Plan d'Action National sur l'Hydrogène et les piles à combustible PAN-H

Appel à projets 2008

AREAS COVERED BY THE 2008 CALL FOR PROJECTS AND SUBMISSION PROCEDURE

Date limite de dépôt des projets de recherche

11 avril 2008 à 12h00

Deadline for electronic submission of proposals to ANR :

April 11th, 2008 at 12h00

1. INTRODUCTION.

The 2008 Call for Projects for the ANR PAN-H programme has been published in French on the ANR web site at the following internet address: http://www.agence-nationale-recherche.fr/documents/aap/2008/aap-panh-2008.pdf . As stated, it is open to transnational cooperation, provided that national funding is obtained for each party. It is particularly open to collaboration between French and German teams, in the frame of a pending agreement between the Federal Ministry of Economy and Technology in Germany (BMWi), together with Projektträger Jülich[1] (PtJ), its committed project management organisation. The submission procedure for French-German projects is recalled in section 3. For details and deadlines of the submission procedure to ANR, it should be referred to the “Appel à projets 2008“full French version.

2. AREAS COVERED BY THE CALL FOR PROJECTS

The 2008 call for projects for the ANR PAN-H programme is divided into the following subjects:

- Subject area 1: Hydrogen production
- Subject area 2: Hydrogen supply
- Subject area 3 : Fuel cell systems
- Subject area 4 : Cross-disciplinary activities.

The subject areas of the call for projects are described in detail below. The lists of subjects are given for information only and are in no way restrictive.

SUBJECT AREA 1: HYDROGEN PRODUCTION

The subject area devoted to hydrogen production can be divided into four topics:

- high temperature water electrolysis for low cost, centralised hydrogen production, where heat may eventually be provided by high-temperature nuclear reactors, solar concentration systems or geothermic sources;
- low temperature water electrolysis for decentralised hydrogen production, using renewable energy sources at isolated sites;
- on-board hydrogen production;
- hydrogen production by photoelectrolysis.

Package 1.1: Production by high temperature water electrolysis

This package focuses on innovative research that will help improve the technical performance and cost-effectiveness of high temperature electrolysers, particularly with the

[1] http://www.fz-juelich.de/ptj/home

aim to work at intermediate temperatures (500-700°C). Developments are expected in the areas of components, cells and stacks. The solutions proposed should take account, from the design stage, of any requirements related to industrialisation (feasibility, costs, etc.).

This package includes the following areas of research:

- developing conductive ceramics for electrolytes and electrodes that meet specifications for industrial fuel cells (ionic conductivity of around 10^{-2} S/cm, electronic conductivity above 100 S/cm, thermomechanical resistance and chemical stability, etc.); this research is aimed at developing anionic conductors working in a 600-800 °C temperature range, together with proton conductors working at 500-600 °C;
- developing of ground-breaking materials manufacturing and shaping procedures (electrolytes, electrodes, electrolyte-electrodes assemblies, interconnectors);
- designing and manufacturing stacks of various power levels (from a hundred or so watts to several dozen kilowatts) based on innovative architectures;
- understanding the mechanisms involved in electrolyser operation, where models validated by experience will help to define the relative importance of physical parameters;
- studying the behaviour of electrolyser materials in the presence of hydrogen, oxygen and water vapour at high temperature and studying the ageing process.

Package 1.2: Production by low temperature water electrolysis in combination with renewable energy sources

This package focuses on the development of processes and technologies and system integration for supplying electricity to remote sites using intermittent renewable energy sources (wind, photovoltaic, etc.), in conjunction with the decentralised production of hydrogen by low temperature electrolysis (PEM or alkaline), hydrogen storage and hydrogen conversion in a fuel cell.

This involves optimising the entire system to increase efficiency, reduce costs and adapt systems to the conditions relating to primary sources and electricity supply.

This package includes the following areas of research:

- R&D in technological innovation, aimed in particular at improving low temperature PEM electrolysers in terms of compactness, energy efficiency, operating parameters (temperature, pressure) and cost
- system design and modelling integrating the combination of an intermittent means of energy production, storage solutions and exporting surplus output to the grid via power fuel cells
- a comparative study of PEM electrolysers and alkaline electrolysers
- experiments in the field, leading to technical and financial validation of solutions, where the technologies developed are sufficiently mature.

Package 1.3: On-board hydrogen production

This package aims to develop compact hydrogen generators used for on-board production - regarded as a step forward in the development of the fuel-cell vehicle market, pending the arrival of economic on-board hydrogen storage solutions. Generators that only use biofuels (such as ethanol), and covered by research packages in 2008 call for projects under the ANR "Bioénergie" programme, are excluded from this call for projects.

This package includes the following areas of research:

- innovative solutions for controlling the quality of hydrogen production to authorise use with fuel cells
- modelling and experiments
- optimisation of integration and overall efficiency of the system.

Package 1.4: Production by photoelectrolysis

The purpose of this package is to analyse the potential low temperature water photoelectrolysis used to produce hydrogen by direct solar illumination of aqueous solutions using photoelectrochemical cells (PEC) in the presence of catalysts which are complex and costly at present (transition metal-oxide and rare-earth-oxide, noble metals, nanoparticle catalysts).

This package includes the following areas of research:

- development of various components: catalysts, semi conductors, etc.
- developing cell manufactoring processes
- quantifying hydrogen production, studying problems relating to corrosion and changes to surface properties of the electrodes.

SUBJECT AREA 2: HYDROGEN SUPPLY

The subject area devoted to hydrogen supply can be divided into four topics

- hydrogen supply logistics (package 2.1)
- high-capacity hydrogen storage facilities connected to the grid (package 2.2)
- very high-pressure gas storage (package 2.3)
- solid storage (package 2.4).

Packages 2.3 and 2.4 concern all mobile, stationary and portable applications, which may be combined with different storage solutions. Research into storage tanks must meet industry specifications (storage capacities, costs, filling time, operating temperature, rate, cycle performance, ease of integration, recycling, etc.). The aim is to increase volume energy density by making more compact tanks and to obtain higher energy density per unit mass by reducing the weight of tanks in relation to the quantity of hydrogen stored. The storage system must also guarantee high safety levels during normal hydrogen filling and extracting operations, as well as in accident situations, to overcome the risk of ignition and explosion.

Package 2.1: Package 2.1: Hydrogen supply logistics

The purpose of this package is to determine the best hydrogen supply solutions. One approach would be to deploy the necessary infrastructures to supply gaseous hydrogen through pipelines. Supply by tanker trucks is part of package 2.3. New networks intended to transport hydrogen raise the problem of the investment cost per kilometre of transported energy. For existing networks, the issues include making the necessary technical adaptations to allow some hydrogen to be introduced into the system or to substitute it for natural gas. The package concerns transport networks (high pressure, steel piping), the distribution network (low pressure, steel or polymer piping), equipment such as compressors, pressure reducers, flowmeters, etc., as well as all the various aspects of supply logistics.

This package includes the following areas of research:

- developing hydrogen-dedicated infrastructures
- conducting research to identify materials with properties offering the best possible resistance to hydrogen diffusion. These solutions should take into account implementation, functionalities (connections, branch lines), lifetime and cost requirements
- developing equipment for the supply logistics
- studying approaches to make the necessary technical adaptations to existing networks.

Package 2.2: High-capacity storage facilities connected to the grid

This package focuses on high-capacity hydrogen storage systems designed for coupling intermittent energy sources to power grids. It concerns buffer storage tanks, with particular emphasis on their volume and durability. It also concerns underground tanks built in geological formations, with a capacity of several tens of thousands of Nm^3.

This package includes the following areas of research:

- research into high-capacity tanks (shapes, materials such as high-performance fibre glass, etc.)
- analysing materials (compatibility with hydrogen, safety, ageing, fatigue)
- carrying out feasibility studies and examining processes relating to underground hydrogen storage
- designing solutions adapted to various scenarios representing the regulation of power grids connected to intermittent energy sources
- studying the above solutions from the technical and economic viewpoints.

Package 2.3: Storage as a gas at very high pressure

This package focuses on storage tanks pressurised to at least 350 bar and the related components (valves, pressure reducers, safety valves, connectors) intended for on-board use (on cars) or for transport by trucks (supply logistics). The aim is to overcome the technological hurdles in this area: overall dimensions of the system, safety, lifetime, availability of components and cost.

This package includes the following areas of research:

- the behaviour of high-pressure tanks under operating conditions and obtaining fresh insight into long-term damage to the materials used to make the tank (liner, composite and interface between liner and composite). This work includes sizing the tank and determining the safety factor and predicted lifetime
- composite materials (new fibres, manufacturing processes, quantities of fibres) to make tanks more compact and less expensive
- new tank designs, introducing the notion of in-service integrity monitoring through the use of built-in sensors or alarms or through periodic testing of control tanks
- hybrid cryo-compressed storage concept which could overcome problems of cost and size. This concept involves finding the optimum pressure and temperature level to define a storage system tailored to the exact requirements of various applications. The gas is maintained cooled when the tank is at full capacity and as soon as the level drops, the system switches back to standard compression mode. Theoretically, this dual operating mode could make it possible to store up to 50% more hydrogen in terms of weight for an almost equal volume. A great deal of research work has been devoted to this concept in the United States over the past two years
- developing high-pressure components that meet specific needs in terms of compactness, lifetime and cost
- studying system safety, especially the tank's behaviour in the event of fire, and investigating possible protective measures against explosion.

Package 2.4: Solid storage

This package focuses on developing a hydrogen storage system based on the reversible absorption or adsorption of large quantities of hydrogen under moderate temperature and pressure conditions. The materials concerned either work by chemical absorption, as is the case for metal and complex hydrides; others, such as porous and nanostructured materials, by physical adsorption. Their properties must meet the specifications of various portable, mobile and stationary applications, including truck-mounted supply tanks.

The performance of these materials in terms of capacity by weight and/or volume must take scale effects into account and meet realistic specifications with regard to manufacturing, implementation and operation (thermodynamic condition, absorption (adsorption) and desorption kinetics, lifetime) at reasonable costs.

This package includes the following areas of research:

- developing innovative materials suitable for storing hydrogen and for its release. Storage and release kinetics must make allowance for problems relating to thermal effects and heat transfer
- optimising storage systems according to the application, adopting an overall approach (covering tank design and auxiliary equipment).

The ultimate goal is not to make these various systems compete against one another, but to identify specific markets based on performance/cost ratio and conditions of use.

Subject area 3: Fuel cell systems;

This subject area deals with expertise in and development of all the different parts of fuel cell systems. The applications targeted are transport, stationary and portable applications. It includes three packages:

- "Polymer exchange membrane fuel cells" (PEMFC) (package 3.1)
- "Solid oxide fuel cells" (SOFC) (package 3.2)
- "Proton ceramic fuel cells" (PCFC) (package 3.3).

The general objectives are to improve performance of different fuel cells, to extend the lifetime of fuel cell systems and reduce costs. Expectations are high for work concerning how fuel cells operate at medium and high temperatures, and for studies into recycling and lifecycle analyses.

Package 3.1: "Polymer exchange membrane fuel cells" (PEMFC)

Package 3.1.1: Membrane-electrode assemblies (MEAs)

This package includes the following areas of research:

- understanding of the different mechanisms that limit the durability of MEAs and proposals for improvements
- developing new polymer membranes for operation at higher temperatures (around 120 °C)
- developing new catalysts and new catalyst layer manufacturing processes to reduce platinum content (< 0.1 mg Pt/cm^2 in liaison with studies on aging.

Projects that incorporate the development of architecture, materials and MEA fabrication processes should validate expected performances through experimentation.

Package 3.1.2: Fuel cell system auxiliaries

The overall efficiency of the fuel cell system, its reliability and cost are currently hindered by the use of non-optimised auxiliary devices (air compressor, pressure regulators, humidifiers, cooling units, etc.).

Based on analysis of the different components that already exist, the research projects proposed should make a contribution toward sizing, developing and qualifying specific "fuel cell system" auxiliaries, aimed at high power applications (>10 kW) for which present solutions are unsuitable, and to assess their effect on the degradation of the system's performance.

Package 3.1.3: Fuel cell assessment and inspection

This package groups together the following areas of research:

- studying the impact of parameters and the fuel cell environmental data on its behaviour
- studying failure modes
- developing reliable assessment methods using specially designed sensors, making it possible to minimise instrumentation, for monitoring, regulating and doing maintenance work on the fuel cell.

Package 3.1.4: System design, construction and experimentation

This package concerns prototype design and development, along with integration and experimentation.

This package includes the following areas of research:

- developing architectures (fuel cell and system) integrated and optimised in terms of fluidic, thermal, electrical and energy management
- carrying out experiments in the laboratory to validate prototypes and develop test protocols to qualify components
- carrying out experiments in the field on full-scale objects, to obtain feedback on the technological and operational aspects of technology solutions based on fuel cell systems.

Package 3.2: "Solid oxide fuel cells" (SOFC)

This package supports the development of SOFC technology by stimulating efforts to lower the operating temperature and design a cell core architecture that limits mechanical stress.

SOFC technology offers some appreciable advantages that give it a competitive edge over PEMFC technology for stationary applications (micro-cogeneration, industrial cogeneration or decentralised electrical power generation).

- high electrical efficiency, up to 60%
- quality of heat available at high temperature for cogeneration and trigeneration applications
- fuel flexibility: natural gas, synthetic gas (H_2 + CO) from biomass, biogas (CH_4 + CO_2), vegetable oil, etc.
- internal reforming, making for a less complex system.

For transport applications (aeronautics, maritime, heavy land transport), SOFC also has much to offer for power auxiliary devices as it can adapt to current fuels after reforming.

However, the development of this technology is hindered by its performance at high temperature, where its components are rapidly degraded. Additional problems are its limited thermal cycling and slow startup and the cost of materials, manufacturing and shaping.

Package 3.2.1: Cell and electrode materials and cell design

Subjects in this package include

- the development of cell core materials for applications at intermediate temperatures (< 750 °C) and with an optimised coefficient of thermal expansion. Special attention shall be given to anode materials capable of withstanding the redox cycles, cathodes with improved electro-catalytic properties, interconnection plates and seals
- the design of architectures aimed at limiting mechanical stress and efforts to achieve higher performance manufacturing processes.

Package 3.2.2: Fuel cell system auxiliaries

This package concerns the development or qualification of SOFC system auxiliary devices: heat exchangers, circulators, air compressors, etc.

Package 3.2.3: System design, construction and experimentation

Subjects in this package include:

- developing the system architecture around SOFCs for a number of particular applications (such as auxiliary power units for transport applications, micro-cogeneration and cogeneration combined with a gas turbine or biomass gasification system)
- prototype work and experimentation on this type of system.

Package 3.3: "Proton ceramic fuel cells" (PCFC)

An innovative avenue for future development is the proton conductive ceramic membrane fuel cell (PCFC), which works within an intermediate range of temperatures (400-600°C). This area of research has yet to be explored in any depth and the development of ceramic materials likely to be good proton conductors at 400-600°C. °C, together with the construction of cells and then stacks constitute real technological breakthroughs.

This package aims to

- develop new PCFC materials (electrolyte, electrodes) to construct a fuel cell core operating with a temperature range of 400-600°C
- suggest examples of assembly technologies.

The conductivity and thickness of the materials proposed should make it possible to manufacture fuel cells with mass power density and power density per unit volume of 1 kW/kg and 1 kW/l, together with an operating lifetime that is compatible with the targeted applications.

SUBJECT AREA 4: CROSS-DISCIPLINARY ACTIVITIES.

The cross-disciplinary activity programme relating to the use of hydrogen as an energy carrier is divided into two packages:

- Technical-economic studies (package 4.1)
- Social acceptability, safety and regulations (package 4.2).

Package 4.1: Technical-economic studies

Technical-economic studies in this call for projects are intended to guide design choices for various production technologies and hydrogen transport, distribution and storage systems with a view to optimising hydrogen deployment.

This package includes the following areas of research:

- analyse of the economic costs of energy services according to the primary energy sources used, conversion efficiency, transport and distribution networks, on-board or local storage facilities, fuel cell performance in technical and economic terms, etc. They should result in technological forecasts based on quantitative elements

- studies to test the viability of the technological concerned and their impact in France and Europe from a macro-economic perspective. This work will draw on the conclusions of the "HyWays" project (development of the European technical- and socio-economic roadmap for the use of hydrogen as an energy carrier)

- carrying out lifecycle analyses (ACV) of the energy chain, from the primary hydrogen source up to the final application concerned. This type of analysis may cover issues relating to primary energy sources, whether renewable, nuclear or fossil, such as greenhouse gas emissions, nuclear waste disposal or limits to material resources.

Package 4.2: Social acceptability, safety and regulations

Areas where the issue of the social acceptability of hydrogen technology is raised should be highlighted.

This package includes the following areas of research:

- stationary uses, based on assessment of current practices, the regulatory background, the probabilities of damage resulting from the use of hydrogen as an energy carrier, compared with other generally accepted energy vectors
- mobile applications based on a forward-looking analysis of its use in transport systems of the future, focusing on what will probably represent the first breakthroughs in hydrogen fuel, namely its use in urban and peri-urban public transport
- analysing risks of leakage and explosion and carrying out experiments and computer simulations of the various mechanisms involved

- preparing and proposing a roadmap relating to changes in regulations concerning the storage and use of hydrogen, in particular in France. This work will be based on existing regulations in other countries as well as ongoing international studies.

Collaboration between technological and socio-economic research teams is strongly recommended.

3. SUBMISSION PROCEDURE FOR FRENCH-GERMAN PROJECTS

In the case of joint French and German submission, applicants should use the following procedure:

- The co-applicants will designate one national coordinator per country and one single project leader from among them.
- Proposals should be submitted in English by the national coordinator in each country (to ANR in France and to PtJ in Germany).
- The proposals must have well-identified collaboration demonstrating clearly the added value of transnational collaboration.
- Proposals should be submitted using the relevant forms for each country and according to the rules and such closing dates as ruled out in each country.
- It is the responsibility of each project partner to ensure the efficient protection and proper distribution of any intellectual property arising from the accomplishment of the joint research projects.
- French-German projects should belong to the « industrial research[2]. » category and include in the partnership at least one German and one French industrial partner.

The selection process of French-German projects will be conducted in two steps:

a) In a first step, ANR and PtJ will separately examine the proposals according to their own evaluation procedures. The projects submitted to ANR will be evaluated according to the same procedure and same criteria as the other projects submitted to this call.

b) In a second step, ANR and PtJ will decide jointly the list of French-German projects to be funded, among those listed in the main list and complementary list of selected projects for the ANR 2008 PANH call.

[2] *Cf. EU Official Journal 30/12/2006 C323/9-10 (http://www.agence-nationale recherche.fr/documents/uploaded/2007/encadrement.pdf)*

4. CONTACTS

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