REFERENCE	EU Fuel Cells
Title:	European Hydrogen and Fuel Cell Technology Platform: Strategic Research Agenda
Date:	July 2005
Author:	Hydrogen and Fuel Cell Platform Secretariat
Funded by:	European Commission
Hard copy reference:	
URL:	www.HFPeurope.org
Date accessed:	July 2006
Web Format:	pdf
IEA topics covered	V.2 Fuel Cells V.1.2 Hydrogen storage Hydrogen generation and distribution
Geographical focus:	Europe
Brief Abstract:	The report outlines a strategic approach for research in Europe to bring hydrogen and fuel cells to market. The report sets out technology targets across a range of sectors and for differing fuel cell, and hydrogen technologies. The focus of the report is hydrogen, with fuel cells seen as important technology in facilitating the transition to a hydrogen economy.

OUTPUTS	
Short Report?	No
Major report?	Yes
Visualisations?	Yes
Information held on dedicated software?	No
- which package?	

ARCHITECTURE	
Timescales used:	• Prioritised - 10-year program • Medium-term strategy up to 2030 • Long-term strategy up to 2050.
Trends and drivers?	Yes
- list	• Reducing greenhouse gas and local emissions • Improving security of energy supply • Strengthening the European economy
Enablers?	
- list	
Performance measures/targets?	
- list areas	• Reduce costs • Increase lifetime
Mapping of RD&D activities?	No
Critical assessment of capabilities?	No

PROCESS	

Methods used:	Steering panel
- Desk study?	
- Consultation	
- Interviews?	
- Facilitated workshop(s)	
- Working groups/task force	
- Integrated Process	
Stakeholders engaged:	Steering panel
– **University based researchers**	
– **Other public sector researchers**	
– **Business – technology**	
– **Business – other**	
– **Government - energy**	
– **Government – SET**	
– **Government - other**	
– **NGOs**	
No of people engaged:	Not known
Budget (if known):	Not known
Commitment to re-visit?	Not mentioned

ACTIONS IDENTIFIED	
List of actions?	Yes
Actions listed according to timescale?	No
Actions prioritised?	No
Sequencing/dependencies identified?	No
Responsibility for actions identified?	No
Types of actions identified:	
- Basic research?	
- list areas	The proposed research is broken down into five areas. Hydrogen production – not considered here Hydrogen storage and distribution – not considered here Stationary applications • For all types of fuel cells stack design, balance of plant component development and industrial production methods are important for further advancement. Gas processing units, i.e. reforming of natural gas & biogas, middle distillates like diesel, heating oil or kerosene and propane and subsequent gas clean-up, are important for early market introduction and, in the long term, for remote applications. • Electronic equipment for fuel cells, including hardware and strategies for operation control, will be of utmost

	importance in the future. This includes power electronics • Sensors and tools for diagnostics and control. The idea of single cell control should be investigated, as well as the map-controlled operation of fuel cells • Integrated catalyst concepts for easy and efficient recycling of stack components have been identified. However, now and for some time in the future, stack components for high- and low-temperature fuel cells will need further advancement. Harnessing and further developing existing PEFC technology will encourage early market entry for the technology. For breaking advance in energy efficiency and cost reduction, special emphasis should be placed on high-temperature polymer membranes and the corresponding stack concepts. In general, modelling of electrode processes, cells and stacks, as well as the systems level, provides great insight into the function of fuel cells and should be increasingly exploited. Transport applications • PEFC needs to be optimised – in particular, with respect to power density, durability, humidification, cathodic water management and contaminant tolerance; • PEFC operated at elevated temperature is considered a breaking technology path for future transport applications. Membranes suitable for operation between 120°C and 160°C, with favourable start-up properties at low temperatures and a good long-term stability are a prerequisite. Improvement of the other stack components for elevated temperatures is imminent. Passive humidification allows for further system simplification and should also be investigated; • For PEFC systems, further advancements in components such as highly efficient air supply units, sensors, controls and power electronics are required. In traction applications, electric motors allow for further improvements. In order to achieve a reasonable range of operation, new hydrogen storage systems based on 700 bar gaseous hydrogen and alternative storage options are essential; • Reformer systems are largely dedicated to auxiliary power units which provide electric power independently of the propulsion unit. Applications currently under development are vehicles, aircraft and ships. The main energy carriers to be investigated for these applications are diesel, kerosene and gasoline, with particular emphasis on desulphurisation; • SOFC for auxiliary power units in transport offers great potential as reforming is simplified. It is therefore expected to fit easily into the existing fuel infrastructure, which will become even more beneficial for the technology as cleaner fuels emerge. Crucial development issues include improving thermal cycling stability, robustness and reliability, plus tolerance to fuel impurities, such as sulphur. Further reduction of the operating temperature will be beneficial for mechanical integrity and is likely to reduce degradation even more;

	• Although stack technology is important, systems integration and verification at an early stage is vital to the success of the entire technology. Efforts to increase systems efficiency, improve systems dynamics and decrease start-up times are particularly important. Cost reduction will rely partly on further systems simplification; • In order to bring hydrogen to market early, it would be desirable to improve the performance of internal hydrogen combustion engines; • Development of new polymer membranes for operation at elevated temperatures, new electrocatalysts with higher activity – and, preferably, with less or even without platinum group metals – plus materials for bipolar plates and seals; investigation of degradation mechanisms; development of methods for lifetime prediction and accelerated testing for PEFCs and SOFCs, plus new SOFC materials for electrolyte sealing and interconnectors operating at lower temperatures; improvement of injection technology and combustion process for hydrogen internal combustion engines development of operation strategies for hybrid configurations, new battery concepts and supercapacitors, plus new stack control procedures; development of reversible hydrogen storage materials and fuel gas processing technology for gasoline, diesel and kerosene. Portable applications • Polymer fuel cells which consume hydrogen and their direct methanol (DMFC) consuming descendents are viable options. Improving stack efficiency and power density, reducing precious metal loading and developing low-cost stack components are the major issues to be solved. For the use of carbon-containing fuels, the improvement of carbon monoxide and sulphur tolerance is essential for PEFC technology. The DMFC requires most research directed at the problem of methanol crossover and reduction of the current, very high precious metal loading, which is a sacrifice for a much simpler system; • More simplified water management for small applications – particularly the development of fluid handling components and water recovery options; • System components for small fuel cells need to be highlighted; • Microreformers suitable for small fuel cell systems; • System integration, miniaturisation and verification efforts should be directed towards the improvement of system efficiency, dynamics and start-up time, e.g. by hybrid system solutions. Miniaturisation, the simplification of systems and the improvement of thermal integration will also lead to further cost reduction and efficiency improvement. As for all other fuel cell systems, novel hydrogen storage approaches are required, as well as improvements to existing hydrogen storage – either pressurised, absorbed by metal hydrides or stored-in chemically; • Small power electronic devices with high efficiency and sensors are important – single-cell control strategies are

	recommended; • The development of high-temperature membranes, carbon–monoxide- and sulphur-tolerant catalysts, new membrane electrode assemblies (MEAs), flow-field design, plus seals and bipolar plates for PEFCs; new methanol oxidation and resistant cathode catalysts, and composite membranes for DMFCs; alternative options for humidification, new battery concepts and stack control procedures; storage materials for hydrogen; fuel gas processors for liquid petroleum gas and hydrocarbon fuels.
- Applied research?	
- list areas	
- Development & demonstration	
- list areas?	
- Other types of action?	
- list other types	Socio-economic research • The strategic assessment of technologies and pathways, with particular focus on developing, refining and using tools for strategic energy systems analyses. Input data for strategic decision-making in science, industry and policy should also be collected and disseminated for public use. Integrated studies on the potential impacts of hydrogen & fuel cell technologies are required. Within this context, analysing and defining boundary conditions for creating added value for the hydrogen transition is necessary. This includes different transition scenarios on the basis of the current technological status and its projections, market trends and policies; • Fundamental analysis of market actors and diffusion mechanisms, together with training and education, will offer deeper insights for market development. This includes creating specific measures to facilitate the demonstration, early-market penetration and design of 'umbrella' measures for the hydrogen & fuel cell market; • Public acceptance needs to be developed, based on a detailed understanding of apprehensions and obstacles. This includes a strong focus on the early education of ever increasing numbers of the public, industrial and academic institutions, and individuals. It is strongly advised that all information be based on honesty – and shown to be complete – yet simple and relevant to the target audience; • A strategic outlook should be created and continually updated. This includes road maps, modelling, experience curves etc. for condensing the technological state of the art. The transformation of system analyses should also be evaluated and monitored with regard to different socio-economic criteria not covered by the research areas mentioned above.