HyWays

Deliverable 3.1

Work Package 3 Data Collection Plan

DRAFT

Official Delivery date: May 2004
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1. Introduction

The aim of this document is to outline the process of collection of necessary data for HyWays Work Package 3 tasks from participating Member States. The deliverable constitutes a reference document of importance for the HyWays "toolbox" which is subject to modifications over the progress of the project.

Work Package 3 is characteristed by an original approach to socio-economic analysis, which combines qualitative and quantitative research. This "hybrid" approach is depicted in Figure 1 below, where two interdependent methods are followed to build the MS-specific roadmap from an initial choice of energy chains. The left side depicts the set of activities which primarily qualitative analysis of the MS scenarios through computational models, whilst the right side ("Transition Analysis") constitutes the qualitative analysis of context, potential and necessary policies.

These tasks correspond the following deliverables.

- Transition Analysis: MS Profiling (Del 3.3) and MS Scenario building (Del 3.5)
- Computational Modelling Energy system, Socio-economic and environmental analysis (Deliverables 3.6-3.9)

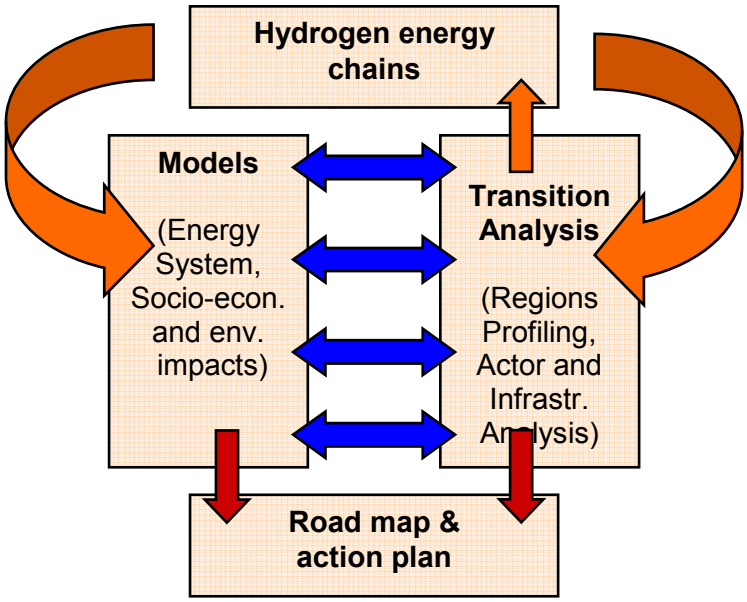


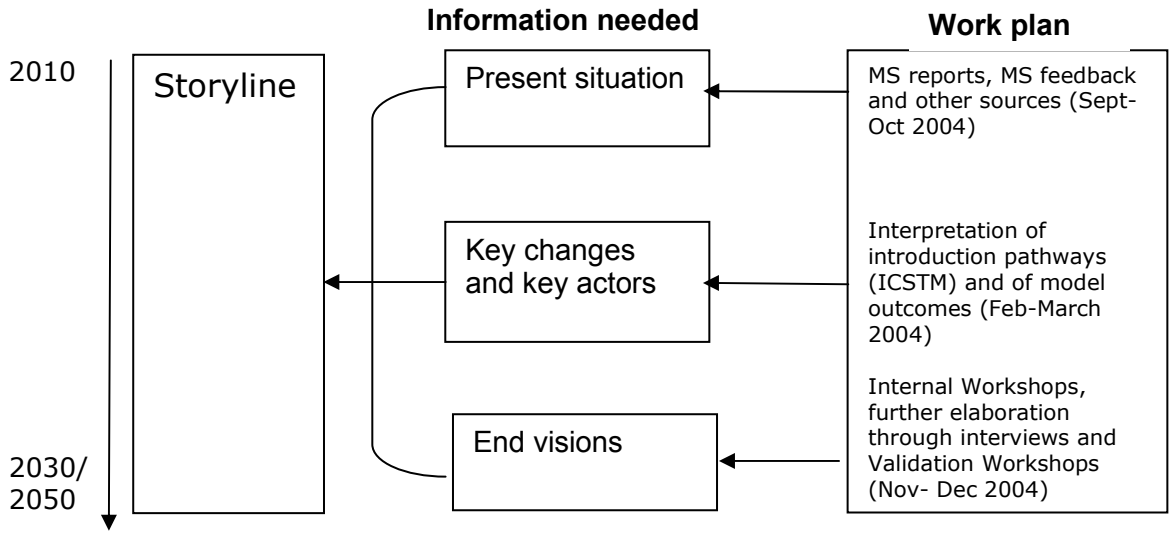
Figure 1. Concept of Hybrid Approach in HyWays WP3

An initial attempt at the set up of a harmonised effort for data collection for all activities took place in June-July 2004. A draft booklet gathering the data requirements for all WP3 tasks was compiled. However, despite the interdependency between these tasks, it was found that their nature and timing of differed significantly. Consequently, **different processes for data collection have been followed in the various tasks**. These are summarized here in turn.

2. MS Profiling (Del 3.3) and MS Scenario Building (Del 3.5)

The **Profiling reports** (Del 3.3) provide a qualitative picture of the country's present energy system, as well as of the drivers and barriers for hydrogen energy systems. This deliverable aims also to draw a MS-specific "end vision" for the energy systems, and to analyse key required changes and actors. The framework for the data collection process and the resulting work plan followed (extracted from Annex 1) is summarised in Figure 2.

Figure 2. Graphical representation of the work plan (as of December 2004).



Scenario building (Del 3.5) aims to…short paragraph and a diagram to explain work plan for Scenario building/Infrastructure Analysis

The detailed plans for these two processes can be found in various memos and documents in the Annexes. The specific **data-collection tasks** that have been carried out to date are organised chronologically as follows (add any other Scenario building tasks):

- Jul-Aug 2004: first draft report with data based on MS contributions and literature outlined the context energy system and potential for hydrogen.
- Sept-Oct 2004: feedback from the MS reps was gathered in a structured fashion.
- Nov-Dec 2004: two sets of workshops took place were data on "end-visions" was gathered as part of the discussion of inputs to socio-economic models.
- Jan-Feb 2005: second draft report based on workshop outcomes and bilateral discussions.
- Mar-Apr 2005: Initiation of infrastructure analysis Scenario building tasks: data collection through bilateral discussions and workshops. The methodology for Key Change and Actor Analysis has been finalized, preliminary data collection.

3. Computational Modelling - Energy system, Socio-economic and environmental analysis (Deliverables 3.6-3.9)

The standard inputs to the WP3 models arise from WP1/2 results (which extracted a set of preferred hydrogen chains for analysis from discussions with MS) and the WP4 Scoping Report (which sets the framework assumptions for the models, and is based on the document "Energy and Transport Trends for 2030").

The exchange of data among the models has followed the basic structure outlined in Figure 3, where the Markal model gathers the bulk of its assumptions from WP1/2 (e.g. technology data, learning curves).The remaining models rely heavily on Markal data. Moreover the HyWays framework underlying the models ("Scoping report") affects all models. The specific interfaces (both with WP1/2 and among the models) are explained in detail in the document Definition of model data exchange and model interfaces (Del 3.2, finalised in Nov 2004).

There are several models where MS-specific data has been sought directly from industry or MS representatives (e.g. ISI).

A recurring issue has been identified: reliable and approved data for input into models are available for the 2010 time frame, but less so for 2020, 2030 and 2050. These data has undergone revision by HyWays partners and is in the process of being transparently validated following the study of the first model outcomes.

Figure 3. Logical model linkage and data flow (from Del 3.2)

The **data-collection** process to date can be summarised in the following steps:

- May-Jun 2004: preliminary choice of chains by MS representatives (WP1/2).
- Jul-Sep 2004: preliminary WP1/2 "gap sheets" compiled for data collection and modifications to CONCAWE/EUCAR data. Definition of model interfaces. Discussion of Scoping report.
- Oct-Nov 2004: Preliminary WP1/2 analysis used to determine set of chain for analysis. Validation of Scoping report assumptions during MS workshops. **Gathering of MS-specific data requirements** (e.g. Markal: topological data, bounds for technology use, ISI: lead markets study through expert interviews)
- Dec 2004-Feb 2005: first run of models.
- Mar-Apr 2005: initial gathering of feedback on input modification from MS at workshops. Development of check-list for consistent monitoring of modifications following "reality-check".

4. Conclusion

The diverse nature of the analyses carried out in HyWays WP3 drives the complexity and volume of HyWays data inputs. Although the aforementioned data collection activities have taken place in different moments, the methods followed can be grouped into five main categories:

1. Direct data flow from other tasks in the project (WP1/2 – energy chain assumptions, and WP4 – framework assumptions).
2. Structured feedback to written documents - MS Profiling reports.
3. Day workshops, in two formats:
    a. Member State Representatives with other HyWays representatives.
    b. Member State Stakeholder workshops (internal or with representation of HyWays partners).
4. Interviews or Bilateral discussions between institute representatives and MS reps or other HyWays representatives.
5. Check-list.

Future data collection will revolve around these methods, and will strive for stronger validation of the data inputs by MS representatives (applies also for WP1/2 and 4)

Annex 1. August 2004 Memo on Transition Analysis

Lisbon, 13 August 2004

HyWays WP3 Memo:
MS Profiling, regionalisation of WP2 chains and Scenario development. Steps leading to MS report (Deliverable 3.3) and Robust MS scenarios (D3.5)

Dear HyWays partners,

We would like to present to you the first basis to the MS Report (Deliverable 3.3) and to the MS scenarios (Deliverable 3.4-3.5), and to kick-off the process which will lead to the delivery of the final versions, respectively in November 2004 and January 2005.

Background
IDMEC (Portugal) is responsible for the task of providing a qualitative analysis of the barriers and opportunities for hydrogen as an energy carrier for the Member States involved in the first phase of HyWays. This exercise has been named Member State Profiling, and is to provide a framework for the interpretation of a number of WP3 outcomes.

ICSTM (UK) is responsible for the development of MS-specific hydrogen introduction scenarios. This activity lays its foundations on Member State Profiling, which provides the necessary background information and data required in order to develop semi-quantitative scenarios. However, results of these scenarios can also be used to complement and help validate the analysis of barriers and opportunities (part of MS Profiling)

MS Profiling
The MS profiling approach is aimed to include those aspects in the HyWays roadmap that cannot be treated within the models but which can strongly influence the implementation of Hydrogen within Member States. Aspects such as current and expected energy policies and characteristics of the transportation sector or energy system influence chances of implementation of Hydrogen in different sectors. One task in WP3 is to describe the attributes of the MS that might influence the penetration of Hydrogen in the MS, The outcomes of WP will provide a input to the MS specific scenario's.

For more information on the objectives and the theoretical backdrop for the methodology of MS Profiling please refer to the document "Regions Profiling" (Annex 1) and the presentations given at Lisbon on May 10th and Russelheim on July 7th, on the HyWays website.

The partners directly involved in in MS profiling include IDMEC, ECN and the six Member State representatives (hereafter referred to MS reps). All HyWays partners are however expected to be actively involved in the discussion of inputs and outputs, up to and beyond the delivery of the final report (Deliverable 3.3).

Methodology for MS Profiling
As introduced in the July 7th meeting in Ruesselheim, the methodology for MS Profiling relies on techniques of social research and transition analysis, including the obtaining of data through semi-structured questionnaires and deliberations at workshops.

The practical aim of the methodology is to reach the highest level of validation possible for the vision of the barriers and opportunities facing hydrogen in the concerned member states. The process to deliver the final output is based on the sequential publication of three versions of the MS reports:

- MS Report no. 1 (August 15th) – outline of energy policy and sketch of hydrogen vision.
- MS Report no. 2 (October 31st) – brainstorm of barriers and opportunities for hydrogen, niche potentials and actor analysis.
- MS Report no. 3 (November 31st) – final analysis of barriers and opportunities and qualitative assessment of implementation routes for the transition to hydrogen (transition analysis).

The methodology will increase the level of validation in these reports in three ways:

1. General (free-format) feedback from all HyWays partners reviewing the three MS reports after the dates indicated above.
2. Specific feedback through a semi-structured questionnaire distributed in September 2004, addressed to stakeholders outside of HyWays partners.
3. Discussion at two sets of workshops.

The three components above result into the work plan in Annex 2, where the coloured boxes are the stepping stones towards the final deliverable.

MS Workshops

IDMEC, CEA and ECN have discussed the necessity to have two workshops per MS, for input and validation. The first (internal) MS workshop is dedicated to acquire information on barriers and opportunities for the introduction of Hydrogen in the MS. Preliminary results will be presented and discussed. The aim of the second workshop is aimed at validation. The aims and expectations for the two workshops are presented in the table in Annex 3. The specific structure for these will be further explained and discussed at the WP3 meeting planned on September 22th in London,

We would like to ask the HyWays Member State representatives to start the process of organizing the internal workshops. We would like to ask the MS to start inviting relevant stakeholders for the internal workshop which should be held between mid September and mid October. Relevant stakeholders are, depending on the MS, representatives of energy agencies, governmental organizations, Hydrogen networks and/ or industry.

We have prepared a draft structure for a letter[1] of invitation for stakeholders in your country (Annex 4). This letter is to be adapted to your special requirements, but is intended to present the HyWays project and the MS Profiling exercise in a consistent manner.

We are at your disposition for any clarification from August 23th onwards and look forward to your comments

Yours sincerely,

María Yetano Roche IDMEC
Anne Kets ECN

[1] Adapted from Nordic Energy Foresight Action Workshop.

Regions profiling (ECN, May 2004)

Introduction
The outcome of the HyWays project is a roadmap towards a European Hydrogen based society. The HyWays approach consists of a modelling approach as well as region specific region profiling approach. The region profiling approach is needed to provide a proper context for the modellers and should be able to turn the outcomes of the modellers into a valid hydrogen introduction scenario. There are many barriers in real life that cannot be dealt with by a modelling approach but can drastically change the barriers and opportunities for Hydrogen introduction (e.g. infrastructure, actions needed to build the infrastructure etceteras). The opportunities and barriers can differ per country. In order to describe these issues we can use the concept of transitions. This concept, theoretically as well as more practically, as well as the consequences on data requirement is briefly described below. The transition approach has implications for the methodology to be used as well as the kind of data that need to be gathered to enable regional profiling of the Hyways roadmap. Some ideas on those two issues are described below.

Transitions
Transitions are social transformation processes in which society or a complex subsystem of society changes in a fundamental way over an extended period (more than one generation). A transition consists of technological, economic, ecological, socio cultural and institutional developments at different scale, which all influence and reinforce each other (Rotmans et al, 2000). Transitions are often described as changes occurring in several dimensions and levels. In the transition theory, a division is made between niche (micro), regime (meso) and landscape level (macro level).

The regime level is central in the approach; regimes are the whole of rules, assumptions and divisions of roles embedded in the material and social practices enabling and steering technological development (Geels en Kemp 2000). Regimes can be compared with the system concept. Dimensions can be used to describe the attributes of a regime. It is possible to choose dimensions at will. In Hysociety, where challenges in different sectors are rated, (challenges in) technological, economic, infrastructural, political, socio cultural, ecological and geographical dimensions are used. Examples of a regime are the regime of energy supply or the regime centred on transport by ship. Niches are protected spaces where technologies that are not yet mature can flourish. Niches can be market niches or technological niches. In the first case actors protect an immature technology because of their high expectations. In the latter case the technology is applied in an environment where costs are less of importance than the performance.

The landscape level consists of trends and events that influence processes on regime level. Examples of events on regime level are the liberalisation of the energy market and the explosion in Chernobyl in 1986. A transition process is the result of an interplay of developments that sustain and reinforce each other. Transitions are not caused by single variables such as price changes, policy acts or subsidy schemes but are the result of changes in different domains (Kemp and Loorbach, 2003).

Transitions often start from niche level where niches are able to add on to developments, opportunities and barriers within the regime or where a succession of niches can grow out to regime level. Transitions are not caused by single variables but are the result of changes in different domains. A transition is a non- linear succession of steps. A certain situation has to exist before a certain change can come about, and his change is possibly necessary for the next necessary change en so forth. It is therefore necessary to describe possible successions of steps in different dimensions

Methodology: practical implications
The transition approach has a number of implications for the methodology to be used:

- Numerous changes have to occur before a transition (e.g towards a Hydrogen based society) occurs. The future cannot be reasoned from the configuration of present systems. We therefore have to reason back from the future and analyse how this future can come about (backcasting). Secondly, the speed in which changes are feasible is also determined by current physical and institutional conditions. Therefore, usually a combined backcasting - forecasting approach is used (the forecasting 'moderates' (approximately) the first decade of the transition pathway that follows from the backcasting approach).
- Numerous changes in numerous dimensions (technological, economic, infrastructural, political, socio cultural, ecological and geographical) have to occur for the desired futures can come about. It is therefore necessary to 'broadly' describe the key changes. Outcomes of a modelling approach (e.g. costs, technologies applied, energy use) don't describe how changes can come about (including involvement/attitudes of key actors). From a transition perspective it is important to describe which circumstances (e.g. which legal framework, changes in infrastructure, the existence of which market parties) enable the changes described in the models
- Various actors influence the chance that changes will come about. It is needed to describe which actors are able to bring about the changes, which actors probably support or oppose them and how various actors can be influenced or even involved.
- The local situation determines of certain changes can come about and, thus, if a transition is likely to happen. A description of the present situation and possible developments thereof are therefore of importance. The next section deals with this.

Several instruments are developed to deal with the concept of transitions while developing a roadmap. These are descriptions of regime dimensions, descriptions of key changes and critical actors and instruments of transition management (boundary mapping). For the largest part these instruments are based on (Laredo et al, 2002).

Data: practical implications
In order to describe the barriers and opportunities for Hydrogen and possible transition processes in the different countries a broad range of data is needed. The idea is to use these data to describe how developments on niche level can add on to developments on regime (meso) level or to describe how a succession of niches (micro level) can lead to the regime change desired.

Barriers and opportunities for the introduction of Hydrogen are amongst others dependent on the following issues:

- Current and expected energy policy
- Current Hydrogen projects/ niche markets
- Characteristics of the power sector including RES potential/ CO2 sequestration potential
- Characterisation of energy demand

Current and expected energy policy
Current and expected energy policies (part of the regime level) can form a barrier as well as an opportunity for the introduction of Hydrogen. Furthermore we should describe current policies in the action plan. The policies (on national as well as EU level) do not have to be specially related to Hydrogen; also policies in the area of, for instance, RUE, RES, and security of supply are of importance.

Current Hydrogen projects/ niche markets
Current projects or niches for Hydrogen are probably less important. But, one could state that current ongoing experiences reflect the niche markets where Hydrogen can enter first (so it is an indictor). These experiments also give an indication of the problems Hydrogen can solve

on different locations within a country (motives for the application of Hydrogen: security of supply, need for back up, local air quality etceteras) as well as a picture of the current actors involved in hydrogen business (supportive of the transition). With respect to man months, this is only a minor activity.

Characteristics of the power sector including RES potential/ CO2 sequestration potential
The characteristics of the power sector determine if the power sector is able to handle differences between demand and supply or that an intermediary (Hydrogen) is needed. The way the electricity and heat demand of sectors is provided for determine possibilities for add on (e.g. gas based heating in the Netherlands). The RES and CO_2 sequestration potential determine in how far a country would be able to produce sustainable Hydrogen or climate neutral Hydrogen (technical potential, costs, indication of societal feasibility).

Characterisation of energy demand
The characteristics of the energy demand (stationary as well as mobile) also determine possibilities for add on. The following data can probably be used to determine the energy demand for stationary applications: quality of the electricity grid (back up options), electricity demand, and heat demand. The following data can probably be used to determine the energy demand for mobile applications: density of the transport network, number and density of fuelling stations, an indication of which part of the road system is in urban area. This information is necessary to decide where to built the infrastructure in which direction to extent.

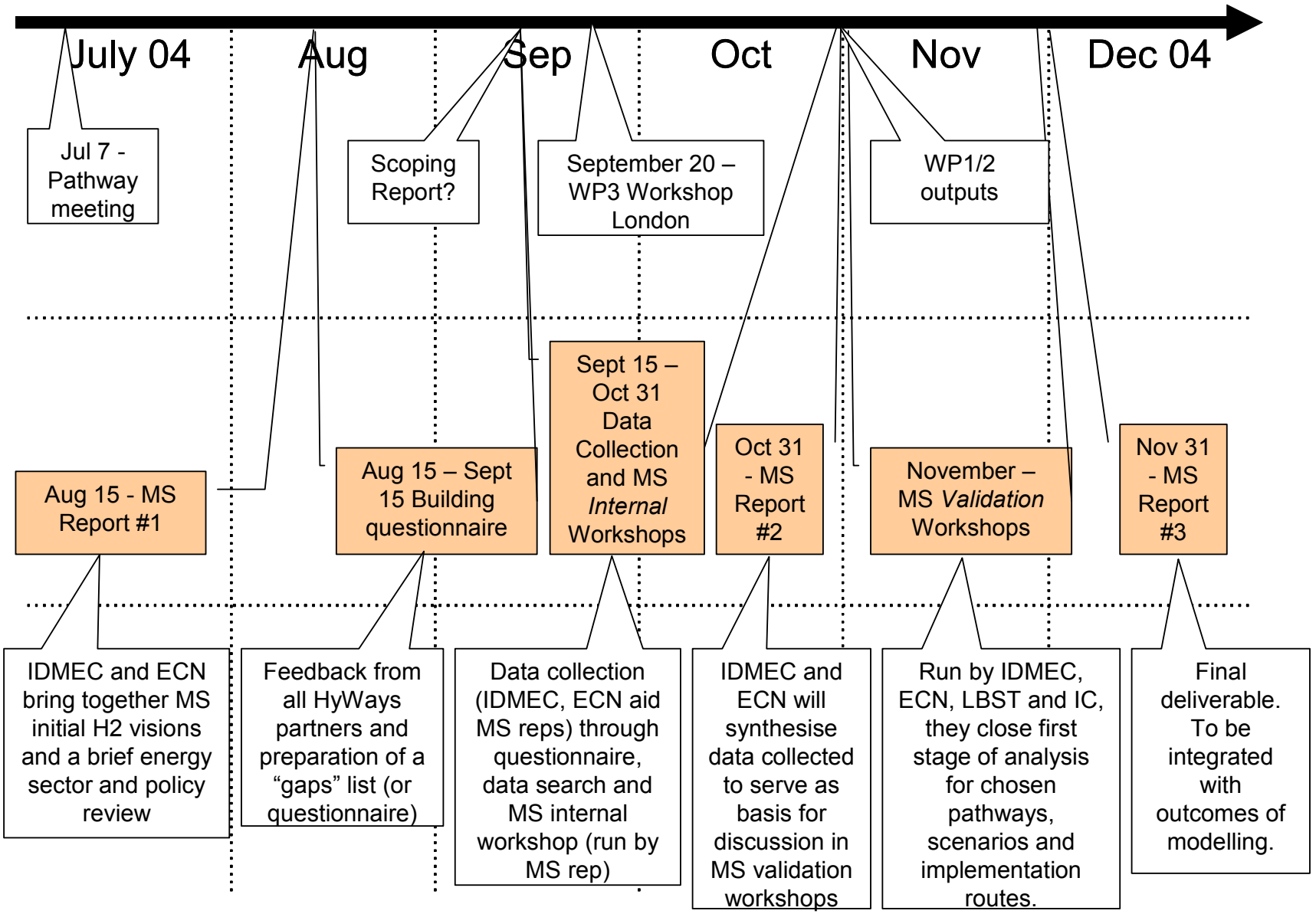
Most probably other developments are also of importance (user acceptance, number of car manufactures etceteras..). One of the key questions to be addressed is whether infrastructure built up will be based on the concept of local (decentral) hydrogen production vs. central hydrogen production. This question can partly be addressed from the perspective of Well to Wheel and Source to User analysis as well as estimates on capital investments. However, the major factor might be the perspective and also the personal benefits of the actors who have to built up the infrastructure. They might opt for the macro-economic sub-optimal solution since this is more in their interest (larger profit, less risk!). If this is the case, one has to consider whether it is feasible to influence current critical actors to change their preferences or whether it has to be accepted that the (first phase?) of the transition will evolve on a sub-optimal pathway.

Input for the modelling framework
In principal, the models as used in HyWays are able to perform their calculations without results or input from the regional profiling / scenario analysis (this has been the occasion in several studies in the past). However, in HyWays, we aim to use a hybrid approach in order to put the model outcomes into the right perspective, or, in other words, to provide a quantitative foundation for the more qualitative transition analysis. So, basically the models will need energy statistics and info on energy conservation / CO_2-reduction options (more specifically: hydrogen options). However, results of the calculations should be adapted based on the country specific analysis.

Further reading
As transitions are mostly a Dutch concept most publications are in Dutch. Here are two English publications with Internet links.

(Rotmans et al, 2000) Summary transitions and transition management, http://www.icis.unimaas.nl/projects/nmp4/downs/00_35_ab.pdf

(Rotmans and Kemp, 2003) Managing societal transitions; Dilemmas and uncertainties, the Dutch case study, http://www.oecd.org/dataoecd/6/31/2483769.pdf


July 04
Aug
Sep
Oct
Nov
Dec 04
Jul 7 - Pathway meeting
Scoping Report?
September 20 – WP3 Workshop London
WP1/2 outputs
Aug 15 - MS Report #1
Aug 15 – Sept 15 Building questionnaire
Sept 15 – Oct 31 Data Collection and MS *Internal* Workshops
Oct 31 - MS Report #2
November – MS *Validation* Workshops
Nov 31 - MS Report #3
IDMEC and ECN bring together MS initial H2 visions and a brief energy sector and policy review
Feedback from all HyWays partners and preparation of a "gaps" list (or questionnaire)
Data collection (IDMEC, ECN aid MS reps) through questionnaire, data search and MS internal workshop (run by MS rep)
IDMEC and ECN will synthesise data collected to serve as basis for discussion in MS validation workshops
Run by IDMEC, ECN, LBST and IC, they close first stage of analysis for chosen pathways, scenarios and implementation routes.
Final deliverable. To be integrated with outcomes of modelling.

	Internal Workshops	**Validation Workshops**
What is the aim?	To present MS report # 1 preliminary results of questionnaire and to review the first results of Scenario development where available To independently discuss data needs for questionnaire, unresolved points and any issue arising, in order to provide agreed inputs and vision to MS report #2.	Further refinement and validation of inputs to HyWays MS report and MS scenarios. Presentation of Work Package 1 and 2 MS results to date.
When?	October 2004 - Note: date should be settled asap	November 2004 – Note: dates should not overlap
Where?	In the MS (Run in language of choice)	In the MS (Run in English)
Who organises the logistics?	HyWays MS representative (hereafter MS rep)	MS rep
Who prepares it?	MS rep in collaboration with Regions Profiling team (ECN, IDMEC, IC, hereafter Team). Further guidelines to be provided.	MS rep in collaboration with Regions Profiling team (ECN, IDMEC, IC, hereafter RP Team). Further guidelines to be provided.
Who runs it on the day?	MS rep	RP Team in collaboration with MS rep
What is basis of discussion?	MS Report #1 and resulting questionnaire.	MS Report #2.
Who participates?	Participants are selected by MS rep, with aim of gathering stakeholders from all concerned sectors (further guidelines to be provided). Member of RP Team will attend where feasible for clarifications and ensuring consistency.	A small number of participants are selected by MS rep, with aim of conveying key perspectives from the concerned sector (further guidelines to be provided).
What happens on the day?	A round table with presentations by different stakeholders is envisaged, followed by structured discussion.	A round table with presentations from HyWays partners and MS stakeholders is envisaged, followed by structured discussion.
What happens afterwards?	Results of discussion are summarized by MS rep for integration into MS report #2, prepared by RP Team.	Results of discussion are summarized by Regions Profiling team and MS rep for integration into MS report #3, prepared by RP Team.

INVITATION TO MEMBER STATE PROFILING WORKSHOP ON SEPTEMBER/OCTOBER XXX, 2004 VENUE AND CITY

Dear Colleague,

You are hereby invited to the first Member State Profiling Workshop of the HyWays project, on **<DATE HERE>,** 2004, at **<VENUE>.**

Background
The HyWays project was recently started by a consortium of 30 partners representing industry, energy agencies, and research institutes across the EU. The aim of HyWays is to develop a European Hydrogen EnergyRoadmap. The project, coordinated by LBST (D) is co-funded by the EC (DG Research) under the 6th Framework Programme and its first phase runs from April 2004 to December 2005. A 1st order version of the roadmap comprising the first 6 participating member states (F, D, GR, I, N and NL) is due after Phase I, the fully validated version after 36 months. For further information see www.hyways.de.

HyWays combines technology databases and socio-economic research tools to evaluate selected scenarios for future sustainable hydrogen energy systems, leading to recommendations for a European Hydrogen Energy Roadmap that reflects the realities in the participating member states. This Roadmap will be based on data and insights of European industry, research institutes and government agencies, and describes systematically the future steps to be taken for large-scale introduction of hydrogen as an energy carrier or fuel. Member state-specific issues will be evaluated in partnership with national experts.

Within HyWays, six member state specific scenario's will be developed as opportunities and barriers differ between countries. The first Workshop in …(city)… is a key element of this exercise. It builds on the first review of policies relevant for <country> and will lead to the refinement of perspectives for the introduction of Hydrogen.

The Workshop is intended to provide well-grounded suggestions and ingredients for the building of an implementation route for Hydrogen in […]. Attention is paid to the development of science and technology, R&D programs, markets and business opportunities, as well as supportive financing, regulations, standardisation, taxation and other policy measures. During previous steps relevant scenarios, visions and technology roadmaps, as well as carriers and barriers for technology developments were identified in the area of hydrogen production, transportation, and stationary use. The Workshop will discuss especially the actions needed to overcome the barriers and to realise the visions and roadmaps.

It is *not* the purpose of this Workshop to arrive at consensus decisions. Rather we want to *explore* the full scope of ideas and arguments of relevance to the purpose. The material to be produced in the workshop is treated as important input for work by the core partners. This work, in turn, will be open for commentary from workshop participants before the subsequent working steps and throughout the project.

Some very general questions to be addressed at the workshop are:

- What are the actions needed if is to introduce hydrogen as a significant energy source by 2030?
- How should hydrogen energy be introduced to the energy market in order to gain the best benefits?
- How can the market and businesses utilize the opportunities provided by the introduction of hydrogen?
- Which possible niches for Hydrogen exists or might exist?
- Which actors (organizations) should play a role during the implementation of Hydrogen?
- Which regional potentials (e.g. renewables, infrastructure) of <country> might play a role during the introduction of Hydrogen?

The workshop gives you the opportunity to contribute to the development of the MS specific scenarios. We therefore hope that you can attend the workshop.

Workshop plan. The contents of the one-day workshop are described in the attached programme (to be provided by the MS representative). All participants will receive a briefing document approximately a week before the Workshop The document will contain draft scenarios, and a list of barriers and opportunities for technological developments, together with some figures and tables describing the investment costs, markets and the energy system.

Registration. We kindly ask you to register to the Action Workshop as soon as possible using the enclosed registration form. Please return the completed form to … In case you prefer to send a print copy please post it to. **The registration deadline is […]**.

[optional info on accommodation and travel]

Please let us also know if you would like to forward the invitation to another person in your organisation.

Queries: [your contacts]

Annex 2. October 2004 Memo on Transition Analysis

HyWays WP3 – Regions Profiling

BUILDING THE STORY-LINE

Anne Kets María Yetano and Marcello Contestabile
October 28, 2004

Contents

1. Introduction

HyWays aims to develop a fully validated Roadmap for the introduction of hydrogen in Europe, further specified per region or country.

HyWays is using an original approach combining models and qualitative analysis. The latter is called Transition Analysis and is one of the key aspects of HyWays. Within Transition Analysis, the ***storyline*** is one of the instruments used to validate the Roadmap. It should give a description of how hydrogen could be produced and used in a certain country and which could be the routes for the implementation. The storylines ground the modellers' outcomes; they describe how the energy chains can be implemented and in which circumstances the implementation of the chains is plausible (validation of modellers outcome).

The storyline:

- provides a context for the implementation of Hydrogen in a certain country
- describes how the changes needed might come about, how barriers might be solved and how opportunities can be used.
- is realistic and based on both desired and feasible targets from the political, technological and societal points of view.

Other initiatives such as the Nordic Hydrogen Energy Foresight (www.h2foresight.info) have taken comparable approaches to Transition Analysis, where qualitative aspects of the transition to hydrogen in the five Nordic countries are discussed over a number of workshops. This document describes the work plan of IDMEC/IST and ECN on how information will be gathered and analysed for the six member states in Hyways, revolving around two main workshops in a short time frame.

2. Steps for developing a story line

The storyline is a description of how the current situation in a country can change into a situation in which hydrogen is applied. To get the best results the storyline reasons from the present as well as the future situation. Changes needed to get to the future situation are

reasoned from the situation desired ('the future') and are later on adapted to enable linking to the present situation (back-casting and fore-casting). The elements for building a storyline are thus:

- A description of the possible situation at present[2]
- A description of the situation in which the energy chains are implemented (when not fully implemented in 2030, the situation in 2050)
- A description of the most important changes that have to occur before the energy chains are fully implemented
- A description of how these changes can come about. This includes the possible role of opposing and supporting actors
- A description of policy frameworks and strategic environment needed for implementation of the energy chains/ changes needed.

The following information is needed:

- Information on the present situation/ starting point of the storyline
- Information on how the country may look like when all energy chains are (partly or fully) implemented. A description of this situation is called an end vision.
- Information on how the present situation could transform into the situation in which the energy chains are implemented

3. General Work plan

The above considerations on the information that is needed led to a work plan proposed in August 2004, which we summarize and update here. The specific steps and deadlines are discussed below.

- **Present situation**: Information on the starting point of the storyline can be obtained from literature, replenished by information from actors involved. Relevant information is already summarized in the first MS reports (available on the HyWays website). These reports have aided in the brainstorming of drivers and barriers for the different energy chains. The reports need to be integrated with final comments arising from MS Workshops.

- **End-vision and key changes**: One of the aims of the first set of "Internal" MS workshops was the development of an end-vision for the MS. The necessary steps where the presentation of the current situation to initiate discussion on what are the desired and feasible elements for the end-vision. In so far this end-vision was not fully discussed during the internal WS, the institutes involved have considered that more information on the end-vision could be obtained by means of a **visualisation** of the share for each energy chain, and **interviews**, as well as through the second set of **"Validation" Workshops**. The **scenarios** and analysis of niches, to be developed by Imperial College should also be an input for this step.

    - **Visualization of the hydrogen energy chains**: explained below, it allows a first discussion of the end-vision.
    - **Interviews** with experts in the mobile and stationary sectors, aiding in the validation of the different elements of the end-vision. Moreover, the ways in which the implementation can occur could be obtained from interviews too.
    - **Validation Workshops**: the end-vision and key changes needed to achieve it are the focus of these Workshops, discussed below.

[2] 2010 for practical reasons.

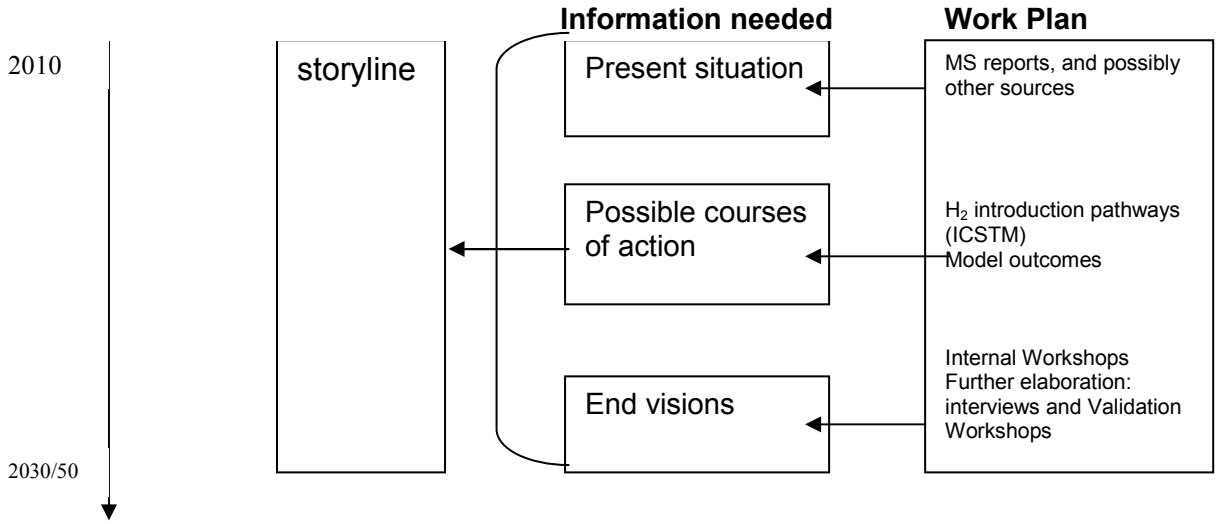


Figure 4: Graphical representation of the work plan

4. Focus: What is the end-vision

The end vision composes of a description of society with a focus on how hydrogen technologies are applied in 2030 and 2050 (note the choice of timeframe may be flexible depending on the MS and the energy chains under discussion). Its basis is both the desired targets and the current understanding of drivers and barriers for the technology and the country‘s resources and policy. Looking at the current problems and barriers need not constrain the "imagination" for this end-vision, as room for uncertain developments and unpredictable events is provided.

The main elements of the end-vision are:

- Consideration of demand and supply trends in future energy system, as considered in Scoping report Technical Annexes.
- Policy drivers and existing targets: security of supply, environment, economy
- Role of economic and policy instruments
- National or international orientation
- Ways in which Hydrogen and other energy carriers are:
    - produced
    - transported
    - used (end use applications)
- Possible interactions between stationary and mobile sectors
- Interactions with other energy carriers.
- Main geographical divisions (focusing on infrastructure development).
- Approximation to role of main actors (first key-actors table)

The specific components of the end-vision in MS Report 2, where quantitative and generic data will be gathered, will be:

1. GENERAL ELEMENTS:
- Critical review of demand and supply trends for the energy system (based on Technical Annexes of scooping report)
- Policy targets: which issues are deemed important during period of study (security of supply, environment, competitiveness) – desired and feasible targets arising from existing or adapted documentation.
- Legislation and economic instruments (role of market regulation, renewable targets, emission trading, taxes)
- Principal ways in which hydrogen and other energy carriers are produced (central/ de-

central), transported and used. Input from energy chain choices and technical annexes.
- Role of international markets: import and export of H and other
- Interactions between stationary and mobile sectors
- Interactions with other energy carriers
2. CHAIN-RELATED ELEMENTS (NB: see section on ”visualising the end-vision”)
- Nature of chains: On-site or Central
- Feedstocks: nature and origin
- Transport: pipe dedicated, pipe mix in, tube trailer, cryogenic trailer
- Carbon capture and Sequestration: level of integration into system.
3. END-USER ELEMENTS:
- Nature and size: stationary business; stationary public/ private; mobile fleet public/private
- Environmental benefits to end users; local air quality vs GHG’s
4. MAJOR REGIONAL DIVISIONS WITHIN MEMBER STATE
- Infrastructure development, share of different end-uses, differences in rate of uptake
5. DEALING WITH UNCERTAIN DEVELOPMENTS
- What room is given in the vision to unexpected developments and disruptive/radical events.
6. ACTOR TABLES
- Political will, engagement of government as principal actor.

NB: MARKAL requirements and synergy with end-vision requirements.
Although the end-vision is at present not directly affecting the input data into the HyWays models (which begin their first run on December 1st, 2004) there is an area of convergence between end-vision requirement and Markal’s requirements on “topological information” for the analysis of the energy system. The following concrete questions can be singled out.

- Hydrogen transport modes:
  - Length of average pipeline for centrally, de-centrally and locally produced H2, with considerations time-dependence (e.g. values for 2000, 2020, and 2050)
  - Characteristics, and thus costs, of pipelines, depending on production technology. (central vs. de-central, or even on a lower level?), Pathway and/or Member State?
  - Types and data of competing transport modes: truck/train/ship
- Electricity transmission strength /grid capacity between MS and the rest of Europe:
- CO2 capture and sequestration:
  - Physical potential of (geological) storage options: totals, utilization growth limits
  - Source-sink matching: characteristical distances per source (mostly central/de-central capture) and sink (sink-type)
  - In case of missing estimates: ‘generic data’

5. Specific Work Plan

Regions profiling aims to provide a context for model outcomes by February 2005. The story-lines are expected to be developed by end of December 2004. The following steps are suggested. Much progress in the storyline should be made *before* the Validation Workshops.

Overview:

Steps	Who	When	Guidelines available?
Visualisation of the end-vision	MS reps (except Germany and Norway)	10 November	Yes
MS Report 2	IST and (ECN)	1 week before Validation workshops	Yes (draft)
Interviews	MS reps	Before and after Validation Workshops	Yes (draft)
Validation Workshop	MS reps	Various dates	Yes (rough draft)
MS Report 3	IST, (ECN), IC	End of Dec	No

The steps are explained in detail here:

A first visualisation of the use of energy chains

Introduction:

A new method to quantify the relative use of energy chains and over time was devised and applied successfully to develop storyline and tentative scenarios by LBST during the first round of MS workshops. Stakeholders were asked to fill in the matrix specifying the relative presence of each hydrogen chain over time (in %)by consensus or voting, providing a first political-industrial evaluation of the possible introduction scenarios. IDMEC proposes that other MS try a similar exercise.

Responsibility: MS representatives (except Norway and Germany)

Deadline:

This form of brainstorming by use of a matrix will be extended to all MS by **November 15th**, requiring immediate mailing to stakeholders by some.

Guidelines:

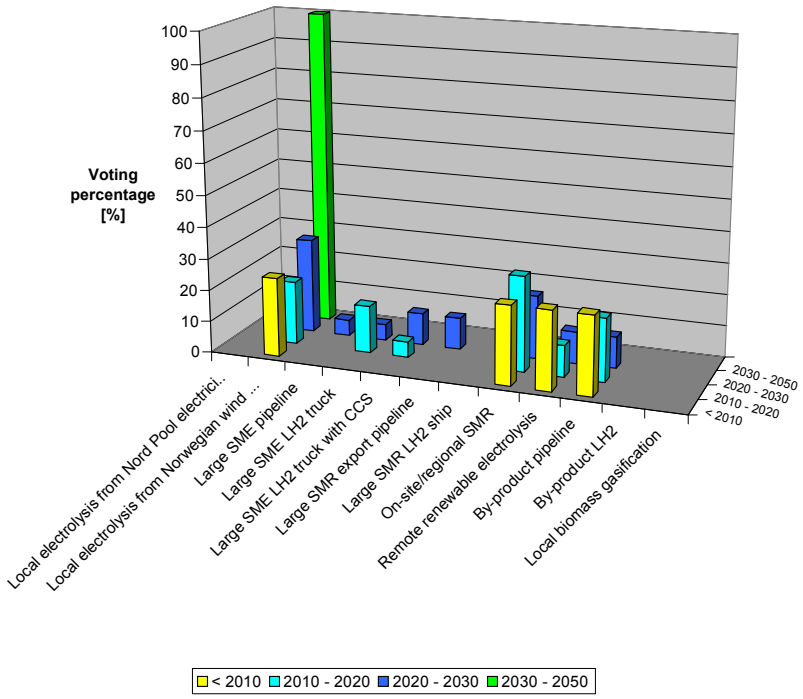
- The brainstorming uses a matrix with the energy chains on the y-axis and time periods on the x-axis. The boxes show the expected relative percentage of an energy chain with respect to all chains. The columns have to add up to 100%. It is suggested to the modellers that the data will be used 1:1 for the first run of WtW and WtStU analysis and as a median to define the bandwidth for the lower and upper band for the MARKAL model.
- The brainstorming starts by developing a general picture for status quo looking at the demonstration projects under consideration. For example, in Norway, an equal distribution to electrolysis from renewables, on-site SMR, waste gasification, remote island supply and chemical by-product was assumed (each 25%).
- Then the vision was developed by defining a “wildcard” pathway after 2030. In Norway this was decided to be hydrogen provided by electrolysis from a renewable energy mix.

This decision was based on the assumption of by then slowly diminishing fossil resources.

- Finally the periods 2010 – 2020 and 2020 – 2030 are filled in by assuming growth and decrease rates

An example of a complete table and its graphical outcome is found below:

No.	Chain	< 2010	2010 - 2020	2020 - 2030	2030 - 2050
1.a)	Local electrolysis from Nord Pool electricity mix	?	?	?	?
1.b)	Local electrolysis from Norwegian wind electricity	25	20	30	100
2.a)	Large SME pipeline	-	-	5	-
2.b)	Large SME LH_2 truck	-	15	5	-
2.c)	Large SME LH_2 truck with CCS	-	5	10	-
2.d)	Large SMR export pipeline	-	-	10	-
2.f)	On-site/regional SMR	25	30	20	-
3.	Remote renewable electrolysis	25	10	10	-
4.a)	By-product pipeline	25	20	10	-
5.	Local biomass gasification	?	?	?	?
		100	100	100	100



MS Report 2
Introduction:
The integration of workshop outcomes (minutes) and the different follow-ups into MS Report 2 is shared by ECN and IST, involving further research where possible.

Responsibility: IST (and ECN).

Deadline: **before Validation Workshops (various dates)**

Guidelines: MS report 2 has a draft structure focusing on:
- end-vision (by element – see table above), including a synthesis of existing documents that are being used in a number of MS (Netherlands, France)
- drivers and barriers

- main actors – critical actors table.
An analysis of the dynamics of the first workshops will also be carried out for future reference.

Interviews

Introduction:
Moreover, as introduced above, the Regions Profiling team suggests that MS representatives undertake a number of in-depth interviews with selected stakeholders in order to:

- further elaborate the end-vision
- begin an approximation to the study of key changes required to achieve them.

Responsibility: MS representatives

Deadline: **before and after Validation Workshop (various dates).** A schedule for these interviews is due from MS representatives on 15th November.

Guidelines:

The interviews should be directed to the questions on how changes necessary for the implementation of Hydrogen could come about, which actors are likely to support or oppose the necessary changes and what are the possibilities to influence these actors.

The current guidelines for interviews are proposed, considering the limited time frame and need for reasonable work load.

- 3-4 in-depth interviews or small-group discussion
- Interviewees are stakeholders with in-depth knowledge of the potential for:
    - Mobile applications
    - Stationary applications
- The following structure is followed:
    - Presentation of end-vision (visualization by matrix and draft MS Report 2) – collection of further impressions.
    - Discussion on key-changes: leading to the creation of a **critical changes table** (template to be provided by IDMEC) using the following starting points
        - Different dimensions at which changes may occur:
            - Economic: policy instruments
            - Institutional:
            - Infrastructure
            - Social
        - Actors responsible or involved in these changes:
            - Key and Marginal actors: creation of a **critical actors table** (template to be provided by IDMEC)
            - Ways of influencing these actors
        - Level of scope for key changes:
            - National (and international)
            - Regional
            - Localised (including geographical niches)

Validation Workshop
Introduction:
The desired process and outcomes for these workshops is to be discussed. One overriding constraint for this workshops is the need to finalise energy-chain discussions and model-specific data validation by end of November, which will inevitably take-up some of the time for discussion of the end-vision.

Responsibility: MS reps.

Deadline: Various dates (NL and Greece yet to confirm).

Guidelines:
The proposal by IDMEC for process and outcomes is as follows. Note that some MS (e.g. France) are expected to have developed refined end-visions and some points may be superfluous, again calling for flexibility of approach.

Process:

- Work dynamics: a series of sessions covering the different topics, led by different HyWays institute partners and followed by round table or split-group discussion.
- Participation: selected MS stakeholders and HyWays partners
- Preparation: materials and other preparations to be organised by IDMEC and the MS rep
- Follow-up: minutes and follow-up documents to be integrated by IDMEC and ECN.

Outcomes: draft list of workshop deliverables below.

	Deliverables
1	Introduction
1.1	Introduction of HyWays project (as concise as possible and only in the case of MS which have had a low range of participants in 1st workshop)
1.2	Introduction of Workshop participants
1.3	Achievements of 1st Workshop and Selected examples of what was done in others.
1.4	Agenda and desired outputs: Focus on main needs in MS: chains/data? Introduction scenarios? End-vision?
	Q&A
2	Energy chains – final choice and data requirements
2.1	Introduction to the chains chosen for preliminary analysis
2.2	Presentation of final results of chain analysis and validation of data for input into models (techno-economic data). If there are data needs remaining => discussion of work-load.
2.3	Presentation and Validation of the matrix for visualising of the relative use of chains (providing a link to following section)
3	Developing a story line and hydrogen introduction pathways
3.1	Presentation and discussion of current End-vision and introduction pathways (MS report 2). Further elaboration on drivers and barriers (MS report 1)
3.2	Discussion and validation of initial introduction markets
3.3	Special discussion: Validation and further characterisation of geographical divisions in end-vision
3.4	Presentation and Validation of topological data for chains (Markal requirements)
3.5	Discussion on any other main gaps in end-vision elements
4	Next steps in process
4.1	Immediate follow-ups: review of MS Report 2, expert interviews, date of model runs.
4.2	Later follow-up: (REALITY) CHECK in Feb/March – possibility of workshops – give a clear message that 2nd model run following this process is not strictly comparable

MS Report 3

Introduction:

Aim is to Integrate minutes of Workshop and issues that have been followed-up. It will culminate the efforts that HyWays is doing to build the country's storyline, although the outcomes of models and the MS individual efforts will further modify it.

Responsibility: IST, (ECN), IC.

Deadline: end of December 2004 (NB: original deadline for D 3.3 is end of October)

Guidelines:
Structure to be defined.

6. Interaction with ICSTM's work

Regions profiling and hydrogen introduction scenario development are parallel activities, closely interlinked to each other. While the former provides a more qualitative picture of the transitions, the latter aims at describing the process on a more quantitative level.

These 2 activities are schematically represented in the table below, which also suggests the type of input needed:

Regions Profiling (Storyline)	Hydrogen introduction pathways (scenarios)
Qualitative (actors, changes, etc)	Quantitative (energy chains, penetration targets)
Starting point (2010) – general situation	Initial phase of the transition – initial niche markets
End vision (how the country will look like when hydrogen energy chains are implemented)	Hydrogen penetration targets (what level of H2 technology penetration is envisaged/desired by 2030 and 2050)
Transition (2010-2030) – changes, barriers and opportunities	Transition (2010-2030) – development of different energy chains (quantitative)
Policy framework (qualitative)	Policy framework (quantitative – e.g.: level of subsidisation, etc)

Annex 3. October 2004 Memo on Infrastructure Analysis

HyWays

Imperial College activities on MS hydrogen introduction and infrastructure Development

Marcello Contestabile, 10 December 2004

The purpose of this document is to inform MS representatives and institutes of the activities being undertaken and planned at Imperial College, following the recent enlargement of the internal team working on HyWays. It must be stressed that these activities are not substantially different from what was discussed so far; however, additional information is given here to make sure that partners are aware of what we are doing and how we are planning to interact with them in the next few months. Finally, the work plan outlined below is subject to future refinements and changes, should this be needed, and is also open to comments.

· **15th of December**: data on hydrogen penetration rates (transport and stationary) and infrastructure development for each of the 6 MS will be supplied to ECN, for the 1st run of the Markal hydrogen scenarios (high and low). Input to Markal will be based on the data collected during the 2 sets of MS workshops held so far and, where appropriate, complemented by activities being undertaken at Imperial to define the possible future spatial distribution of the hydrogen infrastructure (as reported below in more detail). Where gaps or uncertainties should still persist, the relevant MS representatives will be contacted directly within the above mentioned date.

· **After the 1st run of Markal (hydrogen scenarios) has started and before the final output of the 1st model run is available (end of January 2005)**: the objective for us will be to produce robust projections of hydrogen demand and infrastructure development. The process will involve further interaction with the MS representatives and, where appropriate, MS stakeholders; this process will also be harmonised with the modellers.

In more detail this includes the following two processes:

Firstly, a consistency and plausibility check of the suggested hydrogen penetration rates. In cases where the MS have accepted the hydrogen penetration rates as defined by the Scoping Report, these will be translated into national figures of levels of hydrogen demand (e.g.: total number of H2 vehicles ? total amount of hydrogen consumed ? production capacity required from each of the energy chains of choice).

This will then be supplied to the MS for further discussion regarding, for instance, the consistency of these figures with the availability of the relevant feedstocks for hydrogen production. A similar check will also be performed for MS which have developed their own targets for hydrogen introduction. Where discrepancies are found, changes to either the penetration rates or the distribution of energy chains of choice will have to be suggested. Similarly, MS specific policy measures will be taken into account. In this context, MS will be required to provide information on e.g. the potential for (economical) hydrogen generation from local energy sources. The final goal is that these penetration rates reflect major MS characteristics.

Secondly, the spatial development of the hydrogen infrastructure will be addressed at MS level. To complement spatial allocations already obtained from the MS workshops, we are currently developing a simple methodology which derives spatial allocations of hydrogen

production infrastructure on the basis of the local density of demand and on trade offs between scale returns of centralised production and costs of transporting hydrogen. All information supplied by the MS regarding existing infrastructure, preferred sites for centralised plants and CO2 storage, as well as areas where the potential is higher for local renewable energy sources, will be used as a constraint. The methodologies being developed for similar purposes by some MS (France and the Netherlands) will also be integrated as much as possible. All data used will come from either MS or other HyWays sources and, only where necessary, other EC sources will be used. Results of this process will be submitted to MS for feedback, in an iterative way.

Eventually, these two processes will converge into a consistent, robust scenario, where total hydrogen penetration overtime is consistent with the assumptions regarding geographical and pathway distribution.

The interaction with MS during this process will occur in different ways, direct interaction with the MS representative being the most obvious one. In order to engage national stakeholders and obtain their feedback, we envisage a web-based approach where documents (maps, hydrogen uptake curves) are made available (MS area of the HyWays website?) and comments can be sent by stakeholders. In our view this should provide the most convenient and economic way of interacting. However, in specific cases and given the availability of the relevant subjects, we also envisage workshops with a restricted group of national stakeholders to address specific issues. The data and information that we would require from MS (where not yet provided) can be summarised as follows:

- Potential of each of the energy chains considered to supply hydrogen economically and consistently with the overall national policy targets; minimum and maximum utilisation of each of these energy chains would also provide a very useful input for the Markal model.
- Specific (present and possible future) policy measures that can significantly affect the level of hydrogen introduction
- Where fossil-based pathways for H2 generation are considered, possible sites for CCS.
- Also based on the above, favoured sites for centralised production plant location (if any), e.g.: based on existing plants or industrial sites.
- Most favourable sites where renewable energy sources is available for hydrogen production.
- Information on the location and availability of by-product hydrogen.

Harmonisation of this approach with the other modelling activities will be necessary. The modellers meeting in January clearly provides an important opportunity, but interaction and feedback even before that date is advisable and invited.