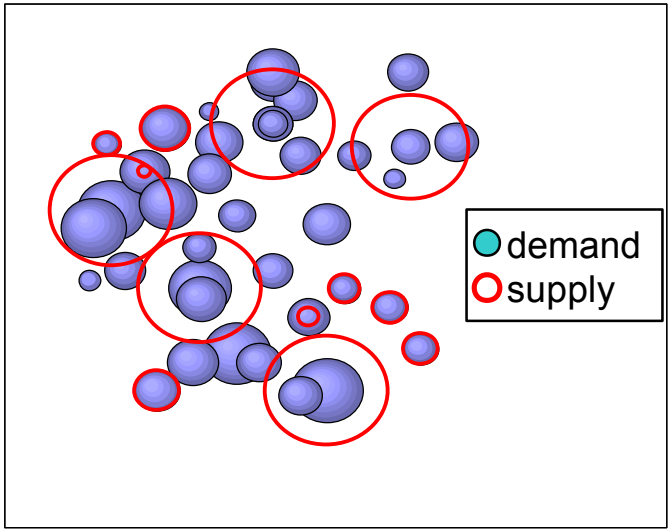
(Air Products, BMW, DaimlerChrysler, LBST, Opel and TOTAL; also representing TES and CONCAWE)

HyWays Infrastructure Analysis – Outline of General Methodology

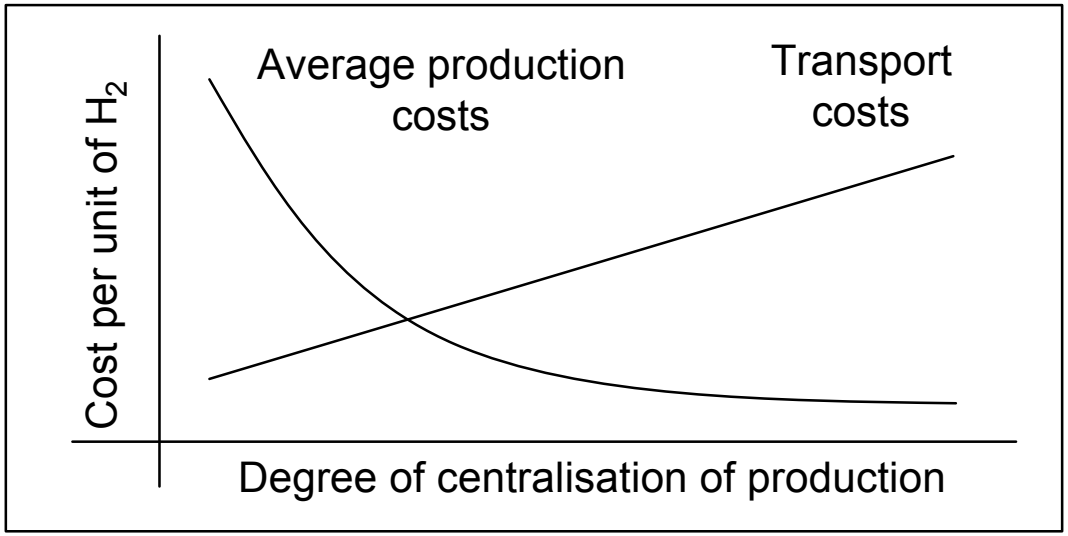
HyWays

- Transient spatial H_2 demand/supply model with *equidistant* nodes
- H_2 demand model from population density (i.e. statistics) or stakeholder input (e.g. H_2 penetration rates)
- Least cost optimisation (= H_2 supply locations, degree of centralisation and transport mode) considering H_2 production and distribution costs
- Various central and decentral H_2 production technologies under consideration
- Data from E3 Database or individual member state stakeholder input

Geogr. demand/supply representation



Break-even point between least supply/transport costs



Source: HyWays, 2005

HyWays Infrastructure Build-up – The Netherlands (I)

HyWays

Method:

1.) identify regional nodes

40 regions in NL *(COROP grid):* Starting nodes for a hydrogen fuelling station network

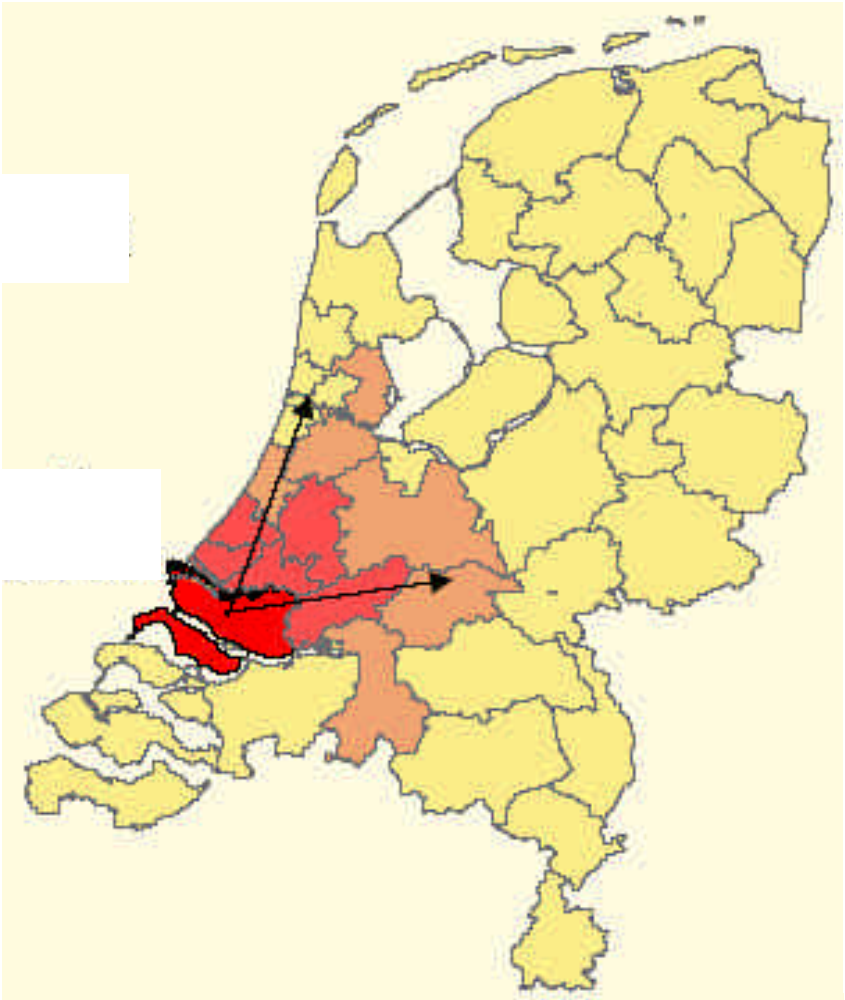
HyWays Infrastructure Build-up – The Netherlands (II)

HyWays

Method:

1.) identify regional nodes

2.) Rotterdam mainly merchant hydrogen as starting point*



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

* Other locations may provide hydrogen (e.g. by-product), but Rotterdam has largest potential