The HYCHAIN MINI-TRANS Project
Deployment of fuel cell and hydrogen infrastructure for early markets

Introduction
Urban transport demand is continuously increasing worldwide and according to the European Commission, it is responsible for 40%\(^1\) of carbon dioxide emission from road transportation thus having a negative effect on climate change, furthermore, urban transport is nearly 95% dependant on fossil fuels thus putting pressure on energy supply.

To respond to these issues, two of the top priorities of the European Commission energy policy are finding sustainable solutions to:

1. Global warming as a result of green house gases produced from the use of fossil fuels
2. Dependence on imported fossil fuels and diversification of energy sources

Locally, urban transport is a key element of our modern life as it affects our well being in many aspects, in particular with regards to increased traffic and urban congestion, which causes air and noise pollution and accidents.

In addition there are other pollutants with a negative impact on the health of town and city inhabitants, such as nitrogen oxides and small particles, causing peaks in ozone levels and other respiratory problems particularly in children, elderly and the ill.

Over the past decade, the use of hydrogen as an energy carrier combined with fuel cells has emerged as a strong potential solution to respond to these major environmental and energy issues.

The HYCHAIN MINI-TRANS project focuses on small urban vehicles to provide a user friendly environmentally clean intramodal and urban transport alternative such as fuel cell tricycles and scooters that will provide a clean and noiseless alternative to two stroke engines. The demonstrators in the project will increase the operating range and decrease dramatically the time of recharge of electrical vehicles thus improving significantly the attractiveness of the use of this type of vehicle, for example in the case of wheelchairs this will translate in an improvement of the quality of life of the end user.

The project consists in the deployment of a number of small fuel cell hybrid vehicle fleets with the accompanying hydrogen refuelling in the four regions in Europe:

- France- Grenoble / Rhone Alps
- Italy – Modena / Emilia Romagna
- Spain - Soria / Castilla y Leon
- Germany – Emscher Lippe/ North Rhine Westphalia

\(^1\) White Paper of the European Commission, “ European Transport Policy for 2010: time to decide”

05/05/2006
The fleets are based on similar modular technology platforms in a variety of applications to achieve a significant enough volume of vehicles at least 158, to justify a pre-industrial approach, lower costs and overcome major cross cutting barriers. Addressing early adopters for transport, the project will initiate the first sustainable business case for hydrogen-based fuel cells in Europe where it will have the best chances to continue and grow beyond this project.

The project will be implemented on a four-step approach; (1) Optimize in design and functionality existing prototypes of low power fuel cell applications. (2) Set up pre-industrial manufacturing facilities to reduce costs as well as to improve quality. (3) Establish the required hydrogen distribution logistics and services (transport, distribution, dispensing) based on an even exchange of innovative refillable storage solution. (4) Implement in the four regions a network of comparable subprojects using the common demonstration vehicles. Thus, this deployment will enable a large and wide variety of end users to be attained in a cost effective way, providing favorable conditions for achieving a significant reduction both in manufacturing and operating costs.

Technical deployment will be complemented by socio-economic research targeted at increasing public awareness and overcoming the main current barriers, such as misperception of the technology that leads to poor public acceptance, lack of certification, training, etc. Dissemination and exploitation activities provide the framework for maintaining the momentum and triggering a sustainable market growth in several lines of applications.

Project Description

Up to 158 small hydrogen powered fuel cell vehicles will be deployed in several captive fleets with a variety of power ranges, there will be five types of vehicles supplied with fuel cells by 4 different manufacturers:

- Wheelchairs (34) integrated in Spain and powered by a 500 watts Axane fuel cell
- Scooters Derby (40) integrated in Spain and powered by a 1 kW MES-DEA fuel cell
- Mini buses (10) integrated in Germany and powered by a 10 kW Enkat, Hydrogenics fuel cell
- Tricycles (40) integrated in Germany and powered by a 250 watts Masterflex fuel cell
- Light utility vehicles, VEM (40) integrated in Italy and powered by a 2,5 kW Axane fuel cell.

Air Liquide and its subsidiaries in each respective country will provide the hydrogen logistics for all vehicles covering the whole Hydrogen supply chain (storage, transport, distribution and dispensing) to final users to demonstrate the technical and economic feasibility of using hydrogen as an alternative fuel.

Except for the mini buses, all vehicles will use the innovative even exchange «Clip On» concept, to be developed by Air Liquide consisting of exchangeable hydrogen cartridges that are easily and safely handled for 300 (900, 20 L Bottles) and 700 bars (1120, 2 L cartridges). This will provide a significant number of refill storage units (2000) using this innovative high-pressure gaseous hydrogen technology, to obtain a representative sample and achieve a critical mass sufficient to seed an early market.

The overall project budget is 37,6 M€ and is co-financed by the partners and the DG TREN of the European Commission with a grant of 17 M€.
The project will last 5 years and it will be executed in two phases:
1). Design and manufacturing of equipment during the first two years
2). Deployment and operation during the last three years.

**Project Objectives**

The key objectives of the project are to:

- Develop industrialized fuel cell power modules that can be deployed and guaranteed to the end user.
- Create and implement a European network of hydrogen vehicle users that can be later expanded to other regions in Europe and the world.
- Demonstrate and obtain operational feedback of 158 fuel cell hydrogen low powered vehicles.
- Validate a hydrogen-fuelling infrastructure based on an even exchange principle supported by the existing industrial hydrogen logistics.
- Reduce fuel cell costs manufacturing by attaining a critical mass to allow pre industrialization of a small series of units.
- Kick start a first business model with the financial participation of the end users from the local communities, through a contribution for the use of the vehicles and the consumption of hydrogen as a fuel.
- Demonstrate support services for maintenance and operation.
- Provide training to end users, maintenance and general public.
- Obtain European certification of small fuel cell powered vehicles.

**Enhancing the competitiveness of European industry**

Based on commercially viable niche markets, the project will contribute to the subsequent scale-up of fuel cell systems to increased power applications as this project will address the need to develop suitable prototypes for mass production as well as establishing the foundations for later industrialization.

The proposed deployment of large fleets of vehicles will allow European designers and manufacturers to achieve an advantageous market position, to optimize their products and to lower costs, thus reinforcing European competitiveness and taking a leading position in the future hydrogen economy.

**Enhancement of the state of the art**

This project will complement other EC financed projects such as CUTE, Hylights, ZERO REGIO and PREMIA, Hychain as it will work together with these other EC projects as an integrated demonstration program.

Focusing on selected niche applications for small electric hybrid vehicles, HYCHAIN MINI-TRANS will provide the ground work for a cascade effect in terms of commercialization, to take the still prevailing State of the Art from rather isolated R&D and pilot projects to a new

05/05/2006
dimension of interconnected market solutions with the best prospects of remaining and developing beyond the HYCHAIN MINI-TRANS project.

The HYCHAIN MINI-TRANS addresses the market of small electrical hybrid vehicles, where available fuel cell technology and innovative hydrogen storage solution advantageously complement electric batteries for significantly increasing autonomy, typically from a 60 km range up to 200 km depending on the vehicle. Moreover, restoring full energy load is conveniently performed within minutes by simple replacement of the empty hydrogen cartridges by full ones. Sequential discharge of the multiple cartridges set allows full use of all the hydrogen on-board. Performance is maintained at rated value regardless of the hydrogen content of the canisters, and ambient temperature conditions.

The HYCHAIN MINI-TRANS project will serve to promote the social acceptance of the use of hydrogen for transportation, through the demonstration of vehicle safety and reliability by obtaining the required certification and standardization of these products.

This collaboration will continue in the field of hydrogen and fuel cells as HYCHAIN MINI-TRANS is one of the first project undertaken within the frame of to a community-wide cooperation to be known as the HYCHAIN initiative bringing together the major players at all levels in a network for future growth.

Innovation-related activities, including exploitation and dissemination

The core tasks of technology development and demonstration provides the basic structure for a strategic development of early markets in Europe, however in order to take benefit from the common technology platforms deployed within the HYCHAIN MINI-TRANS framework, the following complementing innovation activities will be carried out.

- Organizing and ensuring a commercial exploitation of achievements based on intellectual property right protection.
- Spreading information and knowledge generated during the HYCHAIN MINI-TRANS project across Europe and other regions in the world, such as North America, Asia and India, in order to trigger further actions in the field of early Fuel Cell /Hydrogen markets.
- In close cooperation with the PREMIA project, performing technical, economic and environmental assessments of HYCHAIN MINI-TRANS technologies under real-world conditions, to improve or to adapt products.
- Analyzing perspectives for market growth and large-scale deployment of small scale transport applications and foreseeable energy system implications.
- Maintaining, enlarging and adapting appropriate hydrogen infrastructures and logistics to materialize HYCHAIN MINI-TRANS market networks as nuclei for future EU lighthouse activities and evolving hydrogen markets in Europe.
- Exploiting technological advances as a result of market consolidation and enlargement.
- Strengthening the role of the political framework on regional, national and European level to enhance a solid deployment case for early niche markets.
Homologation

One of the most important issues to ensure that society accepts the hydrogen and fuel cells technologies is to guarantee that there is a body of regulations and standards guaranteeing a legal, safe and friendly utilization.

The key challenge for the project will be to obtain European certification to operate the vehicles on the public road since today no European legislation exists for this purpose.

The key objectives of the project will be to analyses all the risks regarding the use of hydrogen and fuel cells in small vehicle applications, define all the actions necessary to ensure that all the steps are taken to mitigate any potential risk so that all the activities are performed in a safe manner, and define the process to obtain the necessary homologation and regulatory framework required so as to obtain the certification approvals for all the vehicles to operate in public roads in all 4 countries.

Early Markets deployment

The HYCHAIN MINI-TRANS project will contribute to the introduction of an early hydrogen-based fuel cell market at European level. This contribution is based on the development, the deployment and promotion of European low-power fuel cells as new means of propulsion for light transport applications using hydrogen as an alternative motor fuel and addressing early adopters. Within the project, first proven products (fuel cell vehicles such as utility vehicles, scooters, tricycles and midi-buses) will be developed, manufactured and tested in a very cost efficient way. The project will establish a sustainable early market for hydrogen based fuel cells in Europe and extend the use of these applications beyond the end of this project to this purpose the project will bring about the introduction of a significant number of vehicles based on a common technology platform maximizing potential technical synergies across the four European regions so as to achieve a minimum critical mass to obtain a manufacturing volume sufficient to justify an industrial approach which will lead to a cost decrease and the overcoming of the major technical barriers to fuel cell technology.

Target end users will be municipalities and city services where the fleets can be operated in a controlled environment.

Research activities

Research activities will focus on 700 bar replaceable storage units for lightweight pressure regulators and “clip on” easy use connective systems, and on process and materials issues associated with the development of an optimized 500 W fuel cell module.

The Hychain Partners

The project consortium consists of a total of 24 partners coordinated by Air Liquide SA, with regional coordinators in each country:

- Germany: The NRW Fuel Cell and Hydrogen Network.
- Spain: Besel who is also the administrative coordinator for the project.
- Italy: Air Liquide Italy.
- France: Axane.

Regional and/or local administrations of the 4 regions actively participate in the project;

05/05/2006
• Germany: The cities of Marl, Gladbeck, Essen, Bottrop and the Emscher-Lippe and the NRW ministry of Energy
• France: The Grenoble Metro, the Isere Dept. and the Rhone-Alps region
• Spain: The city of Soria and the region of Castilla y Leon
• Italy: The city of Modena and the Emilia Romagna region

The project consortium consists of:

1. **Fuel cell developers**
   There are four different fuel cell companies each bringing their own expertise; the diversity of approaches, brought to bear on any problem, gives rise to insightful solutions.
   - AXANE (F)
   - MASTERFLEX (D)
   - PAXITECH (F)
   - ENKAT (D)

2. **Hydrogen logistics**
   The worlds leading company in industrial gases, active in hydrogen logistics, distribution and research in storage.
   - AIR LIQUIDE SA and its subsidiaries in Spain, Italy and Germany.

3. **Small vehicle developers**
   Major European low power vehicle manufacturers and engineering companies with significant expertise in power module integration.
   - RUCKER (E)
   - DERBI (E)
   - VEM (I)
   - BESEL (E)

4. **Consulting companies and engineering companies** (strategy, management, coordination, monitoring and assessment)
   - BESEL (E)
   - ASCOPARG (F)
   - INERIS (F)
   - WIN (D)
   - DEMOCENTER (I)
   - IBERDROLA, Energy utility (E)

5. **Leading academic and scientific institutions**
   - Wuppertal Institute (D)
   - Universidad de San Pablo CEU (E)
   - Institut National Polytechnique de Grenoble, INPG (F)
All of the partners bring their know-how and skills to the project complementing each other to integrate all the components for complete hydrogen fuel cell transportation systems. In particular, Air Liquide, as the specialist in industrial gas distribution, provides the common nexus through its activity in all four regions and ensures a homogeneous approach to hydrogen distribution and logistics.

The Commission last December has officially signed the project contract and all partners have signed a Consortium Agreement stipulating the management of the Consortium. The launching ceremony took in Brussels, January 31\textsuperscript{st} 2006 and the official start up date was January 15\textsuperscript{th} 2006.