HyWays - IPHE

Benchmarking of Hydrogen Energy Roadmaps

Summary of the HyWays-IPHE Roadmap Workshop in Brisbane, Australia

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Agenda

Draft Agenda		
Session	**Time**	**Topic**
I - The HyWays IPHE pro-ject	10 mins 10 mins 40 mins	1. Introduction : Objectives of the workshop - *Rei Fernandes* 2. Overview of HyWays IPHE Project – *Christoph Stiller* 3. Results of Comparison of EU and US Roadmapping Activities. – *Christoph Stiller*
II - Road-mapping activities in IPHE countries	20 mins 20 mins 20 mins	1. The Australian Roadmap – *Rohan Tepper* 2. The New Zealand Roadmap – *Anthony Clemens* 3. Overview of Roadmapping Activities of some IPHE countries.- *Rei Fernandes*
III - Structured Discussion	60 mins	1. Factors influencing approach to modelling in different IPHE countries. 2. Discussion: a. **Different Drivers** – main motivation for the roadmapping exercise b. **Different Objectives** - main objectives of the roadmap-ping exercise c. **Different Approaches –** Highlights of the different meth-odologies used in the roadmapping exercise - discuss pros and cons - compare and contrast approaches 3. General discussion on: a. **Appropriate Models -** b. **Recommendations for roadmaps in third countries, from lessons learned.**

Note: All presentations can be downloaded at www.hyways-iphe.de

Session I - The HyWays IPHE project

Rei Fernandes and Christoph Stiller welcomed the participants and presented an overview of the HyWays-IPHE project.

The objective of the workshop was to disseminate the results of the project to and collect feedback from a wide range of experts. Furthermore the project consortium wants to learn about further roadmap activities and the views of the experts on different drivers, objectives and approaches.

HyWays-IPHE is an EU project receiving funds from the European Commission, the US Department of Energy and the industry partners. The project aims at comparing hydrogen roadmaps, with the goal to improve understanding about the ongoing activities and therewith support the roadmapping process in further IPHE countries, particularly in Asia. Within the project a multi-national group of institutes compared models and approaches applied for hydrogen roadmaps in Europe and the U.S. with the main focus on hydrogen use in road vehicles. Its duration is 24 months, ending in September 2008. Beside the coordination work package (WP1), the project contains three topical workpackages, one on comparison of hydrogen energy pathway analyses in Europe and the U.S. (WP2), one on further comparisons of other roadmapping elements such as socio-economic modelling and stakeholder involvement (WP3) and one on dissemination and comparison with further IPHE countries (WP4).

In work package 2, nine hydrogen energy pathways (production / delivery / distribution) were assessed with regard to costs, energy use and well-to-wheels emissions. Both regions used similar methodology to estimate the technical potential of hydrogen pathways but modelling philosophies and terminology sometimes differed. In the US, three models were used. They were connected to form pathways that could be compared to pathway results generated by European analysts in a single tool. Because the methodologies were similar, parameters in the various tools could be compared. The US focused on business-cases and required a greater rate-of-return than Europe. European analysts assumed vehicles would be smaller and have greater fuel efficiency than US analysts. European energy-price projections are significantly higher than the US projections. Both sides also used similar methodologies for uncertainty analysis.

In work package 3, stakeholder involvement, regional infrastructure build-up analyses, energy system modelling and energy price assumptions, modelling of economic impacts and vehicle cost analyses were assessed quantitatively and qualitatively.

In both regions, stakeholders hold a strong although different input into the programs. Existing models used to analyze regional infrastructure build-up scenarios were mapped with respect to objectives, spatial detail, spatial extent and data handling. An extensive toolbox is available, however lacking models with imperfect foresight and detailed global interactions. Energy system models were similar but the prices assumed exogenously for fossil energy sources (oil, natural gas, coal) were much higher in the European model than the endoge-

nous US price estimates. In addition, the European model was constrained in choice of primary energy according to stakeholder input leading to high diversity, while the US model was not constrained. Employment effects were modelled similarly in both regions. Also vehicle costs are comparable, however based on different assumptions on components and cost reduction.

The key differences in assumptions and results found are summarised in the following figure.

KEY DIFFERENCES:	EU	US
ECONOMIC CALCULATIONS	Macro-economic view: simple approach; lower interest rates	Investor's view: detailed financial and cost calculations; taxes, high rates of return
ENERGY PRICE PROJECTIONS	Higher natural gas, biomass and coal prices	Lower natural gas, biomass and coal prices
KEY ENERGY SCENARIO INPUTS	H_2 vehicle penetration; bounds of H_2 production mix	Resource-cost-curves; technology costs
KEY ENERGY SCENARIO RESULTS	Scenario costs, required infrastructure	H_2 vehicle penetration; least-cost production mix
STAKEHOLDER INVOLVEMENT	Horizontal approach: project and panel level decision making, roadmap tailored to European regions	Vertical approach: Top-down decision making, roadmap (hydrogen energy pathways) by least cost.
LEARNING PROCESS	Learning by doing (global stock)	Three learning mechanisms (domestic stock): searching, manufacturing, doing
INTERLINKAGE OF MODEL TOOLBOX	Socio-economic scope, manual iteration between models+review	Economy and LCA, automated transfers

On top of the differences outlining the variety of approaches and assumptions available, the project has developed recommendations for further roadmapping activities.

The consortium recommends that a standard roadmapping process feature an iterative process starting with the definition and design of the problem, then setup and interaction of adequate models and tools, study of macro-economic and policy impacts including uncertainty / sensitivity analysis and result discussion and analysis. The results are to be discussed within the consortium and stakeholders and the assumptions and approaches modified based on the discussion outcomes. Once all involved parties agree with methodology and results, the roadmap and possibly an action plan can be composed.

Further recommendations for developing a roadmap include the assessment of the position of a specific region in the global hydrogen deployment in order to develop realistic assumptions for the region's hydrogen deployment. Regional aspects such as energy sources, policies, and strengths of research and industry should be focussed on in the activities. Appropriate number and type of models should be used to create comprehensible, robust and trustable results. In order to increase credibility and acceptance of the results, imperfect

foresight and/or sensitivity analyses should be used on the assumptions with the highest uncertainties (e.g. future energy prices and hydrogen penetration levels).

A general conclusion from the findings of the project is that among roadmapping methods, one size does not fit all, but a good foundation of resources has to be established for further efforts. Even though roadmap programmes differ, in both the EU and U.S. case two factors were crucial for the success: 1. A strong collaboration between key industries and government with extensive stakeholder input ensuring that technical and market expertise is brought together with policy goals and programmes. 2. Formal systems analysis describing the energy use, infrastructure, cost and emissions of hydrogen technology and underpinning the feasibility of the implementation of the roadmap.

In workpackage 4 an overview of the roadmapping activities within the IPHE countries was broadly assessed in a qualitative way through the administration of a questionnaire. A summary of the results was presented in Session II of the workshop.

Session II - Road- mapping activities in IPHE countries

Rohan Tepper introduced the ongoing Australian roadmap effort to the participants. The objectives are to assess Australia's chances for an emerging hydrogen economy and actions the government would have to take. The activity is in concert with two other energy roadmaps on geothermal and solar thermal energy. The roadmap is to be launched by the end of 2008. By the end of 2007, stakeholder workshops were held in Melbourne, Perth, and Brisbane. Two timeframes are considered (2020 "mid term"; 2050 "long term"), and relevant hydrogen production technologies are SMR, electrolysis, and coal gasification. The key outcomes of the roadmap will be a vision for hydrogen and fuel cells in Australia as well as suggestions for industry, government and research.

Anthony Clemens presented the key facts of the recently completed hydrogen roadmap in New Zealand. The project budget was 500.000 NZ$, over 14 months, and integrated into the overall NZ Energy Strategy. The initial driver for the government to start the roadmap was the insight that the energy business is changing and the connected wish to understand the role of hydrogen in NZ. An UNISYD optimizing dynamic equilibrium model was used to study the market spread between hydrogen fuel cell and battery electric vehicles under different premises. Based on these analyses, a harmonized vision for the hydrogen uptake in NZ was developed, featuring five phases, and a number of quantitative goals for every phase. Between 2010 and 2015 the introduction of hydrogen is foreseen for Wellington, Auckland, and Christchurch, while 2015-2025 three more regions and several corridors shall be connected. A small share of stationary use of hydrogen is seen as a factor to stimulate the uptake in transportation. Relevant hydrogen production technologies are SMR and electrolysis for the near term, and coal and biomass gasification for the longer term. The stakeholders involved included different ministries and commissions, as well as several companies involved in energy (coal, electricity, renewables), automotive, petroleum, and an engineering research association.

As the final speaker in the session, Rei Fernandes presented the results of a questionnaire that was composed within work package 4 of HyWays-IPHE and sent to all IPHE countries to find out the status of the roadmap and the approaches employed in each country..

The presentation was based on the analysis of responses from 15 out of the 17 member countries of the IPHE. The results provide a broad qualitative overview rather than a quantitative analysis as they are derived from a short questionnaire covering an overview of the roadmap, the models used and the results obtained. In most cases the answers were provided by individuals from each country who had indicated a willingness to participate in the survey at a previous IPHE meeting.

The survey shows that most IPHE countries have a roadmap although in some cases (IT, FR and UK) it is included as part of another activity. In many cases the roadmap is still in progress or being updated. The roadmaps are mostly government sponsored, with the target audience being both government and industry. Common features in their objectives are the introduction of hydrogen in the energy system and the identification of energy pathways and cost competitive technologies. Additionally IPHE members have country specific objectives. In all cases stakeholder participation is recognised as being important. The majority of the countries use models in the preparation of their roadmaps but some major players do not. The hydrogen production technology selected is dependent on the scenario selected by the country and the time frame of implementation. The impacts considered in the roadmaps are mostly environmental whilst the economic impacts are considered as secondary.

Session III - Structured Discussion

Both the presenters of the Australian and the New Zealand roadmaps recognised that time was an important factor and that they would have liked to have had more time for the exercise, the Australian presenter remarking that they might have done things differently had they known what they now know regarding roadmapping. Anthony Clemens noted that the task became more difficult and more complex than was recognised at the outset. More resources were required as there were still have a lot of unanswered questions regarding models that have been used to date.

Karen Hall (UK Hydrogen Association) noted that as a result of the publication of a fuel cells roadmap in 2005, there was very little government support for a hydrogen roadmap, but that they were determined to go ahead as the HyWays stakeholders meetings revealed the need for the UK to address this issue. She was particularly interested therefore in learning from the experience of other countries and to learn more about the programmes to make the outputs and comparisons with Europe easier. The need for government support was highlighted but the question of how to get it remained. Bruce Godfrey (Wyld Group) noted that stakeholders' interest would be much higher if they think the government was behind the roadmap, with possibilities for research funding and large scale demonstration. Roadmaps should also address the commercial point of view and consider alternatives in the overall

energy context. He further noted that most roadmaps seem to focus on transport and within that category on light duty vehicles only, pointing out also the need to distinguish between hydrogen and fuel cells.

Ulrich Bünger (LBST) replied saying that it was a question of timing as exemplified by the GermanHy project where a stepwise process was being applied. Referring to the unique nature of the modelling in New Zealand, Jonathan Leaver (Unitech) outlined the comprehensive cover of vehicle types included in the model taking into account also regional differences such as electricity price profiles. The results led to much debate which served to convince government and stakeholders of the need to take the roadmap forward. Recognising that detailed modelling does not necessarily give you more information, Bruce Godfrey commented on the difficulty in obtaining input data for the models from industry, a view supported by Christoph Stiller for data from Europe. Expressing satisfaction with the Australian roadmap, Rohan Tepper's advice was to define precisely what the roadmap is as the term could have different interpretations. Anthony Clemens remarked that some of the best feedback was from those that do not believe in hydrogen, as their contributions raise question that stimulate thought and test the models.

Geoff Whitfield (DuPont) stated from his experience that no matter how well the modelling might have been done, it is unlikely to attract investment from business, and that that investment will be forthcoming only when the risks of stranded assets and impaired assets are monetized. He believes that when the use of hydrogen is perceived by business as a way of enhancing the economic well being and deriving profit from that, as opposed to just addressing environmental issues, then decisions on investment will proceed. Rei Fernandes recalled the minister's comment that the laws of physics trump economics presenting a diverging point of view.

Tobias Brunner (BMW group) cautioned that regulation could hurt if it's the wrong one. Picking on certain technologies only as was done in California's Zero-Emission Vehicle Mandate could be counterproductive in his opinion. The need for an economic argument was supported by Alistair Gardner who noted that Government should provide a stable framework, defining the pathways to be supported in order to accelerate the uptake of technology and resulting in a scenario with an economic benefit. As a final remark, Anthony Clemens noted that they did model the transitional phase as well, where the ICE vehicle appeared to be a good option in the long term.

List of participants

NB: This list may not be complete, and does not imply that all delegates participated during the entire programme.

Name	Organization	Country
AINSWORTH K.	Blackbird Equity	Australia
ARGUMOSA Maria	INTA	Spain
BRUNNER Tobias	BMW Group	Germany
CLEMENS Tony	CRL Energy	New Zealand
DICKINSON Rob	Hydricity S. A.	Australia
ENDO Eiichi	AIST, Japan	Japan
FELL Chris, Dr.	CSIRO Energy Technology	Australia
FILBEE Sara	Industry Canada / IPHC	Canada
GNÖRICH Bruno	RWTH Aachen University Aachen	Germany
GODFREY Bruce	Wyld Group Pty. Ltd.	Australia
GORTON Peter	International Solar Energy Society	Australia
HALL Karen	U.K. Hydrogen Association	United Kingdom
HONG Seong Ahn	Korea Institute of Science and Tech	Korea
KELLER Jay	Sandia National Labs	USA
KRAINZ Guenter	Magna Steyr	Austria
LEAVER Jonathan	Unitec	New Zealand
LUCCHESE Paul	C.E.A.	France
MAO Z. Q.	CAME	China
MATHIESON Grant, Dr.	Australian Nuclear Science and Technology Organisation (ANSTO)	Australia
MILLER James, Dr.	Argonne National Laboratory	USA
MORPETH Leigh, Dr.	CSIRO Energy Technology	Australia
PEAKMAN Kevin	KANDLS	Australia
PLUMB Ian		Australia

RAND David	CSIRO ENERGY TECHNOLOGY	Australia
RAQUET John	Gasworld	UK
SVERDRUP George	NREL	USA
TEPPER Rohan	Dept. Resources Energy and Tourism	Australia
THAMBAR Kumar	Dept. mines Energy Queensland	Australia
WHITFIELD Geoff, Dr.	Du Pont Canada Inc. (now retired)	Australia
WYDER Joe	Dewha	Australia
YILMAZ Pelin	IAHE, ITU	Turkey, China
ZHENG Fred	Linde	Australia