HyWays

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HyWays

The Development and Detailed Evaluation of a Harmonised “European Hydrogen Energy Roadmap“

Integrated Project

Priority [1.6] Sustainable Development, Global Change and Ecosystems

Final Publishable Activity Report

after 39 months

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Revision [draft 4]

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1. Rationale and Summary

Why do we need hydrogen?

Hydrogen is an energy carrier with zero carbon content. Just like electricity, hydrogen can be produced from all energy resources, like biomass, wind and solar energy, nuclear energy and clean fossil fuels. It can be converted to power and heat with high efficiency and zero emissions, especially when used in fuel cells. It improves security of supply due to the de-coupling of demand and resources, allowing each European member state to choose its own energy sources. Within the HyWays project, a Roadmap and Action Plan for the introduction of hydrogen into the energy system have been developed.

Main conclusions from the HyWays project

- **Emission reduction**: Hydrogen is a cost effective CO_2 emission reduction option. The costs to reduce CO_2 emissions decrease by 4% in 2030 and 15% in 2050 compared to a base line scenario without hydrogen. Emissions from road transport can be reduced by over 50% in 2050. Furthermore, the introduction of hydrogen in road transport contributes to a noticeable improvement of air quality in short to medium term. This holds specifically for the most polluted areas such as city centres where the sense of urgency is highest.
- **Impact on economic growth and employment:** The transition to hydrogen offers an economic opportunity by strengthening Europe's position in car and energy equipment manufacturing. In case import/export shares do not change, net impacts on employment amount to 200,000 – 400,000 jobs per year by 2030. The major benefit for economic growth is a strong decrease in vulnerability of the economy to shocks and structural high oil prices. The (negative) impacts of a (sudden) increase in oil price on economic growth are in the range of -0.20 to -0.40 % per year. In contrast: the impacts on GDP of the introduction of hydrogen are expected to be small but positive (around +0.01 % per year).
- **Security of supply:** Like electricity, hydrogen de-couples energy demand from resources. The total oil consumption of road transport can decrease by around 40% up to 2050 as compared to today by replacing 80% of the conventional vehicles by hydrogen vehicles. Use of hydrogen for electricity production from fossil fuels in large centralized plants will positively contribute to achieve a significant reduction of CO_2 emissions if combined with CO_2 capture and sequestration processes. The resulting diversification potential leads to a substantial improvement of security of supply.
- **Contribution to targets for renewable energy and energy savings**: Introduction of hydrogen in the energy system offers the opportunity to increase the share of renewable energy. In terms of energy savings, for example, hydrogen produced from biomass offers substantial efficiency gains over biofuels when used in a fuel cell and hybrid vehicles.
- **Competitiveness of hydrogen vehicles***:* Hydrogen vehicles can be produced and operated cost effectively once initial barriers such as the cost reduction of drive trains and infrastructure build-up have been overcome. In particular in combination with fuel cells, hydrogen can compete with conventional fuels if oil prices stay above 50 – 60 $ per barrel. Still, policy support schemes are needed to facilitate cost reduction of the drive train through economy of scale and R&D, preventing severe underutilisation of the hydrogen infrastructure.

Main recommendations

- ***We have to act now for a sustainable future!*** Immediate action is needed to overcome initial barriers, enabling a substantial and cost effective contribution to reduction of greenhouse gas emissions and reduction of import dependency while creating economic stability. In addition, the introduction rates for hydrogen and fuel cell vehicles and the build-up rate of a hydrogen fuel infrastructure need to be high to sustain an industrially relevant growth.

- ***A European hydrogen specific support framework is needed:*** This should address the following issues:
  - *Support innovation at EU and Member state level*; At a European level, the R&D budgets for hydrogen production and its end-use applications need to increase to 80 M€ per year.
  - *Market support;* To overcome initial barriers, a hydrogen specific deployment support framework needs to be implemented at Member State level. Total costs of a deployment support scheme are in the range of 180 M€ per year. Starting point is equalising total costs (€ct/km) for road transport through financial measures such as tax incentives.
  - *Creation of early markets;* Early markets for e.g. hydrogen vehicles need to be created utilising the advantages offered by hydrogen applications. Examples are city centre access regulations or procurement of zero emission vehicles within governmental services.
- ***Establish a Public private partnership:*** Production of small series of vehicles has started but has to be scaled up further soon. In the early commercialisation phase, technology specific deployment support and R&D must go hand-in-hand. A European public private partnership between industry and the EC, such as a Joint Technology Initiative (JTI), is the most suitable framework where these conditions can be met.

An executive summary and the full version of the HyWays Roadmap and Action Plan are available for download at www.HyWays.de.

2. Work Package Activities

2.1 General project objectives

HyWays is an integrated project to develop the European Hydrogen Energy Roadmap.

In developing the European Hydrogen Roadmap the HyWays partners closely interlink with the European Commission and the European Hydrogen and Fuel Cell Technology Platform to investigate the techno- and socio-economic conditions for introducing hydrogen as a future energy carrier and fuel. A toolbox from well known, widely accepted and tested simulation tools with well defined interfaces is under development and used for the consensus building process to identify the technical, macro-, meso- and micro-economic and policy framework conditions for the establishment of a sustainable hydrogen energy system. It works on a comparative analysis of regional hydrogen supply options and energy scenarios, including renewable energies. Though an initial emphasis will be pathways to a hydrogen infrastructure for transport fuel, synergies for stationary and portable end-use will also be considered.

Regional or member specific issues were evaluated in partnership with local energy experts. In Phase I (18 months) F, D, GR, I, N and NL were represented to develop and validate the toolbox. Experienced coordinators of other regions/ member and associate states were also invited in Phase I to understand HyWays's methods and progress and to provide input about their specific hydrogen energy policy situation.

For Phase II, from the 25 members states and the 3 candidate states another 4 MS representatives (E, FIN, GB, PL) were selected in a formal call for tender action. On these 4 additional MS the framework as developed in Phase I will be applied and an integral and validated roadmap based on 10 MS will be developed.

Institutes and industry in consensus with the member/associate states will provide and/or elaborate the data and information to later synthesise a harmonised and validated European Hydrogen Energy Roadmap. A 1st order version of the roadmap comprising the first 6 member states was finalised after Phase I (with a delay of about 4 months in January 2006), the fully validated version will become available after 36 months (possibly after 39 months if a contract extension can be obtained from EC).

Major deliverables of HyWays are the European Hydrogen Energy Roadmap including a technical report and strategy document and recommendations for stakeholders concerning realistic regional options to build the hydrogen energy infrastructure. Results of the process will be disseminated to stakeholders and the public via internet.

The timeline considered will be the transition period until 2020 with a visionary view to an established hydrogen energy system until 2050, then mostly based on renewable energies. The project is co-ordinated by LBST and managed on various levels of work by the "Project Steering Group", and the "General Assembly".

2.2 Project objectives per work package

2.2.1 Work package 1

WP1 was the initiating work package for all consecutive modelling activities member state by member state. Its task was to identify a set of relevant hydrogen energy chains, the individual processes belonging to them, the data and information gaps for their compilation and finally select those 6-8 hydrogen energy chains which were the most relevant for each member state. WP2 took over these hydrogen energy chains and calculates specific energy consumption, specific GHG emissions and specific hydrogen provision costs for well to wheel (WtW) and source to user (StU). The relevant member states/countries in Phase I were France, Germany, Greece, Italy, Norway and the Netherlands, in Phase II Finland,Poland, Spain and the UK joined this group. 4 workshops had been planned for each of the Phase I countries, 4 workshops took place for each of the Phase II member states/countries which was based on the methodology which had to be tried out in Phase I at first.

2.2.2 Work package 2:

WP 2 calculated the energy uses, emissions and costs associated to processes of hydrogen chains, from Well-to-Wheel (WtW, for road transport) and Source-to-User (StU, for other uses).

In Phase I of the project, the development of a procedure and interfaces in pursuance of a standard application of the E3database model for individual regions or member/candidate states was developed. Phase I included six member/candidate states for which Well-to-Wheel (WTW) respectively Source-to-User (STU) scenarios were investigated in more detail, i.e. France, Germany, Greece, Italy, the Netherlands and Norway. In Phase II, 4 additional member states (Finland, Poland, Spain, UK) were analysed and had already been informed on the methods, progress and results by a workshop in Phase I.

A limitation of the total number of selected hydrogen energy chains for each member state to 6-8 had proven to be a good choice. The partners of WP 1 in Phase I CEA, ECN, LBST collaborated successfully with relevant industry also in Phase II.

The individual steps to be performed in WP 2 comprise:

- Compilation of process data via extraction from the standard technology dataset documented in E3database, respectively as provided by industry partners implemented additionally into E3database.
- Possibly configuring of mixed pathways/ scenarios for transport, stationary, residential and/or industrial user context respectively pathways for one user context but mixed primary energy input
- Calculation of the defined pathways/ user contexts with E3database based on the input of WP 1 task 3; taking into account the different input data qualities and time frame related uncertainties through Monte-Carlo-simulations for the time horizons 2010, 2020 bearing possible developments until 2050 in mind.
- Evaluation of obtained results and graphical display showing ranges of uncertainty related to the different input data qualities (e.g. time frame considered), the various process variants (e.g. local or remote resources), the various fuel/ process qualities (e.g. for biomass, for natural gas)
- Data transfer e.g. process by process to other simulation models in specified pre-defined fields applicable for a given process as MS-EXCEL spread sheet.
- Besides the calculation of pathways in E3database, the verification of available resources per member/candidate state, in particular renewable energy sources has to be achieved. A common understanding/ basis has to be agreed upon among the partners on which basis to estimate these potentials in order to ensure European compatibility.
- Establishment of interface with the modelling framework for socio-economic analysis.

2.2.3 Work package 3:

The goal of WP 3 was to identify how the most likely routes for the introduction of hydrogen will influence all European sectors of activity: technology modifications, new infrastructure needed and integration with existing ones, changes in the economy, social implications and environmental impact. To ensure realistic results, the analyses were made attending the specificities of each region.

The work in this work package consisted of providing precise region specific data to modelling tools covering the areas of energy, environment and macro-economy as well as to determine the hydrogen introduction pathways on a country/regional level. The work package consisted of 6 distinct objectives (Tasks):

2.2.3.1 Regions profiling and barriers and opportunities analysis

Each Member State region's energy sector was characterised, the present legislation on codes and standards described, and current and future government policies in hydrogen and locally used hydrogen related technologies identified. The information then was refined according to the different model specifications in the next Tasks. Key changes as well as critical actors were identified, and a qualified assessment of their existing and potential impact on hydrogen uptake was conducted. Where possible, a quantitative assessment was be carried out. The information was compiled in a common accepted format (Excel) in order to make it available to all partners. This task was carried out by **IDMEC-IST** together with industry.

2.2.3.2 Scenario development

Socio-economic and other data gathering processes as well as detailed technology inputs from industry were linked together in a cohesive manner in a scenario analysis. Specific emphasis was put on build-up timelines of hydrogen production, hydrogen infrastructure and stationary and transport end-use scenarios. Initial scenario outputs for an iteration process with the E3database and more detailed outputs for the analyses were conducted by means of the MARKAL, ISIS and GEM models. Robust scenarios were developed to fulfil the requirements of the regions, and subsequently they were further validated and implemented in the various next model steps such as MARKAL, ISIS and GEM-E3 and the emissions analysis (see Tasks 3-6). This task was carried out by **ICSTM** in cooperation with **ECN**, **ZEW**, **ISI** and **ENEA** together with industry.

2.2.3.3 Infrastructure analysis

Beyond modelling energy chains and the energy system, socio-economic modelling and stakeholder discussions, infrastructure analysis had the objective to create realistic regional hydrogen demand and supply build-up scenarios over time by considering the available resources as well as national policies and stakeholder interests. The purpose was to evaluate different infrastructure options in economic terms and to derive recommendations for introducing hydrogen as a transportation fuel in the next decades. A methodology for the regional allocation of hydrogen demand and fuelling stations was developed and validated with the stakeholders. On top of that an optimisation model was applied to create a variety of hydrogen supply scenarios based on available resources, stakeholder input and techno-economic data. The results were among other visualised by means of GIS maps and cash flow charts, and aggregated to EU level. The task was carried out by LBST and ISI together with industry and MS representatives.

2.2.3.4 Energy system analysis

Using the MARKAL model, the introduction pathways of hydrogen-based technologies was determined. The energy chains as analysed in WP 1 / WP 2 served as input as well as the qualitative information from Task 1 and the scenario development (Task 2). Effects of new technologies on total system cost, changes in fuel and technology mix, and the level of GHG and other emissions were studied, and the optimal technology solution found in each case. This was done for several scenarios in order to determine impacts of energy policy as well as other factors such as energy prices, final energy demand and technological progress. This task was primarily performed by **ECN**.

2.2.3.5 Socio-economic I/O model

Using the ISIS model, impacts of the introduction of hydrogen-based technologies were assessed on a sectoral level. Input from WP 1 were used as well as regional profiling (Task 1), scenario analysis (Task 2) and the energy systems analysis (Task 3). By means of the ISIS model, changes in several socio-economic and environmental indicators were determined (economic output / value added, sectoral and regional structural change, foreign trade, quantitative and qualitative employment effects, and environmental pressure indicators like energy and greenhouse gases). This Task was primarily be carried out by **ISI** and **ULP/BETA** together with industry.

2.2.3.6 Impacts on a macro-level

By means of the GEM-E3 model, the macroeconomic analysis of ‘hydrogen policies’ were performed, thus integrating the bottom-up description of the energy system into a top-down representation of the remaining economy. This provided an analytical framework for evaluating the macroeconomic implications of policy intervention on resource allocation and incomes of agents. The simultaneous explanation of the origin and spending of the agents’ income made it possible to address both economy-wide efficiency as well as distributional (‘equity’) impacts of policy interference. The model was extended for hydrogen utilisation technologies as provided by the energy system models (WP 1 and Task 3 and Task 4). This task was primarily conducted by **ZEW** in cooperation with **ECN** and **ISI** as well as with industry.

2.2.3.7 Emission analysis

In this Task the emissions resulting from the sectors where hydrogen is significantly used were calculated, including atmospheric pollutants. The inputs needed were basically obtained from the energy systems analysis (Task 3) as well as the energy chains (WP1) and region specific information (Task 1). Emissions were calculated considering all the processes from source to end-user. This meant that the emission model addressed the different phases of fuel life, i.e. production, transport and delivery and consumption. This analysis included both local pollutants (i.e. NOx, CO, etc.) and greenhouse gases (i.e. CO_2, CH_4, etc.). This task was primarily be conducted by **ENEA** in cooperation with **ECN** and industry.

2.2.4 Work package 4:

The first objective of Phase I was to provide an introduction to the European hydrogen energy roadmap (based on the six countries included in Phase I) and to develop a Mission Statement.

The second objective of this workpackage was to derive a toolbox. This toolbox has a twofold function. First it serves the project itself by providing a report, which documents the general approach, the interaction between the workpackages and the related activities, as well as the lessons learned in Phase I, which was used in Phase II to increase the project's efficiency. Secondly, the toolbox serves external needs, i.e. providing a general framework for developing roadmaps on the basis of quantitative and qualitative analysis including stakeholder involvement.

A fully validated European hydrogen energy roadmap (based on 12 representative region/member state specific results as derived in WP 3) has been compiled in Phase II of the project.

2.3 Contractors involved

Air Liquide (F), Air Products (GB), BETA ULP (F), BMW (D), BP (GB), CEA (F), CERTH/HIT (GR), DaimlerChrysler (D), dena (D), DNV (N), DTI (GB) [partner since 01JAN2006], ECN (NL), EdF (F), EHN CR (now Acciona Biocombustibles) (E), ENEA (I), FhG-ISI (D), GE Oil&Gas Nuovo Pignone (I), CMI/GIG (PL) [partner since 01JAN2006], HyGear (B), HYDRO (N), Hydrogenics Europe (B), ICSTM (GB) [partnership ended by 30SEP2005], IDMEC-IST (P), INTA (E) [partner since 01JAN2006], LBST (D), Linde (D), Opel (D), Repsol YPF (E), Senter Novem (NL), Statkraft (N), Total (F), Vattenfall Europe (D), WNRI (N), VTT (FIN) [partner since 01JAN2006], ZEW (D)

2.4 Coordinator contact details

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3. MS-visions

The vision on how hydrogen should be introduced in the energy system played a major role in the HyWays project. Over 50 Member State (MS) workshops were conducted with key stakeholders, during which inputs for the models were collected and outcomes of the analysis discussed, leading to further refinement of the MS-visions. Each country outlined its own preferences. As a result no clear choice for one specific hydrogen energy chain was found. According to the stakeholders, hydrogen production in the early phase (up to 2020) will rely mainly on existing by-product, steam-methane reforming and electrolysis (both on-site) to satisfy early demand. As the energy system evolves until 2050, stakeholders expect the production portfolio to broaden, with centralized electrolysis from renewable feedstocks (solar, wind, biomass) and sustainable sources (coal, natural gas with CCS and nuclear).

4. Main Challenges:

The introduction of hydrogen into the energy system faces two major barriers:

- *Cost reduction;* The costs of the hydrogen end-use applications, especially for road transport, need to be reduced considerably to become competitive. A substantial increase in R&D investments is needed with a well balanced distribution for deployment to ensure that the economic break-even point is reached as soon as possible at minimum cumulative costs.
- *Policy support;* Hydrogen must be moved forward on the agenda of the ministries responsible for the reduction of greenhouse gasses and other pollutants and ministries dealing with security of supply. Currently, the required deployment support schemes for hydrogen end-use technologies and infrastructure build-up are lacking and R&D budgets need to be increased.

5. Introduction to the roadmap

This chapter briefly introduces the HyWays project, by outlining the aim and approach of the project and sketching the context.

5.1 History and context

The success of the European Union is that it brings together diverse economies linking their skills, knowledge and technologies and harnesses them for common purpose. The HyWays project - the European Hydrogen Energy Roadmap is an example of the power of collective representative European research in the face of the challenges posed by the need for more sustainable energy solutions in today's world. The project explores and plans for the potential that the integration of hydrogen technologies into the energy system have to contribute to the challenges of ensuring that Europe's peoples and economies have a secure, environmentally sustainable and economically competitive supply of energy services for generations to come.

The integration of hydrogen into the energy system has the potential to impact directly on the key drivers of European energy policy. Improved system energy efficiency and emission reductions mean that hydrogen has the potential to reduce local and global emissions promoting environmental sustainability. Moreover hydrogen enables the economy to be flexible and rely on a diverse range of primary energy sources ensuring security of supply options are kept open; in particular hydrogen can favour the use of higher shares of renewable sources in the energy sector.

The development of market leading hydrogen technologies and the employment they bring with them means that the integration of hydrogen can contribute significantly to on-going European economic competitiveness.

In short, hydrogen technologies offer enhanced sustainability benefits in terms of cost-competitiveness, low well-to-tank carbon content, high energy efficiency and flexible reliance on diverse primary energy resources. However, hydrogen is a very innovative energy technology option that is not compatible with all existing fueling and propulsion systems. Fueling infrastructure and vehicle fleets will have to be built up in parallel from zero, requiring very diligent planning and governmental support.

5.2 Background and objectives

The inherent nature of an innovative technology, which can be disruptive, explains the need for the European Hydrogen Energy Roadmap and an Action Plan. The early studies of HyNet gained impetus for more detailed work through the High Level Group and the Hydrogen and Fuel Cell Technology Platform (HFP), culminating in an important milestone at European level of a target of 10 to 20% sustainable hydrogen production by 2015 as set by the Implementation Plan and backed by industry. The HyWays project sets out to produce a roadmap for Europe, that clearly demonstrates the advantages and problems posed by this very innovative energy technology option, alongside the timings and expected costs. An Action Plan accompanying the roadmap details the conditions, including measures and their timelines, necessary to overcome the initial barriers in order to facilitate the deployment of hydrogen technologies. The Action Plan addresses politicians and policy makers at a national and European level and is designed to inform decision making with respect to governmental support during the initial phase.

The objective of HyWays, an integrated project co-funded by research institutes, industry and the European Commission under the 6th Framework Programme, is to develop a validated and well-accepted roadmap for the introduction of hydrogen in the energy system in Europe. The HyWays project combines technology databases and socio-/ techno-/ economic analyses to evaluate selected stakeholder scenarios for future sustainable hydrogen energy systems. Scenarios are based on Member States (MS) visions for the introduction of hydrogen technologies with extensive interaction between science and stakeholders involving over 50 workshops. For each country the theoretical economic optimum choice is calculated and evaluated by the member states on an iterative basis. A multinational approach covering, at that time, 80.5% of the EU land area and 71.4% of the population ensures a wide diversity in terms of feedstocks, regional & infrastructure-related conditions and preferences.

5.3 Methodology

The HyWays project compiles all pivotal technological and socio-economic aspects related to a future hydrogen infrastructure build-up and provides a number of scenarios under different assumptions. It shows the advantage of the introduction of hydrogen as a fuel and indicates the financial effort necessary to reach the break-even point.

The HyWays project differs from other road mapping exercises as it integrates stakeholder preferences, obtained from multiple member state workshops, with extensive modelling in an iterative way covering both technological and socio-economic aspects, Figure 5.1. This approach enables qualitative data to be incorporated in a systematic and structured manner with quantitative infrastructure analysis, thus adding significantly to the common quantitative modelling approach adopted by other roadmaps.

The stakeholder validation process, which takes into account country specific conditions, is considered to be a key element of the road mapping process.

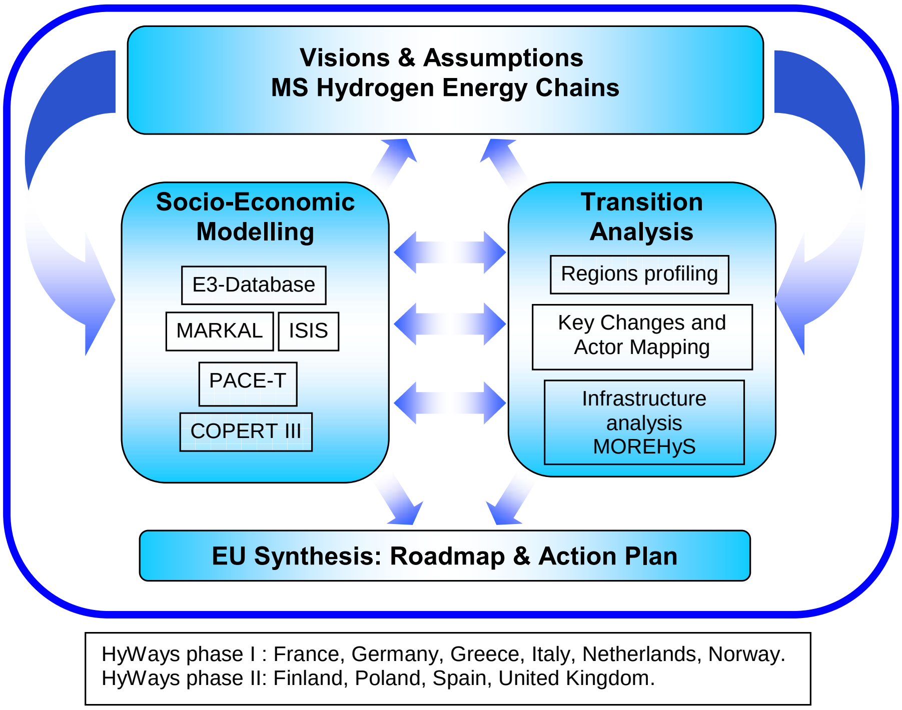

Figure 5.1 ***Schematic representation of the HyWays process***

In the HyWays project the roadmap is based primarily on country-specific analyses of ten member states (MS) (six in HyWays phase I and four in HyWays phase II). The countries selected (FI, FR, DE, GR, IT, NL, NO, PL, ES and UK) ensure a large coverage, both in land and population, and represent the diversity and geographical spread of Europe, increasing the confidence in the validity of the synthesis at European level.

5.4 Transition phases: from demonstration towards mass markets

In 2006, major stakeholders from automotive industry and the energy sector published a common position paper on the next steps for the development of a hydrogen infrastructure for road transport in Europe. Hydrogen-based vehicle roll-out is considered to happen in three phases: (i) a currently ongoing phase focussing on technology development and cost reduction followed by (ii) a pre-commercial phase from 2010 to approximately 2015 comprised of technology refinement and market preparation and (iii) after 2015 a commercialization phase of hydrogen vehicles which is expected to start with a continuous ramp-up of production leading to a mass market within ten years.

5.5 Milestones

The HFP Deployment Strategy published in 2005 proposed commercialization targets for the transport sector in 2020. According to this *'Snapshot 2020'* sales of 0.4 to 1.8 million vehicles per year within the EU are considered to be a realistic goal. The vehicle penetration scenarios calculated in HyWays are in good agreement with the HFP *Snapshot 2020*. Based on various assumptions on future technology development as well as on several levels of policy support, these scenarios have been extrapolated to create a '*Snapshot 2030*', and a further outlook to 2050.

5.6 Competing uses, technologies and synergies

Considering the interaction of hydrogen technologies with competing / alternative options, the analysis shows that, in terms of hydrogen from biomass, there are competing demands for biomass for stationary, food, chemical industry, transportation and other biofuel applications. However there are technical synergies with biomass to liquid processes. No competition is seen from drive train technologies, but simply the development of a broader portfolio including hybrids and battery electric vehicles in niches, where their deployment can help to cut the costs of a large part of the components used in FCVs. Ultimately hydrogen and fuel cell vehicles provide the most promising option.

Hydrogen can also be seen as an energy carrier to be used in combination with electricity. To this end large centralised production plants can provide both electricity and hydrogen, using fossil fuels in a sustainable way through significant CO_2 emission abatement made possible by CO_2 capture and sequestration (CCS). Small-scale CHP generators running on natural gas can provide electricity and hydrogen through their reformer stage - without CCS but with much cleaner natural gas.

For the stationary use of hydrogen HyWays has assessed its use mainly in fuel cells for CHP which can become a relevant option for remote supply of electricity and heat as well as in complex energy infrastructures for use in stationary and transport and combined with energy storage. In terms of combined heat and power (CHP) and power production there is a broad portfolio of competing technologies that have already been established and others that are being established. Fuel cells promise higher efficiencies at comparable unit sizes. Fuel cells also allow for small CHP units for residential use. The technological synergies are likely to have spill-over effects between different applications and sectors.

5.7 Concurrent initiatives

During the course of the project HyWays has been active in links and interaction with other EU and non-EU activities and has communicated with various HFP-bodies. The HLG Vision 2050 report provided long-term goals to HyWays. In turn HyWays has made inputs to the on-going SET (Strategic Energy Technology)-Plan by EC and has been liaising, through the HyWays-IPHE Project, with the US road mapping activities being undertaken by the Department of Energy, the National Renewable Energy Laboratory and Argonne Laboratory. HyWays has also maintained close cooperation and exchange of information with the EC-funded projects NaturalHy, StorHy, HyLights, Roads2HyCom and with MS/regional initiatives such as HyFrance, NorWays and the Dutch Transition Platform. With NaturalHy joint analysis was carried out on combined natural gas and hydrogen transport and distribution pathways for specific case studies.

HyWays has taken into account the EU 20% Renewable Energy Target for 2020 which will lay the foundation for increasing RES use for hydrogen production, and the EU biofuel target of 10% by 2020, which can partly be met by biomass-to-hydrogen conversion.

Analysis performed within the HyWays project indicates that hydrogen can become cost effective in transport with positive economic impacts, reduction in costs of CO_2 whilst simultaneously offering opportunities to increase the share of renewable energy. Nonetheless, hydrogen is an innovative energy technology option that will not happen of its own accord as significant initial barriers of cost reduction of the drive train, build-up of the energy infrastructure and others such as regulations, codes and standards, education and training need to be overcome. The comparative costs of competing energy sources as well as the nature of policy support schemes have also a tremendous importance for the deployment of the hydrogen technologies.

For the transition to a hydrogen economy the relative safety coining the public perception is a very critical issue like for any other innovation. Although the public view on hydrogen is - besides some misunderstandings - in general positive, an early large accident in the public environment could change this quickly. As the new hydrogen applications cover new operational domains, like high pressures or cryogenic temperatures, the quite successful and safe usage in industrial environments might not be translated directly to all these cases. Therefore research especially for a better understanding of all involved phenomena, performance of mitigation and simulation technologies is required. Due to evident limitations of the HyWays project the issues regarding safety were not included. Instead these aspects are addressed by the European Network of Excellence HySafe at least on a technical level. A sufficient information exchange between HyWays and Hy-

Safe was arranged with the HyWays coordinator being a member of the HySafe coordination committee.

The HyWays project makes the case for a transition to hydrogen, showing that with the right policy actions, the introduction of these technologies could have positive economic, social and environmental benefits. This document summarizes the technical and socio-economic analyses and examines the implications for research priorities and future targets and concludes with a summary of the Action Plan.

5.8 Other HyWays reports

Within the context of the HyWays project, a number of reports will be published

- a flyer on main results and recommendations
- an executive summary
- the HyWays Roadmap
- an Action Pan
- a MS-vision report
- various background reports.

These documents are available for download at the HyWays web site: www.HyWays.de. For further detailed information on the issues addressed by HyWays please refer to the full background reports on the website.

6. Main Conclusions:

Emission reduction;

If hydrogen is introduced into the energy system, the costs to reduce one unit of CO_2 decreases by 4% in 2030 and 15% in 2050, implying that hydrogen is a cost effective CO_2 reduction option. A cash flow analysis shows however that a substantial period of time is required to pay back the initial investments (start-up costs). Total well-to-wheel reduction of CO_2 emissions will amount to 190 – 410 Mton per year in 2050.[1] About 85% of this reduction is related to road transport, reducing CO_2 emission from road transport by about 50%.

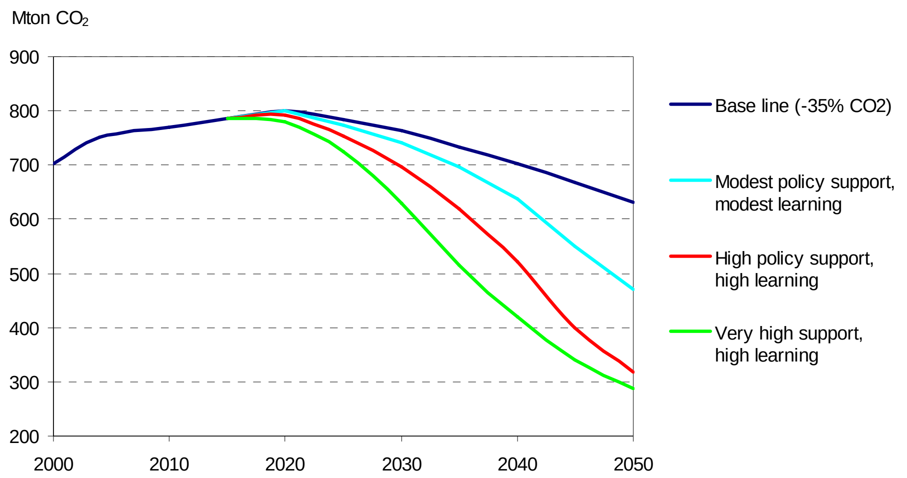

Figure 2 ***Development of total CO_2 emission for road transport[1]***

[1] Results for the 10 countries analysed in HyWays

Hydrogen production mix

The vision on how hydrogen should be introduced in the energy system played a major role in assessing the development of the hydrogen production mix. Over 50 Member State (MS) workshops were conducted with key stakeholders, during which inputs for the models were collected and outcomes of the analysis discussed, leading to further refinement of the MS-visions. In this selection process, both stakeholder preferences and country specific conditions, such as availability of resources and the potential to sequester CO_2 as well as the characteristics of the current and future energy system, are taken into account. Each country outlined its own preferences. This is reflected in the choice for and shares of the hydrogen energy chains that are taken into account.[2] In Figure 3, the hydrogen production mix calculated for the 10 Member States analysed in HyWays is given.

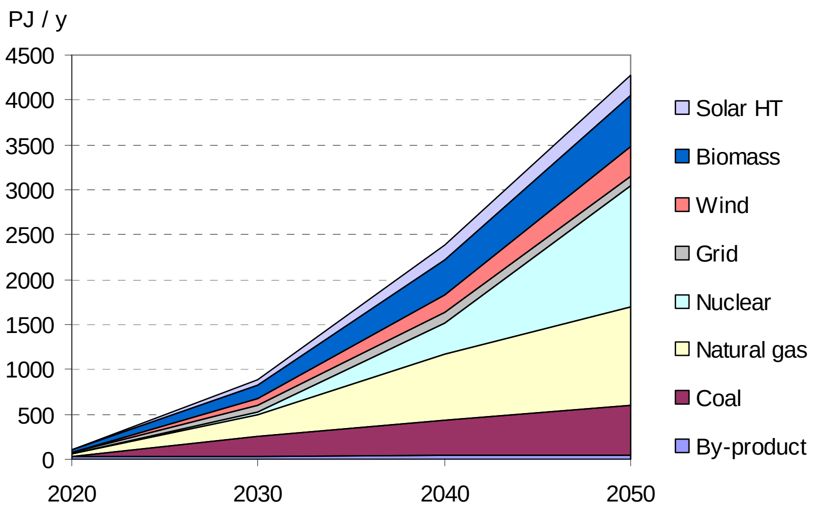

Figure 3 ***Hydrogen production mix for the 10 HyWays countries based on the visions developed in the MS workshops***

As a result, for the 10 members states a rather diversified hydrogen production mix is found, reflecting the inhomogeneous conditions in Europe quite well. Natural gas, biomass and wind energy based pathways were selected by all member states participating in HyWays. Nuclear energy based pathways were selected in France, Finland, Spain, Poland and the UK. For Finland, France and Norway, coal (and lignite) based hydrogen pathways were excluded.

Within a sensitivity analysis, the impact of prices of fossil fuels was investigated as well as a potential failure of carbon capture and sequestration (CCS). In addition, the impact of a more ambitious emission reduction constraint was analysed. In the base line, a (moderate) CO_2 emission reduction constraint of -35% in 2050 compared to the 1990 level was used. In the sensitivity analysis, a CO_2 emission reduction constraint of -80% was set for 2050. The results of the sensitivity analysis can be found in the HyWays Roadmap report.

Security of supply;

Like electricity, hydrogen de-couples energy demand from resources. The resulting diversification potential leads to a substantial improvement of security of supply. As a result of introducing hy-

[2] Besides selecting hydrogen energy chains that are expected to fit best with the country specific conditions, stakeholders were given the opportunity to set minimum and maximum shares for hydrogen production pathways. An addition, calculations were performed without the minimum and maximum shares in order to obtain the (theoretical) least cost solution based on the hydrogen energy chains selected by the stakeholders.

drogen into the energy system, the total oil consumption of road transport decreases by around 40% by 2050 as compared to today. Equally important is the fact that several pathways exist that can produce hydrogen at price levels comparable to conventional fuels and in sufficient amounts. This range of diverging production options ensures a relatively stable hydrogen production price. Use of hydrogen for electricity production from fossil fuels in large centralized plants will positively contribute to achieve a significant reduction of CO_2 emissions if combined with CO_2 capture and sequestration processes. The resulting diversification potential leads to a substantial improvement of security of supply.

Impact on economic growth and employment;

The transition to hydrogen offers an economic opportunity by strengthening Europe's position in car and energy equipment manufacturing. In case import/export shares do not change, impacts on economic growth are small (around +0.01% per year). This situation changes considerably if Europe is not able to maintain its position as major car manufacturer in which case there will be a substantial negative impact on welfare in Europe. The major benefit for economic growth is a strong decrease in vulnerability of the economy to shocks and structural high oil prices. Studies from e.g. the International Energy Agency (IEA) and European Central Bank (ECB) indicate that the temporary impact on GDP growth of prices shocks of 5 to 10 $/barrel amounts to -0.2% to -0.4% of GDP growth. Structural high oil prices are expected to have a comparable negative impact on economic growth. Substantial shifts in employment are observed between sectors, highlighting the need for education and training programmes. Net impacts on employment amount to +200,000 to +400,000 jobs per year by 2030. The shift to the production of dedicated propulsion systems will contribute to maintaining high skilled labour in Europe rather than outsourcing these to countries where labour costs are low.

Contribution to targets for renewable energy and energy saving;

Introduction of hydrogen in the energy system offers the opportunity to increase the share of renewable energy. Since hydrogen also acts as a temporary energy storage option, hydrogen facilitates the large scale introduction of intermittent resources such as wind energy. Hydrogen produced from biomass offers substantial efficiency gains over biofuels (and conventional fuels) when used in a fuel cell vehicle, thus contributing to energy conservation goals. The efficiency gain over biofuels is specifically important since the potential for biomass is limited and strong competition exists (e.g. power sector, feed stocks, food).

End-use applications;

The main markets for hydrogen end-use applications are passenger transport, light duty vehicles and city busses. About half of the transport sector is expected to make a fuel shift towards hydrogen. Heavy duty transport (trucks) and long distance coaches are expected to switch to alternative fuels (e.g. biofuels). The penetration of hydrogen in the residential and tertiary sector is expected to be limited to remote areas and specific niches where a hydrogen infrastructure is already present.

User centres and regional demand development: The initiation of hydrogen infrastructure rollout is seen predominantly in population centres and also to some extent in remote or less populated areas, see Figure 4. The further regional deployment will be based on demographic indicators like population density and will lead to an expansion of existing and a build-up of new user centres (organic growth of hydrogen demand). In order to make hydrogen an attractive fuel and facilitate its deployment among users, it may be necessary to ensure hydrogen supply along an early road network.

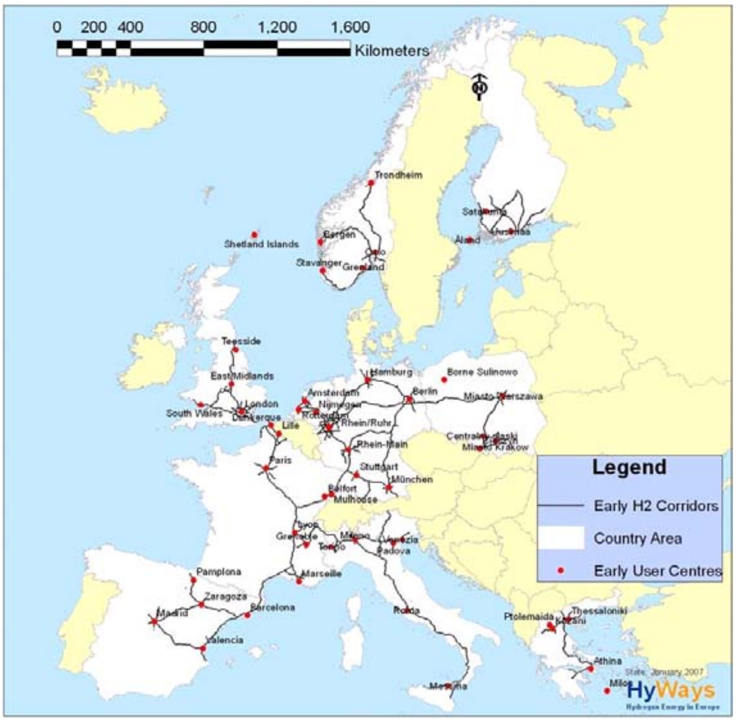

Figure 4 ***Early user centres of the 10 HyWays countries selected by the stakeholders in each country on the basis of regional indicator***

Transport and distribution: In the initial phase, by-product hydrogen and onsite production of hydrogen will dominate in sparsely populated and remote areas. In urban areas also decentral steam methane reformers will play a role. Gaseous trailers will be the major transport option; pipelines to a lesser extent (mainly using and extending existing ones). Central production could play a role if there is an available liquefier with free capacity. In this case, liquid trailers would then be the favoured transport mode. Later on - with increasing hydrogen demand – the role of pipelines will increase significantly (as a solution for central and decentral hydrogen productions which also increase in such a phase and for hydrogen transport to demand areas). However liquid trailers will have market shares in areas with medium demand and longer transport distances. Onsite will compete for the supply of remote areas.

Competitiveness of hydrogen as a fuel; In the full commercialization phase, H_2 costs at the filling station in comparison to oil-based fuels are not a relevant barrier for H_2 as long as the crude oil price remains above 50 $/bbl (in densely populated regions) or 60 $/bbl (in less populated regions). However, the introduction phase with its underutilisation of capacities could be critical due to the small demand.

Break-even point: By means of a cash flow analysis, the expenses for hydrogen production and supply and vehicles are compared to the savings gained from replacing conventional fuel and conventional vehicles over time. Total cumulative investments for infrastructure build-up amount to 60 billion € for the period up to 2030. This is about 1% of the societal costs for meeting the 450 ppm target in Europe. The moment in time where savings of total costs of fuel and vehicle are higher than expenditures, lies, between 2025 and 2035 in nearly all analysed cases. Only in a case with hampered cost reduction for vehicle drive systems and a slow build up of the infrastructure, which leads to a long period of underutilisation, the turn around point is around 2040. The savings through hydrogen after reaching the break-even point can be enormous as long as the oil price is at a level above 50$/barrel for densely populated countries and 60-70$/bbbl for less populated countries. Some countries already grant € 1.200 or more for cleaner or more efficient vehicles. If tax advantages of € 1.000 per vehicle are considered and an oil price of $80/bbl, hydrogen cars may break even with conventional cars already by 2023 and the additional costs will be reimbursed as soon as by 2030. Key outcome is that the development of the hydrogen demand needs to increase at sufficient pace in order to ensure market conditions that are acceptable for industry.

7. Recommendations:

7.1 The need for a European public private partnership

Hydrogen can become a cost-effective innovation with positive impacts on environment and economy. First, the step towards large scale demonstration has to be made. Production of small series of vehicles has started but has to be scaled up further soon. A quick ramp up of market penetration is needed in order to create revenue to earn back the upfront investments in infrastructure build-up. Appropriate deployment incentives, such as financial support schemes, for the deployment of these vehicles are however lacking. The past and current Framework Programmes of the EC have a general nature and focus on R&D. Therefore, they are not applicable in demonstration projects for (significant) series of identical vehicles. In this crucial phase technology specific deployment support and R&D must go hand-in-hand.

A European public private partnership between industry and the EC is the most suitable framework where these conditions can be met. This can be in the form of a so-called Joint Technology Initiative (JTI). Without a European public private partnership, the roll out of large scale demonstration projects will seriously be hampered. This imposes a serious threat, since the large scale demonstration projects play a key role in convincing policy makers that hydrogen has to be supported ***starting now*!** The commitment shown by policy makers to drive hydrogen forward will strongly determine the pace with which industry is able and willing to make the required investments.

7.2 The HyWays Action Plan

As a result of the introduction of hydrogen into the energy, substantial emission reduction can be achieved in a cost effective way. At the same time, security of supply is improved and new economic opportunities are created. Despite these advantages, initial barriers prevent hydrogen to enter the energy system at sufficient pace in case no further policy incentives are provided. The Action Plan provides concrete actions that need to be taken with priority in order to overcome smoothly the initial barriers that hamper hydrogen from entering the energy system.

The following main actions need to be taken with priority:

- *A technology specific support framework* for hydrogen needs to be designed and implemented. Generic frameworks to support sustainability will give hydrogen and alternative options an advantage over conventional technologies. In order to overcome the initial cost gap with alternative options, a technology specific framework for hydrogen is needed. This should comprise the following elements:
  - *Innovation*; The R&D budgets for hydrogen and its end-use applications need to increase to 80 M€ / year.
  - *Market penetration;* Deployment is an important factor in bringing down the costs of hydrogen applications to a level where they can compete, and eventually can become more profitable, than the reference technology. Starting point for such a deployment framework is equalising total costs (€ct/km) for the use of a hydrogen vehicle in comparison to a conventional vehicle. In the initial phase, substantial deployment support is however needed with budgets of around 180 M€ per year.
  - *No tax on hydrogen as a fuel;* In the first phase of the introduction of hydrogen into the energy system, hydrogen as a fuel needs to be de-taxed. Substantial investments are needed in infrastructure build-up. Tax-exemptions can play a crucial role in this initial phase where underutilisation will have a strong negative effect on profitability.

- *Tax exemptions for hydrogen vehicles and creation of early markets;* The additional costs of the hydrogen vehicle have to be (partly) compensated for by tax exemptions (or subsidies). National and local governments need to create early markets which tolerate higher additional costs for the vehicle. Examples are limited city centre access or procurement of zero emission vehicles within governmental services.

- *Planning and financing of infrastructure build-up;* In the early phase of the hydrogen transition, underutilisation of the infrastructure is likely to occur. Careful planning is needed to ensure that the infrastructure build up in the early phase will also fit the longer term and corresponding high demand.
- *Look for synergies with other options;* While preparing for the system change towards hydrogen, investments will also be made in near-term options to optimise the current (internal combustion engine) system for sustainability. Investments should be focussed on options that provide synergies with hydrogen production and end-use applications, such as 2nd generation biomass to liquids (BTL from biomass gasification) and hybrid vehicles (i.e. regenerative breaking, power management).
- *Level playing field;* In order to be able to compete with areas outside Europe (US, Japan) barriers within Europe have to be removed (harmonisation of regulations, codes and standards) and incentives for deployment and R&D need (at a minimum) to be at a comparable level.
- *Monitoring framework;* In order to minimise total cumulative costs to reach the break even point, a monitoring framework needs to be implemented, assuring an appropriate balance between R&D and deployment.
- *Education and training;* To facilitate the large employment shifts, education and training programmes on hydrogen and fuel cells need to be set up and implemented.
- *A European public private partnership* for hydrogen and its end-use applications, e.g. in the form of a Joint Technology Initiative (JTI), is key in achieving these objectives and should be established by 2008.

The main targets and actions as outlined in the HyWays Roadmap and Action Plan are summarised in Table 1 below.

Table 1 ***Summary of the deployment phases targets and main actions outlined in the Roadmap and Action Plan***

	2010	2015	2020	2030	2050
Phases	**Technology development with focus on cost reduction** **Pre-commercial technology refinement & market preparation**	**Start of commercialisation**	**HFP Snapshot 2020** **materialisation of first impacts** • New hydrogen supply capacities partially based on low carbon sources • improvement in local air quality • More than 5% of new car sales H_2 &FC	**HyWays Snapshot 2030** **Hydrogen & FC are competitive** • Creation of new 200.000 – 300.000 jobs/ safeguarding existing jobs • Shift towards carbon-free hydrogen supply • **More than 20% of new car sales H_2 & FC**	**H_2 & FC dominant technologies high impact** • 80% of light duty vehicles & city buses fuelled with CO_2 free hydrogen • reaching more than 80% CO_2 reduction in passenger car transport • In stationary end-sue applications, hydrogen is used in remote locations and island grids
Targets	**LHPs facilitate initial fleet of a few 1,000 vehicles by 2015** • PPP "Lighthouse Projects" • Increase R&D budgets to 80 M€/year • Financial support for large scale demonstration projects		**Vehicles:** **2.5 million of fleet** **Cost** **H_2: 4 €/kg (50 €/barrel)** **FC: 100 €/ kW** **Tank: 10 €/kWh**	**Vehicles:** **25 million of fleet** **Cost** **H_2: 3 €/kg (50 €/barrel)** **FC: 50 €/ kW** **Tank: 5 €/kWh**	
Required Policy Support Actions	**Develop H_2 specific support framework** • Create / support early markets • Implement performance monitoring framework • Long term security for investing stakeholders • Education and training programmes • Harmonisation of regulations codes and standards	**H_2 specific support framework** • In place before 2015 at MS level • Deployment supports, e.g. tax incentives of 180 M€/year • Public procurement • Planning and execution of strategic development of hydrogen infrastructure		**Gradual switch from hydrogen specific support to generic support of sustainability (2020 →)**	**Incentives provided through general support schemes for sustainability**
	2010	2015	2020	2030	2050

The full version of the Roadmap and Action Plan are available for download at www.HyWays.de.

8. Deliverables and milestones of the project

8.1 List of deliverables, including due date and actual/foreseen submission date

No.	Result, Deliverable	Date	Respons.
D1.4	Report on the 6 (+6) region/ MS specific hydrogen energy pathways TECHNOLOGY FACT SHEETS Containing all process specific technology and cost data, D1.1 updated for Phase II (xls-file) (pdf-file)	SEP 2006	LBST
D2.1 - D2.6	"Modelling of hydrogen supply chains for Germany in the E3-database"	20NOV2006	LBST
D2.1 - D2.6	"Modelling of hydrogen supply chains for Poland in the E3-database"	20NOV2006	LBST
D2.1 - D2.6	"Modelling of hydrogen supply chains for Norway in the E3-database"	28NOV2006	LBST
D2.1 - D2.6	Modelling of Hydrogen supply chains for Greece	14DEC2006	ECN
D2.1 - D2.6	"Hydrogen supply chains for Spain"	15DEC2006	CEA
D2.1 - D2.6	"Hydrogen supply chains for France"	15DEC2006	CEA
D2.1 - D2.6	Modelling of Hydrogen supply chains for Finland	27DEC2006	ECN
D2.1 - D2.6	Modelling of Hydrogen supply chains for the Netherlands	28DEC2006	ECN
D2.1 - D2.6	Modelling of Hydrogen supply chains for the UK	09JAN2007	ECN
D2.1 - D2.6	"Hydrogen supply chains for Italy"	25JUN2007	CEA
D3.13	Robust Phase II Region / Country specific scenarios and introduction pathways for the implementation of hydrogen based technologies	FEB 2007	FhG-ISI
D3.14	Member State Profiling Report - Finland Member State Profiling Report - Poland Member State Profiling Report - Spain Member State Profiling Report - UK	MAY - JUN 2006	IDMEC-IST
D3.16	Actor Analysis Report Phase I& II (KCAM)	DEC 2006	IDMEC-IST
D3.17	Report on the I/O analysis of energy systems on all branches of industry	FEB 2007	FhG-ISI

No.	Result, Deliverable	Date	Respons.
D3.18	Report of the macro-economic analysis, providing details of the interac-tion of macro-economy with the environment and energy systems - Phase II	JAN 2007	ZEW
D3.19	Environmental Analysis for hydrogen deployment Run 2 - Draft	JAN 2007	ENEA
No con-tractual deliv-erable	Vision on Hydrogen Chains - France	SEP 2006	HyFrance/CEA
	Vision on Hydrogen Chains - Germany	NOV 2005	DENA
	Vision on Hydrogen Chains - Greece	AUG 2005	CERTH
	Vision on Hydrogen Chains - Italy	JUN 2006	ENEA
	Vision on Hydrogen Chains - Norway	NOV 2006	NorWays/
	Vision on Hydrogen Chains - Poland	JUN 2006	CMI
	Vision on Hydrogen Chains - Spain	FEB 2007	INTA
	Vision on Hydrogen Chains - UK	JUN 2006	DTI
	Vision on Hydrogen Chains - NL	JAN 2007	SN
D3.20	Infrastructure analysis Phase II	JUN 2007	FhG-ISI/LBST
D3.21	5th Member State workshop This workshop never took place and was re-placed by direct exchange between the partici-pating member states and countries. It needs to be stressed that the HyWays partners were ea-ger to foster an exchange between the member states partners. Hence, the consortium advises to organise a MS specific event on behalf of the HFP (MSMG) or JTI to inform a broad group of MS/country and regional stakeholders about the outcome of HyWays allowing for amply discus-sion). The pledge for continuity was brought for-ward by the HyWays coordinator at the HFP-AC meeting on 12JUN2007 in Brussels.		
D3.22	Final report socio-economic analysis Phase II	AUG 2007	FhG-ISI
D3.23	Assessing Member-State Opportunities and Challenges for Hydrogen and Fuel Cells	FEB 2007	ULP-BETA
D3.24	Toolbox	MAR 2007	FhG-ISI
D4.1	HYWAYS SCOPING REPORT - Scope of the Roadmap - Baseline scenario - Hydrogen penetration rates for stationary and mobile applica-tions	OCT 2004	ECN
D4.2	Final report European Synthesis Phase I - HyWays External Document Phase I	FEB 2006	ECN/ All partners
D4.3	Final report European Synthesis Phase I - HyWays Flyer for External Document	FEB 2006	ECN
D4.4	Final report European Synthesis Phase II	JUN 2007	ECN
D4.5	EHER and Action Plan Phase II	JUN 2007	ECN

8.2 List of milestones, including due date and actual achievement date

No.	Date*	Milestone	Result, Deliverable	Respons. Co-ord.
D3.12	FEB2006	Estblished process modules	Established Phase II process modules for the 3rd model run	WP 3
D0.17	25APR2006	7th strategy meeting	Steering Group meeting at DC Kirchheim, Germany	WP 0
D0.18	26APR2006	5th project meeting	General Assembly meeting at DC, Kirchheim, Germany	WP 0
D0.19	MAY2006	2nd financial statement	2nd annual financial statement to the EC	WP 0
D2.1-D2.6	20NOV2006-12JAN2007	Estblished process modules	Established processes modules per region as part of the combined D2.1-D2.6 report issued per participating country (Chronological oder of finalisation: Germany, Poland, Norway, Greece, Italy, Spain, Finland, The Netherlands, UK and France)	WP 2
D3.13	FEB2007	Report on Phase II scenarios and introduction pathways	Robust Phase II region/ MS state specific scenarios and introduction pathways for the implementation of hydrogen based technologies	
D3.14	MAY-JUN 2006	MS Profiling Reports	MS Profiling Reports for Finland, Poland, Spain and the UK, including an overview of the energy sector in each of the regions/ MS reflecting specific conditions and outlining barriers and opportunities	WP 3
D1.4	SEP2006	Report on MS H2 Pathways	Report on the 6(+ up to 6) region / MS specific energy hydrogen pathways Technology Fact Sheets containing all process specific technology and cost data, D1.1 updated for Phase II	WP 1
D2.5	20NOV2006-12JAN2007	Established validated WtW/StU pathways	Established validated WtW/StU pathways for the up to 6 new regions of Phase II (incl. necessary adaptations of Phase I pathways) – [see entry for D2.1-D2.6 above]	WP 2
D3.15	01MAR2007	Report	TENTATIVE RESULTS HYWAYS PHASE II - EXPANSION OF THE MARKAL MODEL, IMPACT ON CO2 EMISSION AND COST EFFECTIVENESS – Restricted dissemination/ not public	WP 3
D3.16	DEC2006	Actor Analysis Report	Actor Analysis Report Phase 2	WP 3
D3.17	FEB2007	Report input/output analysis	Report on the input/output analysis of energy systems on all branches of industry	WP 3
D3.18	JAN2007	Report macro-economic analysis	Report of the macro-economic analysis, providing details of the interaction of macro-economy with the environment and energy systems	WP 3
D3.19	JAN2007	Report on emission impacts	Environmental Analysis for hydrogen deployment Run 2 - Draft	WP 3
No formal deliverable	SEP 2006 NOV 2005 AUG 2005 JUN 2006 NOV 2006 JUN 2006		Vision on Hydrogen Chains - France Vision on Hydrogen Chains - Germany Vision on Hydrogen Chains - Greece Vision on Hydrogen Chains - Italy Vision on Hydrogen Chains - Norway Vision on Hydrogen Chains - Poland	MS responsibles

No.	Date*	Milestone	Result, Deliverable	Respons. Co-ord.
	FEB 2007 JUN 2006 JAN 2007		Vision on Hydrogen Chains - Spain Vision on Hydrogen Chains - UK Vision on Hydrogen Chains - NL	
D3.20	JUN2007	Report on IA	Infrastructure Analysis Phase II	WP3
D3.21	APR-DEC 2006	5th MS workshop 04APR – 27APR2006 29JUN – 24AUG2006 22NOV – 18DEC2006	Series of Phase II MS workshops Phase II 1st round of MS workshops Phase II 2nd round of MS workshops Phase II 3rd round of MS workshops	WP 3
D3.22	OCT2006	Final report socio/economic analysis	Final report socio/economic analysis Phase II	WP 3
D2.6	20NOV2006-12JAN2007	Validated WtW/StU pathways for up to 12 regions	Available WtW/StU analysis output data laid down in predefined EXCEL data output sheets [see entry for D2.1-D2.6 above]	WP 2
D0.20	25OCT2006	8th strategy meeting	Steering Group meeting with EC representation at GE-NP, Florence, Italy	WP 0
	09MAY2007	9th strategy meeting	Steering Group meeting atDTI,Lodon , UK	WP0
D4.4	JUN2007	Final report European Synthesis Phase II	Final report European Synthesis Phase II (Assessment of 6(+6) regions or member/candidate states carried out: in co-operation with WP 3	WP 4
D4.5	JUN2007	EHER and Action Plan (Phase II)	EHER and Action Plan Phase II compiled (report)	WP 4/ WP 0
D0.24	08MAY2007	Workshop Phase II	Validation workshop with industry and invited external experts, Brussels, EC, 08MAY2007	WP 0

* End of month