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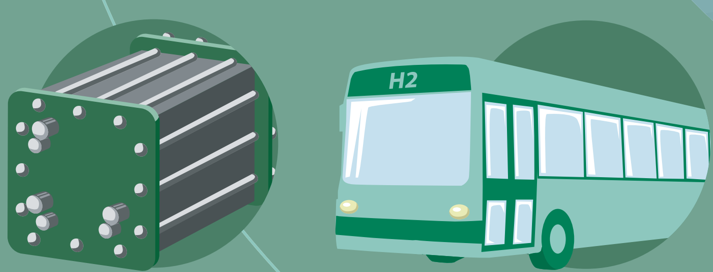

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European **Hydrogen** and **Fuel Cell** projects

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Research objectives

Europe's energy supply is today characterised by structural weaknesses and geopolitical, social and environmental shortcomings, particularly as regards security of supply and climate change. Energy is a major determinant of economic growth and these deficiencies can have a direct impact on EU growth, stability and the well being of Europe's citizens. Energy supply security, mitigating climate change and economic competitiveness are therefore main drivers for energy research, within the context of sustainable development - a high-level EU objective.

Hydrogen and electricity together represent one of the most promising ways to realise sustainable energy, whilst fuel cells provide the most efficient conversion device for converting hydrogen, and possibly other fuels, into electricity. Hydrogen and fuel cells open the way to integrated "open energy systems" that simultaneously address all of the major energy and environmental challenges, and have the flexibility to adapt to the diverse and intermittent renewable energy sources that will be available in the Europe of 2030. Hydrogen can be produced from carbon-free or carbon-neutral energy sources or from fossil fuels with CO_2 capture and storage. Thus, the use of hydrogen could drastically reduce greenhouse gas emissions from the energy sector. Fuel cells are intrinsically clean and very efficient (up to double the efficiency of Internal Combustion Engines (ICE)) and capable of converting hydrogen and other fuels to electricity, heat and power. They can also be sited close to the point of end-use, allowing exploitation of the heat generated in the process.

Several strategic areas of research are currently being pursued for **hydrogen: clean production** (development and techno-socio-economic assessment of cost-effective pathways for hydrogen production from existing and novel processes), **storage** (exploration of innovative methods, including hybrid storage systems, which could lead to breakthrough solutions), **basic materials** (functional materials for electrolysers and fuel processors, novel materials for hydrogen storage and hydrogen separation and purification), **safety** (pre-normative RTD required for the preparation of regulations and safety standards at EU and global level), and **preparing the transition to a hydrogen energy economy** (supporting the consolidation of current EU efforts on hydrogen pathway analysis and road mapping).

EU-funded research in the area of **fuel cell systems** is aimed at **reducing the cost** and improving the **performance, durability and safety** of fuel cell systems for stationary and transport applications, to enable them to compete with conventional combustion technologies. This will include materials and process development, optimisation and simplification of fuel cell components and sub-systems as well as modelling, testing and characterisation. The long-term goal is to achieve commercial viability for many applications by 2020.

The Framework Programmes for research

The main EU funding mechanism for research, technological development and demonstration is the Framework Programme (FP) which is mainly implemented through calls for proposals. Based on the Treaty establishing the European Union, the Framework Programme has to serve two main strategic objectives: strengthening the scientific and technological bases of industry, and encouraging its international competitiveness while promoting research activities in support of other EU policies.

Projects from the previous FP5 (1998-2002) are well advanced, with many entering the critical phase of exploiting and disseminating their results. The EC contribution on hydrogen and fuel cells research within FP5 is of the order of €145 million.

The main objective of FP6, which runs from 2002 to 2006, is to contribute to the creation of a true European Research Area (ERA). ERA is a vision for the future of research in Europe, an internal market for science and technology. It fosters scientific excellence, competitiveness and innovation through the promotion of better co-operation and coordination between relevant actors at all levels.

The FP6 is structured into 'Thematic Priorities'. RTD and demonstration on hydrogen and fuel cells is being implemented mainly in Thematic Priority 6.1 'Sustainable energy systems' which has a total budget of around €890 million. Complementary, projects are funded in other Thematic Priorities, such as 6.2 'Sustainable Surface Transport', 4 'Aeronautics and Space', and 3 'Nanotechnologies and nanosciences, knowledge-based multifunctional materials, new production processes and devices'. Currently, some €100 million of EU funding, matched by an equivalent amount of public and private investment, has been awarded to research and demonstration projects for hydrogen and fuel cells in FP6. This will be reinforced via further calls for RTD and demonstration proposals worth an expected public and private investment in the order of €300 million, of which about half would be funded by the EU (see Chapter 4 on 'Future Priorities').

More information on the FPs can be found on: www.cordis.lu

The European Hydrogen and Fuel Cell Technology Platform (HFP)

Background

Building on the recommendations set out in the **Vision Report of the High Level Group** on Hydrogen and Fuel Cells (HLG) set up in October 2002, the European Commission facilitated the establishment in January 2004 of the European Hydrogen and Fuel Cell Technology Platform (HFP) aimed at accelerating the development and deployment of these key technologies in Europe. The role of the HFP is to assist in the stimulation and efficient coordination of European, national, regional and local research, development and deployment programmes and initiatives, and to ensure a balanced and active participation of the major stakeholders (i.e. industry, scientific community, public authorities, users, and civil society). It should also help promote awareness and understanding of fuel cells and hydrogen market opportunities and foster deeper co-operation, both within the EU and at global scale.

The HFP will be instrumental in structuring socio-economic and technical research on hydrogen and fuel cells at European level. It should stimulate increased public and private investment in research and development. The platform will also help in identifying and promoting deployment opportunities both for energy infrastructure and services. The HFP is built up from ongoing and new projects, clusters and networks in the European Commission's Framework Programme and in Member States, and includes a number of specific steering panels and initiative groups to optimise its functioning and realise the platform's overall goals. These activities will be complemented by new initiatives for public-private partnerships and linked to industry projects, when appropriate.

The results of activities, including research and demonstration projects undertaken under the auspices of the Platform, will be widely disseminated and communicated to the appropriate policy-making bodies. These bodies themselves will be represented in the Platform governance structure and will play a crucial role in target-setting and assessment. Regular annual or biannual meetings of platform participants will ensure shared ownership and a common vision.

The HFP and all its activities will contribute to an integrated strategy to accelerate the realisation of a sustainable hydrogen economy in Europe.

Goal

The main goal of the European Hydrogen and Fuel Cell Technology Platform (HFP) is:

"Facilitating and accelerating the development and deployment of cost-competitive, world-class European hydrogen and fuel cell based energy systems and component technologies for applications in transport, stationary and portable power."

Value added

Through the effective mobilisation of all relevant stakeholders towards a common goal, the HFP will be in a position to deliver substantial benefits for the European Community, including:

1. Accelerating the introduction of hydrogen and fuel cells in order to achieve the development of sustainable, secure and clean energy systems

2. Securing economic prosperity and creating new employment opportunities

3. Improving the effectiveness of European public and private R&D investments in the hydrogen and fuel cell sector through a common vision and a consistent strategic framework at EU level for both R&D funding and deployment initiatives.

Structure of the technology platform

The HFP comprises the following complementary bodies, as set out in the Terms of Reference:

- The **Advisory Council**: sets the overall direction, strategy and vision of the platform. It comprises 36 senior executives with expertise and direct responsibilities in the field of hydrogen and fuel cells. An Executive Group, composed of six representatives, drives the day-to-day operations of the Advisory Council. The first Advisory Council was appointed on 17 December 2003 for an initial 18-month period.

- The Member State's **Mirror Group** is actively involving the EU Member States as regards furthering the European Research

Area in hydrogen and fuel cells. This Group will aim to ensure closer coordination and co-operation between Member States, regional research programmes, high-level representatives within administrations of Member States and the HFP. It will also act as a forum for the exchange of views on the Strategic Research Agenda, the Deployment Strategy and policy- related matters.

- Two **Steering Panels** were established to develop the platform's Strategic Research Agenda and Deployment Strategy:

  • The **Strategic Research Agenda** Steering Panel: its mission is to provide an outline for research and development issues and priorities, including measures and activities for R&D over a ten-year timescale. It will propose a mid-term strategy until 2015 and a long-term strategic outlook until 2050.

  • The **Deployment Strategy** Steering Panel: its mission is to consolidate the overall implementation of a European hydrogen vision. On behalf of the Advisory Council, this Steering Panel shall develop a deployment strategy fostering the commercialisation of mobile, stationary and portable hydrogen and fuel cell applications.

- In order to consolidate the work of the Steering Panels, four **Initiative Groups** have been established:

  • Safety, Codes and Standards
  • Business Development and Finance
  • Education and Training
  • Public Awareness.

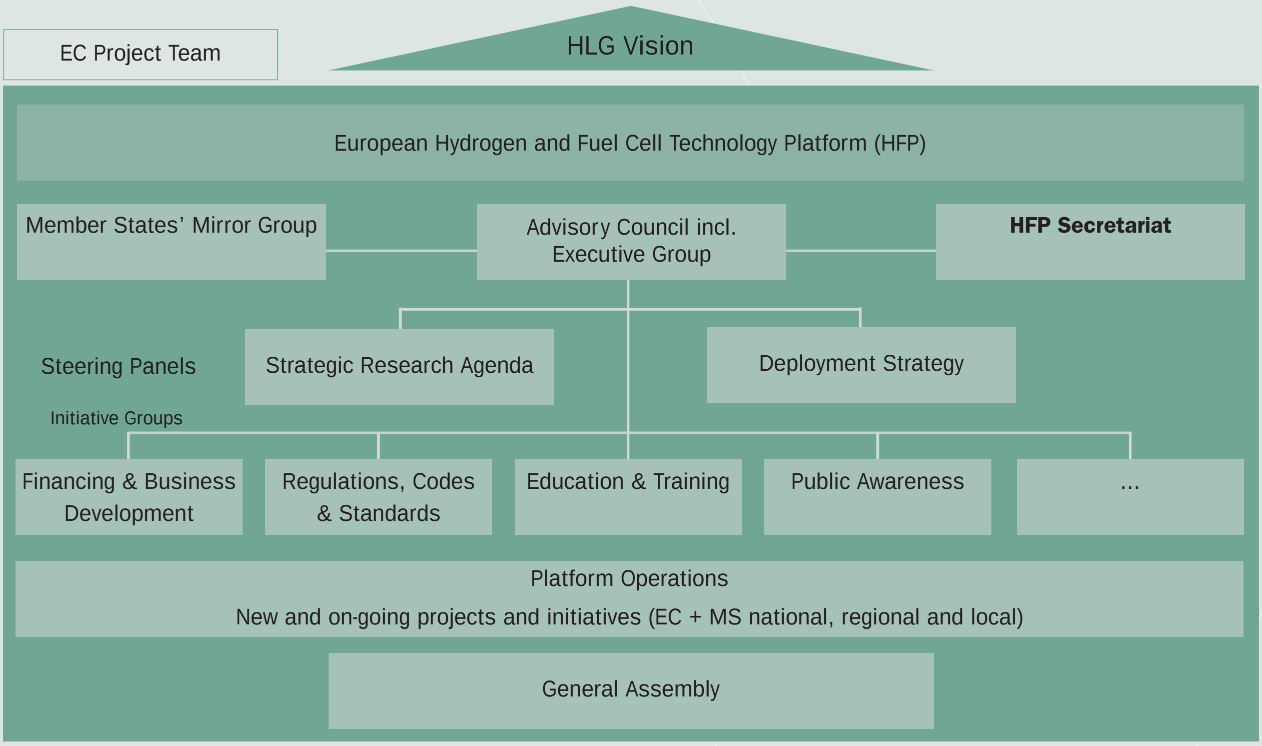
The Advisory Council may set up new Initiative Groups if and when appropriate.

- The **General Assembly** is a forum integrating all HFP participants. It meets at least once a year with the objective of ensuring shared ownership and a common vision.

- The **Platform Secretariat**, funded by the European Commission, has a key role in supporting the administration of the platform operations, coordinating the platform's different activities, and managing information flows inside the platform and vis-à-vis external stakeholders. The Secretariat reports to the Advisory Council.

- The **Platform Operations** include all new and ongoing hydrogen and fuel cell related projects and initiatives from the EC and Member States.

- Each body within the platform has developed its own Terms of Reference which were endorsed by the Advisory Council after internal consultation and are publicly available on the platform's website.



Participation

The participants in the HFP represent a balance of expert knowledge and stakeholder interests and typically include:

- Industry (including SMEs) – embracing the whole production and supply chain

- Users and consumers – to ensure markets for products

- Research community – public and private; technical and socio-economic

- Public authorities – European, national, regional, local

- Financial community – banks, venture capital, insurance

- Civil society – to enhance public awareness.

As of 15 July 2004, more than 200 representatives were actively participating in the activities of one of the bodies within the platform. Three basic principles govern participation in the platform: **commitment, transparency, and inclusiveness**.

Expected deliverables

Following the recommendations of the High Level Group, the platform intends to provide the following deliverables in the short to medium term:

- A **Strategic Research Agenda** to define performance targets, priorities, timelines, appropriate instruments and budgets for industry and publicly funded research and development

- A **Deployment Strategy**, including recommendations on policy measures and demonstration and deployment projects

- A **European Roadmap** for hydrogen and fuel cells

- **Proposals for public-private partnerships** to promote commercialisation

- A **policy interface**, or framework, to promote interaction between the platform and the political institutions and policy-making

- A strategy to develop and implement **international co-operation**.

Further information

Further information concerning the HFP can be accessed on the platform's website: www.HFPeurope.org or through the HFP Secretariat contacts:

Patrick Maio, Stathis Peteves, Mathias Altmann

European Hydrogen and Fuel Cell Technology Platform Secretariat
E-mail: secretariat@HFPeurope.org
General telephone line: +32 2 774 9652

Building on the experience of the Fifth Framework Programme (1998-2002)

The Fifth Framework Programme was conceived to help solve problems and to respond to the major socio-economic challenges facing Europe. To maximise its impact, it focused on a limited number of research areas combining technological, industrial, economic, social and cultural aspects. A major innovation of the Fifth Framework Programme was the concept of 'Key actions' which mobilised a wide range of scientific and technological disciplines – both fundamental and applied – required to address a specific problem.

Research into hydrogen and fuel cells was carried out under the 'Energy, environment and sustainable development' programme, specifically in the key actions 'Cleaner energy systems, including renewables' and 'Economic and efficient energy for a competitive Europe'.

The portfolio of FP5-funded research projects in the field of hydrogen and fuel cells is summarised in Table 1.

Table 1: EU support (in million €) to hydrogen and fuel cell RTD in FP5 for the period 1999-2002

	Hydrogen	FC technology acquisition[1]	FC stationary applications	FC transport applications	FC portable applications	Total
Medium and longer term RTD	23.6	22.4	12.1	28.0[2]	8.4	94.5
Short term (Demonstration and benchmarking)	6.9	-	16.8	26.5[3]	-	50.3
Total	**30.5**	**22.4**	**28.9**	**54.5**	**8.4**	**144.8**

1. Includes generic fuel cell development for stationary, transport and portable applications;
2. Approximately €19 million devoted to projects related to fuel processing;
3. €18 million for fuel cell bus demonstration project CUTE;

The EU is thus contributing some €145 million to support 70 projects in the field of hydrogen and fuel cells.

Details on all of these EU funded projects can be found at the following web site:
- **http://dbs.cordis.lu/**

and in the brochure "European Fuel Cell and Hydrogen Projects 1999-2002"
- **http://europa.eu.int/comm/research/energy/pdf/european_fc_and_h2_projects.pdf**

As indicated in Table 1, the main RTD and demonstration effort in FP5 has been allocated to fuel cell component and system development, as well as fuel reformer/processor development. Stack technologies include PEMFC, DMFC for small portable, stationary and transport applications. SOFC and MCFC technologies are also being developed for stationary COGEN applications up to MW-scale. Hydrogen production (especially from renewable sources such as biomass and wind) and hydrogen storage have also been the focus of considerable RTD effort in FP5. For more details on the projects referred to by acronym in the following brief overview of FP5 activities, please refer to the above brochure "European Fuel Cell and Hydrogen Projects 1999-2002".

The strategic approach in FP5 was to support a number of key fuel cell and hydrogen technologies across the spectrum of research, development and demonstration. Thus, FP5 projects range from basic research on active materials for fuel cells, fuel processors, hydrogen production and storage – through systems integration for stationary, portable and transport applications – to demonstration projects aiming at verifying technology under actual operational conditions. These mainly technical research and demonstration projects are complemented by networking and supporting actions for fuel cell technologies, testing (SOFCNET, FCTESTNET, ELEDRIVE) and hydrogen pathway analysis (HyNET, HySOCIETY). A proposal for elements for a European Roadmap for hydrogen has been published by HyNET stakeholders. Pre-normative research in the EIHP II project has supported the regulatory process. EIHP II carried out safety analysis related to hydrogen vehicles, on-board hydrogen storage, and hydrogen fuelling infrastructure, and has led to the preparation of a draft ECE regulation.

Research on PEM includes efforts on high-temperature membranes and electrode catalysts aiming at reduced cost and improved performance and durability. DMFC systems have also been developed for small portable power and vehicle APUs. Materials and processes have been researched for lower-temperature SOFC, including planar cell technology. In the automotive sector, the FUERO cluster of nine research projects has developed component technologies for fuel processors for a range of fuels including gasoline (conventional and micro-channel reactors), methanol, and bio-ethanol, and has carried out well-to-wheel studies for alternative fuels. The cluster also included research on PEMFC and DMFC stack and system components and life-cycle analysis for stacks and other components. In addition, FUERO has developed FC-component and system models for computer simulation. Test procedures for performance benchmarking have been developed and verified in component testing. A feasibility study on ammonia as a hydrogen carrier is under way. Model development for individual components is also the subject of the NFCCPP project.

The RTD effort on hydrogen production from renewable sources has mainly involved processing different biomass feedstocks – often linked to applications in high-temperature fuel cells. Effort is also being devoted to advancing electrolyser technologies and integrating wind/hydrogen/fuel cell systems (RES_2H_2). Achieving sufficient energy density for hydrogen storage is a well-known bottleneck, particularly for transport applications, and three FP5 projects (FUCHSIA, HYSTORY and HYMOSSES) are researching advanced on-board storage materials, including metal hydrides, carbon nano-structured materials and composites, as well as developing advanced storage prototype vessels.

Technology demonstration and verification has been a key element of FP5. A virtual PEMFC power plant is being demonstrated, comprising a group of interconnected, decentralised residential micro-CHP systems. FP5 also supports the largest hydrogen fuel cell bus demonstration projects (CUTE and ECTOS) worldwide – 30 buses operating in ten European cities. By the end of July 2004, the buses have cumulative service of more than 290 000 km and 22 000 hours, carrying 400 000 passengers. ACCEPTH2 is a global study of public acceptance of hydrogen transport in the EU, US and Australia – based on public reaction to hydrogen bus projects.

Projects funded under the Sixth Framework Programme (2002-2006)

The Sixth Framework Programme (FP6) differs significantly from previous ones. One key difference is its role in contributing to the creation of the European Research Area (ERA) in sustainable energy systems. This means that the aim is to assemble a *critical mass of resources*, to *integrate* research and related efforts by pulling them together in larger, more strategic projects, and to make this research more *coherent* on the European scale. Hydrogen and fuel cells research cuts across a number of the Thematic Priority Areas in FP6:

- Priority 6.1 'Sustainable energy systems'
- Priority 6.2 'Sustainable surface transport'
- Priority 4 'Aeronautics and space'
- Priority 3 'Nanotechnologies and nanosciences, knowledge-based multifunctional materials, new production processes and devices'

Related projects can also be funded under the programmes:

- Horizontal research activities involving SMEs
- New and emerging science and technologies (NEST)
- Support for the coordination of activities (ERA-NET)

Following the FP6 calls for proposals in 2003-2004, the projects shown in Tables 2 and 3 were selected for EC funding in this area, with a total EC contribution of up to €100 million. The portfolio includes the new instruments in FP6, Integrated Projects and Networks of Excellence, as well as projects using the more traditional type of instrument used in FP5.

Brief presentations of the projects are presented in the annex.

Table 2: *Hydrogen* contracts awarded, or under negotiation, after the first calls for proposals in the Sixth Framework Programme (FP6)

Area	Project acronym	Type of action or instrument*	Topic or title	EU indicative funding (€ million)	Coordinator	Contact details
H_2 production	CHRISGAS	IP	Hydrogen rich gas from biomass	9.5	Växjo University, Sweden	Mr Sune Bengtsson sune.bengtsson @power.alstom.com
	SOLREF	STREP	Solar Steam Reforming of Methane Rich Gas for Synthesis Gas Production	2.1	DLR, Germany	Dr Stephan MÖLLER stephan.moeller@dlr.de
	HYTHEC	STREP	Hydrogen THErmochemical Cycles	1.9	CEA, France	Mr Alain LE DUIGOU aleduigou@cea.fr
	Hi_2H_2	STREP	Highly Efficient, High Temperature, Hydrogen Production by Water Electrolysis	1.1	EDF, France	Dr Philippe STEVENS philippe.stevens@edf.fr http://www.hi2h2.com
	SOLAR-H	STREP	Hydrogen production from renewable resources			
H_2 storage	STORHY	IP	Hydrogen Storage Systems for Automotive Application	10.7	Magna Steyr Fahrzeugtechnik, Austria	Dr Guenter KRAINZ guenter.krainz @magnasteyr.com

Area	Project acronym	Type of action or instrument*	Topic or title	EU indicative funding (€ million)	Coordinator	Contact details
H_2 safety, regulations, codes & standards	HYSAFE	NoE	Safety of Hydrogen as an Energy Carrier	7	Forschungs-zentrum Karlsruhe, Germany	Dr Thomas JORDAN thomas.jordan @iket.fzk.de
	HARMONHY	SSA	Harmonisation of Standards and regulations	0.5	Vrije Universiteit Brussels, Belgium	Prof. Gaston MAGGETTO gmagget@vub.ac.be
H_2 pathways	HYWAYS	IP	Elaborating a European Hydrogen Roadmap	4	L-B System-technik, Germany	Dr Ulrich BUENGER buenger@ibst.de
	HYCELL-TPS	SSA	Development and implementation of the European Hydrogen and Fuel Cell Technology Platform Secretariat	1.8	Kellen Europe, Belgium (Alfons Westgeest & Patrick Maio, Brussels)	Mr Alfons WESTGEEST awestgeest @kelleneurope.com secretariat @HFPeurope.org www.HFPeurope.org
	NATURALHY	IP	Investigating infrastructure requirements for H_2 and natural gas mixes	11	Gasunie, The Netherlands	Mr Onno FLORISSON o.florisson@gasunie.nl
	INNOHYP-CA	CA	Innovative high temperature production routes for H_2 production	0.5	CEA, France	Dr Paul LUCCHESE Paul.lucchese@cea.fr
	HY-CO	CA	Co-ordination Action to Establish a Hydrogen and Fuel Cell ERA-Net	2.7	Research Centre Jülich (FZJ), Germany	Dr Hans-Joachim NEEF h.j.neef@fz-juelich.de
	WETO-H2	CA	World Energy Technology Outlook-2050	0.39	ENERDATA, France	Bertrand CHATEAU bertrand.chateau @enerdata.fr
	CASCADE MINTS	STREP	Case Study Comparisons and Development of Energy Models for Integrated Technology Systems	0.95	ICCS/NTUA	Pantelis Capros kapros@central.ntua.gr
H_2 end-use	ZERO REGIO	IP	H2 FC fleet demonstration	7.5	INFRASERV, Germany	Dr Heinrich LIENKAMP heinrich.lienkamp @infraserv.com
	HYICE	IP	Optimisation of the Hydrogen Internal Combustion Engine	5	BMW, Germany	Hans-Christian FICKEL hans.fickel@bmw.de
	PREMIA	SSA	Effectiveness of demonstration initiatives	1	VITO, Belgium	Ms. Leen GOVAERTS leen.govaerts@vito.be
			Total EU funding:	**€67.7 million**		

** Type of action or instrument: IP : Integrated Project, NoE: Network of Excellence, STREP: Specific Targeted Research Project, CA: Coordination Action, NEST: New and Emerging Science and Technology, ERA-Net: Support for the coordination of activities, SSA: Specific Support Action*

Table 3: *Fuel cell* contracts awarded, or under negotiation, after the first calls for proposals in the Sixth Framework Programme (FP6)

Area	Project acronym	Type of action or instrument*	Topic or title	EU indicative funding (€ million)	Coordinator	Contact details
High Temperature Fuel Cells	Real-SOFC	IP	Realising Reliable, Durable, Energy Efficient and Cost Effective SOFC Systems	9	Research Centre Jülich (FZJ), Germany	Dr Robert STEINBERGER-WILCKENS r.steinberger @fz-juelich.de
	BIOCELLUS	STREP	Biomass Fuel Cell Utility System	2.5	TU Munich, Germany	Dr Juergen KARL karl@ltk.mw.tum.de
	GREEN-FUEL-CELL	STREP	SOFC fuelled by biomass gasification gas	3	CCIRAD, France	Dr Philippe GIRARD philippe.girard@cirad.fr
	SOFCSPRAY	STREP	Porous material for Solid Oxide Fuel Cells/High power applications (industry, power stations)	0.6	Nuevas Tecnologias para la Distribución Activa de Energia S.L., Spain	Mr. Carlos Martinez Reira
Solid Polymer Fuel Cells	HYTRAN	IP	Hydrogen and Fuel Cell Technologies for Road Transport	8.8	Volvo, Sweden	Mr Per EKDUNGE Per.Ekdunge @volvo.com
	FURIM	IP	Further Improvement and System Integration of High Temperature Polymer Electrolyte Membrane Fuel Cells	4	Technical University of Denmark (DTU)	Prof. Niels Janniksen BJERRUM njb@kemi.dtu.dk
	PEMTOOL	STREP	Development of novel, efficient and validated software-based tools for PEM fuel component and stack designers	1	Bertin Technologies SA, France	Mr Clement KIRRMANN
	INTELLICON	STREP	Design and prototyping of intelligent DC/DC converter/ fuel cell hybrid power trains	0.5	HIL Tech Developments Limited, UK	Mr. John HOLDEN
	DEMAG	STREP	Integration of a PEM fuel cell with ultra-capacitors and with metal hydrates container for hydrogen storage (prototype)	0.65	Labor S.r.l., Italy	Mr. Alfredo PICANO
Portable applications	MORE-POWER	STREP	Compact direct (m)ethanol fuel cell for portable application	2.2	Geesthacht Research Centre (GKSS), Germany	Dr Suzana PEREIRA NUNES nunes@gkss.de

Area	Project acronym	Type of action or instrument*	Topic or title	EU indicative funding (€ million)	Coordinator	Contact details
	FEMAG	STREP	New product = fuel cell + components + expert system/Small vehicles (non automotive)	0.65	AGT S.r.l., Italy	Prof. Filippo UGOLINI
General	ENFUGEN	SSA	Enlarging fuel cells and hydrogen research co-operation	0.23	Labor S.r.l., Italy	Mr Alfredo PICANO a.picano @labor-roma.it
			Total EU funding:	**€33.13 million**		

** Type of action or instrument: IP : Integrated Project, NoE: Network of Excellence, STREP: Specific Targeted Research Project, CA: Coordination Action, NEST: New and Emerging Science and Technology, ERA-Net: Support for the coordination of activities, SSA: Specific Support Action*

Current and future research priorities

1. Remaining calls for proposals in FP6

To enhance the coherence of European research in hydrogen and fuels cells, co-ordinated and joint calls for proposals are being arranged in 2004. The details of these calls are shown in Table 4.

Deepening co-operation through **coordinated** and **joint calls** will deliver benefits in terms of building critical mass, better coverage of the domain, cross-fertilisation of ideas between an extended range of disciplines and stakeholders, and will ensure that cross-cutting evaluations deliver the best strategic combination of complementary projects.

A well coordinated, strategically selected set of FP6 projects will provide a concerted and essential technical input to the European Hydrogen and Fuel Cell Technology Platform, as well as to the transport-related technology platforms ERTRAC, ERRAC and ACARE, and the Alternative Motor Fuels policy initiative. It will also help establish the definition and detailed planning phase of a substantial and broad-ranging hydrogen communities technology initiative designed to stimulate growth and accelerate the move towards the hydrogen economy, under the EU's Growth initiative.

Table 4: Summary of FP6 calls for proposals incorporating hydrogen and fuel cells, opening in 2004

Call ID	Call launch date	Call closing date	Indicative budget	Hydrogen and fuel cell topics	Instruments available
FP6-2004-Energy-3	8 September 2004	8 December 2004	€190 million	Hydrogen and fuel cells – various topics (see work programme for details)	IP, NoE, STREP and CA
Joint call: FP6-2004-Hydrogen-1	29 June 2004	8 December 2004	€35 million	Fuel Cell and Hybrid Vehicle Development; Integrated fuel cell systems and fuel processors for aeronautics, waterborne and other transport applications	IP and STREP
Joint call: FP6-2004-Hydrogen-2	29 June 2004	8 December 2004	€4.5 million	Support of the coordination, assessment and monitoring of research to contribute to the definition phase for a hydrogen communities initiative	IP
FP6-2004-TREN-3	29 June 2004	8 December 2004	€132 million	European Partnership: 'Hydrogen for transport' and new hydrogen integrated demonstration projects ('seed' projects for large-scale demonstration). Polygeneration.	IP and CA
FP6-2004-NMT-x (tbc)	November 2004 (tbc)	February 2005 (tbc)	(tbc)	Materials development and processes for fuel cells and sustainable hydrogen production and storage technologies	STREP

The call texts and work programmes provide full details of the research areas open in these calls and the conditions of participation. These, and other useful documents, are available on the dedicated call pages on the CORDIS website at: http://www.cordis.lu/

Further call for proposals concerning hydrogen and fuel cells may be opened in 2005.

2. Looking towards the Seventh Framework Programme

At the beginning of 2005, the European Commission will present its proposal for the European Union's Seventh Framework Programme for Research (2006-2010). Along with specific information about the financial support schemes and implementation instruments, it will include the Commission's proposals for thematic research priorities.

The Commission has made strengthening European research a major objective in its Communication on the future financial framework of the Union[2], proposing to increase the European Union's research budget significantly. At the Barcelona European Council of March 2002, the EU set itself the objective of increasing the European research effort to 3% of the European Union's GDP by 2010, two-thirds coming from private investment and one-third from the public sector.

In order to increase the impact of the European Union's action, it is proposed to organise FP7 around six major objectives:

Objective 1. Creating European centres of excellence through collaboration between laboratories.

Programmes to support transnational collaboration between research centres, universities and companies will be implemented using the FP6-type instruments, such as the Networks of Excellence and Integrated Projects.

Objective 2. Launching European technological initiatives

Technology platforms are being set up to bring together different stakeholders to define a common research agenda which should mobilise a critical mass of public and private resources. This approach has been adopted in areas such as the hydrogen economy, with the creation of the European Hydrogen and Fuel Cell Technology Platform.

Often it will be possible to implement the research agenda by means of Integrated Projects. In a limited number of cases, a 'pan-European' approach appears appropriate, involving the implementation of large-scale 'joint technology initiatives'. An appropriate framework for their implementation is that of structures based on Article 171 of the Treaty[3], including possible joint undertakings.

Objective 3. Stimulating the creativity of basic research through competition between teams at European level

Open competition between individual research teams and support for them at European level would boost the dynamism, creativity and excellence of European research whilst increasing its visibility.

The Commission suggests the creation of a support mechanism (e.g. a European Research Council) for research projects conducted by individual teams which are in competition with each other at European level.

Objective 4. Making Europe more attractive to the best researchers

The European Union's objective is to promote the development of European scientific careers[4] while, at the same time, helping to make sure that researchers stay in Europe and attracting the best researchers to Europe. Against the background of growing competition at world level, it is necessary to strengthen the 'Marie Curie' actions which are being conducted for this purpose.

Objective 5. Developing research infrastructure of European interest

With the creation of the ESFRI Forum , an important step has been taken in the field of research infrastructures in Europe. It is proposed to strengthen this action through the introduction of support for the construction and operation of new research infrastructures of European interest.

Objective 6. Improving the coordination of national research programmes

Efforts have successfully been made to improve the coordination of national research programmes in the context of FP6 – such efforts must be strengthened. This involves increasing the resources allocated to ERA-NET activities for the networking of national programmes, extending the financial support they offer to research activities, and an increased effort towards the mutual opening-up of programmes.

1 "Building our common future – Policy changes and budgetary means of the enlarged Union 2007-2013", COM (2004) 101 of 10.2.2004
2 "The Community may set up joint undertakings or any other structure necessary for the efficient execution of Community research, technological development and demonstration programmes."
3 As indicated in the Commission's Communication "Researchers in the European Research Area, one profession, multiple careers", COM (2003) of 18.07.2003.

FP6 Project Descriptions

H_2 production

H_2 storage

H_2 safety, regulations, codes & standards

H_2 pathways

H_2 end use

High Temperature Fuel Cells

Solid Polymer Fuel Cells

General

Portable application

- Sustainable Energy Systems (SES)
- Sustainable Surface Transport (SST)
- New and Emerging Science and Technology (NEST)
- Collective Research and Co-operative Research (SME)
- Networking of national or regional programmes (ERA-NET)
- Scientific Support to Policies (SSP)

Clean Hydrogen-rich Synthesis Gas (CHRISGAS)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2004-502587

Instrument: IP

List of participants:
- Växjo University (SE)
- TPS Termiska Processer (SE)
- Kungl Tekniska Högskolan (SE)
- Pall Schumacher (DE)
- Forschungszentrum Jülich (DE)
- TK Energi (DK)
- Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (ES)
- TU Delft (NL)
- Valutec (FI)
- Växjö Värnamo Biomass Gasification Centre (SE)
- Università di Bologna (IT)
- Catator (SE)
- S.E.P. Scandinavian Energy Project (SE)
- KS Ducente (SE)
- Linde - Linde Engineering Division (DE)
- Växjö Energi AB (SE)
- Helector S.A. - Energy and Environmental Applications (EL)

Projected total cost: €15.6 million

Maximum EC contribution: €9.5 million

Coordinator contact details:
Sune Bengtsson
E-mail: Sune.bengtsson@power.alstom.com

EC Scientific Officer:
Komninos Diamantaras
E-mail: komninos.diamantaras@cec.eu.int

Abstract

The CHRISGAS project will develop and optimise an energy-efficient and cost-efficient method to produce hydrogen-rich gases from biomass. This gas can then be upgraded to commercial quality hydrogen or to synthesis gas for further upgrading to liquid fuels such as DME (di-methyl ether) and methanol or Fischer-Tropsch diesel.

The hub of this project is the Växjö Värnamo Biomass Gasification Centre (VVBGC) in Sweden and the use of the biomass-fuelled pressurised IGCC (integrated gasification combined-cycle) CHP (combined heat and power) plant in Värnamo as a pilot facility. By building VVBGC around this plant, gasification research and demonstration activities can be conducted at a much lower cost than if a new R&D facility was to be built.

The primary objective of this project is to demonstrate within a five-year period and at a scale of 18 MW thermal the manufacture of a clean hydrogen-rich gas (being the intermediate product for the manufacture of vehicle fuel from a renewable feedstock) based on gasification of biomass, followed by gas upgrading by hot gas cleaning to remove particulates, and steam reforming of tar and light hydrocarbons to enhance the hydrogen yield. The project consists of research and development activities, research-related networking activities, training activities and dissemination activities as well as socio-economic research on the non-technical obstacles for penetration into the markets of the technologies concerned.

Plans for the reconstruction of the Värnamo pilot plant, in terms of the technical details, budget, etc., will be made in the first 18 months of the project and will be based partially on support from some parts of the supporting R&D programme. **Following this, plant construction will begin and when the plant is ready for operation in 2008, pilot plant test work will commence.**

The results expected from the project represent a panoply of knowledge and experiences required to engage in the next, very challenging, stage of the development – i.e. to demonstrate production of the motor fuel, first in the Värnamo pilot plant, and then later at commercial scale at competitive costs throughout Europe. The know-how resulting from this project will be representative of a variety of European conditions and will support any plans for large-scale implementation. The results of the CHRISGAS project will be beneficial to the production of synthesis gas from biomass, and also for the production of renewable electricity by IGCC systems where pressurised gasification is often used to generate a low calorific value gas for use in gas turbines, and which utilises similar equipment and processes. Such technology also has relevance for clean coal technologies which use gasification.

Linking molecular genetics and bio-mimetic chemistry to achieve renewable hydrogen production (SOLAR-H)

Programme: New and Emerging Science and Technology (NEST)

Contract number: Under negotiation

EC Scientific Officer:
Dr Gianpietro Van de Goor
E-mail: rtd-nest@cec.eu.int

Abstract:

SOLAR-H brings together a multidisciplinary team of world-leading laboratories to carry out integrated, basic research with the common goal of hydrogen production from renewable resources – our expertise ranges from genetics and molecular biology via biophysics to organo-metallic and physical chemistry. The vision is to develop novel, as yet unproven or even non-existing routes for H_2 production from solar energy and water. In a unique effort, this project integrates, for the first time, two frontline topics – artificial photosynthesis in man-made chemical systems, and photo-biological H_2 production using living organisms. Hydrogen production by these methods is still a long way off, but it has a vast potential and is of utmost importance for the energy-dependent European economy. Clearly, the scientific risk is high – the research is very demanding. Consequently, the objective now is to explore, integrate and carry out the basic science necessary to develop the novel routes. Following one track, the knowledge gained from biophysical studies will be exploited by organo-metallic chemists attempting to synthetise bio-mimetic compounds. The design of these is based on molecular knowledge about (and inspiration from) natural photosynthesis and hydrogenases (the enzymes that form H_2). The second track, photobiological hydrogen production, is interrelated. Here we will perform molecular research at the genetic level to increase our understanding of critical steps in nature's photosynthetic algae and cynaobacteria. Knowledge about these steps, and the enzymes involved, is crucial for synthetic chemists. However, these studies are also aimed at direct improvement of the H_2-forming capability of organisms, using genetic and metabolic engineering. The project intends to link fragmented European research and to provide the critical mass of expertise to challenge and perform ahead of the US in this area, which has salient implications for the coming so-called 'Hydrogen Society'.

Solar Steam Reforming of Methane Rich Gas for Synthesis Gas Production (SOLREF)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2004-502829

Instrument: STREP

List of participants:
- DLR-Deutsches Zentrum für Luft- und Raumfahrt e.V. (DE)
- Centre for Research and Technology - Hellas, Chemical Process Engineering Research Institute (EL)
- Weizmann Institute of Science (IL)
- ETH-Swiss Federal Institute of Technology (CH)
- Johnson Matthey Fuel Cell Ltd (UK)
- Hexion B.V. (NL)
- E.S.CO.Solar S.p.A. (IT)
- Region Basilicata (IT)

Projected total cost: €3.45 million

Maximum EC contribution: €2.1 million

Coordinator contact details:
Dr sc. tech. Stephan Möller
Project Manager
Pfaffenwaldring 38-40
70569 Stuttgart
Germany
Telephone: +49 711 6862 640
Telefax: +49 711 6862 747
E-mail: stephan.moeller@dlr.de
Internet: http://www.dlr.de/Stuttgart

EC Scientific Officer:
Philippe Schild
E-mail: Philippe.Schild@cec.eu.int

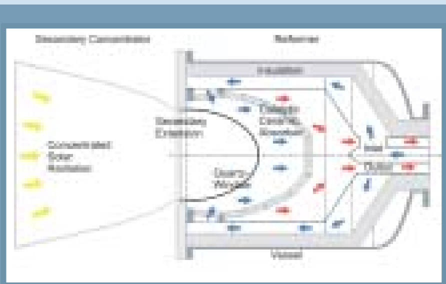


Diagram of the state-of-the-art reformer.

Project main goal

The main purpose of this project is to develop an innovative 400 kWth solar reformer for several applications such as hydrogen production or electricity generation. Depending on the feed source for the reforming process, CO_2 emissions can be reduced significantly (up to 40% using NG), because the process heat required for this highly endothermic reaction is provided by concentrated solar energy. A pre-design of a 1 MW prototype plant in Southern Italy, and a conceptual layout of a commercial 50 MW_{th} reforming plant complete this project.

Key issues

The profitability decides if a new technology has a chance to come on to the market. Therefore, several modifications and improvements to the state-of-the-art solar reformer technology (see diagram and picture) will be introduced before a large-scale and commercial system can be developed. These changes are primarily to the catalytic system, the reactor optimisation and operation procedures, and the associated optics for concentrating the solar radiation.

Technical approach

The work proposed in SOLREF is based upon the activities performed in the previous project SOLASYS, where the technical feasibility of solar reforming has been proven. Since the main partners (Deutsches Zentrum für Luft- und Raumfahrt e.V. and The Weizmann Institute of Science) involved in the SOLASYS project will also participate in SOLREF, the experience and know-how acquired in SOLASYS will be efficiently applied in SOLREF, thus making a significant step towards the integration of this new technology. With the catalysis group headed by the industrial partner Johnson Matthey FC Ltd, it is possible to investigate in the wide spectrum of catalysis and coating leading to the development of the best catalytically-active absorber capable of solar reforming various feedstocks. The involvement of Italian participants and the opportunities opened up in the south of Italy for renewable energy provide an excellent chance to realise the first solar reforming prototype plant on completion of the SOLREF project.

As regards the **advanced catalytically-active absorber**, various catalyst systems will be investigated. The ceramic absorber will be prepared by different methods. The best catalytically-active absorber will be determined by means of a competition. Alongside the manufacturing steps, a model will be developed to simulate the transport and reaction in the porous absorber, thereby determining the steam-reforming kinetics. The simulation will help to maximise the effective use of the catalytic coatings in the absorber system. The catalytically-active absorber should show the following properties: 1) High catalytic activity with high resistance to coking; 2) Good absorption for thermal radiation; 3) Acceptable mechanical strength and thermal shock resistance; 4) High gas permeability together with high turbulence and mixing of the gases, as well as low pressure drop; and 5) Low costs.

A new, more compact **solar reformer** will be designed and manufactured with a new flange containing less material, an advanced insulation configuration with steam protection, and an improved ceramic absorber. The nitrogen purge, which was used in the SOLASYS project, will be replaced. A thermodynamic and thermochemical analyses will be performed to support the system design phase – led by ETH. The SME Hexion B.V. will provide the detailed design based on the layout from DLR, and will manufacture the solar reformer.

The existing **solar test facility** will be modified to include a new purge gas preparation system and a gas mixing system that enables the operation of the solar reformer with gas mixtures representative of a variety of possible feedstocks. The modification of the plant will enable the operation of the new innovative solar reformer with different feedstocks. The new operation strategies will be evaluated. The results of the testing campaign will provide input to the pre-design of the prototype plant in WP 4. The test data will be evaluated and compared with simulation tools in order to verify the calculations and to identify potential problems.

In the pre-design phase, the technical specifications of a **1 MW_{th} prototype reforming plant** will be determined for a Mediterranean site, e.g. in southern Italy in the Region Basilicata. The major components of a solar reforming plant will be analysed to assess their impact on the conceptual layout of the plant. For the upstream part of the reforming loop, the operation with different gaseous feedstocks (natural gas, weak gas, bio-gas, landfill gas), and concepts for gas cleaning and gas treatment will all be assessed. The solar reformer can be located either on the top of a tower or on the ground using a beam-down installation. These two concepts will be compared with a view to identifying the optimal solar optical configuration.

Special emphasis will be given to analysing strategies and concepts for CO_2 separation and sequestration, as well as for CO_2 reforming. The technical and economical feasibility of these options will be assessed. Their implementation in the solar reforming process will be examined. Based on a market analysis, a preliminary model for the cost evaluation of the main plant components will be provided. This model will be used in the further system evaluation.

The regions targeted for the dissemination of solar reforming technology are in Southern Europe and Northern Africa. The **potential markets** and the impact of infrastructure and administrative restrictions will be assessed. The **environmental, socio-economic and institutional impacts** of solar reforming technology exploitation will be assessed with respect to sustainable development. The market potential of solar reforming technology in a liberalised European energy market will be evaluated. Detailed cost estimates for a 50 MW_{th} commercial plant will be determined.

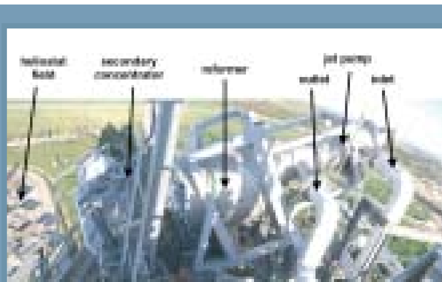
Expected achievements/impact

The SOLREF project is aimed at developing the second generation of the SOLASYS reformer. This second-generation reformer will make an attempt to solve the problems encountered during the previous SOLASYS project and will provide the necessary modifications to advance the solar reformer to the pre-commercial phase. The strategic impact is threefold:

1. First and foremost, introducing solar energy into Europe's energy mix will have a positive ecological impact by reducing the need for fossil fuels and therefore by reducing CO_2 emissions. The solar reformer can also operate with biogas and landfill gas as a feed gas, thus zero net CO_2 emissions can be achieved.

2. The technological and economical impact of the solar reforming technology arises from the combination of optical, chemical, thermal and solar concentrating technologies. The market potential could generate an important production of new plants and new components. Solar reforming has the potential to become a more cost-effective way to drive solar concentration in large-scale power production, because of its efficient integration in hybrid power plants. For a 50 MW_{th} reforming plant, the cost of hydrogen is estimated to be around €0.05kWh (€0.04/kWh conventional). Moreover, the SOLREF concept could offer an alternative for storage in concentrating solar thermal systems. In addition to the high conversion efficiency of the 'solar-upgraded' fuel in turbine cycles, synthesis gas can also be stored at ambient temperature, e.g. in the pipeline system. Southern European countries, like Italy, can implement the SOLREF technology, but the concept can also be a basis for technology export to other regions of the world such as Australia, the Middle East, etc.

3. Further economical and other benefits are: a) the environmental and the associated health aspect (less pollution); b) the energy supply aspect such as reducing the dependence on imported fossil fuels and increasing the security of supply; c) the development of new industrial enterprises and creating new jobs; and d) regional development in Southern European countries.



The state-of-the-art reformer on the WIS Solar Tower in Israel.

HYdrogen THErmochemical Cycles (HYTHEC)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2004-502704

Instrument: STREP

List of participants:
- Commissariat à l'Energie Atomique (FR)
- University of Sheffield (UK)
- Università degli studi – Roma tre (IT)
- Deutsches Zentrum für Luft und Raumfahrt (DE)
- Empresarios Agrupados (ES)
- Société PROSIM (FR)

Projected total cost: €2.9 million

Maximum EC contribution: €1.9 million

Coordinator contact details:
Alain Le Duigou
DEN/DPC/SCP/LM2T - CEN Saclay
91191 Gif sur Yvette Cedex
France
Telephone: +33 01 6908 3136
Telefax: +33 01 6908 9221
E-mail: aleduigou@cea.fr

EC Scientific Officer:
Joaquin Martin Bermejo
E-mail: Joaquin.Martin-Bermejo@cec.eu.int

Project main goals

With regard to a promising medium- and long-term CO_2-free route to produce hydrogen, only two processes are capable of using water as a raw material: electrolysis and thermochemical cycles. The thermochemical cycles are processes whereby water is decomposed into hydrogen and oxygen via chemical reactions using intermediate elements which are recycled. These cycles can potentially offer better efficiency than electrolysis and hence have the potential to reduce significantly the cost of hydrogen production from water. The required energy can be either provided by nuclear energy or by solar energy. Beyond that, hybrid solutions, including solar and nuclear energy input, are both conceivable and desirable, if the production requires a continuous supply of heat.

The objective of HYTHEC is to investigate the effective potential for massive hydrogen production of the S_I thermochemical cycle, described below, and to compare it with the hybrid S cycle, also called Westinghouse cycle, which have an H_2SO_4 decomposition reaction in common. It is not a self-sufficient programme but completes the work currently being undertaken in France, USA and Japan. It consists in the study of:

- specific aspects of the S_I cycle: overall design and cost evaluation (flow-sheet); vapour liquid equilibrium study and membrane distillation of the 'HIx system'; study of the sulphuric acid decomposition

- global evaluation of the Westinghouse cycle.

Key issues

1. Assessment and improvement of the S_I thermo-chemical cycle, including technical and industrial viability:

   - Flow-sheet evaluations;
   - $HI/I_2/H_2O$ system (H_2 production section of the cycle): improvement of the vapour liquid equilibrium model; relevance of membrane separation techniques
   - General feasibility of solar thermal splitting of sulphuric acid for the H_2SO_4 decomposition section of the cycle
   - Feasibility of coupling to a nuclear reactor; safety assessments
   - Feasibility of the main components at industrial scale; and H_2 production costs.

2. Assessment of the Westinghouse thermochemical cycle, for a solar- and/or nuclear-driven process (in comparison with the S_I cycle): safety assessments, feasibility of the main components at industrial scale, and H_2 production costs.

Technical approach

The work has been broken down into seven sub-projects, as described below:

SP1 Project management: organisation of the work (management committees, progress reviews and communications), relations with the European Community, encouragement to the maximum degree of collaboration with world-class teams outside Europe, progress reports and regular progress meetings. Responsibilities are clearly delegated through the Consortium Agreement.

SP2 Optimisation of the entire sulfur-iodine cycle (S_I): flow-sheets will be issued by the CEA at various times during the project, to be distributed to EA and DIMI as a basis for discussion about the industrial scale-up activities (coupling to reactor, component sizing and cost analysis). A final flow-sheet will take into account all the improvements found during the project.

SP3 Vapour liquid equilibrium analysis: it is essential to improve the vapour liquid equilibrium model of the $HI/I_2/H_2O$ system to better estimate the production rate of hydrogen; thus, partial pressure measurements of these gases are required, and we need to identify mass or optical spectrometry methods, such as IR and UV-visible, and to define the apparatus related to those measurements.

SP4 Review of membrane separation techniques: this sub-project will conduct exploratory research into alternative, low-energy separation techniques relevant to the S_I process. Particular attention will be paid to HI_x separation steps. The latter problem

is exacerbated by the azeotrope which exists more or less at the exit conditions from the Bunsen reactor. Even a modest concentration of the HI above the azeotropic point would have a major impact on the heat burden of the resulting distillation and hence the overall economics of the process.

Membrane distillation (MD) will be assessed as a technique to concentrate the HI solution. MD has already been used to separate azeotropes successfully and, working for the first time with the water-iodine-hydrogen iodide azeotrope, we will experiment with configuring it to transport HI through the membrane preferentially retaining the iodine on the feed side.

SP5 Experimental study of membrane distillation of HIx: experiments will be conducted at a laboratory scale in simple cell geometry. The separation performances of the selected membranes will be determined as a function of the extract flow, feed rate and temperature. Partial pressures in the vapour will be measured by optical means (measurements similar to those of SP3).

SP6 Sulphuric acid decomposition: a test reactor will be developed in a solar furnace located in Cologne (up to 25 kW), which allows the direct absorption of concentrated sunlight by the sulphuric acid (T up to 1 100-1 200°C), to be decomposed to sulphur dioxide, oxygen, and steam. Indirect heating in a tube-type reactor using a catalyst will also be performed, applying the VHTR nuclear reactor temperature (850-900°C). The process will be investigated as regards choice of catalyst, corrosion in the boiling region, and decomposition rate. The experimental feasibility studies will be accompanied by process simulations and assessment of the feasibility of scale-up at a commercial scale (including safety and cost evaluations).

SP7 Assessment of the Westinghouse cycle (WH): the results of SP6 may serve as input for a solar operation of WH. The technical feasibility of a solar operation of the WH process will be compared to the iodine-sulphur process. Operation and plant concepts will be created including the solar and nuclear supply of heat for the thermochemical step and of nuclear power for the electrolysis step. Moreover, the cycle safety aspects during normal and transient operation will be studied using this model. The plant concepts will be analysed regarding their economic potential compared to the sulphur-iodine process.

The main technical roles of the partners are as follows:

- CEA: coordination (SP1), S_I and WH reference flow-sheets (SP2, SP7), vapour liquid equilibrium experiments of the HIx system (SP3)
- USFD: review of membrane separation techniques (SP4), MD of HIx (SP5)
- DIMI: components sizing and cost evaluations of S_I (SP2) and solar H_2SO_4 decomposition (SP6), modelling of H_2SO_4 decomposition (SP6)
- DLR: H_2SO_4 decomposition in a solar furnace (SP6), WH assessments (SP7)
- EA: coupling to reactor and safety evaluations of S_I and WH, and solar H_2SO_4 decomposition (SP2, SP7 and SP6), industrial scale-up and costs evaluations of WH (SP7), process modelling of solar H_2SO_4 decomposition and WH (SP6 and SP7), thermo-structural analysis of the solar test reactor (SP6)
- PROSIM: implementations of the S_I models in the code (SP2, SP3).

Expected impact

As regards massive innovative medium- and long-term H_2 production routes, and particularly two major thermochemical cycles, S_I and WH, this STREP will have an impact on:

- the feasibility of those cycles: HIx system knowledge and H_2 production improvement for S_I, and H_2SO_4 direct decomposition for both cycles
- the industrial and economic viability, including the safety aspects.

Highly Efficient, High Temperature, Hydrogen Production by Water Electrolysis (Hi2H2)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2004-503765

Instrument: STREP

List of participants:
- European Institute for Energy Research (DE)
- Risø National Laboratory (DK)
- Swiss Federal Laboratories for Materials Testing and Research (CH)
- German Aerospace Centre (DE)

Projected total cost: €1.77 million

Maximum EC contribution: €1.1 million

Coordinator contact details:
Dr Philippe Stevens
Telephone: +49 721 6105 1315
Telefax: +49 721 6105 1332
E-mail: Philippe.stevens@edf.fr
Project website: http://www.hi2h2.com

EC Scientific Officer:
Joaquin Martin Bermejo
E-mail: Joaquin.Martin-Bermejo@cec.eu.int

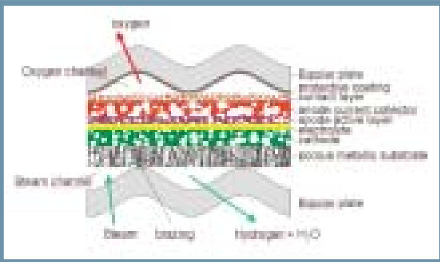
Project main goal(s)

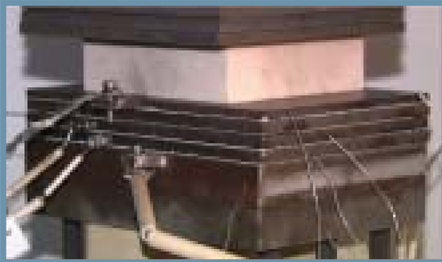
The objective of the proposed project is to investigate and evaluate the feasibility of a planar Solid Oxide Electrochemical Converter (SOEC) based on materials, cell components and fabrication processes of advanced thin-film SOFC technology, and to determine the limitations of the cell materials for SOEC operation at operating temperatures between 700 and 900°C.

The development of ceria electrodes for solid oxide electrolyte cells (at Risoe) indicates comparable electrode performance in the fuel cell and electrolyser operation mode from polarisation characteristics up to 150 mV over potential in each direction (even at lower water contents (3%) than applied in SOEC cells).

Preliminary experiments performed at Risoe have shown that their planar solid oxide fuel cells (SOFC) are reversible, and that the area specific resistance (ASR) near the open circuit voltage (OCV) is the same in both modes. An ASR of 0.2 ohm*cm^2 at 950°C has been obtained. The ASR (corrected for changes in reactant and product concentrations) is relatively constant and does not vary much with current density, in contrast to low temperature electrolysers. This is about four to five times lower than the ASRs of the SOEC investigated in the Hot Elly project. This means that, everything else being equal, the stack investment cost (per m^3 H_2) could be about four times lower.

Two types of manufacturing methods will be used to make planar SOEC cells and stack elements with a size of 5x5 cm^2: (1) advanced plasma spray techniques with DC plasma generation at DLR, and (2) wet ceramic processes at Risoe. The cells and stack elements will be analysed by structural and electrochemical characterisation methods. Special emphasis will be given to corrosion tests of the materials and cells and on long-term tests in the 2 000 hours range in order to obtain the limitations and the applicability of the materials and components for high-temperature solid oxide water electrolysers.





Key issues

Inefficient conversion technologies, as well as improper energy storage systems, are major barriers for the wider application of renewable energy such as wind, photovoltaics and hydropower. Solid Oxide Fuel Cells (SOFC) used in electrolysis mode, called Solid Oxide Electrolyser Cells (SOEC), have the potential to become an efficient and cost-effective way to solve the conversion problem. Because the water-splitting process is endothermic, the electricity needed for electrolysis can be significantly reduced, if the formation of hydrogen takes place at high temperatures (800-1 000°C). The electric energy need is reduced because the unavoidable joule heat of an electrolysis cell is utilised in the water- (steam) splitting process at high temperature. If heat is available from sources such as geothermal (e.g. in Iceland), solar or nuclear in origin, this will further reduce the electrical energy necessary to produce a cubic metre of hydrogen. All heat sources with temperatures above 100°C (the boiling point of water) are beneficial as electric energy for steam raising will be saved and the heat dissipation from the high-temperature electrolyser will be minimised according to the temperature of the surrounding gas – the higher the temperature the greater the dissipation. The consumption of electricity may be reduced further if steam is available at a temperature higher than the operation temperature of the electrolyser. Also, the energy losses due to the sluggishness of the electrochemical reactions are, in principle, lower, the higher the temperature is. To a large degree, this principle seems to be realised in practice through significant improvements in the SOFC technology as the result of extensive international development efforts, which can also be applied to SOEC.

Technical approach

Two types of manufacturing methods will be used to make planar SOEC cells and stack elements with a size of 5x5 cm^2: (1) advanced plasma spray techniques with DC plasma generation at DLR, and (2) wet ceramic processes at Risoe. The cells and stack elements will be analysed by structural and electrochemical characterisation methods. Special emphasis will be given to corrosion tests of the materials and cells and on long-term tests in the 2 000 hours range in order to obtain the limitations and the applicability of the materials and components for high-temperature solid oxide water electrolysers.

Expected achievements/impact

The high efficiencies obtained by this breakthrough technology make the conversion of renewable energy to hydrogen fuel possible in a very clean way and with minimal losses, in situations where it would be 'wasted' if produced by traditional water electrolysis. In so doing, the technology helps to solve some important future socio-economic problems linked to our dependence on imported petrol, the emission of NO_x/SO_x/particles by cars in urban areas, and the production of greenhouse gases.

The potentially very high performance of the SOEC, clearly above any competitive technology, would also give Europe an important scientific, technological and competitive lead.

Hydrogen storage systems for automotive application (StorHy)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2004-502667

Instrument: IP

List of participants:
- Magna Steyr Fahrzeugtechnik AG & Co KG (AT)
- Institut für Verbundwerkstoffe GmbH (DE)
- Institute for Energy Technology (NO)
- Daimler Chrysler AG (DE)
- Commissariat à l'énergie atomique (FR)
- Air Liquide (FR)
- Bundesanstalt für Materialforschung und -prüfung (DE)
- BMW Forschung und Technik GmbH (DE)
- Contraves Space AG (CH)
- Forschungszentrum Karlsruhe GmbH (DE)
- Comat Composite Materials GmbH (DE)
- Faber Industrie Spa (IT)
- Wroclaw University of Technology (PL)
- WEH GmbH (DE)
- Ford Forschungszentrum Aachen GmbH (DE)
- Volvo Technology Corporation (SE)
- Dynetek Europe GmbH (DE)
- University of Nottingham (UK)
- MAN Technologie AG (DE)
- European Commission – Joint Research Centre (NL)
- GKSS Forschungszentrum Geesthacht GmbH (DE)
- National Centre for Scientific Research Demokritos (EL)
- ADETE - Advanced Engineering & Technologies GmbH (DE)
- Pierburg GmbH (DE)
- Peugeot Citroën Automobiles (FR)
- Messer Griesheim GmbH (DE)
- Austrian Aerospace GmbH (AT)
- Linde Aktiengesellschaft (DE)
- Oeko-Institut e.V. (DE)
- Centre National de Recherche Scientifique (FR)
- Fundación para la investigación y desarrollo en Automoción CIDAUT (ES)
- ET- EnergieTechnologie Gesellschaft für innovative Energie und Wasserstofftechnologie mbH (DE)
- Instituto nacional de téchnica aeroespacial Inta (ES)
- Material SA (BE)
- Institute for Protection Systems - Prochain e.V. (DE)

Projected total cost: €18.7 million

EC maximum contribution: €10.7 million

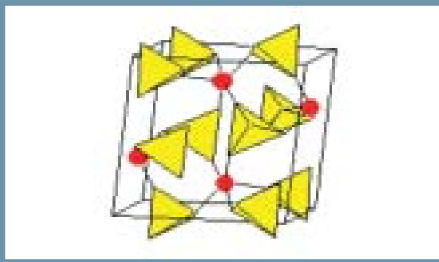
Coordinator contact details:
Dr Volker Strubel
Magna Steyr Fahrzeugtechnik AG & Co KG
Telephone: +49 761 7057 575
E-mail: volker.strubel@magnasteyr.com
Project website: www.storhy.net

EC Scientific Officer:
Joaquin Martin Bermejo
E-mail: Joaquin.Martin-Bermejo@cec.eu.int

STORHY

Pressure Vessel Source: Dynetek

Cryogenic Storage Source: BMW Group



Solid Storage Source: IFE

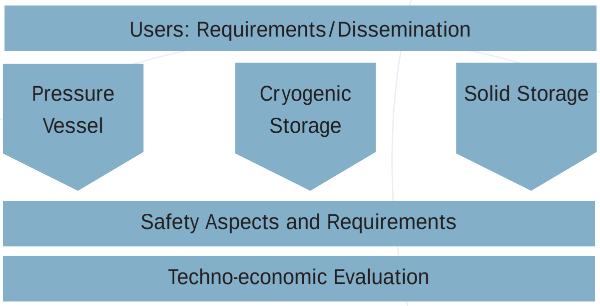
Project main goals

Hydrogen storage is a key enabling technology for the extensive use of H_2 as an energy carrier. None of the current technologies satisfies all of the hydrogen storage attributes sought by manufacturers and end-users. Therefore, the Integrated Project StorHy aims to develop robust, safe and efficient on-board vehicle hydrogen storage systems suitable for use in hydrogen-fuelled fuel cell or internal combustion engine vehicles. Concrete R&D work covering the whole spectrum of hydrogen storage technologies (compressed gas, cryogenic liquid and solid materials) will be carried out with a focus on automotive applications. The aim is to develop economically and environmentally attractive solutions for all three storage options. These systems will be producible at industrial scale and will meet commercially viable goals for cost, energy density and durability. In addition, achieving sufficient hydrogen storage capacity for adequate vehicle range is a major technology goal.

Technical approach

The overall approach of StorHy mainly involves two different types of activities. The vertical type includes the three technical sub-projects (denoted SPs), namely SP Pressure Vessel, SP Cryogenic Storage and SP Solid Storage. These sub-projects concentrate on addressing the technological development of innovative H_2 storage solutions. The horizontal activities include the SP Users, SP Safety Aspects & Requirements (SAR) and SP Evaluation. In these sub-projects, cross-cutting issues are addressed in order to link the vertical activities.

Structure of the STORHY project



In the vertical SPs, viable solutions will be developed based on the defined requirements:

SP Pressure Vessel is concentrating on developing a 700-bar storage technology including production technologies for composite vessels.

SP Cryogenic Storage will develop free form lightweight liquid hydrogen tanks manufactured, for example, from composites, as well as adequate production technologies (higher requirements and cost-efficiency aspects).

SP Solid Storage assesses current progress in the storage of solid materials and will focus its primary research activities on alanates. Furthermore, upscaling of the material production process will be considered resulting in the construction and testing of prototype tanks.

These developments will be accompanied by safety studies and pre-normative research within **SP SAR**.

The three storage technologies will be evaluated applying technical, economic, social and environmental criteria in **SP Evaluation**.

SP Users (representing the major European car manufacturers) will contribute in steering the different S&T approaches according to the needs and requirements for vehicle applications, and will ensure effective dissemination, exploitation and training activities within the project.

Expected achievements/impacts

The final outcome of the project will be to identify the most promising storage solution for different vehicle applications. Such results should illuminate the future perspectives of hydrogen storage for transport and stationary applications and assist decision-makers and stakeholders on the road to the hydrogen economy.

Safety of hydrogen as an energy carrier (HySafe)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2004-502630

Instrument: NoE

List of participants:

- Forschungszentrum Karlsruhe GmbH (DE)
- L'Air Liquide (FR)
- Federal Institute for Materials Research and Testing (DE)
- BMW Forschung und Technik GmbH (DE)
- Building Research Establishment Ltd (UK)
- Commissariat à l'Energie Atomique (FR)
- Det Norske Veritas AS (NO)
- Fraunhofer-Gesellschaft ICT (DE)
- Forschungszentrum Juelich GmbH (DE)
- GexCon AS (NO)
- The United Kingdom's Health and Safety Laboratory (UK)
- Foundation INASMET (ES)
- Inst. Nat. de l'Environnement industriel et des RISques (FR)
- Instituto Superior Technico (PT)
- European Commission - JRC - Institute for Energy (NL)
- National Centre for Scientific Research Demokritos (EL)
- Norsk Hydro ASA (NO)
- Risø National Laboratory (DK)
- TNO (NL)
- University of Calgary (CA)
- University of Pisa (IT)
- Universidad Politécnica de Madrid (ES)
- University of Ulster (UK)
- VOLVO Technology Corporation (SE)
- Warsaw University of Technology (PL)

Projected total cost: €13 million

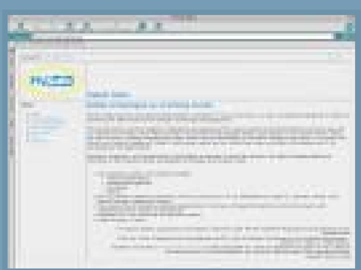
EC maximum contribution: €7 million

Coordinator contact details:

Dr-Ing. Thomas Jordan
Institute for Nuclear and Energy Technologies IKET
Forschungszentrum Karlsruhe
Hermann-von-Helmholtz-Platz 1
D-76344 Eggenstein-Leopoldshafen
Germany
Telephone: +49 7247 82 6105
Telefax: +49 7247 82 4777
E-mail: jordan@iket.fzk.de
Network website: www.hysafe.net

EC Scientific Officer:

Joaquin Martin Bermejo
E-mail: Joaquin.Martin-Bermejo@cec.eu.int



www.hysafe.net

Project main goal(s)

The overall goal of HySafe is to contribute to the safe transition to a more sustainable development in Europe by facilitating the safe introduction of hydrogen technologies and applications.

The objectives of the network include:

- To contribute to common understanding and approaches for addressing hydrogen safety issues
- To integrate experience and knowledge on hydrogen safety in Europe
- To integrate and harmonise the fragmented research base
- To provide contributions to EU safety requirements, standards and codes of practice
- To contribute to an improved technical culture on handling hydrogen as an energy carrier
- To promote public acceptance of hydrogen technologies.

Key issues

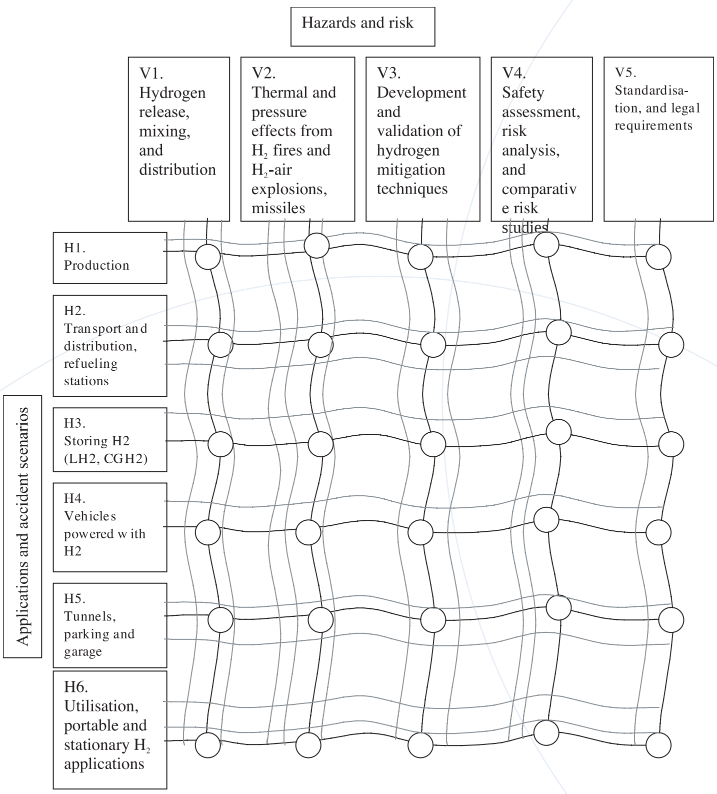
The HySafe network will focus on safety issues relevant to improving and coordinating the knowledge and understanding of hydrogen safety and to supporting the safe and efficient introduction and commercialisation of hydrogen as an energy carrier of the future, including the related hydrogen applications.

Technical approach

- Developing, harmonising and validating methodologies for safety assessments
- Undertaking safety and risk studies
- Establishment of a hydrogen incident and accident database
- Creation of a set of specialised research facilities
- Identification of a set of specialised complementary codes and models that can be used for safety studies
- Promoting fundamental research necessary to address hydrogen safety issues
- Extracting net outcomes from safety and risk assessment studies as input to EU-legal requirements, standards and codes of practice
- Organising training and educational programmes on hydrogen safety, including on-line mode (e-Academy)
- Disseminating the results through a 'HySafe' website, a Biennial Report on Hydrogen Safety, and a Biennial International Symposium on Hydrogen Safety.

Expected achievements/impact

- An integrated research base
- Progress in common understanding of hydrogen safety and risk
- Harmonised tools for safety and risk assessment
- Input to standards where the goal is to establish safe, robust and reliable solutions for hydrogen applications
- A framework for training and education
- A roadmap for future progress.



Matrix of applications and safety issues

Harmonisation of standards and regulations for a sustainable hydrogen and fuel cell technology (HarmonHy)

Programme: Sustainable Energy Systems

Contract number: Under negotiation

Instrument: SSA

List of participants:
- Vrije Universiteit Brussel (BE)
- Bayerische Motoren Werke Aktiengesellschaft (DE)
- Centro Ricerche Fiat (IT)
- Ente per le Nuove Tecnologie, l'Energia el'Ambiente (IT)
- European Natural Gas Vehicles Association (NL)
- Joint Research Centre of the EC (NL)
- L-B-Systemtechnik GmbH (DE)
- Norsk Hydro (NO)
- Stuart Energy Europe N.V (BE)
- European Association for Battery, Hybrid and Fuel Cell Electric Vehicles (BE)
- Volvo Technology Corporation (SE)

Projected total cost: €0.52 million

Maximum EC contribution: €0.5 million

Coordinator contact details:
AVERE
European Association for Battery, Hybrid and Fuel Cell Electric Vehicles
c/o VUB-TW-ETEC
Bd. de la Plaine, 2
BE 1050 Brussels
E-mail: avere@vub.ac.be
Telephone: +32 2 629 2363
Telefax: +32 2 629 3620
http://www.avere.org

EC Scientific Officer:
William Borthwick
E-mail: William.Borthwick@cec.eu.int

Project main goal(s)

HarmonHy is a 12-month project that aims primarily to make an assessment of the activities on hydrogen and fuel cell related regulations and standards on a worldwide level. On this basis, gaps will be identified and suggestions will be made on how to solve fragmentation. Potential conflicts between codes, standards and regulations will also be investigated and propositions to solve the conflicts will be made.

Particular attention will be paid to identifying the needs for standards, as perceived by the industry, as well as action to ensure concordance between standards and regulations.

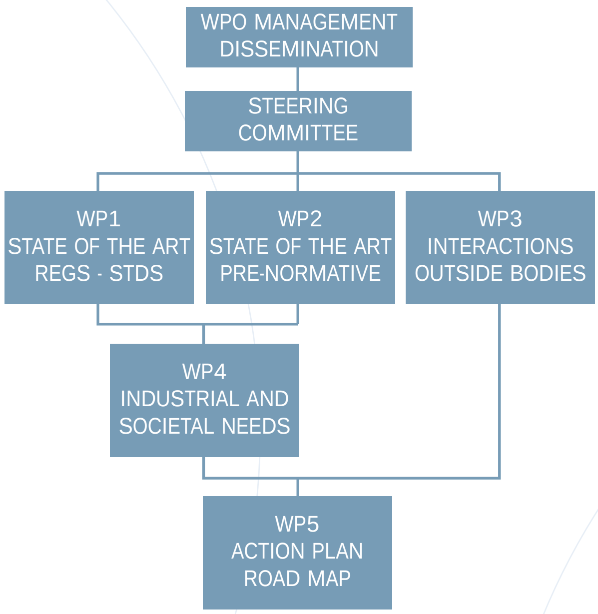
The final project goal at this stage will be to render European collaboration in the field as effective as possible and to increase its contribution at the worldwide level, making it more effective and homogeneous as well as able to correspond to its major interests.

At the second stage, the result of the discussions could also serve as a basis for further projects to be set up as response to the last call series of FP6.

As a conclusion to the different discussion meetings and hearings, the partners intend to organise a conference as a final point of the SSA with the aim of presenting the project results and guidelines for the setting up of adequate bodies to solve the problems identified.

Technical approach

In order to ensure the goals are achieved, the work will be structured in the following set of work packages:



WP0: management (AVERE/VUB)

0.1 Coordination
0.2 Dissemination

WP1: state of the art of codes and standards (VUB)

Organisation of joint meetings with CEN/CENELEC to map ongoing activities (worldwide) in the field of standards and regulations

1.1 For transport applications
1.2 For stationary
1.3 First analysis

WP2: state of the art of pre-normative research (ENEA)

Mapping of ongoing activities (worldwide) in the field of pre-normative research

2.1 For transport applications (Volvo BMW, CRF, ENEA, AVERE)
2.2 For stationary (STUART, ENGVA, NORSKHYDRO)
2.3 First analysis (ENEA)

WP3: interaction with outside bodies (JRC)

3.1 Interaction with ongoing projects at international level (Canada-Japan-USA) (ENEA, AVERE, JRC)
3.2 Interaction with regulation, international, national and regional harmonisation bodies (JRC, VOLVO, CRF, VUB,LBST)

WP4: analysis of industrial and societal needs (CRF)

4.1 Analysis of industrial needs (CRF, BMW, VOLVO, STUART, NORSKHYDRO, ENGVA)
4.2 Analysis of societal needs (VUB, AVERE, LBST)
4.3 Identification of gaps and possible conflicts (CRF, BMW, VOLVO)
4.4 Concordance between standards and regulations (CRF, ENEA, VUB)
4.5 Proposition to solve fragmentation and overlapping (CRF, ENEA, VUB)

WP5 action plan and road map (LBST)

5.1 Definition of action plan and road map (all participants)
5.2 Drafting of recommendations for advisory council (all participants)

Expected achievements/impact

HarmonHy will have a two-fold strategic impact on major policy initiatives put in place by the EC on such key technologies: the European Technology Platform on Fuel Cell and Hydrogen and the promotion of international co-operation. The SSA will rally key information and will propose strategic assessments, such as those related to regulations, standards and pre-normative research projects, aimed at supporting the activities of the European Advisory Council of the above-mentioned Platform and in favour of a work programme revision more focused on supporting research in the field.

The final objective of this SSA is to give support to the hydrogen and fuel cell technology development, through an indication of how to establish a rational and harmonised body of standards and regulations, to serve manufacturing industries, users and governmental and public authorities, for the design and the characterisation of the products in terms of safety, performance and use adequacy.

European Hydrogen Energy Roadmap (HyWays)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2004-502596

Instrument: IP

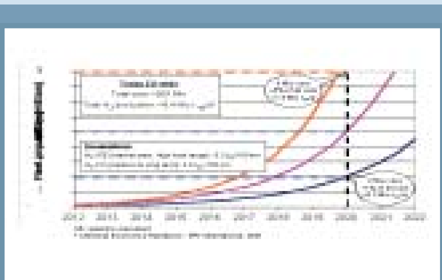
List of participants:
- L-B-Systemtechnik (DE)
- Air Liquide AL (FR)
- Air Products (UK)
- BMW AG (DE)
- BP plc. (UK)
- DaimlerChrysler (DE)
- Det Norske Veritas (NO)
- Electricité de France (FR)
- Energía Hidroeléctrica de Navarra, S.A. (ES)
- Nuovo Pignone SPA (IT)
- Hexion (NL)
- Infraserv Hoechst (DE)
- Linde AG (DE)
- Norsk Hydro (NO)
- Adam Opel AG (DE)
- Repsol YPF, S.A. (ES)
- Statkraft SF
- Total (FR)
- Vandenborre Technologies (BE)
- Vattenfall Europe (DE)
- Université Louis Pasteur (FR)
- French Atomic Energy Commission (FR)
- Energy Research Centre of the Netherlands (NL)
- Italian National Agency for New Technologies, Energy and Environment (IT)
- Fraunhofer Institute for Systems and Innovation Research (DE)
- Imperial College of Science, Technology and Medicine (UK)
- Instituto de Engenharia Mecânica (PT)
- Zentrum für Europäische Wirtschaftsforschung (DE)
- German Energy Agency (DE)
- Hellenic Institute of Transport (EL)
- Netherlands Organisation for Energy and the Environment (NL)
- Western Norway Research Institute (NO)

Projected total cost: €7.9 million

Maximum EC contribution: €4 million

Coordinator contact details:
Dr Reinhold Wurster
c/o L-B-Systemtechnik GmbH
85521 Ottobrunn, Germany
Telephone: +49 89 6081 1033
E-mail: coordinator@hyways.de
Project website: http://www.HyWays.de

EC Scientific Officer:
William Borthwick
E-mail: William.Borthwick@cec.eu.int



Penetration of hydrogen vehicles into the European market

Project main goal(s)

The final output of HyWays will be the development of an agreed set of overall policy guidelines and industrial targets reflecting consensus of the HyWays stakeholders. This will address:

- Greenhouse gas (GHG) emission reduction goals derived from the Kyoto Protocol and beyond
- Energy diversification in order to reduce dependency on finite energy sources which are increasingly becoming concentrated in a few politically sensitive world regions
- Anticipated market shares of FC/ICE hydrogen vehicles (off-road as well as on-road), marine applications and equipment, and the consequential impact on industrial competitiveness and employment

Key issues

HyWays will combine technology databases and socio- techno-economic analysis to evaluate selected stakeholder scenarios for future sustainable hydrogen energy systems. This will lead to recommendations for a European Hydrogen Energy Roadmap reflecting country-specific conditions in the participating Member States. The main characteristic of this Roadmap will be that it reflects real-life conditions by taking into account not only technological but also institutional, geographic and socio-economic barriers and opportunities relevant to the different Member States. Therefore, this Roadmap will be based on inputs from European industry, research institutes and government agencies, and backed up with the best available data. It will describe systematically scenarios for future steps to be taken for the large-scale introduction of hydrogen as an energy carrier in the transport and power market and as storage medium for renewable energy. It will result in an action plan for the implementation of the European Hydrogen Energy Roadmap. Moreover, it will describe the effects and impacts of such an introduction on the EU economy, society and environment. It will propose concrete policy measures, priorities in technology development, and training/education.

Technical approach

Development of datasets

Well-to-Wheel (WtW) or Source-to-User (StU) datasets for hydrogen pathways will be developed and analysed. These will relate to individual geographical and climatic conditions, and local policy orientation. Analysis will take place during the two project phases – from April 2004 to September 2005 the analysis will cover France, Germany, Greece, Italy, Netherlands and Norway; and from October 2005 to March 2007 further Member States will be included.

Scenario development

For the 2020, 2030 and 2050 time horizons, both transition and long-term hydrogen scenarios will be developed showing (with decreasing detail for future time frames):

- The build-up of hydrogen production and supply and infrastructure facilities, taking into account the availability and cost of current as well as expected advanced technologies
- The penetration of hydrogen as an energy carrier in the transport and power market, as renewable energy storage, and stationary and portable end-use, considering the availability of both current and advanced hydrogen energy converters (e.g. gas turbines, internal combustion engines, fuel cells).

Emissions analysis

Determination of potential GHG and pollutant emission reductions under the given scenarios.

Infrastructure build-up analysis

Estimation of capital investment costs and timescales for the hydrogen infrastructure build-up developed through the scenarios.

Economic impacts analysis

Impacts will be assessed at micro-, meso- and macro-economic level. This includes impacts on Gross Domestic Product, EU balance of trade, employment creation/substitution as well as security of supply. The robustness of results will be determined by means of a thorough sensitivity analysis.

Policy measures analysis

Different policy measures, such as carbon trading, differential taxation, and measures for preferential city-centre access for clean vehicles, will be analysed for their effects on hydrogen penetration into different markets.

Analysis of technology impacts

The impacts of technology learning (cost reduction, technology breakthroughs), e.g. price-competitive highly durable fuel cells for transport and residential/industrial end-use, on-board and off-board (e.g. fuel station) hydrogen storage, CO_2-capture and reliable sequestration will be assessed.

Expected achievements/impact

For the timeframes 2020, 2030 and 2050, the aggregated Member State specific results for GHG emissions, preferred hydrogen production and infrastructure technologies, the build-up of supply infrastructure and end-use technologies will be integrated into a proposal for an EU Hydrogen Energy Roadmap for the participating areas. The aim is to deliver a validated roadmap using a transparent approach. In phase two of the project, this process shall be broadened to include other interested Member States and countries which may participate as observers already in the first phase.

Development and implementation of the European hydrogen and fuel cell technology platform secretariat (HyCell-TPS)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2004-006272

Instrument: SSA

List of participants:
- Kellen Europe (BE)
- DG Joint Research Centre, Institute for Energy (NL)
- L-B-Systemtechnik GmbH (DE)

Projected total cost: €1.86 million

Maximum EC contribution: €1.8 million

Coordinator contact details:
Alfons Westgeest and Patrick Maio
Secretariat European Hydrogen and Fuel Cells
Technology Platform
Avenue Marcel Thiry, 204
B-1200 Brussels
Belgium
Telephone: +32 2 774 9652
Telefax: +32 2 774 9690
E-mail: secretariat@HFPeurope.org
Website: www.HFPeurope.org

EC Scientific Officer:
Glyn Evans
E-mail: Glyn.Evans@cec.eu.int

Project main goals

The HyCell-TPS Specific Support Action aims to:

- Develop an efficient coordination and governance mechanism for the Technology Platform in co-operation with the Advisory Council

- Implement the coordination process and offer a complete administrative and organisational support to the different bodies of the platform (Advisory Council, Steering Panels, Initiative Groups and General Assembly)

- Act as Information and Communication Centre for the Technology Platform

- Collect, analyse, validate and disseminate the platform's achievements to the stakeholders within and outside the platform, and raise awareness towards the general public on hydrogen- and fuel-cell-related matters

- Develop the longer-term Secretariat for the Technology Platform.

Key issues

In order to succeed, the HyCell-TPS will have to deal with the following issues:

- Provide flexible and efficient operational and administrative support to the platform operations and different platform governing bodies;

- Deal with the complexity of the coordination and communication process within the platform, which results from the multitude of stakeholders, interests and internal groups, and the need for clarification of governance means, without increasing perceived internal bureaucracy which may have a negative impact on commitment

- Ensure an ongoing balance between transparency, inclusiveness and commitment of participants in the platform

- Support the Advisory Council and the other bodies of the platform in order to meet their ambitious goals in a timely, relevant and qualitative manner

- Act as a neutral and independent party in the platform

- Align priorities of the project, the platform and the political agenda in a changing European environment with regards to environmental, geopolitical and competitiveness objectives linked to the emergence of a hydrogen economy in a global context.

Technical approach

The HyCell-TPS project is organised into six work packages:

- **Work Package 1: "Management Advice, Planning and Initiation"** involves strategic management advice to the Advisory Council to help optimise the management structure, governance issues, coordination and organisation of the platform. This work package also includes the drafting and validation with the Advisory Council and the EC of a Platform Activity Plan.

- **Work Package 2: "Administrative and Operational Support"** involves the provision of administrative and operational support to all the constitutive bodies of the Technology Platform. A flexible support service is offered based on a 'Menu of Services' for each body.

- **Work Package 3: "Communication, Promotion and PR"** aims to develop and implement a communication strategy to raise awareness and promote the developments and results of the platform externally. This external communication strategy should integrate internal communications and streamline the use of all the communication tools developed for the platform.

- **Work Package 4: "Information & Communication Centre"** allows the Technology Platform to have its own internet-based information centre presenting its structure, various bodies, activities, work accomplished and outcomes for the general public. In addition, an extranet site is being developed and maintained with a number of functionalities to support the work and coordination of the platform bodies. This restricted-access site features groupware functionalities such as an interactive document sharing system, automatic groups e-mailing and address database, event manager and registration module, calendar of meetings, all with restricted/differentiated worldwide access via the internet using common browser software.

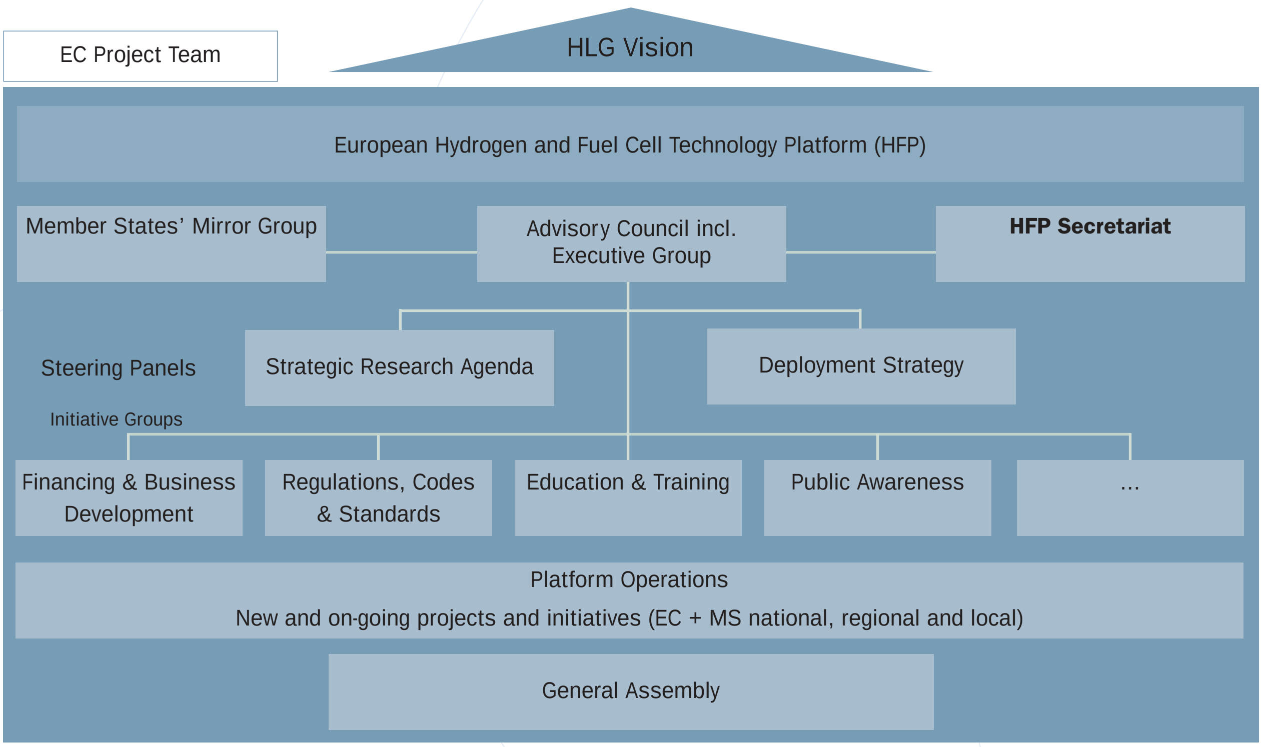
- **Work Package 5: "Platform Knowledge Management"** contributes to the development of an intelligent information flow from the platform operations to the various bodies of the Technology Platform. Upon recommendation from the AC, the Secretariat selectively undertakes the collection, harmonisation and the dissemination of all information necessary within the EHP.

- **Work Package 6: "Consortium Coordination"** aims at providing a consistent and efficient consortium coordination framework among the partners and vis-à-vis the EC.

In general, particular attention is being given to managerial aspects: governance, decision-making, project management, coordination, and communication within and vis-à-vis platform stakeholders. The development of specific internet-based tools (website and extranet) should also facilitate internal communication and information management while, at the same time, enable external information exchange and transparency. Scientific validation will be provided with the expertise of the Joint Research Centre and L-B-Systemtechnik.

Expected achievements/impact

Building on its role and mandate, the platform will be expected to provide recommendations for policy development. HyCell-TPS will have a key role to play in providing the instruments and processes to harmonise existing views. Whilst the interactions with different EU policies will vary according to the challenges to be addressed, effective mechanisms will need to be developed to ensure adequate coordination between the relevant stakeholders. The efficiency of such mechanisms will directly impact the results (quality, speed, relevance) of the platform activities. In addition, this Specific Support Action should contribute to achieving the European Research Area in the field of hydrogen and fuel cells.



Preparing for the hydrogen economy by using the existing natural gas system as a catalyst (NATURALHY)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2004-502661

Instrument: IP

List of participants:
- N.V. Nederlandse Gasunie (NL)
- Högskolan i Borås (SE)
- BP Gas Marketing Limited (UK)
- Commissariat à l'énergie atomique (FR)
- Compagnie d'Etudes des Technologies de l'Hydrogène (FR)
- Computational Mechanics International Ltd (UK)
- The European Association for the Promotion of Cogeneration (BE)
- Centro Sviluppo Materiali Spa (IT)
- DBI Gas- und Umwelttechnik GmbH (DE)
- Public gas corporation S.A. (EL)
- Danish Gas Technology Centre (DK)
- Energy Research Centre of the Netherlands (NL)
- EXERGIA, Energy and Environment Consultants S.A. (EL)
- Technische Universität Berlin (DE)
- Gaz de France (FR)
- General Electric PII Ltd (UK)
- EUROGAS - Groupe Européen de Recherches Gazières (BE)
- The Health and Safety Executive (UK)
- Istanbul Gaz Dagitim Sanayi ve Ticaret A.S (TR)
- Institut Français du Pétrole (FR)
- Instituto de Soldadura e Qualidade (PT)
- University of Leeds (UK)
- Loughborough University (UK)
- Türkiye Bilimsel ve Teknik Arastirma Kurumu (TR)
- Naturgas Midt-Nord I/S (DK)
- Netherlands Standardization Institute (NL)
- National Technical University of Athens (EL)
- Norwegian University of Science and Technology (NO)
- Planet - Planungsgruppe Energie und Technik Gbr (DE)
- Ecole Nationale d'ingénieur de Metz (FR)
- SAVIKO Consultants ApS (DK)
- Shell Hydrogen B.V. (NL)
- STATOIL ASA (NO)
- SQS Portugal - Sistemas de Qualidade de Software, Lda (PT)
- Total S.A (FR) TOTAL
- Netherlands Organisation for Applied Scientific Research (NL)
- X/Open Company Limited (UK)
- Transco plc (part of National Grid Transco plc) (UK)
- University of Warwick (UK)

Projected total cost: €17.2 million

Maximum EC contribution: €11 million

Coordinator contact details:
Onno Florisson
E-mail: o.florisson@gasunie.nl

EC Scientific Officer:
Manuel Sanchez Jimenez
E-mail: Manuel.Sanchez-Jimenez@cec.eu.int

Abstract

The use of hydrogen as an important energy carrier is an essential element for global sustainable development. However, there are many significant challenges for implementing all the components of a complete energy system based on hydrogen. Despite these challenges, there is global interest in hydrogen as an energy carrier with commercial competition emerging for the European Union (EU), Japan and the US. Urgent progress towards the development of a full hydrogen system requires a practical strategy within the context of an existing, extensive natural gas system which has resulted from substantial capital investment over a long period of time. The transition to a full hydrogen system will be lengthy, costly and will require significant research and development.

The aims of NATURALHY are to test all the critical components of a hydrogen system by adding hydrogen to natural gas in existing networks. This transitional approach will provide further experience with the transmission of mixtures of hydrogen and natural gas and, by means of innovative separation technologies, the hydrogen utilisation in stationary end-use applications.

NATURALHY will achieve these aims by means of coherent and complementary objectives. The development by IP HYWAYS of the roadmap for the increased use of hydrogen in the EU will be supported. Obstacles will be isolated and possible solutions identified. The economic, social and environmental costs and benefits of hydrogen systems, including production technologies, will be evaluated and compared with existing systems. Issues of safety, durability and pipeline integrity will be investigated. A decision support tool will be developed to assist the technical implementation of a hydrogen system. In co-operation with NoE HYSAFE, awareness of the prominent attractions of hydrogen will be raised amongst all stakeholders.

A systematic and coordinated approach for the generation of clear outcomes will be adopted in NATURALHY with a comprehensive collection of work packages which focus on all vital components of transitional hydrogen systems. A European consortium of 39 partners with extensive experience and skills is being assembled for NATURALHY and will involve major network operators, hydrogen producers, specialist practitioners, and academic researchers in all relevant fields. In addition to a highly skilled management team, guidance will be provided by a Strategic Advisory Committee consisting of representatives from relevant (inter)national organisations. Potential collaboration and synergies will be fostered with complementary projects. Established information networks will be used in dissemination.

Innovative high temperature routes for Hydrogen Production – Coordinated Action (INNOHYP CA)

Programme: Sustainale Energy Systems

Contract number: Under negotiation

Instrument: CA

List of participants:
- Commissariat à l'Energie Atomique (FR)
- Deutsches Zentrum für Luft -und Raumfahrt e.V. (DE)
- Ente per la Nuove Tecnologie, l'Energia et l'Ambiente (IT)
- Sheffield University (UK)
- Empresarios Agrupados (ES)
- Centro de Investigaciones Energéticas, Medioambientales y Tecnologicas (ES)
- Commonwealth Scientific and Industrial Research Organisation (AU)
- Joint Research Centre – Petten (NL)

Projected total cost: €0.6 million

Maximum EC contribution: €0.5 million

Coordinator contact details:
Mr François Le Naour
Hydrogen Production Project Manager
CEA / CE Grenoble - LITEN
17 avenue des Martyrs
38054 Grenoble
CEDEX 9
Telephone: +33 4 3878 4301
Telefax: +33 4 3878 9463
E-mail: francois.le-naour@cea.fr

EC Scientific Officer:
Joaquin Martin Bermejo
E-mail: Joaquin.Martin-Bermejo@cec.eu.int

Project main goal(s)

INNOHYP CA aims to coordinate efforts on the knowledge of hydrogen production technologies and to propose a roadmap for short-, medium- and long-term research programmes. Gathering together eight organisations implicated in various programmes on the massive production of hydrogen by high-temperature processes, the Coordinating Action INNOHYP-CA has the following objectives.

- To create a platform for sharing and coordinating the results of the Specific Targeted Actions (STREP) in progress, as well as with national programmes and efforts in the EU Member States on high-temperature processes to start clustering the innovative ideas, recourses, and results.

- To define the needs and propose the research activities needed in future leading up to the consolidation of industrial production, to support the roadmaping in Europe mainly being done by the HYWAYS project.

- To offer support to the activities of the European Platform, especially the Advisory Group and the appropriate Steering Committees, and other institutional activities that could be created over the coming years to give them the necessary inputs on massive hydrogen production by high-temperature processes. This support will include the preparation of the roadmap, co-operation agreements, organisation of specific events and training. This roadmap should be completed at the end of the project while organisation of events could be proposed at any time during the project.

- To propose the coordination of European activities at the international level, specifically with the IEA, especially in the Implementing Agreement on Hydrogen and Solar Energy (IA H2 and IA SolarPACES) and alongside the activities the signature of the International Cooperation Agreement for Hydrogen IPHE (especially ILC Implementation and liaison Committee).

Technical approach

In order to establish a document entitled "State of the art on the massive production of hydrogen", the consortium has to explore different sources of information and compile them in a grid defined in a common methodology (definition of the parameters, unities, criteria, a.s.o.):

- **Survey of existing publications:** We propose to conduct a literature survey on the existing publications, distinguishing the short- and medium-term processes containing carbon and innovating long-term processes without carbon. Contributions from all the partners will be compiled by the CEA as regards the carbon content processes and by DLR for the carbon free processes.

- **Survey in European countries:** We will also conduct a survey among European countries to identify scientific activities in this field: existing teams, installations and facilities in which research activities could be performed.

- **Updating of data obtained in recent European projects:** We will integrate the accessible results of the recent Fifth and Sixth FP projects on innovative hydrogen production methods into an overview of the existing knowledge on high-temperature hydrogen production in Europe.

- **Mapping of international programmes:** We will conduct a survey on the international programmes (DOE and JAERI) and on actions carried out within the framework of IEA and IPHE. CEA and CIEMAT are involved in this work package.

This state of the art presents an opportunity to put in perspective the required research programmes and the need to define adequate steps. The objective of this project is to define a possible sequence of activities to be integrated in the European hydrogen roadmap. In addition, the discussion can provide many elements for the development of a major project able to organise the research studies with dynamic evaluation tools. The work on the road-map will be assumed through working groups. Two questions will be addressed:

> How can the transition between the carbon content processes and the free carbon processes be managed? What effort should be devoted to each technology and which synergies are necessary to optimise research in this field?

> Which thermal source is suitable for which processes? Is there a relationship between the parameters of the thermal processes or the high-temperature electrolysis with the type of hot source used (solar, nuclear, and geothermic)?

Expected achievements/impact

As indicated previously, the characteristics of the processes to generate hydrogen by high-temperature fluids involve several areas of knowledge and technologies where coordination activities are needed.

The hydrogen production in the medium to long term will now be considered an important European strategy, and the policy must be defined in such a way that, after consolidation and exploitation of the conventional processes based on natural gas, biomass and steam reforming, the advanced innovative routes will be available. The transition period must be integrated to guarantee that production is able to respond to future, greatly enhanced, requirements in a sustainable manner.

Now is the time to identify all candidate processes, to promote feasibility studies, to identify advantages and drawbacks and to identify the role each technology can play in the future.

But it is not only these technological programmes which are important – the socio-economic impacts expected are also relevant as without these considerations the transition will not be possible.

All of these elements – technologies for hydrogen production, generation systems, socio-economics and training – will be considered in the definition of the medium- to long-term strategy. The European Union will face the challenges of preparing the way forward for the future in parallel with other international programmes to ensure that it is in the lead position to prepare for the future.

In this context, the impact of this Coordinating Action is an important element in the whole process of preparing the medium- to long-term strategy.

Co-ordination action to establish a hydrogen and fuel cell ERA-Net, hydrogen co-ordination (HY-CO)

Programme: Networking of national or regional programmes (ERA-NET)

Contract number: ERAC-CT-2004-011744

Instrument: ERA-NET

List of participants:
- Forschungszentrum Jülich GmbH, Project Management Organisation Jülich (DE)
- Federal Ministry of Economics and Labour (DE)
- Netherlands Agency for Innovation, Energy and the Environment (NL)
- Ministry for Research and New Technologies (FR)
- The Science and Technology Foundation (PT)
- Nordic Energy Research (NO)
- The Czech Energy Agency (CZ)
- Danish Energy Authority (DK)
- General Secretariat for Research and Technology of the Greek Ministry for Development (EL)
- The Research Council of Norway (NO)
- Ministry of Education, Science and Sport (SI)
- The Swedish Energy Agency (SE)
- The Austrian Industrial Research Promotion Fund (AT)
- Ministry of the Walloon Region, General Directorate for Technologies, Research and Energy (BE)
- Ministerie van de Vlaamse Gemeenschap – Administratie Wetenschap en Innovatie (BE)
- National Technology Agency (NO)
- Ministry of Education, University and Research (IT)
- Federal Ministry of Transport, Innovation and Technology (AT)
- The Spanish Ministry of Science and Technology (ES)
- The National Energy Authority of Iceland (Orkustofnun) (IS)
- Commissariat à l'Energie Atomique (FR)

Projected total cost: €2.7 million

Maximum EC contribution: €2.7 million

Coordinator contact details:
Dr Hans-Joachim Neef
Project Management Organisation Juelich (PTJ)
Head of Division ERG
Research Centre Juelich (FZJ)
D 52425 Juelich
Germany
Telephone: +49 2461 61 3213
Telefax: +49 2461 61 6999
E-mail: h.j.neef@fz-juelich.de

EC Scientific Officer:
Marco Weydert
E-mail: Marco.Weydert@cec.eu.int

Project main goals

The goal of the HY-CO project is to network and integrate national R&D activities by establishing a durable European Research Area (ERA-Net) for hydrogen and fuel cells. The main objectives are:

i) To offer a common platform for information and coordination of programmes and R&D activities at national and regional level

ii) To establish a common knowledge base for development of a European policy towards a hydrogen economy as the basis for a contribution to a future sustainable energy system

iii) To strengthen the European R&D and demonstration infrastructure on hydrogen and fuel cells through joint programming, management personnel exchange, and targeted integration activities

iv) To promote and develop a strong and coherent RTD policy on hydrogen and fuel cells in Europe, and stimulate the *"co-operation and co-ordination of national and regional research and innovation activities"*. The vision behind it is to create an internal market in research and development

v) To realise the implementation of durable co-operation with respect to European hydrogen and fuel cell activities. Harmonisation, timing and mutual opening of the programmes and the EC's Framework Programmes are the ultimate goals to aim for.

HY-CO is aiming to provide an active interface with the European Hydrogen and Fuel Cell Technology Platform.

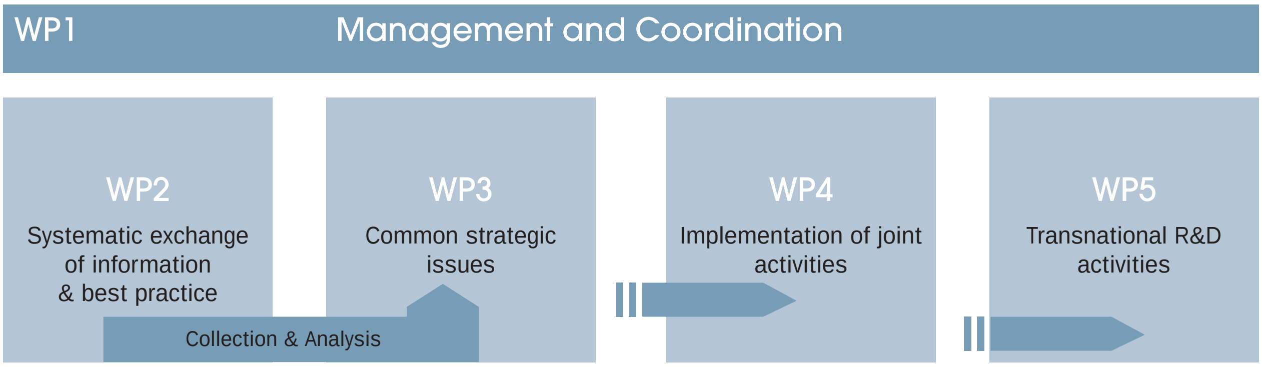
Key issues

The tight coordination and co-operation of the most relevant national programmes (or programme parts) within the European Union and the close contact between key players in the leading funding systems will support the exploitation of the tremendous potentials of hydrogen and fuel cells for the security of supply and a reduction in greenhouse gas emissions in Europe.

Although individual research activities in Europe are of high scientific quality and can compete with research performed all over the world, the strong international competition and drive must be stressed. To meet this global challenge, the European Union and the Member States should work together as stated in the report *Hydrogen and Fuel Cells: a Vision for our Future* published in June 2003 by the High Level Group for Hydrogen and Fuel Cells – a group initiated by the European Commission in October 2002. Actively involving Member States and Associated Candidate Countries in this project is essential to generate the leverage associated with drawing national, regional and local research programmes, projects and initiatives into the European ERA-Net.

Technical approach

The technical approach is based on five **work packages** (WP), each with a WP Leader.



Networking of research, development and demonstration activities carried out at national level in the field of fuel cells and hydrogen technologies is the core of the ERA-NET. With an ambitious integration process, HY-CO aims at a mutual opening of the involved national partner programmes which will enable the implementation of a joint European (transnational) funding scenario. In addition, the programmes of non-participating Member and non-Member States will be evaluated to achieve a complete transnational integration and to enable Europe to position itself better in international activities for the transition to a hydrogen economy.

The general methodology involves all four steps/levels of coordination and co-operation proposed by the European Commission in the relevant documents on the ERA-Net scheme:

- Systematic exchange of best practices
- Strategic activities
- Implementation of joint activities
- Transnational research, development and demonstration activities.

Expected achievements/impact

The impact of the HY-CO project is to provide the basis for and to set up a durable ERA-NET for the promotion of hydrogen and fuel cell technology towards a hydrogen economy.

Providing an interface with the European Hydrogen and Fuel Cell Technology Platform, the HY-CO project will map public funding RTD programmes. In addition, by bringing together 21 hydrogen and fuel cells RTD programme managers/owners, HY-CO will address the issue of breaking down the barriers between national/regional programmes. From a quantitative point of view, an annual funding of €160 million will be coordinated by HY-CO.

By coordinating the fragmented research activities throughout Europe, a critical mass will be achieved through HY-CO to answer both the increasing complexity and the upcoming challenges and chances in hydrogen and fuel cells. As research in these domains demands substantial investments in resources and technology, the public resources have to be used as efficiently as possible. In this regard, HY-CO will help to avoid duplications in research and to structure European RTD efforts with a maximum of potential synergetic effects.

With the help of HY-CO, the necessary efforts at Member State level will be undertaken to improve the position of the hydrogen and fuel cells research field in Europe and to stimulate the translation of its achievements into concrete valuable results.

World Energy Technology Outlook-2050 (WETO-H2)

Programme: Scientific support to policies

Contract number: SSP6-CT-2003-501669

Instrument: CA

List of participants:
- ENERDATA, France
- LEPII-EPE-CNRS, France
- Joint Research Centre, IPTS department (JRC), Belgium
- Federal Planning Bureau (FPB), Belgium
- University of Sussex, SPRU department (UoS), UK
- Mineral and Energy Economy Research Institute of Polish Academy of Sciences (MERRI), Poland
- ECN, The Netherlands

Projected total cost: €0.46 million

Maximum EC contribution: €0.39 million

Coordinator contact details:
ENERDATA, France
Bertrand CHATEAU
2, Avenue de Vignate
38610 Gières- France
Phone: + 33 (0)4 76 42 25 46
Fax: + 33 (0)4 76 51 61 45
bertrand.chateau@enerdata.fr

EC Scientific Officer:
Domenico ROSSETTI di VALDALBERO
E-mail: Domenico.Rossetti-Di-Valdalbero@cec.eu.int

Objectives and problems to be solved

The "WETHO-H2" final objective is to present a world energy and technology outlook for the period to 2050. In addition to the elaboration of the long term baseline projections, WETO H2 assesses various technological breakthroughs likely to occur in the next 50 years in a context of a high value of the carbon, and evaluate two European strategies toward sustainability: hydrogen economy and reduction by a factor 4 of the CO_2 emissions related to energy for Europe. The project relies mainly on the POLES model, a global sectoral model of the world energy system.

Description of work

The work is divided in three main tasks

- *Production of a world energy/technology reference case to 2050*
  This task involves first the extension of the POLES model to address relevantly energy issues up to 2050; it involves the preparation of the reference case to be input in the POLES model: i.e. demographic trends, GDP, oil and gas reserves, relevant policies (e.g. energy taxation). Finally, a mean-variance portfolio optimisation is applied to assess the EU-25 reference electricity mix as produced by the POLES model for their financial "risk-reward" efficiency

- *Analysis of technological breakthrough and trajectories in a context of high carbon value*
  This task aims at identifying technological breakthroughs likely to occur in the next 50 years in a context of high carbon value, and at assessing with POLES their impacts on the energy system evolution and related CO_2 emissions.

- *Evaluation of two EU energy strategies toward sustainability*
  The purpose of this task is to evaluate two strategies towards sustainability, involving technological breakthrough: the first strategy aims at implementing a widely based hydrogen economy throughout Europe in the next 50 years; the second one so-called "factor 4" strategy, aims at reducing the CO_2 emissions related to energy by a factor 4 in 2050 as compared to 1990.

Expected results and exploitation plans

The WETO H2 report will be largely disseminated and a conference on long term energy and technology outlook, relevant for CO_2 emissions analysis, will be organised. The publication and the conference are dedicated to: provide immediate key information on energy and CO_2 issues in the main regions of the world, for those, in the European institutions and in EU national Governments, in charge of energy policy and international negotiations on greenhouse gases; disseminate the results towards all the sectors of the European economy concerned by international energy and global environmental issues; serve as a reference for international organisations and institutions outside Europe in the debate on sustainable development.

Case Study Comparisons and Development of Energy Models for Integrated Technology Systems (CASCADE MINTS)

Programme: Scientific support to policies

Contract number: SSP6-CT-2003-502445

Instrument: STREP

List of participants:
- Institute of Communications and Computer Systems of the National Technical University of Athens, Greece
- ECN, Energy Research Centre of the Netherlands
- LEPII/EPE, France
- International Institute for Applied Systems Analysis), Austria
- European Commission - Joint Research Centre, Institute for Prospective Technological Studies, Spain
- PAUL SCHERRER INSTITUT, Switzerland
- Environmental and Resource Economics, Environmental Management Centre for European Economic Research (ZEW), Germany
- German Aerospace Center (DLR), Germany
- Institute of Energy Economics and the Rational Use of Energy, University of Stuttgart (IER), Germany
- ERASME, Ecole Centrale de PARIS, France

Scientific participants:
- International Energy Agency, Energy Technology Policy Division
- U.S. DOE/EIA Energy Information Administration of the U.S. Department of Energy
- Research Institute of Innovative Technology for the Earth, Japan
- Analysis and Modelling Division of Natural Resources Canada
- National Institute for Environmental Studies, Japan

Projected total cost: €1.73 million

Maximum EC contribution: €0.95 million

Coordinator contact details:
ICCS/NTUA
Institute of Communications and Computer Systems of the National Technical University of Athens
9, Iroon Politechniou str
15773 Zografou Campus
Athens – Greece
Pantelis Capros & Nikos Kouvaritakis
tel: +30 210 7723641,
fax: +30 210 7723630
e-mail: kapros@central.ntua.gr

EC Scientific Officer:
Domenico ROSSETTI di VALDALBERO
E-mail: Domenico.Rossetti-Di-Valdalbero@cec.eu.int

Objectives and problems to be solved

Hydrogen Technologies are perhaps the only generic technology that can transform the whole energy system. Most detailed energy models until now treat hydrogen as one of the options but are generally inadequate in simulating a potential complete transformation towards a hydrogen based economy. This project aims at providing such modelling capability in view of analysing the technology dynamics in conjunction with appropriate policies, notably R&D efforts that could facilitate such a transformation. By means of model based scenarios the timing, extent and possible obstacles to such a transition are identified while its likelihood is assessed.

Another aim of the project is to use a wide range of models under harmonised conditions in order to derive robust conclusions on the extent to which policies fostering the development and deployment of hydrogen and fuel cells, CO_2 capture and storage, renewables and nuclear energy can contribute to lowering greenhouse gas emissions and import dependence.

Description of work

Existing models are extended and radically re-designed so as to describe all possible configurations of a hydrogen economy including all demand categories where fuel cells can be used as well as the different options for producing, distributing and storing hydrogen from different primary sources.

The models are used to analyse scenarios assuming favourable trajectories for the technical and economic characteristics of hydrogen related technologies (both on the demand and supply side). Special attention is placed on technology clusters where particular breakthroughs may produce cumulative effects. Technology dynamics mechanisms are incorporated in the models to enable them to perform R&D policy simulations (increase in R&D effort produces improvements leading to higher technology adoption and hence to further improvements through experience gained in a virtuous learning circle). Stochastic modelling is undertaken to allow a systematic assessment of the likelihood of different paths towards a hydrogen dominated energy system.

In analysing the robustness of responses to policies a wide range of detailed energy-economy-environment models are used. Some harmonisation of assumptions is achieved early in the project in order to generate broadly comparable reference cases against which the impact of policy scenarios is evaluated for each model. The scenarios are carefully designed to enable their full and identical implementation in as wide a range of models as possible. Results are subsequently compared, differences explained and a synthesis is elaborated identifying key policy conclusions.

Expected Results and Exploitation Plans

The modelling work on hydrogen will result in a set of extended detailed energy models capable of a thorough analysis of the prospects of a hydrogen economy both in the medium and the longer term covering EU countries and the World. In addition it will produce a set of coherent and quantified visions of future energy system configurations and measures of the risks associated with them. These results will be useful to policy makers and other stakeholders concerned with the prospects of the hydrogen economy, especially those involved in the definition of R&D strategies. It is expected that partners will use the analytical tools developed in the project to carry out further studies at the industry, national and international level. The main outcome of model result comparisons will be synthesised in policy reports addressing the potential role of technologies in promoting sustainable development. These reports will be published in order to enhance the communication between model experts and policy-makers and build consensus among main model results.

Lombardia and Rhein-Main towards Zero Emission: Development and Demonstration of Infrastructure Systems for Hydrogen as an Alternative Motor Fuel (ZERO REGIO)

Programme: Sustainable Energy Systems

Contract number: Under negotiation

Instrument: IP

List of participants:
- Infraserv GmbH & Co. Höchst KG (DE)
- Linde Gas & Engineering AG (DE)
- DaimlerChrysler AG (DE)
- Fraport AG (DE)
- TÜV Hessen (DE)
- Agip Deutschland GmbH (DE)
- Lunds Universitet (SE)
- Roskilde University (DK)
- Saviko Consultants Ltd (DK)
- European Commission - JRC at Ispra (IT)
- Eni Tecnologie S.p.A. (IT)
- Regione Lombardia (IT)
- SAPIO Prod. Idro.Ossigeno S.r.l. (IT)
- Comune di Mantova (IT)
- Universita comm.Luigi Bocconi (IT)
- C.R.F Societe Consort. per Azioni (IT)

Projected total cost: € 21.4 million

Maximum EC contribution: €7.5 million

Coordinator contact details:
Dr Heinrich Lienkamp
Infraserv GmbH & Co. Hoechst KG
Industriepark Hoechst
C 526, 65926 Frankfurt am Main
Germany
Telephone: +49 69 305 7571
Telefax: +49 69 305 20646
E-mail: heinrich.lienkamp@infraserv.com

EC Scientific Officer:
Iñigo Sabater
E-mail: inigo.sabater@cec.eu.int

Project main goal(s)

- Use of hydrogen as an alternative motor fuel, produced as primary or waste stream in a chemical plant or alternatively through small 'on-site' production facilities

- Development of infrastructure systems for hydrogen consisting of transport lines, hydrogen production, compression, storage and distribution equipment, and integration of these in conventional refuelling stations

- Adaptation and demonstration of 700-bar refuelling technology for hydrogen

- Demonstration of hydrogen as an alternative fuel via automobile-fleet field tests at two different urban locations in the EU, Rhein-Main, Germany, and Lombardia, Italy

- Showing ways and prospects for faster penetration of hydrogen as a zero-emission alternative motor fuel in the transportation market in the short and medium term.

Key issues

- Use of hydrogen waste stream as an alternative fuel for transport

- Demonstration of 700-bar refuelling technology for hydrogen

- Integration of hydrogen (CGH2 and LH2) refuelling infrastructures in conventional service stations

- Reliability of fuel cell cars

- Socio-economic and environmental impact of using hydrogen as a fuel.

Technical approach

A project duration of 60 months is planned, divided in two phases.

- Phase 1 (0-24 months): Infrastructure will be built in Rhein-Main and Lombardia. A modern multi-energy conventional service station will be available at both locations. Transport lines, production, compression and distribution equipment for hydrogen will be built, integrated and tested in accordance with safety and licensing regulations. An external evaluation will be carried out before starting phase 2.

- Phase 2 (25-60 months): The second phase comprises demonstration and evaluation. Fleets of fuel cell cars will undergo field tests at the two locations, accompanied by necessary training programmes. Data on technical performance will be collected, analysed and evaluated for the vehicles as well as the infrastructures. Field tests will be accompanied by extensive socio-economic evaluations on competitiveness, acceptance and stimulation of demand.

Expected achievements/impact

- The two island demonstrations with passenger cars will provide experience and the technical basis for larger demonstrations necessary for wider penetration of hydrogen as a transport fuel in Europe.

- Effective marketing of the project, as well as dissemination and exploitation of project results, will support the wider implementation of hydrogen in the European transport sector.

Optimisation of the hydrogen internal combustion engine (HyICE)

Programme: Sustainable Surface Transport

Contract number: Under negotiation

Instrument: IP

List of participants:
- BMW Group (DE)
- Ford AG (DE)
- Volvo Technology (SE)
- MAN AG (DE)
- IFP (FR)
- Hoerbiger ValveTec (AT)
- Mecel AB (SE)
- Technische Universität Graz (AT)
- Universität der Bundeswehr München (DE)
- Irion Management Consulting (DE)

Projected total cost: €7.71 million

Maximum EC contribution: €5 million

Coordinator contact details:
Hans-Christian Fickel
BMW Research and Technology
Project Hydrogen Engine
Forschungs- und Innovationszentrum Knorrstraße 147
D 80788 München
Germany
Telephone: +49 89 382 68395
Telefax: +49 89 382 70 68395
E-mail: hans.fickel@bmw.de

EC Scientific Officer:
Maurizio Maggiore
E-mail: Maurizio.Maggiore@cec.eu.int

HyICE concepts of mixture formation

Project main goal(s)

All over the world, great efforts are being made concerning hydrogen and fuel cell technology. Hydrogen releases energy through a chemical reaction with oxygen. This can be used for powering vehicles either in a fuel cell delivering electricity output or in an internal combustion engine similar to that in present-day vehicles.

The goal of HyICE is to work out a hydrogen combustion engine concept which has the potential to be better than gasoline and diesel engines, regarding power density and efficiency, at reasonable costs.

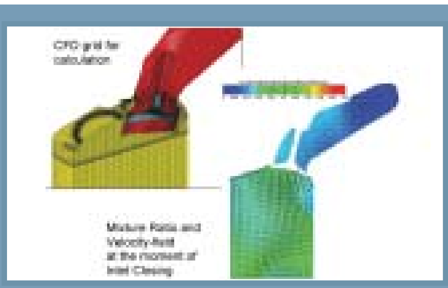
Key issues

The two most promising concepts of mixture formation are Cryogenic Port Injection and Direct Injection (figure 1).

Due to the special properties of hydrogen, in particular the low density, high diffusivity and real gas effects, the *direct injection* of hydrogen leads to a number of research and development steps. The important element to ensure a gaseous direct supply of hydrogen to the combustion chamber is the injector which has to be designed completely different from those for liquid fuels (gasoline or diesel).

A high efficiency could also be achieved by *cryogenic port injection*. At present, no such engine exists. Combustion engines running on cryogenic hydrogen require fuel valves or injectors providing a highly dynamic operation and a large flow-rate range. Only a sophisticated injector system enables such an engine to run at its optimum.

In order to receive an effective development process for series engines, CFD tools for mixture formation and combustion have to be adapted to the specific behaviour of fluid mechanics and reaction kinetics of hydrogen (figure 2).



CFD calculation of mixture formation

Technical approach

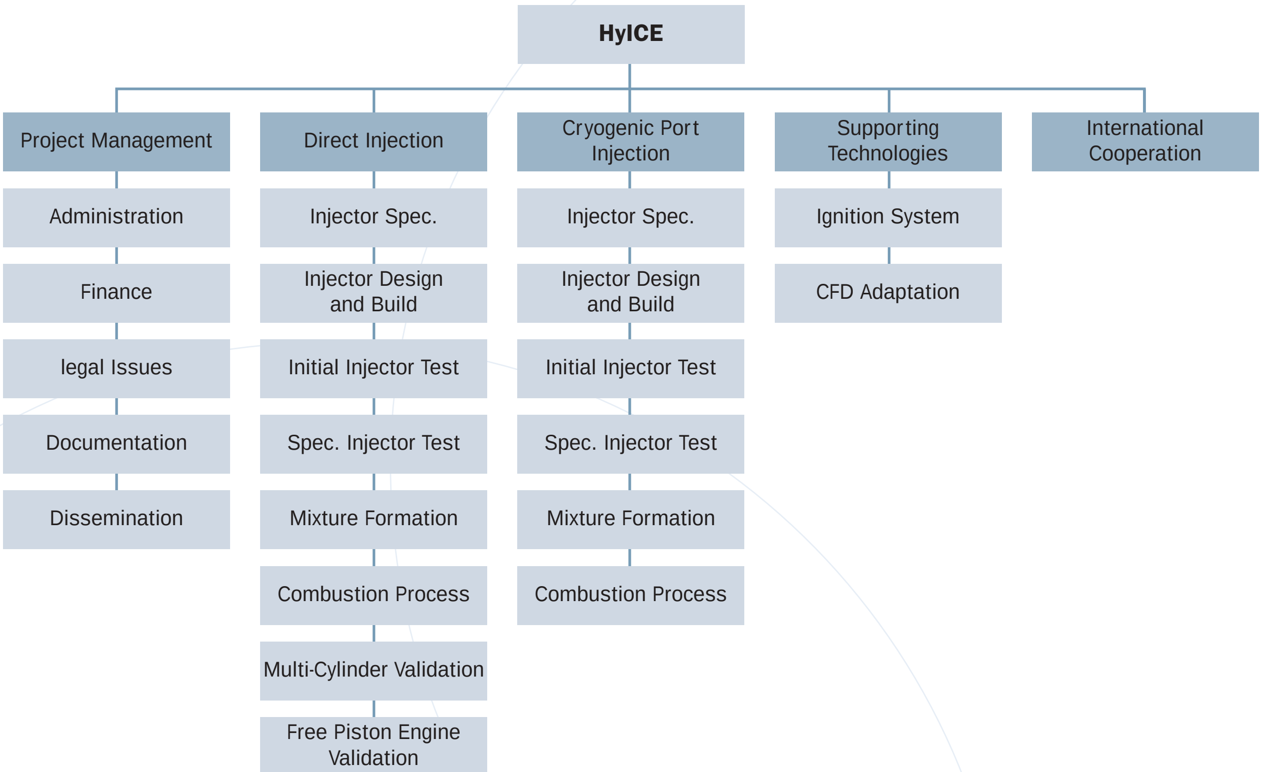
HyICE is structured in four technical sub-projects as shown in figure 3. The first two are dedicated to Direct Injection and Cryogenic Port Injection. Both these sub-projects start with an initial injector specification. Subsequently, the specified injectors are then built, tested and the mixture formation and combustion processes are investigated. The results of the tests and investigations are used to refine the injector specifications. For direct injection, the step towards multi-cylinder engines and free piston engines is then taken. The sub-project "Supporting Technologies" is running in parallel and is dedicated to the ignition system and CFD calculations.

An exceptional position is being taken by the sub-project "International Cooperation": HyICE is the first project in which the exchange of results of research work between the EC and the USA has been achieved as the result of a preconcerted effort by the European Research Commissioner Philippe Busquin and the Secretary of State at the US Department of Energy, Mr Sp. Abraham in March 2003.

Expected achievements/impact

In Europe, public awareness of environmental issues is already well developed. By supporting hydrogen technologies, there is a real chance to take over the leadership in the production and marketing of sustainable energy systems. Hydrogen from renewable and carbon-neutral energy resources will bring in a new era.

Internal combustion engines fed with hydrogen are considered preferable for universal use. Within this range, hydrogen internal combustion engines are considered not just an intermediate but also a long-term solution with significant market share. Hydrogen powered internal combustion engines would also be available earlier at reasonable prices significantly lower than full-size fuel cell power-trains. Therefore, a relatively early market introduction of hydrogen in the automotive sector could be supported by a massive build-up of vehicles with hydrogen powered internal combustion engines.



The HyICE work plan

R&D, demonstration and incentive programmes' effectiveness to facilitate and secure market introduction of alternative motor fuels (PREMIA)

Programme: Sustainable Energy Systems

Contract number: TREN/04/FP6EN/S07.31083/503081

Instrument: SSA

List of participants:
- Vito, Flemish Institute for Technological Research (BE)
- European Commission - Joint Research Centre - Institute for Prospective Technological Studies (ES)
- Centre for Research and Technology Hellas/Hellenic Institute of Transport (EL)
- VTT Technical Research Centre of Finland (FI)
- South-East European Transport Research Forum (EL)

Projected total cost: €1.2 million

Maximum EC contribution: €1 million

Coordinator contact details:
Ms. Leen Govaerts
VITO
Boeretang 200
B-2400 Mol
Belgium
Telephone: +32 1433 5821
Telefax: +32 1432 1185
E-mail: leen.govaerts@vito.be,

EC Scientific Officer:
Iñigo Sabater
E-mail: Inigo.Sabater@cec.eu.int

Project main goal(s)

The overall objective of the project is to investigate the cost-effectiveness of measures to support the introduction of alternative motor fuels in the EU and in the international context, in relation to the market maturity of the technology and the country-dependent situation. Focus is on biofuels as a short-term alternative and hydrogen as a long-term alternative motor fuel.

Key issues

1. Description of market maturity and technical prospects of alternative motor fuels and alternative fuel vehicles, development of indicators to describe market maturity of AMF

2. Review of initiatives outside the EU to support the market introduction of AMF and international co-operation to develop common assessment framework for R&D and demonstration

3. Evaluation of ongoing support projects to accelerate research and development in the field of alternative motor fuels, to demonstrate the technology in the market, and the definition of a common framework for assessment, with the focus on hydrogen for transport applications

4. Evaluation of past and ongoing national incentive programmes to facilitate the market introduction of alternative motor fuels, with a focus on biofuels for transport applications

5. Description of country-specific boundaries which impact the potential for AMF market introduction

6. Scenario calculations to simulate the impact of certain initiatives on the market demand of alternative motor fuels

7. Options for cost-efficient measures to stimulate the market demand of alternative motor fuels

8. Dissemination of policy recommendations and suggestions to facilitate and secure the market introduction of alternative motor fuels.

Technical approach

Literature review: state of the art of AMF; development of indicators

Local workshops: national boundary conditions for the introduction of AMF and policy measures; dissemination

Expert interviews: effectiveness of ongoing and past RD&D; incentive programmes

International workshops: international co-operation on assessment framework; dissemination

Modelling: scenario calculations for the introduction of AMF in the EU; policy recommendations

Expected achievements/impact

- Through dissemination to the stakeholders at national and international level, the common framework for assessment of measures has the potential to become a standard for evaluation and assessment of measures.
- PREMIA will contribute to the further development of the EU policy on AMF.
- Knowledge on good practices in policy support for alternative fuels will be generated and will serve as input for the definition and evaluation of future research, demonstration and support programmes. The dissemination of the knowledge generated will be done by means of dedicated workshops at national and international level.
- The European dimension is important in the knowledge transfer from countries that have implemented or are conducting effective strategies to support the market introduction of alternative fuels to other countries which are in the first stage of defining a policy aimed at the substitution of conventional fuels by alternative ones.
- By integrating the review of initiatives on the support of AMF outside the EU, international co-operation on the assessment of projects and the definition of best practices will be enhanced.

Realising reliable, durable, energy-efficient and cost-effective SOFC systems (Real-SOFC)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2003-502612

Instrument: IP

List of participants:
- Forschungszentrum Jülich GmbH (DE)
- Rolls-Royce plc (UK)
- Ugine-Alz (Groupe Arcelor) (FR)
- Commisariat à l´ Energie Atomique (FR)
- University of St Andrew (UK)
- Deutsches Zentrum für Luft- und Raumfahrt e.V. (DE)
- Entwicklungs- und Vertriebsgesellschaft Brennstoffzelle mbH (DE)
- Energy Research Centre of the Netherlands (NL)
- Electricité de France (FR)
- Swiss Federal Laboratories for Materials Testing and Research (CH)
- ENERGOPROECT AD – Science Research and Technological Institute (BG)
- Gaz de France (FR)
- H.C. Starck GmbH (DE)
- Haldor Topsøe A/S (DK)
- HTceramix SA (CH)
- Imperial College (UK)
- Foundation for Research & Technology Hellas (EL)
- Plansee AG (AT)
- Risø National Laboratory (DK)
- Stiftelsen for industriell og teknisk forskning ved Norges (NO)
- Sulzer Hexis Ltd (CH)
- University of Birmingham (UK)
- University of Chemical Technology & Metallurgy, Sofia (BG)
- Technical Research Centre of Finland (FI)
- Wärtsilä Corporation (FI)
- University of Genoa (IT)

Projected total cost: €18.3 million

Maximum EC contribution: €9 million

Coordinator contact details:
Dr. Robert Steinberger-Wilckens
Project Fuel Cells
Forschungszentrum Jülich GmbH
D-52425 Jülich
Germany
Telephone: +49 2461 61 5124
Telefax: +49 2461 61 4155
E-mail: r.steinberger@fz-juelich.de

EC Scientific Officer:
Hugues Van Honacker
E-mail: Hugues.Van-Honacker@cec.eu.int

Project main goal(s)

In close co-operation between industry and research institutions, the following steps are to be accomplished:

- improved understanding of ageing in planar SOFC stacks, taking into consideration all modes of operation, including long-term testing over 10 000 hours, thermal cycling up to 100 cycles, and the influences of fuel composition; these results will flow into:

- adaptation of materials and protective coatings in order to reduce ageing to well below 0.5%/1 000 hours, the modified materials then are used in:

- manufacturing of improved components under commercial conditions and subsequent characterisation in long-term and cycling tests – re-referring to step 1.

Besides materials development, the project will address:

- life cycle analysis as an essential tool for assessing the environmental impact and recycling of the materials used

- industrial standardisation as a means of lowering costs and improving industry competitiveness

- training and dissemination as a tool of human resource management and a contribution towards gender equality.

Following the state-of–the-art first testing campaign at the start of the project, two further 'feedback loops' are planned for a second- and third-generation development of cells and stacks.

Key issues

Understanding of aging in SOFC for industrial applica-tions

- Improved and new materials, components, cells and con-cepts for systems with increased dura-bility and performance

- Manufacturing of cells and stacks

- Standardisation of SOFCs and test methods

- Environmental as-pects of SOFC operation

Technical approach

The project aims to generate materials and components of two subsequent waves of improvements, termed 'Generation 2' and '3'.

- step 1: characterisation and collection of existing data for materials at the state-of-the-art stage at the beginning of the project; continuous development of new materials and access to analysis data by all project participants for review and inclusion in their component development

- step 2: communal review and assessment after 12 months; agreement on 'Generation 2' standard 'by definition' after 18 months, agreement on further progress and possible re-adjustment of working programme; beginning of long-term testing (> 10 000 hours) on basis of Generation 2; further continuous development of new materials as above

- step 3: communal review and assessment after 30 months; agreement on 'Generation 3' standard 'by definition' after 36 months, agreement on further progress and possible re-adjustment of working programme; final testing (> 3 000 hrs.) of Generation 3 components

Expected achievements/impact

- Geometric volume, compactness: high power density > 0.6 W/cm³ cell area at 700°C

- Lifetime, reliability, durability operation: 10 000 hours of operation at degradation < 0.5% /1 000 hrs at operating temperatures T 800°C

- Lifetime verification: lifetime models; advanced testing procedures for lifetime prediction

- CO_2 reduction/sustainability of energy supply: suitability for biogas and syngas from biomass gasification; sulphur tolerance > 10ppm

- Cost competitiveness: potential for stack costs < 2 500 € /kW at 800°C; SOFC standards and classification agreement

- High reproducibility of results: European Agreement on SOFC Quality Assurance

- Minimisation of environmental impact: SOFC Life Cycle Inventory and Analysis

- Human resources: joint training and high student (and staff) mobility in the fuel cell field

- Dissemination: international networking

- Gender equality: equal opportunities regardless of sex, religion and origin.

Biomass Fuel Cell Utility System (Biocellus)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2004-502759

Instrument: STREP

List of participants:
- Technische Universität München (DE)
- National Technical University Athens (EL)
- MAB Anlagenbau GmbH & Co. KG (AT)
- Technische Universiteit Delft (NL)
- Energy Research Centre of the Netherlands (NL)
- HTM Reetz GmbH (DE)
- Prototech AS (NO)
- Unversity of Stuttgart (DE)
- Technische Universität Graz (AT)
- Siemens – Erlangen (DE)
- University of Ljubljana (SI)
- D.M.2 Verwertungstechnologien, Dr. Mühlen GmbH & Co. KG (DE)
- COWI A/S (DK)
- Technical University of Denmark (DK)
- IT Consult GmbH (DE)
- Aristotle University of Thessaloniki (EL)

Projected total cost: €3.4 million

Maximum EC contribution: € 2.5 million

Coordinator contact details:
Dr Jürgen Karl
Institute for Thermal Power Plant System, Technische Universität München
Boltzmannstrasse 15, DE-85748 Garching
Germany
Telephone: +49 89 289 16269
karl@ltk.mw.tum.de)
Website: http://www.biocellus.net

EC Scientific Officer:
Jeroen Schuppers
E-mail: Jeroen.Schuppers@cec.eu.int

http://www.biocellus.net

Project main goal(s)

Energy from biomass needs highly efficient small-scale energy systems in order to achieve cost-effective solutions for decentralised generation, especially in Mediterranean and Southern areas, and for applications without adequate heat consumers. Thus fuel cells are an attractive option for decentralised generation from biomass and agricultural residues but they have to meet at least two outstanding challenges:

1. Fuel cell materials and gas cleaning technologies have to treat the high dust loads of fuel gas and pollutants like tars, alkalines and heavy metals.

2. The system integration has to allow for efficiencies of at least 40-50%, even within a power range of few tens or hundreds of kW.

Technical approach

This proposal addresses these two aims in particular. Hence, the first part of the project will focus on an investigation into the impact of these pollutants on degradation and performance characteristics of SOFC fuel cells in order to specify the requirements for appropriate gas cleaning system (WP 1-2). These tests will be performed at six existing gasification sites, which represent the most common and applicable gasification technologies. Finally, WP 3 will test and demonstrate the selected gas cleaning technologies so as to verify the specifications obtained from the gasification tests. The results will be used for the development, installation and testing of an innovative SOFC-gasification concept which, in particular, will match the specific requirements of fuel cell systems for the conversion of biomass feedstock (WP 4 and 5). The innovative concept comprises heating an allothermal gasifier with the exhaust heat of the fuel cell by means of liquid metal heat pipes. Internal cooling of the stack and the recirculation of waste heat significantly increases the system efficiency. This so-called TopCycle concept promises electrical efficiencies of above 50% even for small-scale systems without any combined processes.

Expected achievements/impact

Finally, the consortium will investigate the economic prospects and environmental impact of these technologies in order to prepare adequate dissemination activities (WP 6, 7). These activities will mainly focus on the feasibility of a first semi-commercial demonstration of small-scale SOFC plants with integrated gasification of biomass.

Development of low temperature and cost effective solid oxide Fuel Cells (SOFCSPRAY)

Programme: Collective Research and Co-operative Research

Contract number: Under negotiation

Instrument: STREP

List of participants:
- Nuevas Tecnologias para la Distribución Activa de Energia (ES)
- Adelan Ltd (UK)
- Céramiques Techniques Industrielles (FR)
- Promocell S.A. (BE)
- Telemaq (FR)
- Foundation Inasmet (ES)
- Forschungszentrum Juelich GmbH (DE)

Projected total cost: €1.19 million

Maximum contribution: €0.6 million

EC Scientific Officer:
Nathalie Legros
E-mail: Nathalie.Legros@cec.eu.int

Abstract:

Solid Oxide Fuel Cells (SOFC) enabling the direct conversion of the chemical energy of hydrocarbons into electricity are drawing much and increasing interest as a power generation system. They possess high power generation efficiency (up to 70%) which is the highest conversion efficiency compared with any of the developed fuel cells (PEMFC, MCFC etc.). SOFC could be used today in large high-power applications including industrial and large-scale central electricity generation stations. Some developers also see SOFC use in motor vehicles and are developing fuel cell auxiliary power units.

The main objectives of the project are to reduce the working temperatures of planar SOFC from 1 000-800°C to 650-700°C and their manufacturing costs by 50% by using new powders and advanced thermal spraying techniques. In order to achieve these objectives new powders will be developed for use in the development of materials for the fuel cell elements. For manufacturing SOFC, technology will be used high-velocity oxy-fuel (HVOF) spraying and a novel micro plasma spraying (MPS).These two spray techniques have not been used so far for design and development of the SOFC elements, and will enable the manufacture low-temperature and cost-effective SOFC. There will be provided Characterisation of the developed powders will be pointed and they will be optimised to meet the requirements and specifications of industrial partners.

The structure and properties of the elements of SOFC (anode, cathode and electrolyte) developed by thermal spraying using these powders will be evaluated in order to establish the optimum structure-properties relationships. The SOFC elements will be assembled in a stack which will be tested under the industrial conditions, taking into account the industrial specifications.

SOFC fuel cell fuelled by biomass gasification gas (GREEN-FUEL-CELL)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2004-503122

Instrument: STREP

List of participants:
- Centre de Coopération Internationale en Recherche Agronomique pour le Développement (FR)
- Commissariat à l'Energie Atomique (FR)
- Energy Research Centre of the Netherlands (NL)
- Force technology (DK)
- Institute of Chemical Technology (CZ)
- Risoe (DK)
- Technical University of Denmark (DK)
- TK Energi AS (DK)

Projected total cost: €5.17 million

Maximum EC contribution: €3 million

Coordinator contact details:
Dr Philippe Girard
Cirad Forestry Department
Biomass Energy research Unit
TA 10/16
34398 Montpellier cedex 5
France
Telephone: +33 (0) 4 6761 4490
Telefax: +33 (0) 4 6761 6515
E-mail: philippe.girard@cirad.fr

EC Scientific Officer:
Jeroen Schuppers
E-mail: Jeroen.Schuppers@cec.eu.int

Project main goal(s)

The main objective of this project is to produce a gas that can meet the requirements for fuel to feed SOFC fuel cells through reliable, upscalable and cost-effective staged gasification of biomass. The **overall technical objective** of the project, therefore, is to develop a tar decomposition and gas cleaning system that can be integrated with biomass gasifiers in order to make them able to produces a gas suitable for SOFC fuel cell application.

Key issues

The resulting **challenge** for GREEN-FUEL-CELL is to prepare a basic design for a full-scale (1-50 MW_{th}) innovative **gasifier system** and a **gas treatment** for integrated biomass gasification SOFC systems, with the following expectations:

- Tar content of the gas below 10 mg tar/Nm3 gas
- Cold-gas efficiency of more than 85% for the total gasification process
- Carbon conversion of more than 99%
- Minimal process waste streams and by-products so as to reduce the environmental impact of the waste from the gasifier and the operational cost.

Technical approach

The GREEN-FUEL-CELL project deals with the development of a biomass-to-electricity concept with high electric efficiency based on SOFC technology. The figure below shows the units of the system with the working packages acting on the different parts.

The technical idea of this project is to **design an upscalable char bed that can be integrated into existing gasifiers** in order to reduce tar concentrations to a level low enough to avoid tar-related problems in an SOFC-system. The char has been proven to be suitable as a catalytic agent for the reduction of tar concentration at high temperatures (900°C or higher). This means that: (1) it keeps the high-efficiency option open of coupling a gasifier and SOFC without intermediate cooling, and (2) if cooling is applied, tars are removed before condensation problems can occur.

Within the project, two ways of creating the necessary char bed are being developed and tested. For simplicity, these two are referred to as char bed *without* and *with* bed material (or the TKE-concept and ECN-concept, respectively):

- a char bed *without* bed material (TKE-concept): the concept is based on laboratory-scale fixed-bed pilot-scale gasifiers at TKE and DTU. It has been shown in the past three years that the tar concentration can be as low as 10 mg/mn^3.

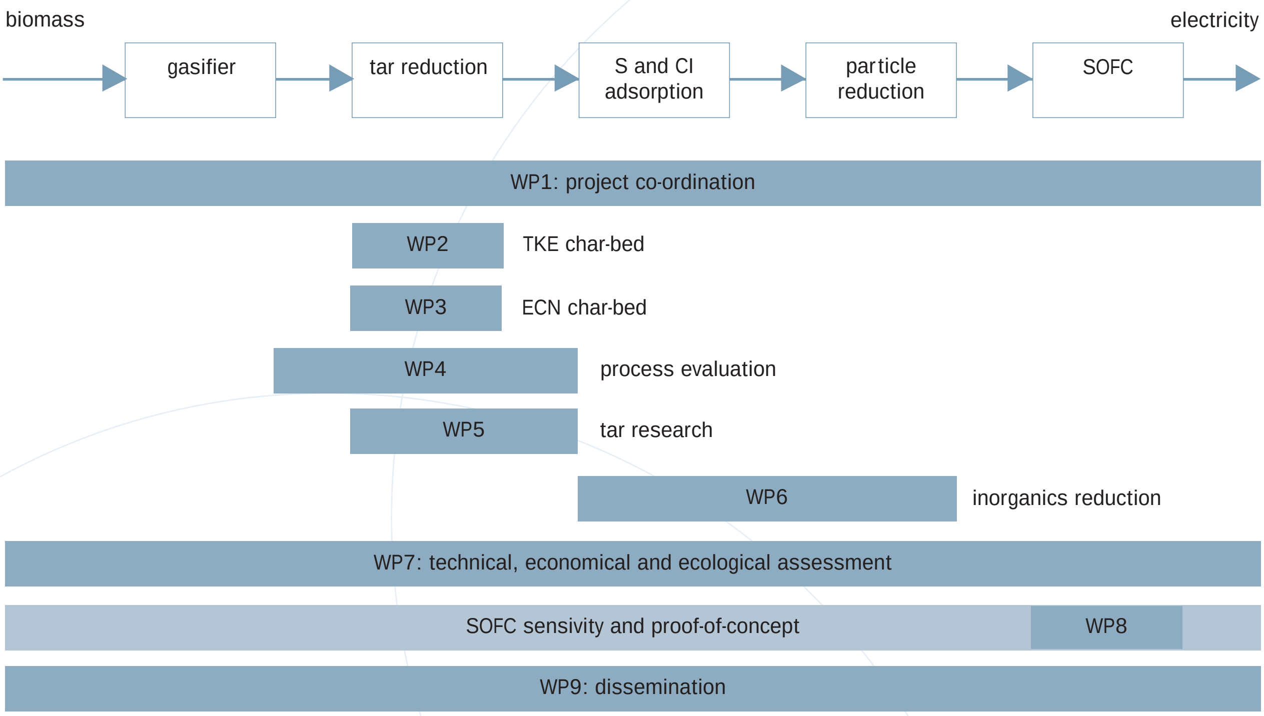
- a char bed *with* bed material (ECN-concept): the concept has been developed by ECN and is called the TREC-concept. Laboratory tests were performed in 2002 and 2003 and it has been proven that tars can be significantly reduced.

In order to judge the tar removal systems for use in a biomass-to-electricity route, the effects of different tars on the operation of an SOFC will be quantified within the project. Furthermore, this project will identify the operation parameters for a dry gas cleaning system in order to be sure that the inorganic impurities are also removed to a level where the gas can be fed directly into an SOFC fuel cell.

Expected achievements/impact

The two suggested concepts are innovative gasification technologies which enable an efficient conversion of biomass into a tar free produced gas. As the produced gas is expected to be a clean gas with very low tar content, and because appropriate dry clean system will solve inorganic contamination, various applications can be considered including fuel synthesis. The achievement within the project will be the two fuel cells coupled to gasifiers for at least 100 hours each.

Green Fuel Cell



Hydrogen and Fuel Cell Technologies for Road Transport (HyTRAN)

Programme: Sustainable Surfgace Transport

Contract number: TIP3-CT-2003-502577

Instrument: IP

List of participants:
- Volvo Technology Corporation (SE)
- Centro Ricerche FIAT (IT)
- Renault Recherche Innovation (FR)
- Volkswagen AG (DE)
- DaimlerChrysler AG (DE)
- DAF Trucks N.V. (NL)
- Nuvera Fuel Cells Europe Srl (IT)
- Johnson Matthey Fuel Cells Ltd (UK)
- Opcon Autorotor AB (SE)
- Gillet GmbH (DE)
- Weidmann Plastics Technology AG (CH)
- Adrop Feuchtemesstechnik GmbH (DE)
- Reinisch-Westfaelische Technische Hochschule Aachen (DE)
- Energy Research Centre of the Netherlands (NL)
- Politechnico di Torino (IT)
- Paul Scherer Institute (CH)
- Institute für Mikrorechnik Mainz GmbH (DE)
- Imperial College of Science, Technology and Medicine (UK)
- Environment Park S.A. (IT)

Projected total cost: €16.8 million

Maximum EC contribution: €8.8 million

Coordinator contact details:
Per Ekdunge
Telelephone: +46 31 772 4016
Telefax: +46 31 772 4086
E-mail: per.ekdunge@volvo.com

EC Scientific Officer:
Maurizio Maggiore
E-mail: Maurizio.Maggiore@cec.eu.int

Project main goal(s)

The overall objectives of HyTRAN are to advance the fuel cell technology towards a commercially viable solution by developing components and systems, and to integrate the sub-systems into two innovative fully integrated and compact fuel cell systems:

1. Direct Hydrogen PEM Fuel Cell (DHFC) system, 80 kW power size (innovative stack and balance of plant (BoP))

2. APU Diesel reformed gas PEM fuel cell system 10 kW power size, including micro-structured steam reformer, and clean-up reactors, innovative stack and balance of plant.

Key issues

Key issues in the work are the fuel cell stack, components and main sub-systems including the fuel processor and auxiliary components, the fuel cell system and the vehicle integration, as well as the choice of fuel with its implications for technology and infrastructure.

Technical approach

Components and sub-systems are major bottlenecks en route to the commercialisation of fuel cell based powertrains. The factors that must be dealt with are: cost, durability, weight, volume, and efficiency, all of which needs to be improved. HyTRAN is therefore focusing largely on the development of the necessary components and sub-systems to make them meet the requirements derived from the two applications. The table below gives an overview of the 'component challenges' that HyTRAN will address.

The need for breakthroughs and innovations at the component level so as to meet the project objectives will lead to the following developments within HyTRAN:

- Innovative 80 kW direct hydrogen stack with strong weight and volume reduction, increased efficiency, durability and start-up time, and with innovative MEAs

- Innovative 10 kW reformate stack, which will contain innovative electrocatalyst and MEA elements: introducing novel catalysts and electrode structures which will result in an MEA tolerant to very high CO concentrations

Fuel cell system components		Challenge addressed
Stack components	MEA Catalyst Bipolar plates	Cost reduction, platinum reduction, ease of manufacturing, cell performance, durability, CO tolerance, lower resistivity…
Fuel processing	Catalyst Materials Components	Weight and volume reduction, cost, manufacturing, start-up time…
Gas purification	Catalyst Materials Components	Weight and volume reduction, cost, manufacturing, start-up time…
Balance of Plants	Air compressor Blower Humidification Heat exchanger	Efficiency, performance, cost, size and weight, optimum system packaging, noise level

- Variable displacement compressor
- Innovative humidification/dehumidification apparatus
- Heat exchanger and radiator customised for the application
- Micro-structured diesel steam reformer
- Micro-structured gas purification unit for diesel reframing

To validate the progress towards these objectives, two corresponding Technical Platforms (TP) will be developed and used for assessment:

- TP1 'POWERTRAIN': development of a compact system for traction power by an 80 kW direct hydrogen PEM fuel cell system implemented in a passenger car.
- TP2 'APU': development of a compact 10 kW Auxiliary Power Unit for both light-duty and heavy-duty vehicles, including micro-structured diesel oil steam reformer, clean-up reactors, an innovative reformate hydrogen stack, and balance of plant components.

Expected achievements/impact

The energy efficiency of a direct hydrogen PEM fuel cell can reach values of some 55-60% at the stack level and some 45% at the system level, so that the overall potential efficiency on the NEDC is really competitive in respect of conventional vehicles: a fuel consumption reduction of some 30-35% in comparison with conventional vehicles has been estimated and even obtained in a certain number of FC vehicles.

Since fuel cells can provide electrical energy with much higher efficiency than the generator in ICE-vehicles, a fuel cell APU running on diesel will contribute to reducing the fuel consumption of the vehicle. Moreover, an APU application, even utilising fossil fuel, will have a bridging function for the commercialisation of fuel cells for propulsion.

A fuel cell system incorporates various technologies in vehicles, even those not directly related to the typical products developed by the automotive industry, e.g. chemistry, chemical and process systems engineering. Since the project strongly involves the components suppliers, this growing technology is a chance for such companies to achieve a considerable share in the very dynamic automotive sector. This will result in good opportunities to establish new jobs by covering this new market of fuel cell technology. As a part of the project, the automotive manufacturer, together with the supplier, will develop common requirements and specifications for the components, which will help to create a market for the suppliers involved by avoiding unique solutions.

Further improvement and system integration of high temperature polymer electrolyte membrane fuel cells (FURIM)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2004-502782

Instrument: IP

List of participants:
- Technical University of Denmark (DK)
- Volvo Technology Corp (SE)
- Norwegian University of Science and Technology (NO)
- University of Newcastle upon Tyne (UK)
- Elsam A/S (DK)
- Danish Power Systems ApS (DK)
- Case West Reserve University (USA)
- University of Stuttgart (DE)
- Hexion B.V. (NL)
- Freudenberg FCCT (DE)
- IRD Fuel Cell A/S (DK)
- Foundation of Research and Technology (EL)
- Between Lizenz GmbH (DE)

Projected total cost: €6.1 million

Maximum EC contribution: €4 million

Coordinator contact details:
Prof. Niels J. Bjerrum
Department of Chemistry, Technical University of Denmark
DK-2800 Lyngby
Denmark
Telephone: +45 4525 2307
Telefax: +45 4588 3136
E-mail: njb@kemi.dtu.dk

EC Scientific Officer:
Hugues Van Honacker
E-mail: Hugues.Van-Honacker@cec.eu.int

Project main goal(s)

The main goal of the project is a $2kW_{el}$ HT-PEMFC stack operating in a temperature range of 120-220°C, with a single cell performance target of 0.7 A/cm_ at a cell voltage around 0.6 V. The durability will be more than 5 000 hours. A hydrocarbon reformer and a catalytic burner will be developed and integrated with the stack.

Key issues

The key issues of the project include: (1) development and improvement of the temperature-resistant polymer membranes with respect to durability, conductivity, mechanical and other properties; (2) optimising catalysts and gas diffusion electrodes; and (3) stack materials and construction.

Technical approaches

For temperature-resistant membranes, first, polymers will be synthesised and optimised. The technical approaches include cross-linking, blending, and fabricating inorganic-organic composite membranes. For electro-catalysts and electrode materials, binary and ternary metal alloy catalysts and novel high-surface-area carbon supports will be the focus, as well as fabrication techniques for both catalysts and electrodes.

Expected achievements/impact

Development of advanced materials, demonstration of the high-temperature PEMFC stack and integration of such a system are expected to promote sufficiently the commercialisation of the fuel cell technology for both vehicle propulsion and stationary applications. The commercialisation of this technology will substantially increase the energy efficiency and reduce polluting emissions, which are the main objectives of the programme.

Development of novel, efficient and validated software-based tools for PEM fuel cell component and stack designers (PEMTOOL)

Programme: Collective Research and Co-operative Research

Contract number: Under negotiation

Instrument: STREP

List of participants:
- Bertin Technologies SA (FR)
- Cellkraft AB (SE)
- COMSOL AB (SE)
- David Fuel Cell Components S.L (ES)
- NedStack fuel cell technology BV (NL)
- SCANDIUZZI s.r.l (IT)
- Volvo Technology Corp. (SE)
- Kungl Tekniska Högskolan (SE)
- Foundation INASMET (ES)

Projected total cost: €1.6 million

Maximum EC contribution: €1.0 million

Coordinator details:
Mr Clement Kirrmann

EC Scientific Officer:
Nathalie Legros
E-mail: Nathalie.Legros@cec.eu.int

Abstract:

Reductions m cost and improvements in both performance and reliability are the key factors on the road to the mass commercialisation of proton exchange membrane (PEM) fuel cells in Europe.

These depend principally on the design and properties of cell components and stacks that are developed by SMEs. In order to be able to design and construct a PEM fuel cell as cheaply, efficiently and reliably as possible, it is necessary to be able to understand qualitatively and predict quantitatively how it functions. To do this, and to do it in a more time- and cost-effective manner, SMEs' experimental methods must be complemented by modelling.

This project aims to provide SMEs with validated modelling tools, in the form of computer software, which will enable them to develop better-performing fuel-cell-related products more efficiently. In so doing, this will accelerate the long-awaited wide-scale acceptance of PEM fuel cells as a whole, and in turn will boost the core business of the SMEs themselves. The steps to the overall objective of the project will be:

1. To establish a focused SME priority list of key problems, associated with cell performance, stability and degradation, that they wish to see addressed;

2. To address those problems by modelling;

3. To program the derived models into user-friendly software;

4. To carry out extensive parameter studies using the software for key operating conditions;

5. To perform experiments in order to validate the models;

6. To demonstrate the optimisation, by experiment and modelling, of an industrial PEM fuel cell stack.

As compared to the state of the art, the innovations will be modelling tools that:

a. Lead to savings in time for PEM fuel cell product development of 50-60%;

b. Lead to savings in cost for PEM fuel cell product development of 50-60%;

c. Lead to 30-50% improvements in PEM fuel cell performance;

d. Can predict how to optimise the operation of an industrial-use PEM.

Intelligent DC/DC converter for fuel cell road vehicles (INTELLICON)

Programme: Collective Research and Co-operative Research

Contract number: Under negotiation

Instrument: STREP

List of participants:
- HILTech Developments Limited (UK)
- Sloan Electronics Limited (UK)
- IRD Fuel Cell A/S (DK)
- Trans-Electric bv (NL)
- Ransomes Jacobsen Ltd (UK)
- Maxwell Technology SA (CH)
- Vrije Universiteit Brussel (BE)
- University of Birmingham (UK)

Projected total cost: €0.96 million

Maximum EC contribution: €0.5 million

EC Scientific Officer:
Nathalie Legros
E-mail: Nathalie.Legros@cec.eu.int

Abstract:

Current hybrid electric vehicle power trains comprise on-board energy generation, energy storage and traction drive, where the battery is used for energy storage is heavy, expensive or both and requires regular maintenance. The best practice is to use super-capacitors with batteries, reducing the deep charge-discharge cycle and battery size (hence weight and cost). The Intellicon power train replaces batteries with a novel DC/DC converter (the project deliverable) as an interface between the fuel cell and traction system and super-capacitors. Super-capacitors are lightweight, high-power energy storage devices which typically have an operational life equal to that of the vehicle. The DC/DC converter will monitor fuel cell operational safety and reliability through intelligent control which will allow super-capacitor voltage to vary within acceptable limits as the traction system accelerates and decelerates, whilst maintaining a steady optimised power flow from the fuel cell without risk. The simple replacement of batteries by super-capacitors alone would result in system instability because the super-capacitor needs to charge up until its maximum rated terminal voltage is reached. The DC/DC converter will be lightweight with a small dimensional profile, and its unit cost will allow the new power train to be competitive against its more conventional battery counterpart. The key objectives of Intellicon are to reduce unit overall power train weight, unit cost and maintenance. To achieve a high-power density, a high-operating frequency is used (circa 200 kHz) to ensure high efficiency; modem soft-switching techniques will be employed in the power topology, coupled with state-of-the-art high frequency magnetics. This represents a substantial research challenge since these techniques are not normally applied at such power levels, especially in weight/space/cost critical applications. The system thermal management may also have water- or oil-cooling options.

Domestic EMergency Advanced Generator (DEMAG)

Programme: Collective Research and Co-operative Research

Contract number: Under negotiation

Instrument: STREP

List of participants:
- Labor S.r.l. (IT)
- Seira elettronica industriale S.r.l. (IT)
- ENERTRON - Stromversorgungsgeräte und Elektronik GmbH (DE)
- Linnet Technology Limited (UK)
- SZWED Sp. Z o.o (PL)
- Ideal Case S.A.S. di Scapin Paolo & C (IT)
- Ideatel Ingenieria (ES)
- AGT S.r.l. (IT)
- Universita' di Roma "Tor Vergata" (IT)
- University of Technology (AT)

Projected total cost: €6.99 million

Maximum EC contribution: €0.65 million

EC Scientific Officer:
Nathalie Legros
E-mail: Nathalie.Legros@cec.eu.int

Abstract

DEMAG intends to investigate the indoor domestic application of advanced hydrogen technologies to life-saving emergency energy generators, and to deliver an emergency power supply, rated at 10 kWh, based on the integration of a PEM fuel cell with ultra-capacitors and with a metal hydrate container for hydrogen storage – the fuel cell is expected to provide a basic power output, whereas ultra-capacitors can supply temporary peak loads. The system will be designed to provide the best retrofit potential. An in-depth safety assessment will be performed to support the integration of hydrogen-based devices in domestic environments.

Enlarging fuel cells and hydrogen research co-operation (ENFUGEN)

Programme: Sustainable Energy Systems

Contract number: Under negotiation

Instrument: SSA

List of participants:
- Labor S.r.l. (IT)
- Institute of Fundamental Technological Research - Polish Academy of Sciences (PL)
- Technology Centre AS CR (CZ)
- BIC Bratislava, spol. S.r.o. (SK)
- Energy Centre Bratislava (SK)
- Enviros s.r.o. (CZ)
- Technical Support for European Organisations Sprl (BE)
- Università di Roma "Tor Vergata" – Dept. Physical and Energetic Sciences and Technologies (IT)

Projected total cost: €0.21 million

Maximum EC contribution: €0.21 million

Coordinator contact details:
Alfredo Picano
Labor S.r.l.
Via del Pantheon 57
00186 Rome - Italy
Telephone: +39 06 6992 5716
Telefax: +39 06 6780 091
www.labor-eu.net

EC Scientific Officer:
Hugues Van Honacker
E-mail: Hugues.Van-Honacker@cec.eu.int

Project main goal(s)

The ENFUGEN support action aims at **stimulating and supporting** the research activities from Poland, Czech Republic and Slovakia and from Associated Candidate Countries, having an impact in the medium to long term, in the technology sectors, including *fuel cells* and *new technologies for hydrogen carriers/transport and storage*.

ENFUGEN addresses research-related supporting and networking activities; it is incorporated in a multidisciplinary approach based on socio-economic research needs to overcome the obstacles to penetration into the markets by fuel cells and hydrogen energy in Poland, the Czech Republic and Slovakia.

In the context of enabling the European Community to achieve its RTD strategic objectives, the ENFUGEN project will **contribute actively** to develop **new ideas for NoE/IP**. In particular, domestic market/research barriers and possibilities for the following themes will be discussed during virtual round tables and traditional workshops organised in conjunction with the RE events in the targeted candidate countries.

Emphasis will be placed on:
- **mapping and networking competencies**, promoting these activities to strategic objectives, notably regarding the European Research Area;
- **stimulating, encouraging and facilitating** the participation of research organisations from these three candidate countries in the activities of the thematic priority area concerning fuel cells and hydrogen energy, by:
  - information exchange between the experts in Member States and those in Poland, the Czech Republic and the Slovak Republic by means of interactive virtual scientific forums, virtual round tables and traditional workshops;
  - reinforcement in Poland, the Czech Republic and the Slovak Republic of a network of existing centres of excellence in the field of RES by the integration of an organised research group for fuel cells and hydrogen energy;
  - promotion of candidate countries' competencies during dissemination activities;
  - training activities for improving RTD systems in the three targeted countries.
- **preparing future community RTD activities**, via prospective studies such as Roadmap and brokerage events, for the creation of RTD/industry clusters, database and other printed and electronic catalogues of research competencies for wide dissemination. Channels for international co-operation, necessary to build good proposals for Integrated Projects and Networks of Excellence with strong participation of the three targeted countries promoted by the ENFUGEN project, will therefore be developed.

Key issues

The European research system is still too fragmented, such fragmentation being much more visible between Member States and candidate countries. The gap between the Eastern and Western Europe may be attributed to a considerable extent to regulatory, entrepreneurial, fiscal and financial factors, to the ACC's dependence on closed national systems and very **low integration of research with industrial practice**.

By **promoting** the activity of Polish, Czech and Slovak **research groups, training activities** emphasising industry–university relations, and by **creating the 'entrepreneurial university'**, the ENFUGEN project will contribute to addressing the problem properly, hence paving the way to its solution (even though this is on a long-term basis).

Fuel cell and the hydrogen economy must be understood as a system or network. Innovative activities, as well as production and commercialisation, rest on and involve a large variety of actors, either directly or indirectly – different types of firms, other research organisations like universities and non-industrial research centres, financial institutions, regulatory authorities, governments, systems, consumers, etc.

The competitiveness of innovation and production systems in this sector cannot be assessed by only looking at individual firms but also at the broader set of institutions, infrastructures and policies that influence the actions of companies and – even more important – at the dynamic interactions between these levels of analysis. US, Canada and Japan have accumulated and are maintaining a dominant advantage in innovative activities in this sector compared to Europe. Nevertheless, European Western countries (Germany and the UK above all,) appear to specialise successfully in fuel cells and have been defining strategies to develop the 'Synthetic Liquid Hydrocarbon Economy'.

Technical approach

The work will last **24 months** and will be structured in **five operative work packages**.

During **WP1**, the Polish, Czech and Slovak partners will work in their respective countries on the **expertise localisation and mapping**, establishing contacts with universities, centres of excellence, research organisations, etc. At the same time, the Italian and Belgium partners will involve key experts in the targeted sector from the Member States.

The objective of **WP2**, will be to **analyse** the state of the art, the existing **barriers** and **needs** for the successful performance of research in the field of fuel cells and hydrogen energy in the targeted candidate countries. Then, from the beginning of the third month of the project, the ENFUGEN virtual platform and *database* will be implemented containing a list of research organisations and individual experts. The most interesting profiles collected during WP1 will be invited to enter the *scientific forum*, the activities of which will be developed in the *ENFUGEN virtual platform*.

WP3 will involve **stimulating the researchers' interaction** through virtual multi-session **round tables** to work on possible ideas for *IP/NoE*, as well as through traditional **workshops** within RE events in Poland and the Czech and Slovak Republics, so as to create awareness among, and synergies with, researchers operating in the field of RES.

The **WP4** will provide **assistance to research performers** through **training activities** based on transferring European *best practices*, successful models stimulating entrepreneurial skills, as well as by *brokerage activity*, to assist the researchers to build up industrial partnership for the targeted NoE/IP.

The **WP5** will consist in **dissemination** of ENFUGEN results and planning successful exploitation of the ENFUGEN model so as to be implemented in other ACC.

By networking capacities of the ENFUGEN project partners, the **Polish, Czech and Slovak research** competencies in fuel cells and hydrogen energy previously stimulated will be **promoted and made visible** both at European and national level. A tangible output of the ENFUGEN project will also be the **database** of Polish, Czech and Slovak expertise in the targeted sector as a partners' search utility. A **roadmap**, consisting of guidelines towards achieving a **successful interaction among R&D and industry** clusters in the targeted ACC, will be delivered. Besides, the ENFUGEN project targets to make emerge **35 research ideas for IP/NoE** building at the same time, strong consortia composed by ACC/MS R&D performers and industrial partners.

Expected achievements/impact

The ENFUGEN action is expected to contribute to strengthening the European Research Area (ERA), being a support instrument that will create synergies between the scientific communities of MS and ACC countries so as to take advantage of and produce other instruments necessary to implement the research, such as Networks of Excellence and Integrated Projects.

In particular, it will bring about a stronger structuring effect on European research in fuel cells and hydrogen energy, making it possible to put together critical masses of resources – present in Poland, the Czech Republic and Slovakia – to better co-ordinate national research efforts and to strengthen the activities carried out in Member States.

A dedicated and detailed database of researchers and research bodies, public as well as private ones, and centres of excellence, together with the potential industrial partners interested to join the research consortia will thus be created as the main instrument in the partners' search activity for the whole Sixth Framework Programme. It is foreseen that the database will contain approximately 50 research organisation, 30 scientists, 20 centres of excellence and 40 industrial partners from Poland; approximately 40 research organisation, 20 scientists, ten centres of excellence and 30 industrial partners from the Czech Republic; and approximately 30 research organisation, ten scientists, ten centres of excellence and 30 industrial partners from the Slovak Republic;

The **website** created for this purpose will be divided into a *Public section* as the main instrument for creating awareness and promoting candidate countries' competencies, and a restricted *Scientific forum*, where successful interaction among those researchers involved through thematic **virtual multi-session round tables** will enable new ideas for joint projects to emerge.

Three **workshops** will be organised by candidate country partners within the RE events in Poland, Slovakia and the Czech Republic, thereby integrating a group for fuel cells and hydrogen energy as an organised sub-sector of renewable sources of an energy research national group.

NCPs, IEN, Energy Centre Bratislava and Enviros will organise at least **two brokerage events**, in conjunction with special RE or other events organised in Poland, the Czech and Slovak Republics by the IRC, Chamber of Commerce, Regional Development Agencies, and EuroInfoCentres, where the group of potentially interested and selected industrial partners will be invited to discuss the technical possibilities of building joint proposals.

It must be stressed that the ENFUGEN proposers ensure an impressive dimension as regards the potential contacts and audience.

Compact Direct (m)ethanol fuel cell for portable application (MOREPOWER)

Programme: Sustainable Energy Systems

Contract number: SES6-CT-2003-502652

Instrument: STREP

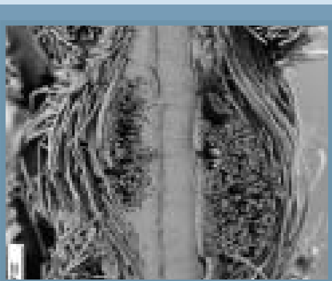
List of participants:
- GKSS Forschungszentrum Geesthacht GmbH GKSS (D) (The co-ordinator)
- Centro Ricerche Fiat CRF (I)
- Solvay SA Solvay (B)
- Johnson Matthey JM (UK)
- Consiglio Nazionale delle Ricerche – Istituto di Tecnologie Avanzate per l'Energia "Nicola Giordano" CNR ITAE (I)
- Institut für Mikrotechnik Mainz IMM (D)
- Politecnico di Torino POLITO (I)
- Nedstack Fuel Cell Technology NFCT (NL)
- Nedstack Components NFCC (NL)

Projected total cost: €3.9 million

Maximum EC contribution: €2.1 million

Coordinator contact details:
Dr. Suzana Pereira Nunes
Institute of Chemistry
GKSS Forschungszentrum Geesthacht GmbH
Max-Planck-Str. 1
D-21502 Geesthacht
Germany
Telephone: +49 4152 87 2440
Telefax: +49 4152 87 2466
E-mail: Suzana.Nunes@gkss.de

EC Scientific Officer:
Hugues Van Honacker
E-mail: Hugues.Van-Honacker@cec.eu.int



Project main goals

Fuel cells are expected to play a major role in any future sustainable energy supply. In the long term, fuel cells may replace a large part of the current combustion systems in all end use sectors. The potential market for **portable fuel cell devices** includes weather stations, medical devices, signal units, auxiliary power units (APU), gas sensors, etc. Fuel cells can make major contributions toward achieving key EU objectives such as energy savings, reduction of CO_2 emissions and other pollutants, diversification of energy supply, and an overall sustainable development.

The objective of the MOREPOWER project is to develop a low cost, low temperature portable direct methanol fuel cell (DMFC) device of compact construction and modular design. The aimed electrical characteristics of 40 A, 12.5 V (total power 500 W) will be the targets of the project. The aimed values of DMFC single cell performance will be 0.5V/cell at 0.2A/cm^2 at 30-60°C (in atmospheric pressure air). The effective operation at this low temperature is particularly challenging and can be achieved by the development of:

- new low-cost proton exchange membranes with reduced fuel crossover;
- new electrocatalyst materials with enhanced low temperature (m)ethanol electro-oxidation activity of the anode;
- new catalyst for the cathode with enhanced oxygen reduction activity and decreased adsorption of carbon monoxide;
- optimised structure of the electrocatalyst and electrode for efficient operation at low temperatures with practical flows and pressures;
- optimised, simplified and miniaturised design of the DMFC device.

The project goals will be achieved by a narrow collaboration inside the project consortium comprising public and industrial research centres, big industrial companies and SME.

Key issues

The state-of-the-art DMFC devices developed mainly for automotive applications operate at temperatures up to 140°C using advantage of enhanced electrochemical and transport kinetic at higher temperatures. The targeted DMFC device has to work at relatively low temperatures and atmospheric pressure. Thus, the key issue of the project is the development of membrane electrode assemblies (MEA) effectively operating at low temperatures (30 - 60°C) with reduced fuel crossover.

Another challenging issue is optimisation of the cell design to provide the efficient transport of the reactants in very compact device.

The use of ethanol as a fuel requires the development of effective catalytic materials for ethanol electrooxidation and membranes with low ethanol crossover. Fundamental electrochemical investigation will be carried out to assess the physico–chemical parameters influencing the reaction rate for ethanol oxidation. The second step in the development of the ethanol oxidation catalysts will regard the use of proper promoters able to favour the electrochemical dissociation of the C-C bond at low temperatures.

Technical approach

The overall system specification together with experimental approach and common methodologies for tests has been developed by partner CRF together with IMM and NFCT.

The issue of MEA development is divided to several stages:

- Development of high proton conducting membranes with methanol, ethanol and water crossover at least 10-fold lower than the Nafion® value. The base organic polymers for the membrane preparation will be supplied by Solvay. GKSS, Solvay, CRF and NFCC will explore possibilities of solution and extrusion membrane formation. The reduction of liquid crossover shall be achieved either by inorganic modification or by polymer crosslinking. Suitable inorganic modification can also improve the proton conductivity of polymeric membrane.

- Catalyst development (provided by partners JM and CNR) will include the development of anode catalysts for methanol and ethanol electrooxidation and cathode catalysts with improved alcohol tolerance than the platinum black materials currently used. The application of nanotechnology and the examination of new compositions of transition metals are tools to achieve the goals.

- MEA preparation and characterisation will be carried out by partners JM, CNR, CRF, NFCT. MEA design will incorporate new membrane concepts and new catalytic systems and will be tuned to the requirements of the overall stack design terms of operating conditions and performance.

The design of the DMFC device will be based on the results of the MEA development. The key issues will be:

- Optimisation of the gas and liquid flow distribution using micro channel plates and improved sealing system (IMM, CRF, NFCC, NFCT). Various materials for the stack will be tested to find an optimum solution concerning material and manufacturing cost and taking into consideration the aspect of future mass production. Liquid handling system will be designed, constructed and assembled to an integrated computer controlled prototype device with optimised heat management and reduced start-up time.

- Selection of the most appropriate plate technology for low cost mass production will be accomplished by NFCT and NFCC.

- The overall system modelling design and control will be carried out by partner POLITO together with CRF, NFCT and NFCC basing on the chemical/electrochemical reaction description. Complete system model validation will be accomplished towards the end of the project when bench results of the developed MOREPOWER unit will be available.

Expected achievements/impact

The interest in fuel cells is based on their potential for a cleaner and more effective energy production. Therefore the immediate contribution is the stimulation of a new technology, which enables the use of energy in a more effective way.

Main project goal is the development of a market competitive more compact portable fuel cell. Starting with the lower power range, a consequence would be to expand the already growing versatility of multifunctional wireless electronic devices, which demands increasing power combined to small size and weight. Today, some 400 million phones are sold annually compared to about 15 million portable digital assistants (PDAs) and 25 million to 35 million notebooks. The annual global market for portable power supplies is now served mainly with batteries. It reaches a $6 billion and is rising due to the proliferation of portable electronic devices. Common batteries seldom yield sufficient lifetimes or can be purchased at costs that are acceptable. The waste disposal of the used electrochemical power sources is an additional problem. The introduction of the developed portable fuel cell device into the market will bring considerable advance in this power sector and will contribute to a sustainable and competitive European manufacturing industry in a constantly growing market.

A further important goal is the power range of some hundreds Watts, suitable for devices such as weather stations, medical devices, signal units, APU's, gas sensors, and security cameras. Here the fuel cell will care for a much longer power autonomy and will enable the use of different devices even in remote areas.

Fuel cells are clean technology with low emission levels and could mainly work on the bases of renewable fuels. Methanol and ethanol can be produced from biomass (i.e. cellulosic material, mostly wood) in large scale and are already used as a fuel for internal combustion engines. Its dissemination in fuel cells will contribute to replace conventional power systems which work on fossil fuels or electrochemical batteries and will lead to reduced CO_2 emissions. In this sense it will also help to meet the targets of the Kyoto Protocol.

Flexible Environmental Multipurpose Advanced Generator (FEMAG)

Programme: Collective Research and Co-operative Research

Contract number: 508119

Instrument: STREP

List of participants:
- AGT S.r.l. (IT)
- Nuova Fima SpA (IT)
- Szwed Sp. z.o.o. (PL)
- ENERTRON GmbH (DE)
- Ingegneria Bioenergetica SL (ES)
- Wilhelm Meyer GmbH&Co KG (DE)
- Labor S.r.l. (IT)
- Università di Roma "Tor Vergata" (IT)
- Molecular NETWORKS Gmbh (DE)
- Technical University Of Graz (AT)

Projected total cost: €1.17 million

Maximum EC contribution: €0.65 million

EC Scientific Officer:
Nathalie Legros
Nathalie.Legros@cec.eu.int

Abstract

FEMAG's target is an energy generator **box**, closed and of low power, based on the integration of a fuel cell in the range of 0.125 to 1 kW with a battery pack and super-capacitors, for the flexible supply at variable power of small portable non-automotive devices, comprising the manufacturing systems of all those companies potentially suitable to be supplied by fuel cells, but of size and value lower that those presently requested for an ad hoc development of similar systems.

The project is targeted at SMEs and will also produce an advanced expert system for the design of complex generators based on PCs in the range of 0.125 to 1 kW. FEMAG proposes to develop a product which is based on fuel cells but is combined with all the components required to make its application flexible, simple and able to satisfy not only the base power consumption, but also relative peaks of consumption of associated machines, within utilisation profiles prefixed at the design stage. A clear and remarkable target market exists for such systems made up. The approach proposed by FEMAG is very original and with impressive replication potential since, further to the development of prototypes optimised by experimental design for the specific target applications of the project, it envisages the application of advanced mathematical methodologies in order to formalise the knowledge generated by the project into an expert system for the virtual design of integrated generators.

European Commission

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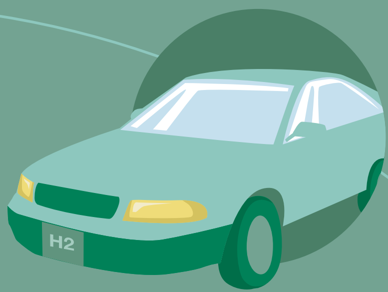
This compilation of project synopses covers research and demonstration projects on hydrogen and fuel cells, as well as supporting activities such as Co-ordination Actions and Specific Support Actions. The projects concerned are those funded in the first half of the Sixth Framework Programme, mainly, but not exclusively, under the Thematic Priority 6 "Sustainable Development, Global Change and Ecosystems". For each project, basic information is provided with regard to the scientific and technical scope, expected impact, the participating organisations and contact points.



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