R2H6029PU

IMPLEMENTATION PANEL

DRAFT
"IMPLEMENTATION PLAN – Status 2006"

Public Consultation
10-31 October 2006

RESPONSE FORM
from

Roads2HyCom
www.roads2hy.com

How to participate in the public consultation:

1. Enter you comments in this template – preferably with reference to the specific chapter you are referring to
2. Save the file and upload it through the dedicated website: https://www.lbstserver.de/ip_consultation/up/index.html

Deadlines for comments is 31 October 2006, 3 pm.

Contacts:

For information or questions with regards to the Implementation Panel or the Draft "Implementation Plan - Status 2006" you may contact the HFP Secretariat responsible Mr Stathis PETEVES (+31 224 565245)

For technical information concerning the submission procedure, please contact Mr Patrick SCHMIDT (+49 89 60811036) from the HFP Secretariat

For information with regards to the proposed Joint Technology Initiative (JTI), please contact the HFP Secretariat responsible Mrs Silvia VAGHI (+32 2 774-9652)

Contact details sender:

First Name:	Nick
Family Name:	Owen
Institution:	Project Roads2HyCom / Ricardo plc
Country:	UK (representing Roads2HyCom members from various countries)
E-mail:	nick.owen@ricardo.com / coordinator@roads2hy.com

Roads2HyCom contributors:
Bruno Gnoerich (IKA)
Robert Steinberger & Soeren Truemper (PLANET)
Suzanne Shaw (JRC)
Nikos Lymberoupolos (CRES)
With feedback from:
Phil Doran (CoreTec Ventures)
J-F Gruson (IFP)
Christian Klein (DaimlerChrysler)
Marcel Weeda (ECN)

This response is made on behalf of the FP6 project Roads2HyCom. The term "Roads2HyCom" is used below to represent a view developed using data from the project, with feedback from the Core Group of the project, which does not necessarily imply unanimous agreement of that Core Group or other project members to this response.

Roads2HyCom is a project to assess and monitor Hydrogen and Fuel Cell technologies for stationary and mobile energy application against current and future infrastructures, and the needs of communities which may be early adopters of the technology, in order to support the Commission and stakeholders in planning future activities. Roads2HyCom is a partnership of 30 industrial, research and academic stakeholders embracing technology and socio-economic aspects of Hydrogen and Fuel Cells for Transport and Stationary applications. Road2HyCom will:

- Assess the capability of technologies against the availability of infrastructure and the needs of users based on an objective methodology
- Analyse evolutionary pathways by which current mainstream technologies can evolve towards the needs of a sustainable future
- Identify gaps and opportunities in technologies and infrastructure, and related economic issues·
- Contribute to the engagement and planning of early-adopting Hydrogen Communities (HYCOM) to promote technology development and creation

The European Commission is supporting the Coordination Action "HyLights" and the Integrated Project "Roads2HyCom" in the field of Hydrogen and Fuel Cells. The two projects support the Commission in the monitoring and coordination of ongoing activities of the HFP, and provide input to the HFP for the planning and preparation of future research and demonstration activities within an integrated EU strategy.

The two projects are complementary and are working in close coordination. HyLights focuses on the preparation of the large scale demonstration for transport applications, while Roads2Hycom focuses on identifying opportunities for research activities relative to the needs of industrial stakeholders and Hydrogen Communities that could contribute to the early adoption of hydrogen as a universal energy vector.

Further information on the projects and their partners is available on the project web-sites www.roads2hy.com and www.hylights.org

Comments:

Roads2HyCom welcomes the latest draft of the Implementation Plan, having submitted feedback on the July draft. It is clear from the events of this year's HFP General Assembly, that there is growing clarity of commitment in many sectors to the IP and JTI.

Since July, Roads2HyCom has completed several important pieces of work that may be of interest to the HFP in developing this Implementation Plan. Comments from Roads2HyCom are presented under the following headings below:

- Landscape of Hydrogen and Fuel Cell technology development
- State of the Art in Hydrogen and Fuel Cell technologies and Hydrogen supply
- Characteristics and Needs of potential "Hydrogen Communities"
- International Perspectives on Hydrogen and Fuel Cell research

The Roads2HyCom project runs from October 2005 to October 2008, and will be further developing the data and analysis used to support comments made here. Roads2HyCom welcomes the opportunity to provide further information, as required, to support the HFP and Commission in developing this Implementation Plan. In the meantime, key suggestions for the October draft of the HFP's Implementation Plan are:

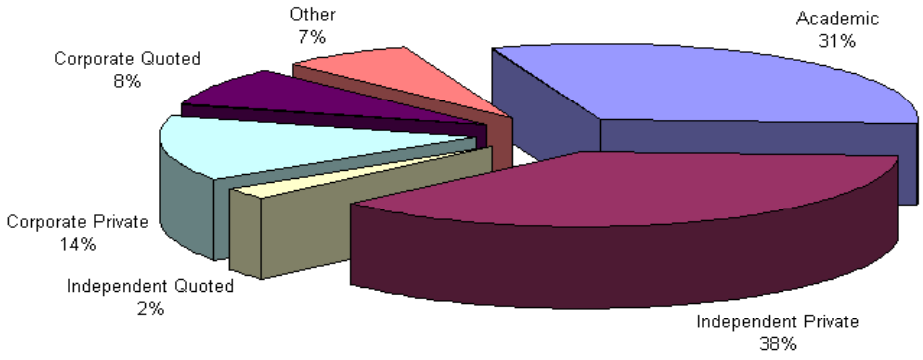
- To ensure that the proposed JTI embraces SMEs (including future start-ups from the academic sector), in terms of addressing their difficulties in co-funding grant-based projects, accessing new financial instruments, and transferring technology to the large corporate industrial sector.
- To ensure that the proposed JTI has a "friendly boundary" towards non-JTI activities (including FP7, National, Regional and non-grant funded projects) where cooperation may be useful.
- To communicate the content and focus of the JTI to other sources of research grants, such that their efforts may either be used to join it (same focus) or complement it (focussing on sectors or organisations less likely to be well supported by a JTI).
- To consider a holistic approach to financing instruments in the JTI, including grants and the EIB's Risk Sharing schemes, in order to provide smooth pathways to commercialisation for organisations that need them.
- To develop for the JTI, FP7 and broader adoption, an indicative methodology for presenting progress in the most critical area of *cost reduction*. It may be possible to build on work by the US DoE in this field. Such a methodology can indicate a cost improvement relative to a defined starting-point, and must avoid any commercial confidentiality issues. The benefit of such a tool is that progress toward commercialisation can be robustly monitored and compared to the cost/benefit of alternative solutions.
- To strengthen the emphasis on research into, and demonstration of, sustainable / renewable Hydrogen production (including CCS). This need derives from a measured "pull" from early-adopting communities and their driving politics, the need to reduce the cost of sustainable Hydrogen, and the large number of active researchers in this field who would otherwise be under-supported by a JTI.
- To recognise the importance of "Transition Technologies" (such as Hybrid/Electric vehicles and Hydrogen combustion-engines for transport; Sterling and Combustion engines for CHP; and stationary fuel-cells for flexible Hydrogen-rich gas mixes), whether or not they are directly included in the JTI. Such technologies are also continuously improving benchmarks which the more advanced technologies must improve upon.
- To develop a more extensive set of targets, embracing costs of Hydrogen fuel, cost, durability and capacity of transport storage systems, cost and efficiency of renewable production plants, and durability targets for the key fuel cell applications.

1. Landscape of Hydrogen and Fuel Cell technology development

This section is relevant to the general structure, principles and funding of a JTI

Roads2HyCom has conducted a web-based survey of over 200 Hydrogen and Fuel Cell technology developers, using a questionnaire to characterise organisations in terms of their business type, sources of finance, and technology focus. This survey shows the field of Hydrogen and Fuel Cell technology development to be highly diverse in terms of the types of organisations involved. It may be relevant to consider this landscape in the context of the JTI (and also non-JTI funding in FP7, National and Regional programs), especially regarding the differing situation of large corporations, SMEs, the plethora of innovative but poorly funded micro companies, and academic/institutional researchers.

1.1. Structure of the European Fuel Cell Industry: Numerically dominated by innovative Independent and Academic organisations



The European Hydrogen and Fuel Cell scene:
Type of organisations

Provisional data from Roads2HyCom

The pie-chart above shows a numeric analysis of the type of organisations who responded to the survey. Definitions used are:

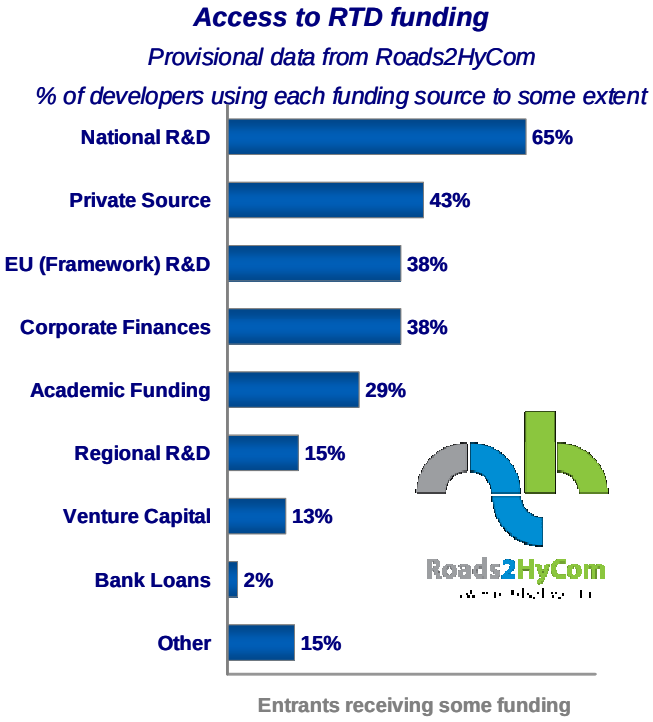
- *Corporate Developers* refers to companies whose main business activity is not the development of H2&FC technologies
- *Independent developers* refers to companies whose business activity is exclusively the development of H2&FC technologies
- *Academic developers* refers to both universities and national research institutes which are developing H2&FC technologies
- *Quoted* means that the organisation is listed on a stock-market
- *Private* means that the organisation is privately owned or non-quoted

By number, 22% of the organisations were “corporate”. This type of organisation has a “core business” other than Hydrogen or Fuel Cells which can generate the necessary revenues to co-fund research (in the JTI or elsewhere), and also pay any “administration fee” of the JTI.

A much larger number are smaller organisations – academics, institutions, SMEs and micro-companies - focussed on Hydrogen / Fuel Cell technologies. Clearly these organisations will tend to have a lower annual investment, however in innovation-led sectors, a high proportion of technological breakthrough can emerge from this type of organisation. Issues which will need to be addressed are:

- Ensuring that there is effective transfer of technology from these numerous smaller organisations to major corporations with the power to commercialise it on a large scale.
- Ensuring that smaller organisations (SMEs and micro-companies) can operate within the JTI, if appropriate for them to do so, without having to find punitive levels of co-funding. It must be recognised that the term "SME" covers any organisation with up to 250 employees, and that the issues of a 5-employee company can be much more acute than one with 249).
- Ensuring that the JTI, where appropriate, provides the correct incentives for technology to be commercialised out of academia and institutions. Links to new EIB instruments are likely to be appropriate here.

1.2. The current technology funding scene in Hydrogen and Fuel Cells: Dominated by grant-funded research, with National funding as the largest contributor



The chart above shows what percentage of survey respondents accessed the different types of funding shown (most accessed more than one type). This data indicates the strong presence of grant-funded research – given that State Aid rules require commercial entities to co-fund at 50-75%, the private and corporate sources of funding shown as major elements may be mostly used for this purpose.

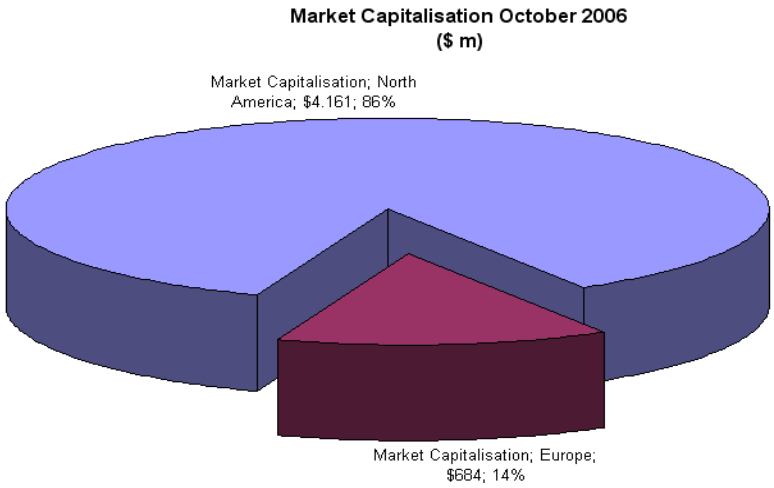
It should be noted here that some respondants to the survey did not wish to provide this information, and it has been suggested that some large corporate organisations will spend far more "internally" than they receive in grants, especially as products approach commercialisation.

It is also worthy of note that National research funding is accessed by more organisations than Framework funding. This is confirmed by other Roads2HyCom data, which suggests that National and Regional funds amount to around 2.5x the Framework fund (based on FP6).

Implications for a JTI are:

- With much of the research and technology development community currently accessing grant-based research subsidies, it is necessary to ensure that they can continue to access those subsidies if their research is to continue. This means that either:
  - The JTI needs to embrace a representative landscape of all types of organisation, or
  - Non-JTI funds, including both FP7 and National / Regional funds, need to be appropriately directed towards any type of organisation less likely to benefit from the JTI (for example, basic research is proposed to be outside the JTI)

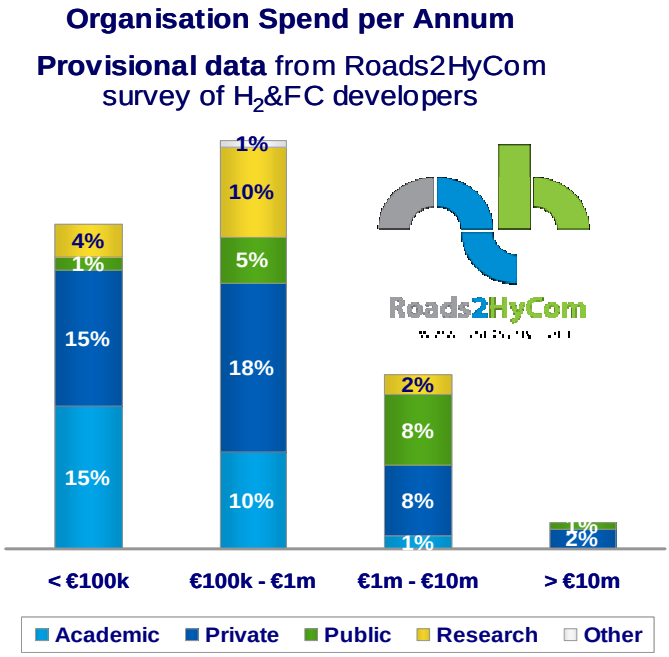
  The JTI as presented is likely to focus on more industry-oriented research within each IDA, meaning that the second option may be more appropriate, If this is the case, and there is a genuine shift of funding relative to current practise, this needs to be communicated to National and Regional funding bodies so that they can focus their efforts accordingly.
- With National and Regional funding playing such an important role, it is important to ensure that their activities complement the JTI appropriately. This could be by:
  - Focussing on useful non-JTI activities as described above, or
  - Adding funding to JTI projects in support of a national or regional agenda linked to the JTI
- The "equity gap" issue of smaller players (as described in 1.1 above), who often struggle to co-fund research, need to be considered. This is an issue for the EIB to consider in developing new instruments. As an illustration of this issue, the data below (published by PriceWaterhouseCoopers) seems to indicate much greater access to equity by North American independent developers, compared to Europe:



Source: Core Tec Ventures based on data from:
LSE & Yahoo: Stock Prices
Reuters: Exchange Rates

- Communication and technology transfer between the JTI and non-JTI activity needs to be robust. The Commission may need to facilitate this via Coordination & Support Actions, etc.

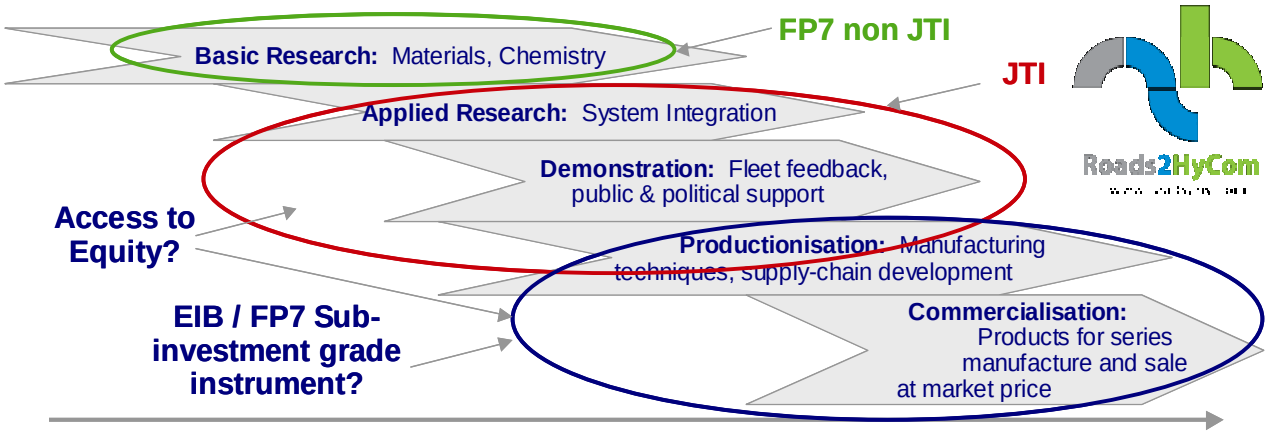
1.3. The typical organisation has a relatively small annual investment, below the level one would expect for technology commercialisation



The chart above shows the typical annual research spend for organisations who responded to the survey. This indicates a modal spend of a few hundreds of k€'s per year. To put this in context, commercialisation of a mass-produced device (e.g. Automotive powertrain, Domestic CHP unit, with volumes of 10,000 to 1 million per year) typically requires an investment of €100m - €1000m over 5 years in product development and establishing manufacturing and logistic infrastructure. The vast bulk of this Commercialisation Spend is typically provided by the stock-markets one way or another: either by direct share investment in independent developers, or via holdings in existing large corporates. There are so far only seven respondents investing over €10m per year in the Roads2HyCom survey.

Implications for a JTI are:

- Supply chains of smaller players need to be integrated via JTI collaboration so that their joint investment can be nearer the levels required to make genuine progress toward commercialisation
- Other appropriate financial instruments, such as the European Investment Bank's Risk Sharing Finance Facility (RFFF), need to be considered as a "next step" by those JTI participants for whom it is appropriate (see diagram below)
- Care should be taken to avoid a perception amongst politicians and the public, that the JTI will result in full commercialisation of every technology developed or demonstrated within it. "Snapshot 2020" should be clearly communicated in this respect.


FP7 non JTI
JTI
Basic Research: Materials, Chemistry
Applied Research: System Integration
Demonstration: Fleet feedback, public & political support
Productionisation: Manufacturing techniques, supply-chain development
Commercialisation: Products for series manufacture and sale at market price
Access to Equity?
EIB / FP7 Sub-investment grade instrument?
Roads2HyCom

2. State of the Art in Hydrogen and Fuel Cell technologies and Hydrogen supply

This section is relevant to the research topics proposed for IDAs in section 3 of the IP, and comments are arranged per IDA.

Roads2HyCom is developing a State of the Art assessment of all Hydrogen and Fuel Cell technologies, based on objective data from the public domain and Framework programme projects. This assessment is based on a large number of "metrics" (numerical performance indicators) which are specific to each type of technology, but can be classified into eleven categories:

- Technology Accessibility
- Global environmental impacts
- Local environmental impacts
- Efficiency
- Capacity and Availability
- Cost
- Safety
- Public Acceptance
- Political Will
- Security and Sustainability
- Potential for Growth

This analysis is "work in progress" and is yet to be fully validated, but an outline comparison of IDA priorities and Roads2HyCom results is made below. It is hoped in due course to extend this analysis if desired. The objective here is to confirm independently the strategy presented in the IP, and highlight any issues that may require further action to address them.

2.1. IDA 1: H_2 vehicles and infrastructure technology

The HFP Implementation Panel has developed a complex Action Plan for IDA1 outlining different types of actions for different types of focus within the transportation sector. The HFP IP Action Plan for IDA1 is shown on the next page.

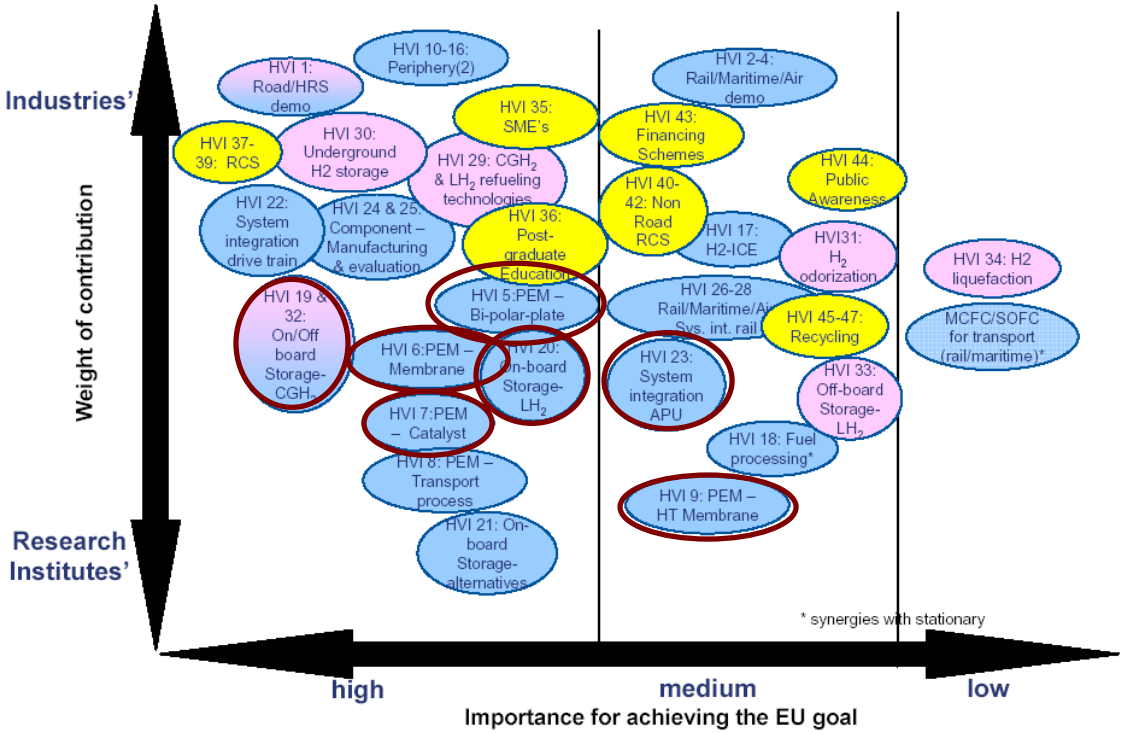
The IP places a strong emphasis on large scale demonstration projects. Initial data from Roads2HyCom suggests that technologies are most ready for application in Road and Maritime (on-board) sectors, whereas rail and air applications may be less ready for *large scale* demonstration projects today (but research should not be neglected in these areas).

Initial work by Roads2HyCom has highlighted the importance of "transition technologies" as offering opportunities for early introduction that may then make more advanced solutions easier to apply. It may not be appropriate to include these in the JTI, but strong links to non-JTI activity could be beneficial. In terms of Transport this could mean:

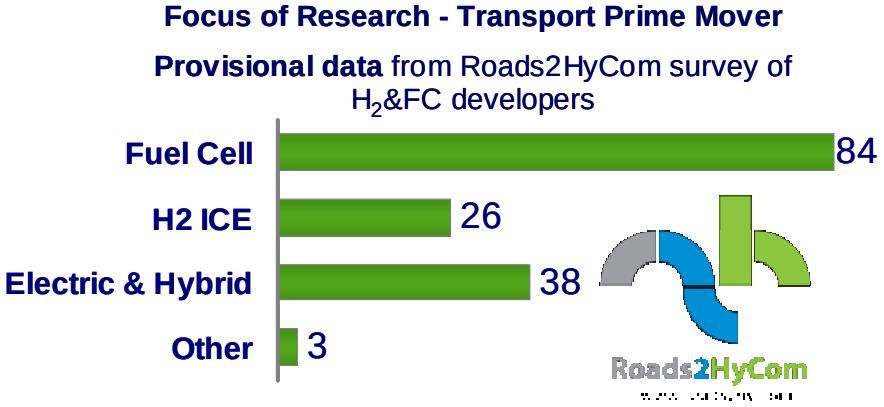
- **Hybrid and Electric vehicles** and their associated energy storage, motors and electronics – it is understood that these topics are covered outside the JTI in other parts of FP7, but opportunities for synergy should be sought where possible. The possibility of a breakthrough in electrical energy storage, which would strengthen the case for electricity as a transport energy vector, should not be disregarded.

- **Hydrogen ICEs** – these are covered in the IP (HVI17), it is suggested that opportunities to encourage their cost-effective use should not be overlooked in demonstrations, especially in view of high Community interest in this technology (section 3 of this report).
- **Fuel Cells as APUs for Transport** – in APU applications early markets will be prepared to pay a higher price for this technology if it offers the required benefits (including absence of pollution and unpleasant noise) in any application (road, marine, rail and air may all benefit). This is covered by HVI23, though it is noted that this is not considered a high priority in the draft IP.

Initial SOTA analysis confirms that membranes (including higher/lower temperature operation), catalysts and bipolar plate development, along with on-board storage, are important topics for research, with equally important contribution of industries and researchers (see below), and a focus on low cost. It may be worthwhile to ensure that the "boundary" between JTI and non-JTI activity embraces these within the JTI to ensure a strong link to industry.



Ranking from the October draft IP with some Roads2HyCom critical technologies hylighted

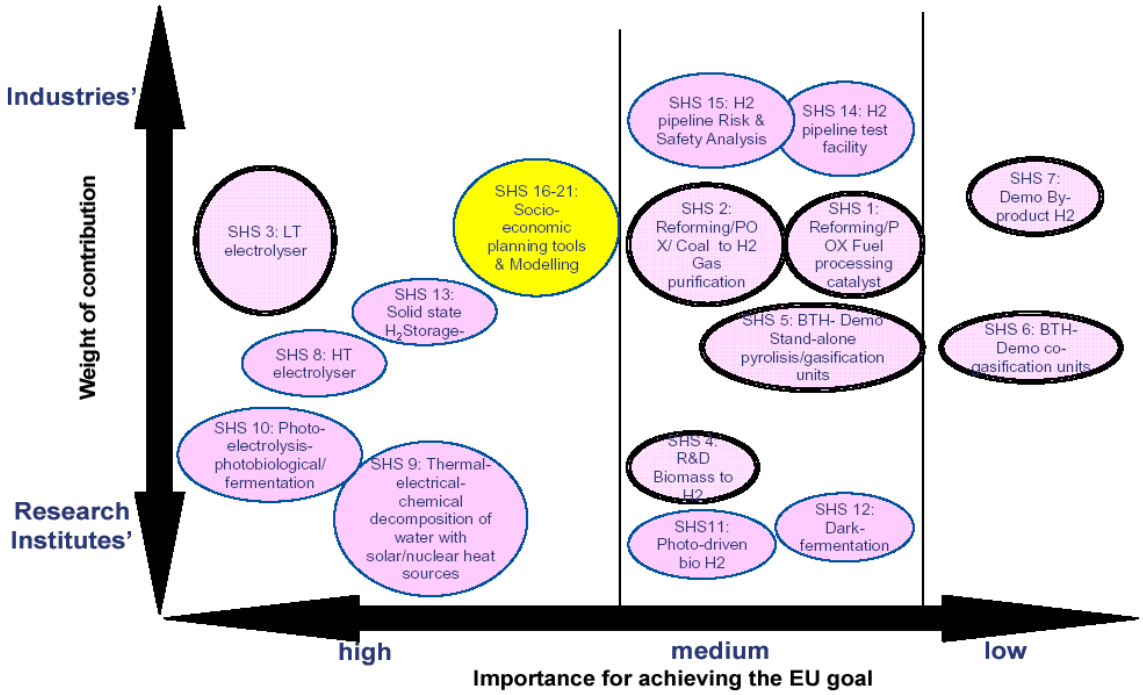


The Roads2HyCom technology developers' questionnaire (see section 2 above) indicated the distribution (number of answers) shown above for research focus in prime movers for the sector's stakeholders. This shows broad consistency with the focus of IDA1 given the points above. The allocated budget for IDA1 focuses on road transport, which again broadly matches the stakeholder distribution in the Roads2HyCom survey.

A final point however is worthy of note: Cost in production is, as expected, the most challenging issue for Transport applications highlighted by the Roads2HyCom SOTA analysis. While it is relatively straightforward to present observed data on other attributes of the technology – for example, efficiency, physical size, noise, or durability – presenting progress on reducing cost is very challenging due to limited public availability of suitable methodologies and commercial sensitivity. A method of indicating progress in cost reduction would be a very valuable addition indeed to IDA1, perhaps building on work by the US DoE.

2.2. IDA2: Sustainable H_2 Supply

No SOTA assessment is yet available in the Supply field from Roads2HyCom. The Action Plan for IDA2 shows generally good correlation with the Roads2HyCom timeline, with reforming and biomass pathways being medium term technologies.



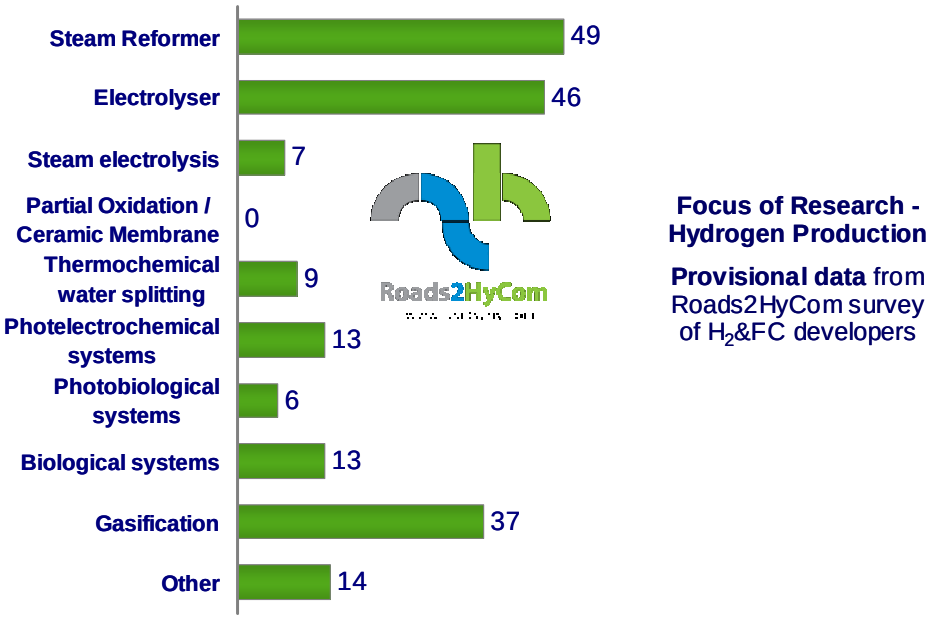
IDA2 matrix from the October draft IP, with medium term technologies highlighted.

Roads2HyCom has identified substantial community "pull" for R&D effort (budget) to support long-term sustainable technologies for Hydrogen supply, which is discussed further in section 3 of this report. The data below indicates current research activity, by number of organisations. This indicates a strong presence of researchers in these areas, on an overall level comparable (by number) to the activity in transport applications described above. With this in mind, and the strong "pull" for renewable Hydrogen described in Section 3, it is perhaps surprising that IDA2 is relatively small in budget terms.

On the same theme, it is perhaps also surprising that Carbon Capture and Storage (CCS)

from fossil fuels (including coal, widely used in Eastern Europe, the USA and China as an energy source) is not more emphasised.

Below are further comments on specific research actions within IDA2, which have been developed out of Roads2HyCom analysis of Hydrogen production routes.



2.2.1. SHS 4-6: Biomass to Hydrogen

In the Roads2HyCOM-analysis for the production potential of hydrogen from biomass it was shown that the current price of 5.40 €/kg hydrogen is still considerable higher than one kilogram of hydrogen from coal or natural gas. However, could the costs of biomass feedstock be lowered, biomass could potentially become competitive by 2015 (see table below). More research in this field is therefore suggested in order to achieve a competitive cost, in line with international cost targets discussed in section 4 below.

Comparison of production prices of biomass and other fuels from which hydrogen can be derived. Provided that technology advances as projected, the price of hydrogen from biomass can half by the year 2015.

	H_2 from biomass	H_2 from coal +CCS	H_2 from CH_4 +CCS
2006			
Production	3.49 €/kg	0.81 €/kg	0.91 €/kg
Distribution	1.42 €/kg	0.33 €/kg	0.33 €/kg
Dispensing	0.49 €/kg	0.43 €/kg	0.43 €/kg
CCS		0.13 €/kg	0.07 €/kg
Total	**5.40 €/kg**	**1.70 €/kg**	**1.79 €/kg**
2015			
Production	1.74 €/kg		
Distribution	0.87 €/kg		
Dispensing	0.24 €/kg		
Total	**2.85 €/kg**		

As most biomass fuels are bulky and of relatively low energy density, transport costs quickly

become prohibitive outside a radius of 50 to 100 km. This also limits facility size - the average biomass plant has a capacity of 20 to 50 MW_{th}. If larger plants are envisaged, any **supply chain** will has to balance transport costs with the savings from deploying such a centralised, large-scale facility. Supply chains are part of the proposed actions and will serve as testing bed for different approaches to this problem.

On the other hand, any decentralised **stand-alone plant** will maybe face the problem of inconsistent supplies. Biomass feedstock vary greatly in both composition and form. At the same time moisture and energy content are important parameters for the chemical or biological conversion process. Especially gasification plants require a supply of uniform feedstock and reliable feed preparation, storage, and handling systems. This needs to be considered in the layout of the proposed BTH conversion demonstrations. Industry would also have the chance during the proposed demonstrations to develop quality control procedures to ensure uniformity in biomass feedstock.

The same applies to **syngas clean-up and conditioning** where raw gases currently do not meet strict quality standards for downstream fuels or those for some power technologies (fuel cells or fuel cell/turbine hybrids), and will require gas cleaning and conditioning to remove contaminants such as tar, particulates, alkali, ammonia, chlorine, and sulphur. Available cleanup technologies do not meet the needed cost, performance or environmental criteria needed to achieve widespread commercial implementation. It is considered as important and useful that this aspect will be dealt with in the planned R&D programme.

2.2.2. SHS 7: By-product H_2 and Purification

Analysis in Roads2HyCom show that there is a realistic potential of 2-10bn m^3 of hydrogen available in Europe as **surplus**, either in the form of excess capacity or by-product hydrogen. These volumes are far from negligible: with 5-10bn m^3 it is possible to supply about 3-6 million vehicles. This number, though, represents only 1.5-3% of all vehicles in the EU (~190m) and indicates that surplus hydrogen can hence be only considered as being a source for the transition phase.

When the available surplus, however, cannot even fully satisfy a growing hydrogen driven transportation fleet, it will be even less accessible as fuel for a MW-scale fuel cell infrastructure. Strong competition can be foreseen during the transition phase, in which existing, conventional and cheap hydrogen sources are needed to accelerate the development of technologies in respect to costs and fuel infrastructure. Although MW-scale CHPs are an important technology, the problematic supply with fuel after the demonstration phase needs to be solved beforehand.

2.2.3. SHS 9-12: Advanced technologies

Roads2HyCom analyses came to the conclusion that the status of several biological methods of converting biomass to hydrogen is on a laboratory level and their potential is uncertain. Much R&D is needed in this field and taking these issues into the long-term technology strategy can be regarded as a sensible step towards the development of new and innovative production paths.

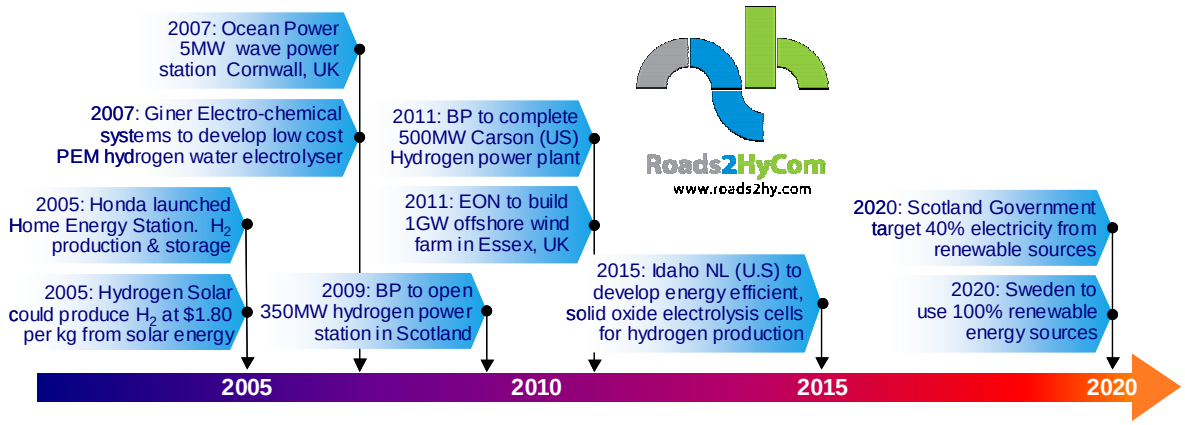
2.2.4. SHS 14-15: Pipelines

According to the Roads2HyCom report “Mapping of Existing Industrial Hydrogen Infrastructures”, soon to be published, pipelines already exist up to a pressure of 100 bar. This suggests that the focus should be on lowering costs. In addition, joint planning for a future pipeline infrastructure for hydrogen, syn-gases, green methane (upgraded biogas) etc. should be addressed (a suitable topic for Coordinated Actions and Specific Support Actions).

2.3. IDA3: Fuel Cells for CHP and power generation

The Action Plan for IDA3 covers a wide range of competing technologies, as reflected in Roads2HyCom's own "technology tree".

Roads2HyCom has identified the Fuel Cell for CHP and smaller scale power generation as a key technology for short and medium term application. Within Roads2HyCom's "technology watch" (example shown below), these applications appear alongside renewable power generation and CCS schemes in a growing portfolio of activity from demonstration scale upwards. It is suggested that the R&D and demonstration agenda within IDA3 could be developed to include more specific detail on appropriate technologies.



On this topic it is also worth noting the value of transitional technologies such as Sterling and Combustion engines for CHP applications. Based on the performance of these units under real market conditions and demand profiles the potential/added value of this type of decentralised power generation can be evaluated with respect to improving security of supply (energy saving and diversification of resources), reducing GHG's (climate) and other emissions (air quality) and improving grid performances (reduction power outages etc). As in the case of Transport discussed in IDA1, these technologies may not appear in the JTI but learning from these fields should be linked to JTI activity.

The budget distribution for different fuel cell technologies within IDA3 is similar to the stakeholders answers to the Roads2HyCom researchers' questionnaire. In this questionnaire, domestic CHP applications were the greatest area of focus, followed by distributed and co-generated power.

The link between IDA2 and IDA3 needs to be made clear in terms of infrastructure for stationary applications.

2.4. IDA4: Fuel Cells for Early Markets

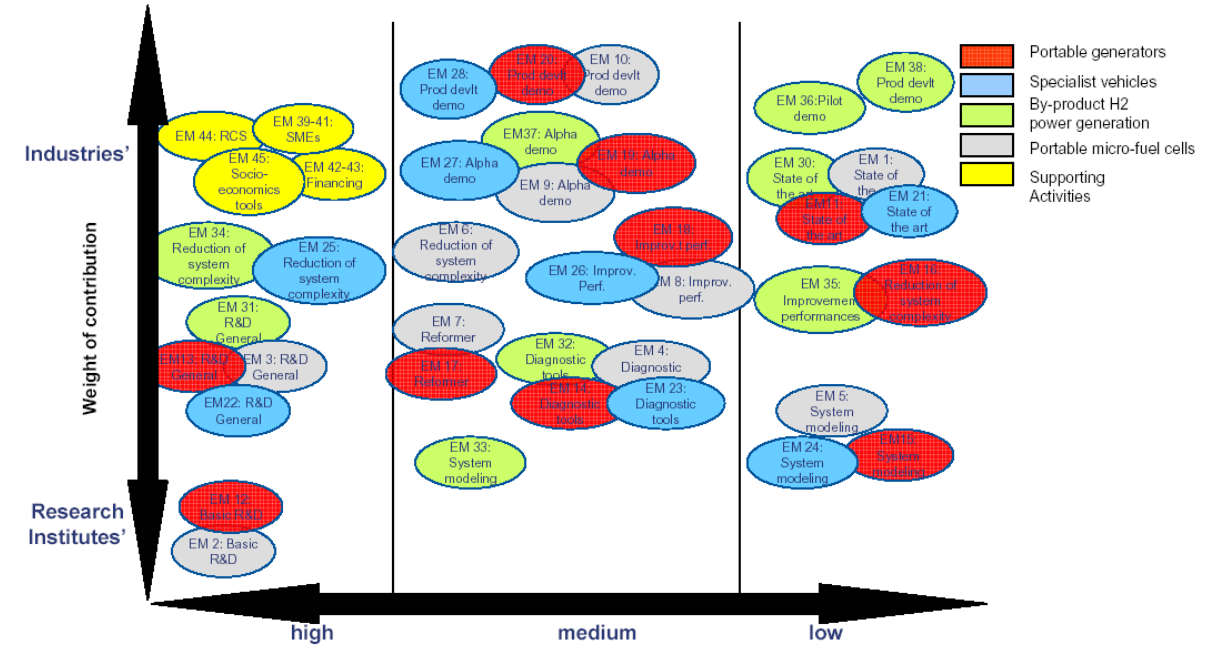
Data from Roads2HyCom's SOTA analysis and Technology Watch indicates that early markets for fuel cells are likely to be:

- Domestic CHP systems sized to mean electrical load (circa 1kW, 1:1 heat/power ratio), using Natural Gas as a fuel for SOFC and PEM fuel cells
- Specialised portable applications, at around "kilowatt" scale, where power supply is required beyond the capabilities of other gen-set devices, using a variety of fuels for SOFC and PEM fuel cells – e.g. telecommunication, field-hospitals)

- Auxiliary Power Units in commercial transport applications, of a few kilowatts, using SOFC or possibly PEM technology with conventional fuels (pump Diesel)
- Watt-scale DMFC units for portable electronic equipment, offering greater duration than a battery

These adopters will not require a fully developed H_2 infrastructure, and in cases where H_2 is seen as desirable as a fuel, can make use of currently produced industrial or by-product H_2.

Figure 6: Action portfolio of IDA in its analytical framework



The Action portfolio (above, illustration taken from the draft IP) shows that the focus of the top-left "high priority" section is socio-economics, financing and cost reduction. This is entirely appropriate to an Early Markets initiative. Issues such as community and public acceptance will be well addressed with these types of action. However, it is critical that the financing needs of SMEs, and cross-over of technology to larger industrial players, is addressed. In this respect it is useful to consider the current initiatives of the European Investment Bank (EIB). These issues are discussed in Section 1 of this feedback document.

In terms of R&D effort, Roads2HyCom has not (yet) identified this sector to be at high priority for the major players in the FC and H_2 industry. It plays a more significant role for SMEs, which could be well funded from IDA4. This focus is also set in the allocated budget for IDA4.

2.5. Innovation and Development Actions (Targets)

The HFP Implementation Plan includes a comprehensive list of technological targets to be achieved by 2015. The Roads2HyCom WP1 technology assessment confirms the vast majority of this data, with some targets being set to conservative values (e.g. H_2-ICE efficiency). It is noted that portable generators, APU and backup power as well as specialist vehicles (IDA4) have been defined as part of the early market without stating any targets for 2015. It may be desirable to set such targets in the near future.

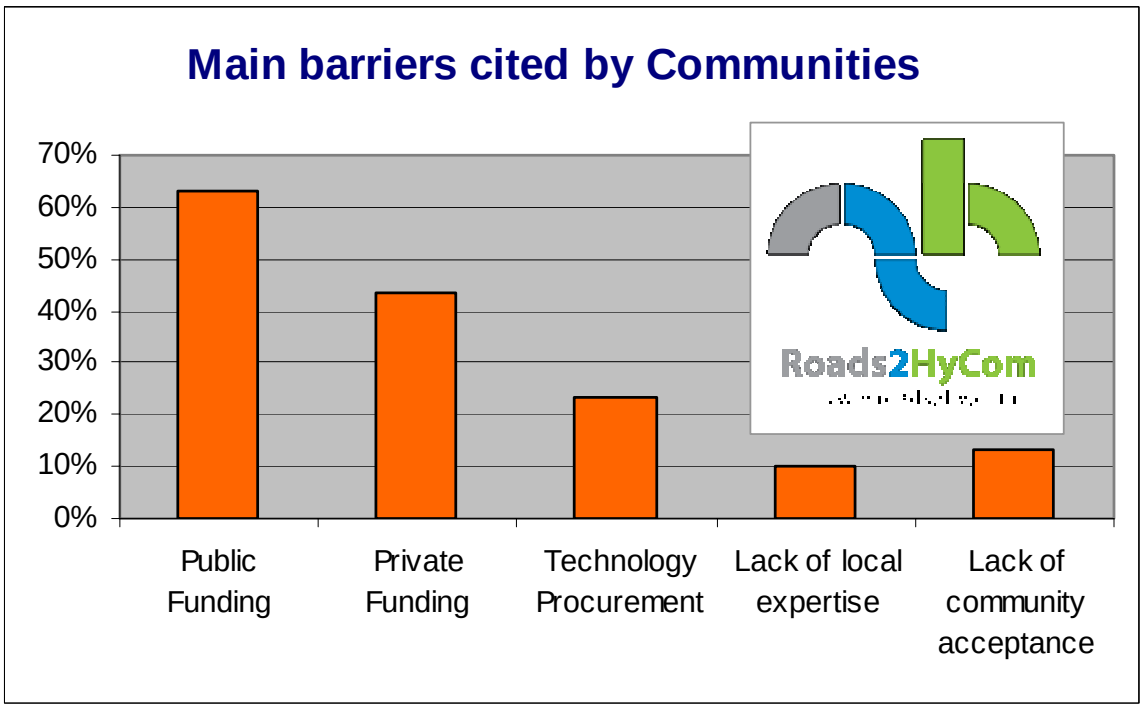
3. Characteristics & Needs of potential "Hydrogen Communities"

This section is relevant to the research topics proposed for IDAs in section 3 of the IP, and reflects "public and political will" for the various themes presented in the IP.

Roads2HyCom has conducted an on-line survey of over 50 current and potential "hydrogen communities", meaning collective projects employing either Hydrogen or Fuel Cell technologies (or both) in an integrated manner. These could embrace the "demonstrations" envisaged in the IDAs. This survey shows some interesting trends in terms of issues faced by these communities, technologies that they are currently using, and motives behind their existence.

It should be noted that a number of major players from the Transport sector (manufacturers and oil companies) have published a "position paper" stating which projects they wish to support, and limiting (out of necessity) this support to a few key projects. The potential communities in the survey response indicates a broader field of interest / expectation, and the issue of how to constructively address such interest does need addressing.

3.1. Funding is cited as the main barrier by most communities

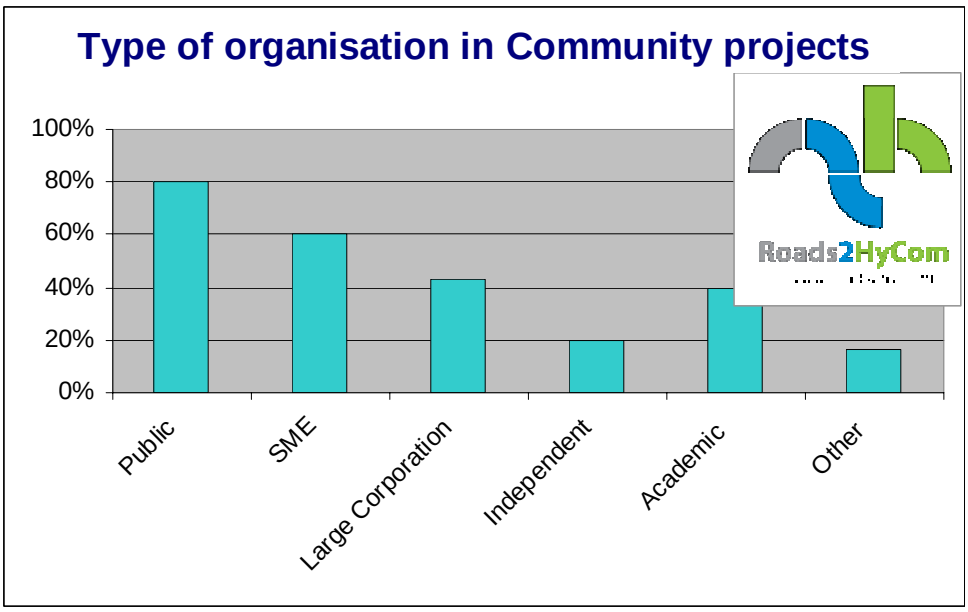


Access to both public funding (grants) and private funding (co-funding by commercial partners) is the most commonly cited issue for communities, and is perceived as much more of a challenge than access to technology or expertise. The implications for the IP and JTI are:

- There will be a need to strike the right balance between quantity and quality/diversity of projects undertaken in the JTI
- Financing schemes (HVI 43, EM 42-43) are of primary importance for achieving EU goals in a community framework
- In view of the European Investment Bank's proposed Risk Sharing Finance Facility (RFFF), which is intended to be a debt-based instrument to support JTI projects as they

move out of grant support towards commercialisation, there is a need to understand the "bankability" of community projects and demonstrations (meaning their ability to ultimately generate revenue to repay debt, from downstream commercialisation revenues). The current assumption in the IP / JTI appears to focus only on grant funding as a mechanism. Debt-based finance may not, however, be appropriate in some cases.

3.2. SMEs are major players in Community projects



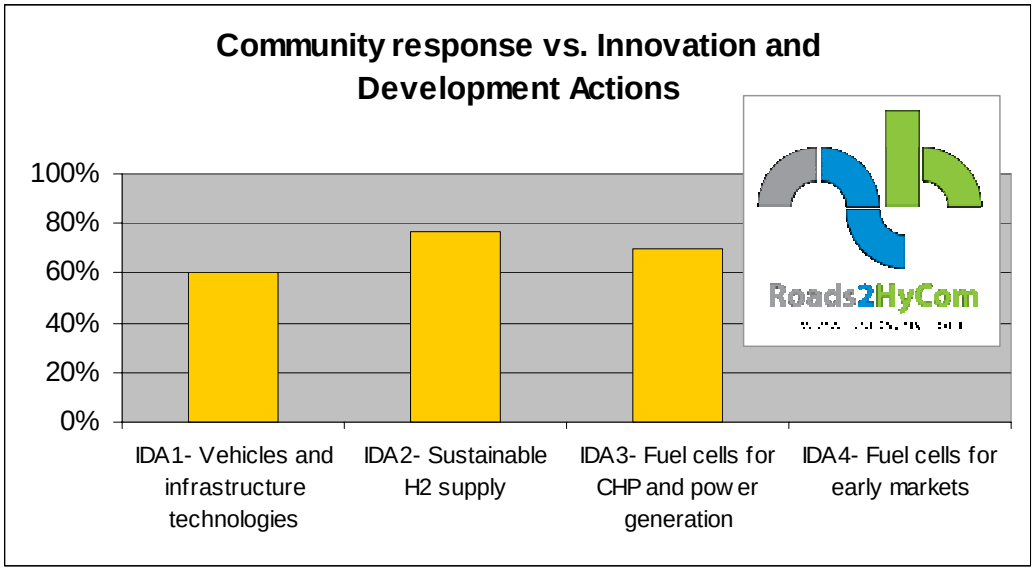
After Public bodies (typically local authorities or national laboratories), SMEs are the most numerous type of organisation in the communities surveyed. Of course, it is likely that the slightly less numerous Large Corporations invest more, but in view of their capacity for flexibility and innovation the role of SMEs is important. Implications are:

- Support for SME's (HVI 35, EM 39-41) in the IDAs is important
- Issues regarding the ability of SMEs to co-fund projects, pay JTI administration fees, and participate in voluntary-basis forums like the HFP, need to be considered as previously described

3.3. Community interest reflects the IP's balance between Transport and Stationary projects, but places more emphasis on sustainable H_2 supply

The data below reflects the stated interests of existing and potential communities in the survey, as applied to the four IDAs:

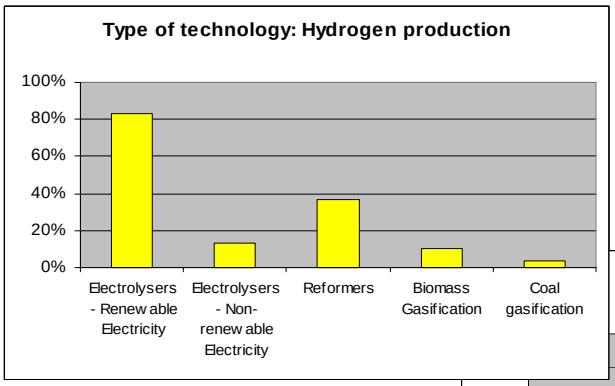
- IDA1: communities expressing interest in transport applications (fuel cells AND ICE)
- IDA2: communities expressing interest in H_2 production from renewable energy sources (RES - note that 96% of communities interested in H_2 production use RES as a primary source, either alone or together with fossil fuels)
- IDA3: communities expressing intereste in fuel cells for stationary applications (CHP and/or power generation). 100% of these projects in the response focus on PEM FC application, but as discussed below this is probably not representative
- IDA4: community interest in micro CHP for domestic application is included in the IDA3 data, otherwise other early market applications were not generally cited. These tend to be portable and non-specific to community needs (e.g. leisure power, portable electronics)

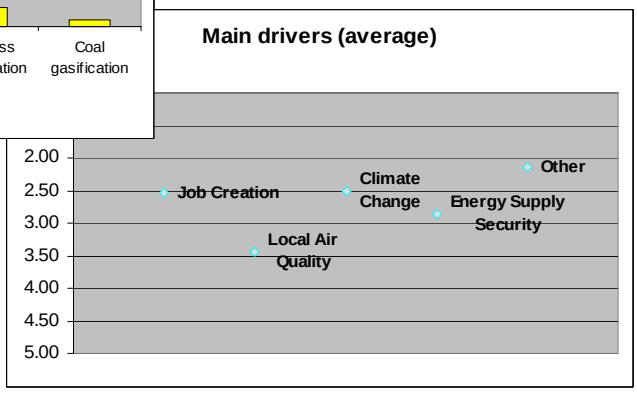


The key point here is the emphasis on Renewable H_2, which is discussed further below.

3.4. Renewable hydrogen production, and climate change, are dominant considerations in community projects

The data depicted below shows two responses from the communities surveyed: their chosen / preferred source of Hydrogen, and their key drivers in creating the "Hydrogen Community". This data indicates a strong preference for renewable hydrogen sources (electrolysis of renewable electricity over non-renewable; synthesis from bio-mass over fossil fuels), and the presence of Climate Change as one of the stronger reasons for creating the community.





Provisional data from Roads2HyCom: Community favoured Hydrogen production sources, and key drivers (1=strongest)

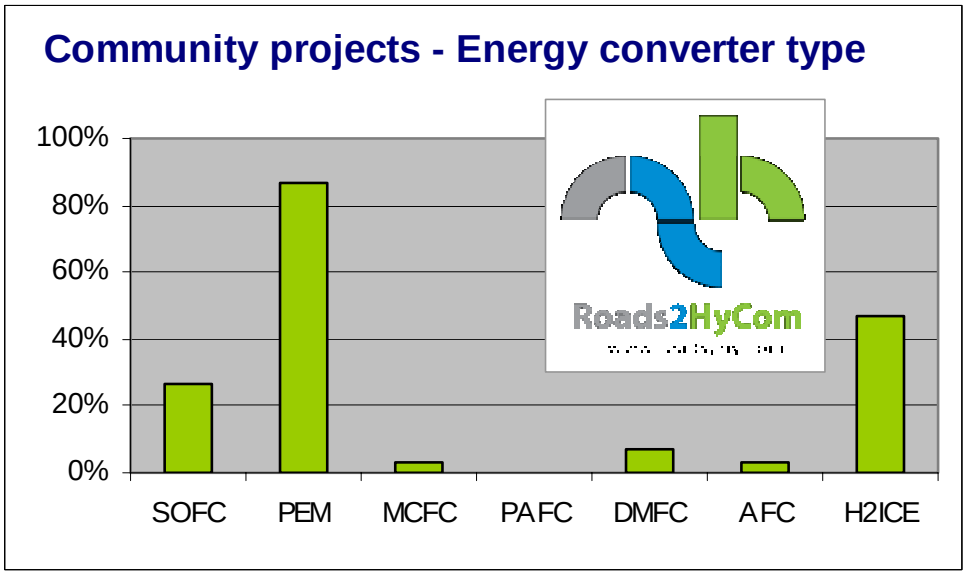
This has some important implications for IDA2 (Hydrogen Supply) and the supply-related parts of IDA1:

- The size of IDA2 as a whole is relatively small compared to other IDAs, whereas community interest (and perhaps local political will) in this area is strong
- The budget for Hydrogen Supply in IDA1 is less than 10% of the total, and the text of the Draft IP suggests that this relates to disribution rather than sustainable production
- Within IDA2, the Sustainable / Renewable technologies appear to be positioned to the right and lower portions of Figure 4, these being the areas less likely to be embraced by a JTI with limited funds

If the drive for sustainable Hydrogen is seen as a key priority by National and Regional authorities, these bodies may express a desire to see it given more focus in a JTI. Alternatively, this area could be seen as a key priority for non-JTI activities.

It may be worth recognising that applications using non-sustainable Hydrogen (made by steam-reforming from Natural Gas or electrolysis from a standard grid electricity supply) tend to perform poorly compared to conventional benchmarks on a "source to user" CO_2 metric. A lack of renewable Hydrogen supply research could therefore incur the risk of criticism on this basis.

3.5. PEM Fuel Cells and H_2- ICEs are community-favoured technologies



Communities (esisting or potential) who responded to the survey indicated a preference for PEM fuel cells and Hydrogen ICEs as power conversion devices. However, it is not the opinion of the Roads2HyCom team that these technologies should be favoured in the JTI or other research, because other types of fuel cell are more typically used in stationary applications (domestic to commercial scale power / CHP), which uses Natural Gas as a fuel; although the definition adopted by Roads2HyCom would include such projects as "hydrogen communities" they may not see themselves as such and may not have responded in such great numbers to the survey.

However, the following may be worthy of consideration:

- The potential of Hydrogen Internal Combustion Engines, as a transition step or long-term solution, should not be overlooked (HVI1, HVI17)
- The capability of other types, especially SOFC, to accept a range of gases from Natural Gas to hydrogen-rich gases and pure hydrogen, should be understood by communities as a potential transition step

4. International Perspectives on Hydrogen and Fuel Cell research

This information is most relevant to the Snapshot 2020 (section 2 of the draft IP), but may also apply to individual IDAs.

As part of its activities, Roads2HyCom has been benchmarking Europe's technology portfolio against other major international powers, including the activities of the IPHE, US DoE and Japanese METI.

4.1. The IPHE view – Scorecard workshop 2006

This table of research priorities was generated at the IPHE's Scorecard workshop in Lyon, 9-10 June 2006.

IPHE Objective	IPHE score	Comment
70% of hydrogen as an energy carrier from carbon neutral resources by 2050	19.13	Consistent with IDA2 goal "10-20% H_2 to be CO_2 lean / free by 2015"
Vehicular fuel cells system (including storage, stack and fuel cell BOP) will cost $25 - 45 per kW (projected in 2015 – 2020 for high volume manufacture in the future.) [4 – 5X reduction from present cost]	17.94	Snapshot 2020 target is €100/kw for 2020. Lower IPHE target is what will be *projected* in 2015-2020 (i.e. for a later time), but is very challenging
Delivered hydrogen from carbon neutral sources at $3-$5 per kg on a cost per mile and kWh basis by 2020-2025	14.69	No specific targets in IDA2 or supply part of IDA1 for Hydrogen cost
Codes, standards and regulations for transportation related hydrogen and fuel cells will ensure a standard of safety that is at least as high as that required from conventionally fuelled vehicles on a worldwide basis by 2015-2020.	14.44	HVI37-42 (IDA1) cover this important area and are ranked high priority (especially Road) for a JTI
Stationary fuel cell system will achieve a lifetime of 40000 – 80000 hours by 2020 with at least 4000 start-stop cycles for low-temperature residential and back-up systems and 100 start-stop cycles for industrial and SOFC residential, continuous operation	14.25	Snapshot 2020 calls for Market Growth, which is consistent with these targets. There are no specific durability-focussed action clusters but likely to be covered by many IDA3&4 items
The cost of hydrogen delivery (centralized production) will be less than $1.20/ kg (or gge) at the pump by 2020-2030	14.13	No specific targets in IDA2 or supply part of IDA1 for Hydrogen cost
Vehicular fuel cells will achieve a lifetime of 5000 – 8000 hours by 2015 – 2020	13.88	Snapshot 2020 calls for mass market roll-out, which will require this level of durability. Targets stated in IP annex.
Produce hydrogen sufficient to supply 15% of light duty vehicles on the road in IPHE countries by 2030	13.63	Consistent with 2020 mass market rollout and subsequent successful uptake
All hydrogen as an energy carrier from carbon neutral resources by 2050	13.63	See top item, though this IPHE target is more ambitious
The installed cost of stationary fuel cells (including the reformer) will be $1200 – 1800/kW (industrial) and $2400/kW (residential) by 2020	13.56	Snapshot 2020 targets €1k-€1.5k/kw (industrial) and €2k/kw (domestic) are comparable

The table shows, in general, very good correlation to the draft IP, which adds confidence to its robustness. Points worthy of note are:

- **Carbon-neutral Hydrogen** was ranked as the highest priority by the IPHE, which may appear inconsistent with the relatively small budget of IDA2 and the tendency for carbon-neutral technologies within it to be ranked outside the "Industrial / European" (top left) area likely to be included in a JTI (see also comments in section 3.3 regarding high Community demand for renewable Hydrogen)
- **Cost and Durability** are ranked by the IPHE as important issues. The Snapshot 2020 has Cost targets only for Fuel Cells (not Hydrogen), and there are no specific durability targets described. The use of such targets (and defined means for measuring them in a research program, especially the commercially sensitive area of Cost) may be useful

4.2. The US DoE view – US RD&D plan

The targets tabulated below are taken from the US DoE's current RD&D plan, presented in May 2006:

US DoE objective	Comment
Reduce cost of hydrogen at the pump to 2-3$/gge* by 2015 (2.5$/gge from distributed NG reforming, 2.85$/gge from distributed electrolysis, 2.6 $/gge from biomass)	No specific targets in IDA2 or supply part of IDA1 for Hydrogen cost. IPHE and DoE have a mix of cost targets that are not strictly consistent.
Reduce cost of hydrogen delivery to 0.90$/gge by 2010	
Improved hydrogen storage aiming for 2kWh/kg, 1.5kWh/L and 4$/kWh by 2010 and 3kWh/kg, 2.7kWh/L and 2$/kWh by 2015	HVI19-21 are ranked as key priorities, though no targets are stated.
Develop a PEM for transport applications running on hydrogen, that is 60% efficient and costs 45$/kW by 2010 and 30$/kW by 2015	Snapshot 2020 target is €100/kw for 2020. By comparison DoE targets are ambitious (and possibly unobtainable)
Develop a PEM for stationary applications running on NG that is 40% elec. efficient, has 40,000 hours of durability and costs 400-700$/kW by 2010	Snapshot 2020 targets €1k-€1.5k/kw (industrial) and €2k/kw (domestic) are less ambitious (more realistic?)
Validate H_2 vehicles with +250miles range and 2,000 hour FC durability by 2009 and +300 miles and 5,000 hours respectively by 2015	No specific targets in this timeframe but demo vehicles will need to approach this performance
Validate wind-driven electrolyser costing 400$/kW an efficiency of 65% and operating pressure of 350 bar.	No specific targets, these technologies feature in IDA2

Some of the US DoE's targets are quite ambitious by comparison to both the IPHE and HFP Snapshot 2020. Many believe that such targets are unrealistic, however the following are worthy of note:

- **The adoption of targets for the cost of Hydrogen** may be a useful enhancement of Snapshot 2020 and IDA2
- **The adoption of cost and capacity targets for transport Hydrogen storage** may be a useful enhancement of Snapshot 2020 and IDA1
- **The adoption of cost and efficiency targets for key sustainable Hydrogen production devices** (such as the example of the wind-driven electrolyser used by the DoE, but perhaps including other devices which may receive political support in early adopting hydrogen communities) may be a useful enhancement of Snapshot 2020 and IDA2

The DoE has an annual RD&D budget of approx. $280m, where 50% is for Applied research, 22% for Development, 15% for demonstration and 13% for Basic research. By comparison the draft IP calls for a budget of €6700m over ten years, or €670m per year. A key difference is that 67% of the IP budget is classified as Demonstration (vs 15% in the USA).

4.3. The Japanese view – METI Hydrogen and Fuel Cells program

The targets tabulated below are taken from the Japanese METI's current RD&D plan:

Japan METI objective	Comment
Transport (Vehicle) FC Stack: Power generation efficiency over 65%(LHV) and over 55%(HHV)	No specific targets in IDA1, although cost is more of a barrier to adoption than efficiency
Transport Tank to wheel efficiency: - Hydrogen fuelled - approx. 60%(LHV), 51%(HHV) - Gasoline fuelled - approx. 48%(LHV), 45%(HHV) - Stack: Power generation efficiency over 55%	No specific targets in IDA1, although cost is more of a barrier to adoption than efficiency
Transport FC Cost: below 5,000 yen* / kW (1 yen = €150, so this is circa €35/kw)	Snapshot 2020 target is €100/kw for 2020. By comparison METI targets are ambitious (and possibly unobtainable)
Transport Onboard Hydrogen storage: On vehicle 5kg hydrogen storage (over 500km cruising)	This is not a challenging target, but in densely populated Japan, range is less of an issue.
Stationary Stack: Power generation efficiency over 55%	No specific targets in IDA3 or 4. In commercial sizes, efficiency is key to operating cost but current state of the art is reasonable. For domestic CHP, 50% efficiency is adequate.
Stationary System: Power generation efficiency over 40%(HHV); total efficiency over 80%(HHV); durability over 40,000hours	See above. There are no specific Snapshot 2020 durability targets although durability of this level will be required in stationary applications.
Stationary FC Cost: Home use below 300,000 yen/system (€2000/kw); business use below 150,000 yen/kW (€1000/kw)	Snapshot 2020 targets €1k-€1.5k/kw (industrial) and €2k/kw (domestic) are similar

METI's targets are generally comparable to those of the Snapshot 2020, and tend to focus on key issues of efficiency, cost and durability that will be addressed by the IDAs. It is interesting that METI's transport cost targets, like those of the US DoE, are very aggressive, reflecting what is needed to compete with near term fossil-fuelled combustion engines.

The annual RD&D budget of the METI Hydrogen and Fuel cells programme is approx. €240m.

5. Other Points

It should be noted that Roads2HyCom has delivered a number of reports of relevance:

- Area Reports on the HFP Review Days 2005
- Area Reports on the US DoE's May 2006 program review

These and further reports, when published, are available at www.roads2hy.com