The European Hydrogen and Fuel Cell Technology Platform

**ADVISORY COUNCIL**

# Hydrogen and Fuel Cells Education and Training Programme

**INITIATIVE GROUP OF EDUCATION AND TRAINING**

**FINAL VERSION - 6 September 2005 -**

## *1* Executive Summary

This *Education and Training Programme (ETP)* is part of the activities of the *European Hydrogen and Fuel Cell Technology Platform (HFP),* which was initiated by the European Commission, as recommended by the *High Level Group*, with the aim of bringing hydrogen and fuel cells to the market exploiting their outstanding environmental and economic potential. The *Initiative Group Education and Training* (IG E&T) was created by the *Advisory Council* (AC) of the HFP in 2004 t o develop the ETP to ensure that hydrogen and fuel cell technologies are integrated in the curriculum of Europe's educational system to facilitate market introduction and a role of market leader for Europe's industry and research institutes.

Green house gas emissions and energy security are major issues besides local emissions and economic considerations as outlined in the Final Report of the High Level Group. The Report provides a coherent strategy on hydrogen and fuel cells. Main pillars of this strategy are the *Strategic Research Agenda (SRA)* and the *Deployment Strategy (DS)*, which are worked out already in the framework of the HFP. Human capital in educational institutions with high-level knowledge of the hydrogen and fuel cell area spanning form primary schooling to world-class research, is paramount to facilitate a smooth execution of both strategies.

Educators understanding Hydrogen and Fuel Cell (H2&FC) technologies are required in schools, universities, research centres, trade, industry, state and local governments. These communities are the main addressees of the ETP.

The ETP is designed to provide guidance for H2&FC education and training measures for the different above-mentioned addressees in order to train and educate people with H2&FC knowledge designed for the different levels, to help establish a H2&FC market to ensure that European competencies are at the forefront of science & technology worldwide. The IG E&T suggests a strong collaboration with existing clean energy education activities to use their networks with local and national authorities and to strengthen the effort of increasing the presence in educational institutions of clean energy in general and to speed up the curriculum integration process for hydrogen and fuel cell topics.

A European H2&FC Education and Training Coordination Unit for all 6 addresses (HYFED6) has to be established to ensure continuity and coordinated activities.

The ETP takes into account the imminent FP7. Therefore the ETP will cover especially the period until 2013, i.e. until the end of the FP 7 in detail.

The ETP in the field of hydrogen and fuel cell technology is broken down into four sub-programmes: schools, academia&research, trade&industry, and government. For these four areas of education and training specific targets and pathways to

achieve those targets have been formulated, by dedicated *working groups* (WG) in the IG E&T.

***Schools***

Energy education, teaching students from elementary and secondary schools about the use of energy, is not part of European national school curricula. Knowledge about the efficient use of energy, clean energy sources and future energy resource solutions of elementary and secondary level students in the schools of Europe depends on the interest and initiative of individual teachers. To facilitate the national curriculum integration of hydrogen and fuel cell topics in all EU member states the following tasks are recommended:

- Establishment of a strong European H2&FC Education and Training Coordination Unit (HYFED6) to coordinate the different components of the European School Strategy on European and national levels: curriculum integration, permanent exhibitions in science museums and database of educational materials
- Active collaboration with HFP Mirror Group members to facilitate quick uptake of national curriculum integration procedures
- Creation of network of national coordinators in all EU member states based at local institutions involved in environmental education to facilitate national curriculum integration process
- Development of network of interested industry partners to sponsor permanent exhibitions and activities in science museums;
- Establishment of close collaboration with existing networks of science museums to facilitate permanent exhibitions.

***Academia& Research***

Most universities do not offer specialised hydrogen energy and FC courses. A few have started graduate courses on the subject and most of them include hydrogen and FCs as a part of their chemistry, physics or energy engineering curricula. It is a widespread belief that this needs to be changed and hydrogen and fuel cells have to receive more attention at Universities.

The range of Research Institutes under consideration for the enhancement of Hydrogen and FC education is large and varied. Mostly research institutes which are directly involved into the Hydrogen and FC Technology taking care for the education and training of their young and experienced researchers. For an intensive and professional training of researchers in general these research institutes only have insufficient resources.

The following tasks are recommended:

- Establishment of a European H2&FC Education and Training Coordination Unit (HYFED6) to coordinate the different components of the European Academia&Research Strategy on European and national levels and disseminate information on educational material and programmes;
- Forming a H2&FC University and R&D Institute Network to combine and to improve the experiences of the different universities.
- Forming European H2&FC Education and Training Centres at university and R&D Institute levels to give selected members of the *H2&FC University Network* an experimental basic.
- Establishment of a European Virtual H2&FC University based on the *H2&FC University and R&D Institute Network* and *European H2&FC Education and Training Centres.*
- European Young Scientists Competition should be offered awarding a special prize in the area of H2&FCs.
- Training courses for young and high level/experienced researchers in agreement with the demand of the SRA
- Establishment of a high level research oriented European H2&FC conference
- Worldwide dissemination of H2&FC education materials in cooperation with the IPHE, the IEA, the United Nations, and National H2&FC Organizations with special connections to non-European countries.

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***Trade&Industry***

Information on hydrogen and fuel cell technologies is available via the general media as well as specific publications issued from industrial bulletins as well as from trade organisations. Some industrial sectors and trades already have established working groups on hydrogen and fuel cell technology. Information frequently is reproduced from Internet sources and manufacturers brochures if available. Selected technicians in trade have been trained on specific products during the ongoing field tests of automobiles, residential fuel cells and cogeneration units.

Training in trade and industry is extremely dependent on the availability of excellent training materials in all languages spoken in Europe.

The following tasks are recommended:

*Short Term E&T Recommendations*

- Establishment of a European H2&FC Education and Training Coordination Unit (HYFED6)

to coordinate the different components of the European Trade&Industry Strategy on European and national levels and disseminate information on educational material and programmes;

- Internet Portal
  should give access to Information about current demonstrations, reference to Codes and Standards, and Basic distant learning modules. The portal should be tailor-made on the basis of user profiles.
- Written Information adapted from Internet portal
- Information tour through European facilities of vocational training and demonstration centres
- Information trailer demonstrating hydrogen and fuel cell technologies
- Workshops for Builders, Architects and Planners

*Longer Term E&T Recommendations*

- Socio Economic Studies
  A - comparative study on the state of the art of E&T activities summarizing the vocational training systems followed and the qualifications required within Europe.

  B - study on the effects of distant learning in vocational training throughout Europe
- Establishment of a knowledge database
  with information of:
  a - existing codes and standards
  b - best practice and implementation guidelines.
- Definition of a curriculum
  Education and training of people in trade and industry could start by "infiltration" of technical training of advanced technicials in cooperation with the Grundvik and Leonardo program. The curriculum should be specific for industry, trade, builders, planners, and architects.
- Walk in Info Center
  dedicated exhibitions should be available as "Walk in Info Centers".
- Training Centers for vocational training
  Approximately 5-10 vocational training centers focussing on hydrogen and fuel cell technologies should be established throughout Europe.

***Government***

The education and training for decision makers (central and local government employees, regulatory organizations, members of parliament and VIPs on the EU, national, state and local level) will be fundamental in facilitating the development of

hydrogen and fuel cell technologies. The target groups will also include end-users decision makers.

The following tasks are recommended:

- Establishment of a European H2&FC Education and Training Coordination Unit (HYFED6) to coordinate the different components of the European Strategy for Education of government and regulatory bodies on European and national levels.

- Education and training of decision makers In three phases:
  *A - Preparatory phase for the identification of needs and target groups*
  The results of the survey should be a database of potential interested bodies, a priority list of needs of information in the field of hydrogen and fuel cells, and a selection of preferred tools for education and training.

  B - Evaluation phase for developing and testing educational tools for a restricted reference group

  C - Regular phase with annual updates and continuous courses for the defined target groups.

Most important is the formation of an Education and Training Infrastructure to realize these recommendations. For the ***coordination*** of the E&T activities in all fields, an European H2&FC Education and Training Coordination Unit (HYFED6) should be established. This HYFED6 should be responsible for all main tasks (school, academia&research, trade&industry, and government) to create synergies and to reinforce each other.

For the actual ***E&T work***, however, European H2&FC Education and Training Centers (EETCs) are to be formed. These centers should be located in the south, west, north, east and middle of Europe. The EETCs should cover E&T in a greater European region and establish close cooperation with other clean energy educational activitesFurthermore, they should be a nucleous for National H2&FC Education and Training Centers (NETC) to be founded in a later stage.

Very important is to have such a EETC in one or two of the new member states, because in these states the H2&FC knowledge is relatively low. General the new member states should be in the focus of the European H2&FC E&T work.

Both the HYFED6 and the EETCs will be an effective umbrella for all European E&T actions.

The E&T programme activities shall come to an agreement with the Strategic Research Agenda and the Deployment Strategy and with a merged Implementation Panel. Furthermore, a very close cooperation has to take place with the Initiative Group Public Awareness.

The E&T programme presented here is taking into account the already existing national, other European and non-European H2&FC activities in the field of education and training, as from IPHE, IEA, and United Nations. One important current activity is the presentation of Education and Training activities (special section) during the World Hydrogen Energy Conference (WHEC) in Lyon, 2006 together with the IPHE, IEA and the United Nation.

Appropriate funds need to be allocated within current and future framework programs to tackle the issue of education and training as well as public awareness of these new technologies to a level where a successful market introduction can take place.

The ETP is designed for the 7th FP. Therefore most of the support money is to be placed in the 7th FP. In the moment it is very difficult to estimate the total sum to be allocated for education and training activities in the 7th FP, because the details are not clear enough for all WG activities. Nevertheless for a significant part of the measures proposed, approximations are given in the chapters of the WGs dedicated to financing. An indicator for the finacial demand could be the present EC rule to use about 10% of the total RT&D budget of the commission contribution for dissemination and education&training. In the 7th FP two ways of E&T funding are to go:

a- E&T activities should be explicitly integrated into RT&D calls

b- Special E&T activities of Education and Training Program should be funded separately

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The relatively costs distribution for the 4 WGs and the coordination should be as follows:

| | 2007-2010 | 2010-2013 |
|---|---|---|
| WG School | 20 % | 25 % |
| WG Academia&Research | 40 % | 35 % |
| WG Trade&Industry | 27,5 % | 27,5 % |
| WG Government | 10 % | 10 % |
| Coordination | 2,5 % | 2,5 % |

Additionally, funding from DG Education could support the proposed E&T activities. Furthermore, regional and infrastructure funds should be considered. In parallel with the market introduction of the H2&FC technology most of the Trade&Industry E&T activities should became step by step self-financing after an initial financial support by the EU.

For a transitional period of one year till the beginning of the 7th FP, a sum of about 1 Mill EUR should be allocated to summer schools, young scientist award, formation of an European H2&FC Education and Training Coordination Unit (HYFED6), and Education materials. Besides this should be used the still existing EU FP VI funding possibilities like the current TREN IV Call and the upcoming Intelligent Energy Call.

It is very important to continue the already started E&T work and not to wait until the 7th FP, otherwise the ongoing ET activities cannot be sustained.

## 2 Introduction

As recognised in the summary report of the European High Level Group for Hydrogen and Fuel Cells a European-wide education and training programme spanning primary schooling to world-class research needs to be developed.

The Deployment Strategy Report from the European Hydrogen and Fuel Cell Technology Platform states that the education process is a key factor for the management of large socio-economic and technological changes. The report urges particular attention from the political level to the priorities of the educational programmes in order to increase the capacity of the education system to respond, in an adequate and timely way, to the new challenges.

Also the Strategic Research Agenda argues that future research into the R&D needs of hydrogen must elucidate the best system for efficient use of resources, e.g. by avoiding duplication and by allowing a steady stream of trained scientists and technicians to develop the area. A proposed European Research Area Network on Hydrogen and Fuel Cell research could become the channel for these efforts. In this context, socio-economic research should deepen the understanding on the appropriate design and effective implementation of research and technology policies“.

To realize these tasks the Advisory Council of the European and Fuel Cell Technology Platform has initiated the Initiative Group Education and Training.

The Initiative Group Education and Training was established with a kick-off meeting on July 19, 2004. At the beginning the work was started with the working groups Academia&Research and Trade&Industry and at the end of 2004 the working groups School and Government were founded. These four working groups have worked out specific tasks for relevant education and training actions, which are the basics for an education and training program.

This report covers European-wide Education and Training Programme on different levels in order to increase the H2&FC knowledge in schools, universities of applied science, universities, research centres, trade, industry, state and local governments.

Appropriate funds need to be allocated within future framework programs to tackle the issue of education and training as well as public awareness of these new technologies to a level where a successful market introduction can take place. Close collaboration should be sought with existing clean energy educational activities to use their well-established networks of contacts at different governmental levels and to integrate clean energy topics in national curriculum.

## 3 Assessment of E&T

The Education and Training Programme (ETP) in general should help to bring hydrogen and fuel cells to the market - exploiting their outstanding environmental and economical potential. In more specific terms, the Education and Training Programme provides an outline to stimulate a broad European education and training spanning primary schooling to world-class research.

This programme should be guidance for necessary education and training actions in Europe. The ETP describes realistic and inspirational ways for education and training on different levels and for different addressees.

The programme include the most important areas for education and training:

- School
- Academia&research
- Trade&industry
- Government

The programme will cover the period until 2013, i.e. until the end of the FP 7 (2007-2013) in detail. This document, however, is a living document. Milestones and new areas shall be added as they emerge and parts of the documents periodically refreshed whenever changes in the development of FC and Hydrogen required this.
The E&T programme activities shall come to an agreement with the Strategic Research Agenda and the Deployment Strategy and with a merged Implementation Panel. Furthermore, a very close cooperation has to take place with the Initiative Group Public Awareness.

Further steps will be necessary to meet the 2020 milestone set by the DS. It is of prime importance that E&T will have sufficient impact and lead time to successfully precede and accompany the different steps of market introduction.

The E&T programme presented here is taking the already existing national, other European and non-European activities in the field of education and training, as well as the World IPHE activities into account.
A very important aspect in E&T will be the intimate inking of E&T aspects into the upcoming R&D projects in Hydrogen and Fuel Cell Technology.

## 3.1 Schools

### 3.1.1 General

Energy education, teaching students have elementary and secondary schools about the use of energy, is not part of European national school curricula. Knowledge about the efficient use of energy, clean energy sources and future energy resource solutions of elementary and secondary level students in the schools of Europe depends on the interest and initiative of individual teachers.

On February 24, 2005 the United Nations Educational, Scientific and Cultural Organisation (UNESCO) launched the Decade of Education for Sustainable Development (DESD) that will run from 2005 till 2014. The DESD is a new United Nations (UN) scheme that puts education at the heart of sustainable development and encourages governments worldwide to integrate this important issue into mainstream school curricula.

In order to ensure that knowledge about energy and in particular of hydrogen and fuel cells is included in national school curricula the WG Schools has teamed up with existing energy education initiatives to ensure that the use of hydrogen and fuel cells is presented as part of a sustainable energy system to European school children in all great levels. A European H2&FC Education and Training Coordination Unit (HYFED6) will coordinate the different components of the strategy

Eight year-old fourth graders will be choosing their first car in ten years time, just when the automobile industry is planning the first phase of mass production. Introducing the concept of clean energy alternatives and creating awareness of the role of hydrogen and fuel cells in a sustainable energy future to facilitate educated choices is the main goal of the WG School.

### 3.1.2 State of the Art

A variety of European and national environmental organisations include energy topics in their programmes for schools. Hydrogen and Fuel Cell topics are only rarely included.

*The European Sustainable Energy Education Forum (ESEEF)* represents local and national organisations involved in energy education in schools. They established a European database that includes educational material and programmes on energy in different languages. Hydrogen and fuel cell materials is lacking in this database.

*Eco-Schools* is an example of an umbrella non-profit organisation that provides incentives to a wide range of stakeholders for practical environmental education policies. The initiative began as a EU pilot, which now works in 35 countries, providing a policy instrument for policy implementation in Europe through curriculum integration and extra-curricular activities in schools. Its Climate Change programme

encourages the schools involved to develop a programme for climate change education and action for schools.
*ManagEnergy, DGTREN*, coordinates actions for cooperation in the field of energy education, such as the workshop on “Local & Regional Energy Action through Schools and Education” of March 12, 2004. Contacts have been established with individual project coordinators of different local initiatives.
Many EU projects on Hydrogen and Fuel cells include dissemination activities;
*The EU CUTE project* includes activities for school children in each of the participating cities.
*The Zeroregio Project* includes activities in the local schools coordinated by LABTER CREA in Mantova.
*Networks and initiatives for promoting scientific awareness* among school children could provide a portal for hydrogen education.
*The EU’s Science Shops*, which are independent centres for public involvement in scientific research, provide solutions to topics of communities’ concerns.
*ECSITE* is a network of European science museums that collaborate on the development of theme exhibitions.
An increasing list of national initiatives provides material and programmes in the local language:
*Icelandic New Energy (INE)* has developed an education program in collaboration with the University of Iceland and CD-Rom for grammar schools.
In the Region Piemont, Italy an initiative by the local Energy Agency of Biella, Agenbiella, in which a fuel and hydrogen laboratory was established in a local high school, led to the installation of 9 other laboratories in schools of the main cities in Piemont
*NordRhein Westfalen* in collaboration with Fuel Cell Europe and H-tec developed the Fuel Cell Box Project in which a fuel cell kit is provided to high schools to enter in a competition to develop a fuel cell powered device.
*NEMO* a Science Museum in Amsterdam has established a model of a hydrogen infrastructure in collaboration with SHELL Hydrogen.

### 3.1.3 Tasks

The main task of the WG Schools is to formulate a strategy to ensure that hydrogen and fuel cell topics are included in what European school children learn about energy in school. The strategy includes three objectives;

1. Curriculum integration;
2. Creation of a model for Permanent and portable exhibitions in collaboration with Science Museums;
3. Development of a Central Database and Website of Educational Material and Programmes.

#### 3.1.3.1 Curriculum integration

Each European country has its own specific procedure to integrate a topic into the national school curriculum. Furthermore in federal systems like Germany the different states have their own state school curriculum. Curriculum integration is often a long process involving Ministries together with educational experts at Universities and teacher and parent organisations are involved to develop content and methods. The WG Schools has established a network of national coordinators to identify the national curriculum process, collect suitable materials and ensure rapid integration. With the help of HFP Mirror Group members a detailed description of necessary action steps in each country will be defined. A European H2&FC Education and Training Coordination Unit (HYFED6) will coordinate the work in each member state country and facilitate exchange of best practices.

#### 3.1.3.2 Permanent Exhibitions and Activities in Science Museums

Science museums offer an excellent opportunity to increase the visibility of the use of hydrogen not only to school audiences but also to their families in the short term. With their practical expertise, extensive network of contacts at local schools and close collaboration with teachers they guarantee a quality venue for hydrogen and fuel cell demonstrations. The WG Schools in collaboration with educational material suppliers and a network of local science museums will develop a model for permanent exhibitions and activities that can be used in different science museums in Europe.

#### 3.1.3.3 Central Database and Website of Educational Material and Programmes

To facilitate easy access for teachers and parents to educational material and programmes a database will be established that covers different languages and age levels. Examples of material and programmes of initiatives of national and federal programmes in the US and Japan will be included. A European H2&FC Education and Training Coordination Unit (HYFED6) will manage the central database and website.

### 3.1.4 Methods

Hydrogen and fuel cells are part of a sustainable energy solution and should be presented in relation to other sustainable energy sources. Therefore the WG Schools of the IG Education and Training has teamed up with existing energy education initiatives, teachers active in local energy programmes and energy agencies to establish a network of national coordinators to identify the national procedures of curriculum integration of energy topics and more specifically to guarantee that hydrogen and fuel cell technologies will be included in what European students learn

in school.
The network of national coordinators will be managed by the European H2&FC Education and Training Coordination Unit (HYFED66) to follow the national curriculum integration process. It will also create liaisons with similar international initiatives in other parts of the world. Contacts have already been established with the Californian Fuel Cell Partnership and Public Fuel Cell Alliance in the US, Hydrogen Education Centre in Beijing and NEDO, Japan.
The national coordinators have three main tasks:

1. Identify the national curriculum integration process in collaboration with his/her HFP Mirror Group Member and facilitate start of national curriculum integration procedure;
2. Identify local science museums and interest them in permanent exhibitions and activities on hydrogen and fuel cells;
3. Collect and stimulate development of educational material and programmes.

#### 3.1.4.1 Curriculum Integration

National coordinators will identify and describe the national curriculum integration process in collaboration with his/her HFP Mirror Group Member. They will make sure that key stakeholders on all educational levels will be involved. Where possible they will seek collaboration with existing energy education initiatives to seek joint curriculum integration of energy topics. The coordinators in collaboration with the European H2&FC Education and Training Coordination Unit (HYFED6) will distribute information on existing educational material that could be adopted in a national curriculum. The commitment of the national coordinators should be long term as in most cases the curriculum process will take years. Annual curriculum exchange workshops and regular national updates organized by the European H2&FC Education and Training Coordination Unit (HYFED6) will provide insight in the progress in other countries and necessary support to stimulate the process in one's own country.
The Italian coordination team established a model of curriculum integration in Italy based on an existing network of organisations and regional institutions involved in environmental education that could develop and test programmes to facilitate national curriculum integration.

#### 3.1.4.2 Permanent Exhibition and Activities in Science Museums

In order to facilitate activities that could be developed in the short term and to allow students to check out different applications of hydrogen and fuel cells already today, the WG Schools seeks to establish a collaboration, coordinated by the European H2&FC Education and Training Coordination Unit (HYFED6), with European networks of science museums (ECSITE) to stimulate the creation and exchange of models for permanent hydrogen and fuel cell exhibitions and activities and seek input

from museum staff. Developing teacher-training courses to introduce teachers to the hydrogen and fuel cell topic should be included in the museum project. NEMO in Amsterdam developed a small permanent model that could be duplicated and distributed to other museums**.**

#### 3.1.4.3 Central Database and Website of Educational Material and Programmes

Easy access to educational materials and programmes allows teachers to identify the most suitable product for their classroom activity or to check activities in local science museums. The database will be developed in close cooperation with ESEEF to benefit from their experience with the energy education database. ESEEF will include the material on hydrogen and fuel cells in their database thus increasing the visibility of the topic. Suppliers of hydrogen and fuel cell educational material are developing a user-friendly format for the database that will provide direct links to suppliers or local distributors. The European H2&FC Education and Training Coordination Unit (HYFED6) will be responsible for regular updates of the database using information of local coordinators and identify gaps to stimulate development of new material. A website will be created with updates on the national curriculum integration progress in each country, an events calendar in collaboration with the science museum networks, new educational material and programmes. An interactive area for national coordinators will be created where comments, questions or requests can be posted as well as progress on national curriculum integration.

### 3.1.5 Financing

The total cost of executing the proposed School Strategy will be relatively low if a strong European H2&FC Education and Training Coordination Unit (HYFED6) can be established that could tap into a network of local national coordinators already employed by other institutions.

In order to facilitate structured progress of all three components of the Schools Strategy, long term financing has to be secured for the creation of a European H2&FC Education and Training Coordination Unit (HYFED6) in charge of coordinating the national activities on all three components of the School Strategy. Cost for an European office, a full time, two person, multi lingual staff, website and database creation, annual workshops and out of pocket costs for the coordination activities will be Euro 200.000 per year, amounting to Euro 2.000.000 for ten years.

To secure adequate support for the national activities, reimbursement of office use and travel expenses of the national coordinators, would be the minimum. Cost of national coordinators on an annual basis is Euro 50.000 per country, amounting to Euro 1.250. 000 for the 25 member states per year. National curriculum integration procedures will not start at the same time in all member state countries and will have

different end dates as well. If active coordinators closely monitor the progress an average of three years for each country should be feasible. The total cost of curriculum integration for all 25 countries would then amount to Euro 3.750.000.
For short-term activities in science museums, upcoming EU programmes and projects will be identified to secure participation in Work packages Dissemination. Presentations at Programme Info days in Brussels have to be coordinated with the European Commission to communicate the School Strategy needs to proposal coordinators. In addition national and local funding should be identified for permanent exhibitions and activities in local science museums.

### 3.1.6 Appraisal of Benefit for Europe

A hydrogen and fuel cell market needs educated customers as well as educated custodians. Market prognoses from industry for the first applications vary from today till 2020; exactly the average school career of a 4 year old entering school this summer. An European School Strategy implemented tomorrow will follow this child through all grade levels so that by the time he is leaving school, starting his/her independent life, hydrogen and fuel cell applications will be perceived as safe, clean and “cool” everyday commodities. The European School Strategy is addressing the whole school community including Ministries of Education, local suppliers and families. Schools through the classroom activities become the first customers not only of educational models but also small systems to demonstrate real life applications as classroom computers.
In addition in creating awareness and building knowledge of the use and potential of hydrogen and fuel cell technologies will stimulate students to choose a career in R&D to help build up the hydrogen and fuel cell infrastructure to its full sustainable potential in 2050.

### 3.1.7 E&T Recommendations of the WG Schools

**1. Establishment of a European H2&FC Education and Training Coordination Unit (HYFED6):**
to coordinate the different components of the European School Strategy on European and national levels and disseminate information on educational material and programmes;

***Timeline:***

- 2006: Prepare the structure of HYFED6 and preparing the foundation of the European H2&FC Education and Training Centres;
- Mid 2006 database of educational material and programmes established;
- Beginning of 2007 HYFED6 structure established.

**2. National Curriculum Integration of Hydrogen and Fuel Cell topics**

***Timeline**:*

- Beginning 2006; Establish concrete collaboration activities with European Sustainable Energy Education Forum and Managenergy;
- Beginning 2006; in collaboration with the HFP Mirror Group define national curriculum integration procedures in all 25 member states;
- Mid 2006 network of national coordinators completed in all EU member states based at local institutions involved in environmental education;
- Beginning 2007: National Curriculum integration is initiated for all K-12 grade levels;
- Beginning 2010: Curriculum integration at secondary school level completed in EU member states;
- End 2013: 2013 Full Curriculum Integration for all K –12 grade levels completed in all 25 EU member states.

**3. Develop permanent and portable exhibitions and programmes at local science museums, nature centres and learning centres**

***Timeline**:*

- 2005/2006 Guarantee presentations at EU Programme Info days in Brussels to present topics related to School Strategy components to proposal coordinators that could be included in Work packages Dissemination; such as School Competitions, Road shows, Permanent Museum activities in 2005-2006, collection and development of educational materials;
- Mid 2006: Establishment of close collaboration with existing networks of local science museums, nature centres, learning centres established;
- Mid 2006: Development of network of interested industry partners to sponsor permanent and portable exhibitions and activities in collaboration with science museums;
- End 2006: Two models of permanent and two models of portable interactive exhibitions defined;
- Mid 2007 Pan European Hydrogen and Fuel Cell Competition for secondary schools in place;
- End 2007 permanent exhibitions established in one science museum per EU member state and one portable exhibition per country;
- 2010 permanent interactive exhibitions in all major city science museums in the EU.

**4. Central Database and Website of Educational Material and Programmes**
by end of 2006

## 3.2 Academia&Research

### 3.2.1 Universities and Universities of Applied Sciences

#### 3.2.1.1 General

The main target groups and purpose of this endeavour is to take steps to ensure that university students, undergraduate as well as graduate ones obtain the best possible education in the area of hydrogen and FCs. Classical universities as well as technical universities and colleges also fall under this heading.

The university authorities can use the following criteria as a checklist for improving the portfolio of education offered.

Universities will play an important role in the transition to a Hydrogen economy. They can serve as a training centre for both providing basic understanding of the new components of an energy system such as fuel cells as well as the link between the present energy supply structure to a new one. Within the universities the aim should be to foster knowledge and skills to address the innovative challenges ahead. In the Hydrogen economy it may turn out that in order to meet many of the challenges a new approach is needed. Graduate programmes and basic research at the highest level will be needed to move hydrogen and FCs closer to an economically favourable energy system component. The competitiveness of industry will depend, to a considerable extent, upon how the university training is organised and carried out.

As pointed out in the Draft Deployment Strategy report from the European Hydrogen and Fuel Cell Technology Platform the needed investment in human capital required by the transition to a hydrogen economy may need new organisation of education. The report goes as far as calling for a clear orientation of the technological and economic universities to support new profiles of scientists, engineers, technicians and economists specifically prepared in this field.

In the SRA report on the Strategic Research Agenda, it is clearly pointed out that hydrogen and FC research in the near future needs to tackle the problem from the point of view of crosscutting through a number of disciplines. This recommendation will be adopted in the present analysis.

#### 3.2.1.2 State of the Art

For most universities the subject of Hydrogen enters the curriculum in chemistry or physics as one of the best-researched elements. From atomic physics to

spectroscopy and from chemical engineering to nuclear physics, hydrogen constitutes an important part of a number of scientific and engineering disciplines.

With the advent of fuel cells, the emphasis has changed to ionic conduction, polymer chemistry, membranes and diffusion to name a few basic aspects.

Most universities do not offer specialised hydrogen energy and FC courses. A few have started graduate courses on the subject and most of them include hydrogen and FRCS as a part of their chemistry, physics or energy engineering curricula.

It is a widespread belief that this needs to be changed and hydrogen as an energy carrier or vector be given its proper status as the hydrogen economy emerges.

As regards universities of applied sciences the general approach to hydrogen education should rest upon similar criteria as was defined for universities in general. The degree of fundamental knowledge could be more limited in a curriculum whereas the degree of the understanding of energy systems, socioeconomic implications and the important area of codes and standards should be kept at a maximum

#### 3.2.1.3 Tasks

##### 3.2.1.3.1 Network

There are a number of possibilities to actively intertwine the European universities into a network in harmony with the concept of the **European Research Area**. One such network could materialise into a **European Hydrogen and FC University**, a virtual university embracing an umbrella of dissemination of educational materials and exchange of teachers in the area of hydrogen and FCs. Another way of approaching the same idea would be to join forces with the nascent concept of a **Renewable Energy University** and define the **Hydrogen and FC Campus** as the venue for education in the field of **renewable energy vectors or carriers**.

On more global scale cooperation with IPHE, IEA could further enhance the outreach of a network. The IPHE is currently working towards a possible education approach through the United Nations.

##### 3.2.1.3.2 Curriculum

The curriculum of university education in Hydrogen can be separated into a number of approaches. A first approach could be through:

**The basics of energy and environment.**

*The theme here should be to give an overview of the connectivity between the resources of earth and its environment, the concept of energy efficiency and life cycle analysis of energy sources and fuels*.

A possible syllabus should include: The nature and definition of energy, its origins and use in modern society. Energy resources of earth. Decarbonisation.

Special attention to renewable energy sources with emphasis on direct solar energy and the related solar/lunar effects of wind energy, hydroelectric energy, tidal energy, wave energy; and geothermal energy as a special energy of geological nature. Biological sources of energy and their technological variations should be included along with nuclear fission and nuclear fusion. Finally the use of fossil fuels as the currently most widely employed energy source should be covered along with its emission consequences. The general impact on the environment from the use of energy should be analysed along with energy efficiency, Carnot efficiency law and the concept of exergy.

The students should be made aware of the concepts of life cycle analysis. In this way a pathway of energy from its source to its utilisation, for example well-to-wheel analysis, can become a familiar tool when energy efficiency and effects are analysed. Impact of various energy sources on the environment as regards other aspects than emissions should also be included and assessed. Human health issues should be covered.

As the students have been made aware of the basics of energy and environment the attention should be directed towards fundamental aspects of **the physics and chemistry of Hydrogen.**

Syllabus should cover: Origins of hydrogen, isotopes, hydrogen bond and carbohydrates. Auto ignition temperature, Boiling point (1 atm), Density, Diffusivity, Flame temperature, Flammable range % by vol in air, Freezing/melting point, Heat of combustion by mass, Ignition energy, Molecular weight, Specific gravity, Specific volume, Viscosity, Volumetric energy density, Heat of combustion, lower and higher values definitions.

The various phases of hydrogen, gas and liquid together with their phase transitional energies. Ortho- and para-Hydrogen and the liquid phase.

After introducing the above basics, the students need to be made aware of the various methods available for producing the energy carrier Hydrogen.

In **Hydrogen production**, the theme should be to show the students the potential multitude of pathways for producing hydrogen.

The syllabus should include: Electrolysis, and the effect of temperature on electrical energy required. High-temperature electrolysis. Alkaline electrolysis, PEM electrolysis. Fossil fuel reforming. Thermochemical processes and hybrid processes.

The important aspects of hydrogen from natural gas, steam reforming, partial oxidation, pyrolytic cracking. The processes involving both high volatile fuels as well as low volatile fuels. Gasification of coal or heavy oil fractions. The steam iron process, Pathways of Hydrogen from biomass. The general use of catalysts. photochemical methods, photo electrochemical methods, photobiological methods. The selection of the source of energy to produce the hydrogen should receive particular attention. Also production costs and life cycle analysis. It is urged that the development in the area of carbon sequestration be monitored carefully as this could in some cases be essential to the viability of a hydrogen economy in many areas.

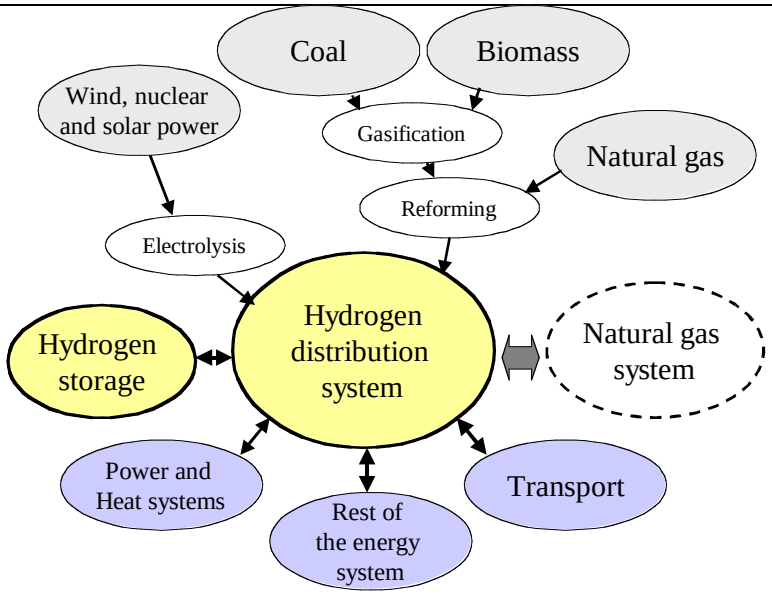
As the concepts of production have been clarified it becomes important to address the important area of **Hydrogen storage.** The theme of storage education is to give an overview over the challenging task of storing or confining Hydrogen.

Syllabus: Hydrogen storage criteria based on physical and chemical properties. Compressibility and deviation from ideal gas laws. Piston mechanical compression and compressed hydrogen storage technology. Storage tanks and their properties.

Liquefaction, boil-off, cryogenic storage. Transport of Hydrogen by pipelines. Transport of hydrogen in gaseous or liquid form. In this area production methods, storage and transport become intertwined.

The ability to store Hydrogen in hydrides of various forms: Metal hydrides and van´tHoff diagrams, cyclic stability, alanates, complex hydrides, reproducibility, metal hydrides for heat pumping, costs of hydrogen storage and its development,safety aspects of hydrogen storage.

As the understanding of the role of production and storage is becoming clearer, it becomes possible to introduce the element into an energy system. The approach here may depend heavily of the nature of the study of a given student and the concept of Hydrogen Energy Systems should rest upon an understanding of the different pathways shown in the figure:




As the student becomes familiar with the role of **Hydrogen in the energy system** the discussion can go further into **Hydrogen fuelling infrastructure**. The existing **demonstration projects** can serve as a good example to show the multitude of possibilities here.

Syllabus should contain: Centralised production vs. decentralised. On site production. Transportation short/long distances, pipelines, trucked hydrogen (LH2-GH2). Production capacity, storage on site. Demand and supply curves, space, land cost and regional development. Variations depending on fuel source. Distribution networking: gaseous, different pressure levels, liquid. Centralised electrolysis or reforming. Large scale transport. Dispensers. Hydrogen fuelling station experience world wide. Urban planning and fuelling stations.

**Utilisation of Hydrogen** is of course a major issue and theme in any educational approach. Many universities will choose to place it earlier in a curriculum and for example introduce Hydrogen through the concept of fuel cells. In the present context it is recommended that **Fuel Cells** are placed in a curriculum following production and storage. The advantage of Fuel Cells over ICE for converting hydrogen to electrical power is paramount.

*The theme here needs to be to show the student the basic principles of the new energy conversion system opened up by fuel cell technology. It is crucial to view it in the light of the existing combustion energy conversion and realise the potential of increased efficiencies, small number of components as well as realise the technical*

*challenges facing the new technology*. Basic aspects of the thermodynamics of energy conversion are necessary at this point.

The syllabus for Fuel cells as the primary application technology for hydrogen should include

- Historical introduction,
- Fundamentals of FC systems as Gibbs free energy, NERNST equation, the working principles of FC, PEFC,PAFC, MCFC, and SOFC.
- Material questions as membranes/electrolytes, electrocatalysts, and interconnectors,
- Applications
    - Stationary applications, including reforming of natural gas for decentralized power generation (CHP – district, residential)
    - Transportation application as major driver for hydrogen and fuel cell technology, including SOFC for APU and reforming
    - Portable applications for off-grids and electronics
- Economy, ecology, and market

The concept of **Hydrogen and FC safety, codes and standards** remains a vital aspect in the introduction of the new technology. Any education of Hydrogen would be incomplete without this important aspect.

The theme here should be to make the students aware of how hydrogen safety can be maximised and outline the unique characteristics of hydrogen with respect to safety. Which codes and standards exist and the implications for future standardisation.

Syllabus should cover: The enormous energy profile of hydrogen, the flammability range, flame temperature and colour, ignition energy etc. Corrosive properties of hydrogen, brittleness aspects of interstitial Hydrogen. Hydrogen sensor technology. General codes and standards for Hydrogen.

An important target group for receiving such education is represented by the various officials in agencies permitting and registering new vehicles, the building of new facilities, fuelling stations or other infrastructure and fire-brigade officers and officials of the various municipal agencies serving this sector.

As the theme has been covered from physics and chemistry, to production, storage and utilisation including infrastructure, the necessity to view the whole socioeconomic scenario is by many seen as another crucial pillar of Hydrogen education. Different

universities will address this point in various ways. At this point it is recommended that the socioeconomic dimension is given a very important place in any curriculum, whether science/engineering oriented or not. This cross disciplinary approach is by many seen as the most modern one.

***SocioEconomic aspects of the Hydrogen economy.***

The theme here should be to assess the overall applications in society and understand the environmental impact. The understanding of greenhouse gas emissions and the reduction caused by a renewable Hydrogen economy or a carbon sequestration-assisted Hydrogen economy. Other social and health consequences related to emissions. The impacts of global warming and the geo-political consequences and energy security issues. International treaties such as the Kyoto protocol and the overall Hydrogen Economy impact. The important aspects of indirect effects on the economy and the hidden parameters and externalities

The students can be expected to better understand the effect of changed fuel base. They will have the ammunition to act responsibly in society. They will have gained insight into how a technology process and system changes society and at the same time create a more sustainable future. Syllabus includes a number of published works on socioeconomics of hydrogen.

It is very important that the spirit of the above university level syllabus is introduced into the education of various public regulators. The contact between the university education work and the outreach to regulatory agencies should be a focus for further development.

After studying the cross cutting disciplines as depicted by the SRA report, the importance of tailoring education of hydrogen in the same manner seems inevitable. The course designs for future hydrogen education need to take into account this fact.

#### 3.2.1.3.3 Graduate studies

As regards master or PhD studies it is essential that the aspects of the previous chapter be well understood by the student. In a graduate study, the student can select a much deeper specialisation and here the degree of innovation and originality becomes paramount.

Universities offering graduate studies need to base their education on a solid ground regarding basic research performed in-house. It is not advisable to offer graduate studies in university environments lacking fundamental research in hydrogen.

Graduate studies in hydrogen could easily be done in much more proximity to industry. Industrial companies should be encouraged to host master students and other graduate students in order to build bridges between education and industry.

By special agreements between universities and industry involving proprietary information, students could tackle relevant projects related to Hydrogen technology. It is outside the scope of the present paper to delve deeper into this aspect at this stage.

Student exchange The Marie Curie programme of the EU has been a very successful one. Its important mobility aspect has furthered student exchanges within Europe and secured continuity in the less favoured regions of Europe through for example support to an academic returning home after having received training in a foreign country.

In a nascent industry such as the Hydrogen and FC industry in Europe it becomes vital to promote interactions of corporations and universities and within the Marie Curie Programme such interactions should also be given special attention. The possibility of using another important instrument of the Community, namely the Leonardo system and similar should be examined positively.

#### 3.2.1.3.4 Summer schools

One of the instruments of the Marie Curie Programme is conferences and training courses which also cover the organisation of summer schools.

At an early stage of an organised hydrogen education this instrument can serve as a very important unifying measure. From a European point of view the summer schools are an excellent instrument to disseminate the outcome of the various projects undertaken around Europe.

One novelty could be the establishment of an umbrella of summer schools with a common background perhaps run by a selected number of university groups from a number of countries. Consideration should be given to international participation by involving actors like IPHE and IEA.

### 3.2.1.4 Methods

Referring generally to the educational programmes defined by objective 3 funds from the European Union, our analysis points in the same direction as the Draft Deployment Strategy (DDS) Report from the European Hydrogen and Fuel Cell Technology Platform, which strongly recommends new projects dedicated to hydrogen and fuel cells. It is rightly pointed out in the DDS report that „Lighthouse projects can provide a „real life“ pilot test frame for the development of educational methods, materials and processes and thus, education should be an integral part of it.“

As general methods could involve the Thematic Networks philosophy of the EU, the main aim of **Thematic Networks** (TN) is to enhance quality and to define and develop a European dimension within a given academic discipline or study area, or as regards a topic of an interdisciplinary/multidisciplinary nature, or in other matters of common interest (such as university management, quality assurance etc.). This is achieved by means of cooperation between universities, university faculties or departments. Such cooperation should also involve academic associations, learned societies, professional bodies, and partners of socio-economic importance in the public or private sector and, where appropriate, student organisations.

The beneficiary as well as the co-ordinating organisation of an **Erasmus** Thematic Network has to be a university (nearly all universities in Europe take part in Erasmus) or any non-university higher education establishment or post-university studies organisation, which is recognised to participate in Erasmus

As regards technical universities and colleges the **Leonardo** methodology may be very suitable. The contents are studied further in the section on “Trade and industry”.

#### 3.2.1.5 Financing

At this level financing of education throughout Europe will have to rely on national commitments apart from networks and possible Hydrogen University activities, which should be able to enjoy Community support. The costs for the larger tasks as the European Virtual H2&FC University are to calculate in detail by the European H2&FC Education and Training Coordination Unit (HYFED6). For Summer Schools it should beplaned already for tne 2006 a summ of 100.000 €.

#### 3.2.1.6 Appraisal Benefit for Europe.

The competitiveness of Europe in the area of Hydrogen and Fuel Cells depends to a large extent on its access to advanced education and training in this field. European corporations have to be able to rely on a very high level of fundamental knowledge as well as engineering applications of the new technology in order to lead the way in the future hydrogen economy.

Europe, as a birthplace of Fuel Cell Technology, is a natural venue for creating a world movement in this new field. The initiatives already taken through the Hydrogen and Fuel Cell Platform in Europe already point towards this leadership role.

### 3.2.2 Research Institutes

#### 3.2.2.1 General

This target group addresses the education of researchers operating within a public or private research institute. Many of the recommendations of the previous chapter on “methods” apply to this present chapter.

#### 3.2.2.2 State of the Art

The range of Research Institutes under consideration for the enhancement of Hydrogen and FC education is large and varied. The appropriate level of primary and continuing education required will depend upon whether the institute is tied into the Hydrogen economy directly such as an institute associated with one or more industrial organisations or whether it is simply offering a service against payment or whether it is fulfilling a public duty in connection with a government’s policy. The training requirements will also vary from those for young graduates to those needed by experienced researchers but also the technical support group should not be forgotten. This group would cover not only technical staff working in research laboratories but also those offering support in safety, security, health and environment issues, infrastructure and quality assurance. As a result of the diversity in recipients of the training, a universal panacea for hydrogen and FC training is unlikely to be found and indeed even if available would probably not be appropriate. To date ad hoc solutions have been employed to suit the needs of the trainees and a more systematic approach would offer significant improvements. Although Research Institutes often employ senior researchers capable of providing educational courses to colleagues they are limited in number and rarely available for such a function as their primary duty to the organisation is the execution of research. Hence the provision of a resource for actually carrying out the training is a key concern for the RI’s which forms a key difference to the case of the Universities.

#### 3.2.2.3 Tasks

##### 3.2.2.3.1 Training of young researchers

Research Institutes take on young graduates for permanent employment positions within their organisations but many have schemes for short term appointments for example for undergraduate trainees, Ph.D. studentships, and Post-Docs. A common training for this category should be achievable in conjunction with the courses planned for Universities above. The RI trainees could attend specific recommended modules at Universities depending on logistic possibilities of course. External training using modern methods would also be an acceptable route in particular for RI’s remote from the source of University training. RI’s should combine in order yield a sufficient quantity of trainees around which specific courses should be organised. Also summer schools should figure in the possibilities offered. As these are termed summer schools to reflect the availability of the predominantly University based

teachers, some effort should also be placed on restricting the scope of individual courses (reducing the number of teachers) such that “year round” schools might be possible.

It should be emphasised that for those young researchers with activities directly in the Hydrogen economy field, it might be assumed that many of the basic courses have already been accomplished. This will only be the case in some years time when the basic education courses in Hydrogen have been fully implemented. Hence for the five years plan it is safer to assume that all young researchers will also need the basic general courses prescribed for undergraduates. The RI trainees will also select courses close to their planned research activity but it may be useful for all to receive a general course on “ How to carry out Hydrogen related research”.

In the area of training of young researchers there are considerable opportunities to secure Marie Curie Programme support. In particular, individual fellowships (Intra-European and International) and Host Fellowships for Early Stage Training and for Transfer of Knowledge should be applied for by, or with the help of, the RI’s.

#### 3.2.2.3.2 Young scientist competition

It should be organized a European young scientist competition for the young scientist of the research institues and the universities. For the best works it will be offered a special prize in the different area of H2&FCs.

#### 3.2.2.3.3 Training of high level/experienced researchers

In the blossoming area of Hydrogen, even the highest-level researchers have quite short experience. Hence many training courses reserved for young researchers, provided that they are in specific fields related to the interests of the high-level researcher, may still be appropriate and the connection with the Universities should be made. Of course the traditional route of gaining knowledge through dedicated seminars and conferences will form the backbone of the training of high-level researchers. This does not happen out of the blue, and it will be necessary to identify subjects for such seminars and conferences on the basis of priorities established by the Technology Platform, through networking or directly from the industry or government. Financing is not to be underestimated and is addressed below.

Marie Curie possibilities also should be applied for using the instruments of Chairs, Excellence Grants and Awards and Reintegration.

#### 3.2.2.3.4 Training of technical and support staff

This aspect of training is probably RI specific and the extent and depth of training will depend on the RI staff training policy. Nevertheless the practicalities of carrying out research involving hydrogen can better be learnt first in the classroom rather than in the laboratory. A common course should be created for all technical staff who will work with or support work on hydrogen. The course will include a number of obligatory aspects and a number of additional options tied more to the need for in-depth knowledge. The obligatory part will include aspects such as: physical and chemical properties, containment, pipework and fittings, flow and pressure measurement, construction materials, safety containment, health and safety measures.

A further general course should also be offered which explains the reasons for carrying out hydrogen related research in order to increase motivation of those technical staff involved. This will promote a pubic awareness of the hydrogen economy through word of mouth outside the RI's. In this regard it may be beneficial to offer this general course also to other staff not involved with hydrogen research, even including administrative staff such as in purchasing, site management, infrastructure supplies, building maintenance but not excluding any interested member of staff.

It should not be forgotten that these courses will probably have to be given in the local language of the Research Institute and therefore if common courses are to be set up among a group of RI's from different countries, technical translation facilities must be provided.

#### 3.2.2.4 Methods

As mentioned above the resource for the provision of training must be mainly outsourced. Sharing the duties amongst RI networks forms one option but sharing with Universities is likely to offer the most suitable solution to the problem. The RI's senior researchers will be expected to contribute to the trainer resource but only as a minority even in the case when a joint activity between RI's is enacted. The financial consequences of this approach are not insignificant and will be addressed below.

#### 3.2.2.5 Financing

The training for young and experienced researchers within Research Institutes will mainly rely on outsourced teaching. It is unlikely that the RI itself will have sufficient funding to cover this situation. The RI will have to rely on the same resource invested in the Universities plus own funding and sponsorship. Obviously the latter will be required for the case of large seminars and conferences. Marie Curie funding can also be applied for but the chance of success is not high and, in view of the FP6 call

dates, considerable time may be lost. For the financing of the young scientist awards about 25,000 €/year should be planed.

#### *3.2.2.6* Appraisal Benefit for Europe

The cutting edge for Europe´s competitiveness in Hydrogen and Fuel Cells rests within its higher education system. Advances within the corporations of Europe will be tied to the education level of the research task force of the corporate structure. Based on the tradition of Hydrogen and Fuel Cell research in Europe it would be natural to expect the industrial output of Europe to reflect this. Unfortunately, this may not be the case in reality.

### 3.2.3 E&T Recommendations of the WG Academia&Research

**Establishment of a European H2&FC Education and Training Coordination Unit (HYFED6)**
to coordinate the different components of the European Academia & Research Strategy on European and national levels and disseminate information on educational material and programmes;

> ***Timeline:*** Already now to prepare the structure of HYFED6 and to prepare the foundation of the European H2&FC Education and Training Centres.

**Forming a H2&FC University and R&D Institute Network**
to combine and to improve the experiences of the different universities.
One important task of this network is to development basic H2&FC teaching materials (software and cheap hardware).

> ***Timeline:*** The network could be formed already in 2006. A broader extension will be take place in the 7 FP.

**Formig European H2&FC Education and Training Centres**
at university and R&D Institute level to give selected members of the *H2&FC University Network* an experimental basic.

> ***Timeline:*** The development of the centers will be start with the 7 FP.

**Establishment of a European Virtual H2&FC University**
based on the *H2&FC University and R&D Institute Network* and *European H2&FC Education and Training Centres.*
Later an extension to a *World Virtual H2&FC University* in cooperation with the IHPE, the IEA and the UNO is planed

> ***Timeline****:* The development of the virtual universities will be take place in

the 7 FP.

**Using the Marie Curie fellowships**
as a vehicle for effectively organising a new educational approach at the level of universities and research centers with the most widespread impact.

***Timeline:*** This action should start already now.

**European Young Scientists Competition**
should be offered awarding a special prize in the area of H2&FCs.

***Timeline:*** This action should start already now.

**Training courses for young and high level/experienced researchers**
in agreement with the demand of the SRA.

***Timeline:*** This action should start already now, but should be extended in the 7 FP.

**Establishment of a high level research oriented European H2&FC conference**
in the style of the Gordon research conferences should be considered.

***Timeline:*** This action should be prepared now, but realized with the beginning of the 7 FP.

**Worldwide dissemination of H2&FC education materials**
in cooperation with the IPHE, the IEA, the United Nations, and National H2&FC Organizations with special connections to non-European countries.

***Timeline:*** This action should be started with the 7 FP.

## 3.3 Trade and Industry

### 3.3.1 General

The following general tasks need to be addressed in an E&T-program connected to trade and industry.

- Creation of technology awareness in trade and industry connected with hydrogen and fuel cell technology.
    - Representatives from Organizations in trade and industry
    - Management level
    - Trainers
    - Sales persons
    - Technicians
    - Builders and architects
- Setting the time frame by e.g. communication of technology implementation road maps.
- Education of trainers on technological background (scientific background, technology development, emerging and existing codes and standards, safety and handling issues).
- Creation of access to actual demonstration sites.
- Creation an implementation of specific theoretical and practical training modules for technicians on a generic technology level.
- Harmonization of product specific training for technicians.
- Differentiation among different trades (e.g. plumbers, electrician, chimney sweep …)

### 3.3.2 State of the Art

Information on hydrogen and fuel cell technologies is available via the general media as well as specific publications issued from industrial bulletins as well as from trade organisations. Some industrial sectors and trades already have established working groups on hydrogen and fuel cell technology. Information frequently is reproduced from internet sources and manufacturers brochures if available. Selected technicians in trade have been trained on specific products during the ongoing field tests of automobiles, residential fuel cells and cogeneration units.

Nationally funded projects have been started e.g. in Germany to provide unbiased information on the state of technology as well as to provide first hands-on training experience. So far no consistent approach concerning E&T in hydrogen and fuel cell technologies has been adopted within Europe. Considering such activities in trade

and small businesses, existing language barriers within Europe need to be taken into account.

### 3.3.3 Tasks

Members from trade and industrial firms should be involved in the technology demonstration phase during 6th and 7th FRP projects, particularly in networks of excellence and projects having their focus on demonstration and testing in order to be able to independently assess and monitor the current state of the technology. Projects under negotiation should be encouraged to include a significant amount of E&T-aspects particularly for members from trade. Existing national education and training centres should be encouraged to offer their hydrogen and fuel cell technology training modules on a European basis. Translation services of the Commission should be made available to help the dissemination of proven education and training modules within the member states. Actions mentioned above should be focussed during the 7th FRP possibly in a network of excellence.

Training aspects have to be adapted differently to the various target groups in trade and industry. A very important aspect is a timely introduction of information on all levels.

As opposite to the situation in universities and research, English cannot be considered as “lingua franca” among the addressees. Therefore, education and training materials addressing people in trade have to be locally adapted to the languages spoken in Europe.

Eventually, a large number of training facilities currently active in education and training in trade need to be qualified to reach a sufficient number of trainees.

Therefore, it is of crucial importance to have skilled trainers and teachers for these new technologies such as hydrogen and fuel cells.

With reference to the previous remark, education and training should be considered as including knowledge transfer in a broad sense. The following activities might be considered with the framework of education and training for trade and industry:

- Exchange of experiences and good practices
- Awareness of codes and standards, particularly concerning safety.
- Application of databases and information sources, with information retrieval based on a standard characterization of the organisation requesting the information. In other words, the available subset of information and the requesting organization must be matched before information is retrieved. This

will avoid situations where too much non-relevant information is made available, and the inquirer (representative of T&I) is lost.

- Smart data handling and clustering, on the basis of available databases (with well documented sources)
- Competitive elements such as a contest to build ones own $H_2$-application, the '$H_2$ – entrepreneur of the year', etc.
- Making people / organisations more aware through dedicated information, roadshows
- Trend-investigations with regular updates. Trend watching resulting in a kind of 'trend-thermometer', being published every year, not so much focussing on the technological developments but mainly on the business opportunities.
- Roadmaps
- Regional and trans-regional cooperation

It is suggested to have priority areas within the different member states according to the degree of technology penetration.

#### 3.3.3.1 Specific Training Content in Trade

For final deployment of hydrogen and fuel cell technology, trade is an important partner due to its close connection to the final customers. Sales, installation and maintenance will be the responsibility of different branches in trade (e.g. plumbing, electricity, chimney sweep etc.) requiring a management aware of these new and emerging technologies as well as skilled and well-trained technicians. The situation in trade is comparatively complicated since the majority of the businesses in trade are small or medium sized enterprises. Such organisations typically have a limited budget for education and training. Furthermore, training efforts typically are started when the technology is ready for the market.

In contrast to the situation found at universities and research centres, people working in trade are organised regionally and typically do not travel for more then 200 km for training measures. Furthermore, time allocated for training measures is comparatively short. Training units for trade should be very concise and compact. Moreover, training units preferably should be offered outside ordinary business hours, e.g. in the evening or during weekends.

##### 3.3.3.1.1 Addressees for Education and Training in Trade

In contrast to the situation found at universities and research centres, people working in trade are organised regionally and typically do not travel for more then 200 km for training measures. Furthermore, time allocated for training measures is comparatively short. Training units for trade should be very concise and compact.

Moreover, training units preferably should be offered outside ordinary business hours, e.g. in the evening or during weekends.

#### 3.3.3.1.1.1 Organisations in Trade

Organizations in trade play a major role in disseminating information to their member organizations. Furthermore, these organizations are frequently providing vocational training. It is of prime importance to address decision makers and people responsible for training and to make them aware of new technologies.

#### 3.3.3.1.1.2 Owners and executive level

Training at owners and executive level should be started in a very early stage. Clear information on the status of technology and the expected schedule of market introduction are required. Skilled trainers and concise training modules ideally provided from trade organisations are a prerequisite.

### 3.3.3.1.2 Sales and consultants

In small businesses, sales issues are normally taken care of by the owner. Training for other persons working in sales and consultants, besides general information could be oriented towards general issues on energy, economic and market impacts as well as benefits and drawbacks related to specific applications.

#### 3.3.3.1.2.1 Work floor level

Training at the work floor level should be mainly oriented towards practical aspects of hydrogen and fuel cell technologies. Important aspects will be related to device installation and safety issues. It is important to create some early awareness of the technology at the work floor level in order to facilitate later contact with hardware.

#### 3.3.3.1.2.2 Builders, Planners and Architects

Builders, planners and architects will play an important role during the market introduction phase of fuel cell based CHP and micro CHP. Therefore, it will be necessary to keep this group informed about the development of state of the art in CHP as well as in hydrogen and fuel cell technology. It is also important to encourage their participation in demonstration projects. Furthermore, it is important to encourage the use / demonstration of hydrogen and fuel cell technologies particularly in public buildings in order to support the visibility of such technologies in the general public.

### 3.3.3.2 Specific Training Content in Industry

Regarding education and training needs in industry, differences need to be taken into account between organizations already working in the field of fuel cell development and production, companies that so far have not been affected by fuel cell technology, particularly companies active in a sector that could provide components for the “fuel

cell industry". Furthermore, one needs to differentiate between large industrial companies and small and medium sized enterprises (SME).

Except for very small businesses, people working in industry are more ready to travel longer distances than people connected to trade. For employees / workers on the work floor level, instruments developed for employees on the work floor level in trade could be used in this context.

In principle, instruments applicable to universities and research centres could also be used in an industrial environment, particularly, when addressing large companies. However, for the majority of companies one needs to consider the following restrictions:

- Travelling typically is limited by three days per occasion
- For larger numbers of attendants, there is a preference for training at the location of the company.
- For SMEs, a focus on regional training in local language can be assumed
- Preference for combination with study at home, facilitated by distant learning tools
- Preference for training, based on a combination of basic knowledge and practical state of the art training

The effect of training is based on the following aspects:

- Target group
- Location of training
- Training instrument

Education and training measures in industry also need to be differentiated according to the target groups.

- Management and executives
- Engineering, research and development
- Sales and marketing
- Production
    - Engineering
    - Work floor

Depending on the size of the company and the qualification of the trainees, the location of training measures for industry can be:

- Local inside the company premises
- Regional events held in the local language
- At national education and training centres held in the local language

- At international education and training centres held in a common language involving attendants from different nationalities
- In the framework of international scientific or business oriented conferences including summer schools

Furthermore, one might distinguish the following training instruments:

- Classical training in groups, focussing on the fundamentals
- Training, being a combination of knowledge and practices
- Practical training
- Specialized short training courses, summer schools
- Conferences, possibly including a special (one-day) tutorial
- Network activities
- Road shows
- Distant learning
- Exchange of staff, apprenticeships
- Case studies
- Project approach (application of knowledge, bachelor- and master projects, Ph-D), hosting of (ones own or other) student
- Knowledge exchange through RTD project
- Database application and access, including access strategy based on profile of requesting organisation

### 3.3.4 Methods

#### 3.3.4.1 Definition of a curriculum for trainers and teachers

Education and training in trade typically is organised by trade organisations or by public schools. Therefore, trainers and teachers working in this sector are the most important target group for education and training in trade.

The curriculum should provide a comprehensive understanding of the following topics:

- Energy supply and among demand.
- Concepts of renewable energies.
- Production and availability of fuels.
- Concepts of hydrogen energy.
    - Production
    - Distribution
    - Handling
    - Safety

  - Cost
- Fuel cell technology.
  - General concepts
  - Technical realisation
  - Application potential
  - Installation and operation of systems
  - Safety
  - Market introduction schedule
  - Cost

#### 3.3.4.2 Establishing of primary training centers for trainers and teachers in trade

At the present time, institutes active in, training of people working in trade and industry are not equipped to provide the facilities necessary for training of trainers and teachers. Therefore training facilities adapted to the needs of trainers and teachers need to be created. This could happen in cooperation with universities and research institutes.

An already existing example for a vocational training centre offering experimental facilities is the “Weiterbildungszentrum Brennstoffzelle Ulm” (Fuel Cell Training Center Ulm) which has been established in close vicinity to the university of Ulm and the Solar and Hydrogen Energy Research Center (ZSW) in Ulm Germany. WBZU provides facilities to carry out experimental work on fuel cell prototypes. Besides classrooms, a total of 7 laboratories are available.

Additionally, the HAN University is aiming to establish an experimental training and technology centre on hydrogen applications in Arnhem with the following objectives:

- To demonstrate realistic practical examples of technological achievements
- To allow Trade and Industry to practice on real relevant objects as part of training
- To initiate knowledge transfer between HAN University and external organisations (industry, but also research organisations, local authorities,..), partly through student research projects (Bachelor, Master) with low access threshold (low costs)
- To offer secondary schools the opportunity to familiarize their students with nowadays inspiring technological developments.

It is intended to bring together, in such centres as the ones mentioned above, objects (products, facilities) being owned either by the centres themselves as well as from other sources. In this approach, the 'Training and Technology Centre' offers a full range of knowledge transfer activities.

More in general, it is argued to replace *'academic and vocational training'* by *'transfer of knowledge from academic and business origin to practical application and industrial use'*

#### 3.3.4.3 Generation of general information modules

In preparation of the market introduction of hydrogen and fuel cell technologies, Considerable efforts should be undertaken to create awareness of these new technologies and to provide unbiased information of the benefits and drawbacks as well as the technology readiness I market introduction perspectives, and cost issues. Further more, competing technologies and concepts should also be presented.

- Energy issues
- Economic issues
- Ecological issues which are the second basic criterion in the deployment strategy, focussing on the potential of $CO_2$ or other pollutant reduction
- Road maps
- Technology dissemination

The information modules and the media selected should, if possible, provide a multilingual platform. The following media should be taken into account:

- Brochures
- CDs / DVDs
- Films / videos
- Internet platform

#### 3.3.4.4 Generation of teaching materials

When addressing target groups in trade and industry, adapted information and training materials should be available to address the needs of each group (e.g. owners and executives, sales and consultants, persons in the work floor etc.). Materials should be available to cover the following topics:

- Fuelling issues
- Specific to technology (gas processing, production and distribution of hydrogen, Fuel cell technology e.g. specific issues concerning PEFC, MCFC, SOFC etc.)
- Specific to application (portable, stationary, transport)
- Codes and standards (existing and in development)

- Safety
- Economic issues and business opportunities.
- Energy policy.

Obviously, it is necessary to generate these materials in all relevant European languages.

#### 3.3.4.5 Distant Learning

A major restriction in training of staff from T&I and related training organisations is the fact that people do not like to be away from their business too long. Distant learning modules offer training without the need to spend too much time outside of the company, and should therefore be considered in the E&T programme. On the other hand, practical training sessions need to be accounted for as well. It is suggested to start a special group within HFP to investigate the potential and limitations of distant learning tools for T&I training. Distant learning tools should thereby not be considered as a substitute for other E&T approaches, but merely as an alternative for part present E&T.

Distant learning tools also offer advantages in teaching in several different languages. It invites (or better: requires) for a modular approach in preparing of educational material

#### 3.3.4.6 Dedicated Access to Information Databases

This issue has been addressed above. Database, being serviced through Internet offer the possibility to control the effective use of the information using a mapping between the user profile and the information subset. This requires a standardized structured description of database information and user profiles.
In addition to this, we note that this information should not be restricted to the curriculum topics. One may also included (especially for T&I and with emphasis on training by learning from good practices of other companies):

- Description of components, products, applications,
- Access to a ‘who is who’ – list
- Event calendar
- Access to external databanks
- Regional/national/trans-national/international branch networking associations
- Cooperation (trans-national) in education

all with hyperlinks to more educational material.

### 3.3.4.7 Education in socio-economic issues

This education should take place with rigorous reference to well documented research from authorities in the field. Within the present society dealing with hydrogen opportunities, the majority of people involved is not well educated in relevant technology, Their interest is in the socio-economic issues, and their views are very important for Trade and Industry (T&I). Information on socio-economic impact of hydrogen and hydrogen related developments tend to be not very well based on well-defined sources of research. The political value of views may dominate the proper reference to these sources. This may lead to public statements and views, considered to be valid in a much broader sense then originally demonstrated. T&I representatives have to face such statements, with a need to distinguish between sense and non-sense. It is therefore crucial to include a large amount of the education for T&I on the socio-economic issues, with a rigorous reference to well established sources, and with well documented research conditions and assumptions. This issue should be tackled in a cooperative effort with the IG public awareness / public relations.

### 3.3.4.8 From well to application, value chain management

It is a general experience that many discussions only focus on part of the chain of energy transfer steps from well to application. An approach should be followed where Education and Training treats this full chain of steps in energy transfer, transportation, energy consumption for pressurization and temperature control, etc. It explains the own potential position within this chain with respect to clients and suppliers. Awareness of this chain approach should get high priority, with the relevant problem issues and benefits addressed at each step, in terms of:

- Energy efficiency
- Emissions
- Storage
- Safety risks
- Local socio-economic restrictions
- Dependency on politically unstable regions (not only for fossil fuels, but also a potential risk in deriving biomass)
- Technology business opportunities

### 3.3.4.9 Regulations and Standards

This is a topic including more than codes and standards (existing and under development). It also includes regulations (local, national,..), codes of good practice. Training in trade and industry should emphasize these aspects as well.

### 3.3.4.10 Information Tours and Roadshows

In an early stage, information has to be brought to the relevant addressees in trade. In this stage, information tours organised by trade organisations will help to create technology awareness. One possible instrument could be the creation of an information truck.

Furthermore, one may also think of roadshows, where different target groups are offered training material in combination with practical items to create awareness of existing technology and, from that, of business opportunities. In this way, an information tour will be part of the training strategy. This approach should be dedicated for the different target groups. For example, energy supply for residential areas (heating) requires a different approach than applying hydrogen in transport. In addition, the position in the energy transfer chain from well to application also determines the specific approach where, as mentioned earlier, awareness of the full chain is always an essential part of the training approach. The HAN University has run such roadshows on clean vehicles for very different target groups, with measurement of the impact with respect to knowledge transfer. Based on these measuerement, these roadshows appeared to be very effective.

Experiences with information events in the context of FC heating appliances showed that events in the evening without costs (perhaps with a snack offered, compare the Aperitivi of Marieke Reijalt) are well visited.
Distant learning offers the possibility to take part of a vocational training without being absent from the business.

### 3.3.4.11 Match of Instruments, Groups of Interest and Location

It is evident that different kinds of personalities need a different kind of E&T approach, where some match of personalities might occur with the target groups but with this match being for from 100 %.

| | Management & executives | Engineering, R&D | Sales & marketing | Production, engineering | Production, workfloor |
|---|---|---|---|---|---|
| Local, inside company | | | | | |
| Regional, local language | | | | | |
| External, common language | | | | | |
| | | | | | |
| Classical training | | | | | |
| Knowledge/practices | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Practical training | | | | | |
| Short training | | | | | |
| Conference/tutorial | | | | | |
| Network activities | | | | | |
| Road shows | | | | | |
| Distant learning | | | | | |
| Exchange of staff | | | | | |
| Casestudies | | | | | |
| Project approach | | | | | |
| RTD projects | | | | | |
| Database application | | | | | |

One may distinguish between the following E&T approaches:

- Lateral (not too systematic) approach, with dialogue, interactive between trainer and student, exchange of ideas, including open-end problems.
- A less open but more systematic approach, more task related than the previous approach, with hands-on examples.
- More direct, interactive with the topic, with reference to realistic experiences and values. Not open ended and not much room for variation on the topics. The student needs to be aware of the final goal and benefits of the training.
- Bi-directional communication, affective, focus and selective on the individual interests of the student.

### 3.3.5 Financing

The financing of the different Trade and Industry related E&T projects is listed directly in chapter 3.3.7 (page 44).

### 3.3.6 Appraisal Benefit for Europe

Education and training measures even at a comparatively early stage of technology development and availability will strengthen the European position in the worldwide competition of market introduction of a hydrogen economy and fuel cells in all kinds of applications. E&T measures are essential for a successful market introduction, especially the market introduction of a new technology. The maturity of the

technology, competitive prices and venture capital assumed, E&T activities belong to the soft conditions for market introduction. They pave the way for a smooth and frictionless market introduction

Within Europe several countries have reached a high level in research concerning hydrogen technology and fuel cells. The skills are reaching from the materials level to system technology.

However, at the present instruments fostering market introduction are not that effective in Europe when compared to the situation in the U.S. or in Asia. Development and demonstration of industrial products is one of the key tasks to be accomplished. The availability and visibility of industrial products is a prerequisite for creating awareness and actions in trade.

The preparation of a-strong education and training landscape for trade will help to speed up market penetration of hydrogen and fuel cell technologies. It is expected that businesses in trade should start preparing for these new technologies approximately three to five years in advance to the market introduction of commercial products.

Investment in education and training for trade will strengthen the European competitiveness by having a trained and skilled workforce ready at the time of market introduction.

Furthermore, in cases like combined heat and power generation using residential fuel cell systems, trade has a significant influence in marketing due to the proximity to the final customer. As already seen in history (e.g. heat pumps or condensing boilers), the market introduction of new technologies can be slowed down significantly when trade is not aware of their benefits.

### 3.3.7 E&T Recommendations of the WG Trade&Industry

Although hydrogen and fuel cell technology is still in a very early stage of technology introduction, dissemination of information already available is of key importance in order to prepare the ground for a fast market introduction as soon as products will become available. Nevertheless, it should be avoided to raise too high expectations with respect to the time line. Therefore, one should distinguish short-term actions and more long-term actions.
Close cooperation with the efforts in the deployment strategy including participation of representatives from trade in the generation of a reliable road map for technology introduction is suggested.

**Short Term E&T Recommendations**

Measures having implementation time constants up to 3 years will be summarized in the following chapter.

**Establishment of a European H2&FC Education and Training Coordination Unit (HYFED6)**
to coordinate the different components of the European Trade&Industry Strategy on European and national levels and disseminate information on educational material and programmes;

**Internet Portal**
The Internet portal should give access to the following information

- Information on current demonstrations
- Reference to Codes and Standards
- Basic distant learning modules

Establishment of the Internet portal has high priority. The basic version should be in English. Gradual translation into the different languages within the EU should be achieved using the Commission services. Sustained operation of the portal should be sponsored by the Commission e.g. via the Cordis platform. Another possibility could be the use of the already existing portal "Fuel Cell markets" as a basis.

***Timeline:*** This action should start immediately, but should be extended in the 7th FP.
***Effort:*** approx. 2PJ, ~200 T€
***Implementation:*** by call for tender.

**Written Information**
Besides the internet portal, provision of unbiased written information materials have a high priority. The contents could be adapted from Internet portal. The translation into different EU languages could be done by the Commission Services. Printing cost could also be covered by the FP6 and FP7 dissemination budget. Information materials should be provided in the form of brochures and electronic media.

***Timeline:*** This action should start immediately, but should be extended in the 7th FP.
***Effort:*** approx. 2PJ, ~250 T€
***Implementation:*** by call for tender.

**Information tour**
Information on hydrogen and fuel cell technology should be disseminated via aecture tour through European facilities of vocational training giving presentations on:

- Properties and visions on hydrogen
- Fuel cell basics
- Reports from current RT&D projects
- Technical exhibit

Total duration about 2.5 hours during the evening. It is suggested to carry out approximately 150 events during a 2 years period. The effort could be supported by information trailers as proposed in the next chapter.

***Timeline:*** This action should start at the beginning of the 7th FP.

***Effort:*** Preparation approximately 30 T€ including teaching materials. Cost per event including travel: approx. 5 T€. Total cost ~ 780 T€.

***Implementation:*** by call for tender.

**Information trailer**

A prototype of an info trailer demonstration hydrogen and fuel cell technologies should be built. The trailer should demonstrate the best practice. Eventually, such trailers could be replicated in a number that one trailer could serv a “medium sized” region. The info trailer has a medium priority. Replication of the trailer could be financed by industrial sponsoring or regional funds.

***Timeline:*** This action should start at the beginning of the 7th FP.

***Effort:*** Total cost for a prototype approx. 150 T€.

***Implementation:*** by call for tender.

**Workshops for Builders and Planners**

Dedicated workshops on hydrogen and fuel cell technologies for builders, architects and planners should be carried out. Each workshop should serve approximately 20-50 participants. Approximately 5 workshops should be held per member state giving a total of 125 workshops.

***Timeline:*** This action should start at the beginning of the 7th FP.

***Effort:*** Preparation of workshop concept including selection of info-material approx. 75 T€. Realization of the workshops, including travel and materials approx 5 T€ per workshop (625 T€ for all workshops) Total effort approx. 700 T€. Participants should contribute to the workshop costs.

***Implementation:*** by call for tender.

## Longer Term E&T Recommendations

In the following chapters, measures having implementation time constants above 3 years will be summarized.

**Socio Economic Studies**

A- a comparative study on the state of the art of E&T activities in the field of hydrogen and fuel cell technologies within Europe summarizing the vocational

training systems followed and the qualifications required within Europe should be carried out. The comparative study has a high priority.

***Timeline:*** This action should start at the beginning of the 7th FP.

***Effort:*** approx. 5 PJ ~ 500 T€
***Implementation:*** by call for proposal.

B - a study on the effects of distant learning in vocational training throughout Europe should be carried out.The study has a medium priority.

***Timeline:*** This action should start within the 7th FP.

***Effort:*** approx. 5 PJ ~ 500 T€
***Implementation:*** by call for proposal.

**Establishment of a knowledge database**

The Establishment of an easily accessible and searchable knowledge database has a high priority. The potential users are multipliers, trainers, developers etc. The database should:

- Collect existing codes and standards
- Give reference to best practice

The database needs updating on a regular basis.

***Timeline:*** This action should start at the beginning of the 7th FP.

***Effort:*** approx. 2.000 T€ - 2.500 T€
***Implementation:*** by call for proposal (STREP).

**Definition of a curriculum**

The definition of a curriculum has a medium priority. Education and training of people in trade and industry could start by “infiltration” of technical training of advanced technicials. This effort should be done in cooperation with the Grundvik and Leonardo program. The curriculum should be specific for the following target groups:

- Industry
- Trade
- Builders, planners, architects

***Timeline:*** This action should start withinthe 7th FP.

***Effort:***
***Implementation:***

**Walk in Info Center**

Dedicated exhibitions should be available as “Walk in Info Centers” e.g. in the Innovation relay Centers of the EU. The exhibitions could be “poster type only”. Preferably the exhibition should be supported by some rugged hardware. Ehibitions could be rotated.

***Timeline:*** This action should start withing the 7th FP.

***Effort:***

***Implementation:*** by call for tender.

**Training Centers for vocational training**

Approximately 5-10 vocational training centers focussing on hydrogen and fuel cell technologies should be established throughout Europe. Such centers could be organized similar to the ones established within the German fuel cell education projects. The centers should take the differences in regulations within Europe into account. Establishing of the training centers have a high priority. In the beginning, the training centers should adopt a “train the trainer” concept. Although the total training demand is hard to predict, the following considerations should give a hint:

It is expected that eventually 100.000 stationary units will be deployed per year. This will be done by approximately 1.000 to 2.000 businesses. Furthermore, 500.000 vehicles will be expected to be in service by approximately 5.000 businesses. Assuming a trainer will take care of about 10 businesses, this will require approximately 700 skilled trainers in the market introduction phase.

***Timeline:*** This action should start at the beginning of the7th FP.

***Effort:*** approx. 3.500 T€ per center. Co-financing by the local industry and EU-regional funds is suggested.

***Implementation:*** by call for proposal.

## 3.4 Government

### 3.4.1 General

The introduction of hydrogen and fuel cell technologies will require a significant change of "vision" of "early-stage" facilitators and accelerators of the process. The education and training of such facilitators (target groups) should be fast and adequate to prepare the ground for new generations coming out from more conventional educational phases, such as, schools, universities and research centres. The education and training of central and local government employees, regulatory organizations, members of parliament and other decision makers on the EU, national, state and local level, will be fundamental and instrumental in facilitating the development, demonstration, dissemination and application of hydrogen and fuel cell technologies. The target groups will also include end-users decision makers, who will play an important role in accelerating the introduction of hydrogen and fuel cells in the market place, by means of demonstration and preliminary applications.

The target groups will be addressed in different ways, because of the different roles and need of information.

The educational and training objective for government and regulatory bodies is to supply scientific and technical information aimed to assist definition of policy, research initiatives and regulations (including the preparatory work on codes and standards).
For decision makers at local government level (regional and municipal authorities, public fleet managers and so on) and in end-user organizations the educational program must address advantages of fuel cell and hydrogen technologies in order to facilitate demonstration and introduction decisions.

### 3.4.2 State of the Art

Educational programs and projects for the specific target groups considered by this WG have been already defined in USA [1] and under discussion in the framework of the IPHE activities [2]. In addition, NEDO in Japan has been running projects to promote the introduction of new energy systems "vision" at local authorities level.
In 2004 the US DOE's Education Program has had an overall budget of US $ 4,31M, of which only 160 k$ were specifically devoted to state and local governments education. In 2005 no further budget was approved with a deferring of the running

[1] U.S. DOE's **Hydrogen, Fuel Cells & Infrastructure Technologies Program:** Multi-Year Research, Development and Demonstration Plan, planned activities for 2003-2010.

[2] IPHE Education Scoping Paper, ILC-054-05, July 2005, draft.

projects from 2005 to 2006. The request for funding appropriation for 2006 is US $ 1.881M for the entire Education Program element. The key objectives for the target groups of this WG are:

- *Provide objective, accurate information that government representatives can rely.*
- *Provide objective, accurate information that potential end users can use as part of their research to make informed decisions.*
- *Support training for potential end users*.
- *Provide objective, accurate information that government representatives can rely on as part of their research to make informed decisions.*
- *Provide objective scientific and technical information to support the timely development of hydrogen and fuel cell policies and regulations.*

Major achievements of the running projects are the completion of a baseline survey and the first series of hydrogen learning workshops. Next steps will be the establishment of collaborations for the leverage of scarce resources in the sector.

IPHE Scoping paper on Education focuses on a near- term target of establishing a database of educational resources in participating countries. Japan though NEDO is creating the “vision” for the introduction of new energy at local level by means of workshops, symposia and demonstrations.
The EU through the creation of the HFP Mirror Group and the start in October 2004 of the Coordination Action “HY-CO” has first addressed the need to put together government decision makers to exchange information on programmes, projects and methodology. These existing bodies are already an example of possible cooperation scheme. These bodies should be used as “nucleation” point for starting the agglomeration of basic information to create the necessary “network” of associations, organizations and public bodies (central and local government). Appropriate educational and information transfer tools should be developed. Some other running Projects involve government officers (e.g. Zero Regio Project) and can be used as education tool for non-prepared officers.

### 3.4.3 Tasks

Government and end-users decision makers should be timely informed of the status of the hydrogen and fuel cell technology by using all the existing instruments, already in place at European and national level. Present and new actions in the FP6 should be better oriented to these target groups to faster identify needs and meet requirements. Furthermore, a more structured intervention should be planned for the coming FP7.
Information on hydrogen and fuel cells is normally available in forms not adequate for decision makers in governments and end-users.

The key objectives of a near-term and long-term structured education and training of defined target groups are mainly based on the interpretation of the real needs and the status of existing decisional process, based on objective information. The approach will then, in the near term, consider a preliminary analysis of the needs and the classification of potential tools, which may be used for a subsequent, in a longer term, educational program.

### 3.4.4 Methods

A preliminary identification of the specific needs of the various categories should be performed to better tune the different educational instruments. The work may be carried out publicly by surveying in various manners the specific needs of the targeted categories. Workshops and questionnaires should be the preferred methods for the survey.

The education and training activities for this target audience may have a beneficial contribution and integration with the activities of the Mirror Group and the results of the running Project HY-CO. The Mirror Group may be the primary source for the creation of a European database containing the list of potential target groups to which address the information. On the other hand, a structured approach to the education and training of the decision makers in government and end-users may transfer and disseminate the results of HY-CO to a larger audience, outside the participating countries in HY-CO and other target groups not involved in the Mirror Group, in a professional manner.

This information will include:

- Inventory of R&D project/programs at national and international level
- Survey of demonstration projects
- Executive summary of best practices and success story
- Survey of safety, regulatory and standards situation
- Survey of barriers to the introduction of hydrogen and fuel cells and possible solution for their limitation
- Formation and identification of trainers
- Preparation of tailored educational tools
- Technical tours to demonstration and application projects.

In this near term phase, some EU running projects may be a practical and effective way to quick present and disseminate information, lessons learned and day-by-day best practices to decision makers. Limitations to the widespread exploitation of these funded projects should be investigated to simplify the adaptation as educational tools.

The results of these preparatory activities will be used for the definition of a better focused program, which will address the specific categories of the targeted audience with an accurate selection of educational tools to make the information transfer

neutral, effective and accurate, but also timely and compatible with the specific working modes in different bodies and countries.
The use of modern tools with spontaneous and direct use by the decision makers, such as website or distance training, seems inadequate in terms of quality and efficacy.
Well-structured packages divided by topics should be more appropriate:

- Safety aspects
- Potential applications and demonstrations
- Socio-economic impact
- Environmental and energetic impact

These packages may be formed of a variety of educational tools:

- Workshops
- Videos
- Brochures
- Class materials
- Technical visits

### 3.4.5 Financing

The near term approach makes possible to take advantage of the last calls of the FP6. The preliminary survey phase may be carried out through a Coordination Action and/or a Specific Support Action integrating and complementing the activities of the Mirror Group and the HY-CO Project, in which an inventory of projects and programs is already planned. This activity can be carried out in 1 year with a total budget of about Euro 300.000-500.000, depending on the number of involved countries and organizations and the target groups considered.
In a longer term, the budget will be better defined with the results of the survey.
The preparation of specific educational tools for direct information, as stated in the previous chapter (with an update every two years) will require at least Euro 150.000/y. Technical visits and short courses/workshop will require other Euro 200.000/y (4 per year with 25 participants each).
The work can be better organized and structured by a specific Committee involving the target groups representatives, some coordinating organizations, education centres and the European Commission: this Committee can be also the interface to international bodies, such as IPHE. The running costs of such Committee, involving at least EU Member States, can be in the order of Euro 150.000/y.

### 3.4.6 Appraisal of Benefit for Europe

An hydrogen and fuel technology society will require to start on possible facilitators, who have the sufficient information to take adequate decisions. Decision makers

must be educated now to prepare the new classes of decision makers prepared with new school curricula. Europe needs to take the lead in this process, in a moment in which the activities in the field are just starting all over the world. The preparation of a class of decision makers at various organizational levels may take advantage of the experiences and the lessons learned in some demonstration projects already funded, able to facilitate a faster use of these technologies.
The existence of already established groups (Mirror Group and HY-CO Project) may further accrue the possibility of the creation of an informed class of decision makers, giving to Europe the leadership in a more diffuse market.

### 3.4.7 E&T Recommendations of the WG Government

**Establishment of a European H2&FC Education and Training Coordination Unit (HYFED6)**

to coordinate the different components of the European Strategy for Education of government and regulatory bodies on European and national levels.

**Education and training of decision makers**

as central and local government employees, regulatory organizations, members of parliament, other decision makers on the EU, national, state and local level, and end-users decision makers.

In three phases:

**A - Preparatory phase for the identification of needs and target groups**

The results of the survey should be:

- A database of potential interested bodies,
- A priority list of needs of information in the field of hydrogen and fuel cells
- A selection of preferred tools for education and training.

***timeline:*** Starting already now

**B - Evaluation phase for developing and testing educational tools**

for a restricted reference group

***timeline:*** Starting in 2006

**C - Regular phase with annual updates and continuous courses**

for the defined target groups.

***timeline:*** Starting with the 7$^{th}$ FP

# 4 Education and training infrastructure

Education and Training needs a stable infrastructure in order to realize the Education and Training Program (ETP) for the 7th FP, which has been worked out by the Initiative Group Education and Training in the framework of the European H2&FC Technology Platform.

Within the framework of the ETP measures in four areas are proposed:

- Schools
- Academia&Research
- Trade&Industry
- Government.

For the ***coordination*** of the E&T activities in all fields, an European H2&FC Education and Training Coordination Unit (HYFED6) should be established.

For the actual ***E&T work***, however, European H2&FC Education and Training Centers (EETCs) are to be formed. These centers should be located in the south, west, north, east and middle of Europe. The EETCs should cover E&T in a greater European region. Furthermore, they should be a nucleous for National H2&FC Education and Training Centers (NETC) to be founded in a later stage. The selection and locations of the EETCs shall be done via a competitive call for proposals.

Very important is to have such a EETC in one or two of the new member states, because in these states the H2&FC knowledge is relatively low. General the new member states should be in the focus of the European H2&FC E&T work.

The HYFED6 and the EETCs have to coordinate their work carefully. They will be a effective umbrella for all European E&T actions.

Because the HYFED6 and the EECTs are the central point for realizing the ETP, it is very important, that they shoud be established immediately. Otherwise the ongoing ET activities, initiated and driven by the IGE&T cannnot be sustained .

# 5 General Financing Aspects

Financing of education and training measures should have four components:

- European
- National
- Industrial
- Individual

**European Aspect**
There are European programs available covering vocational training and adult education. These are:

- Leonardo da Vinci actions (vocational training)
- Grundvik (adult education)

Within the framework of these programs, exchange of personnel etc. could be arranged.

An additional instrument could be provided by the Era Net actions. In this context, regional cooperation could be sponsored.

Education and training aspects could explicitly be integrated in R&D calls for proposals.

Education and training is also a matter of learning by doing. Therefore, EU-tools like CRAFT (as the 'engine' for knowledge transfer with SME's) should be used as well. The idea of training centres may be linked to CRAFT initiatives where relevant problem areas are exploited to demonstrate/develop practices as part of education and training.

**National Aspect**
Instruments available nationally for support of R&D work as well as education should be partly converted to initiate the actions necessary for education and training in the field of hydrogen and fuel cell technology. Particularly, national and European demonstration projects could be used to strengthen the education and training aspects.

**Industrial Aspect**
Although the "fuel cell industry currently is in it's infancy and far from being a profitable business, it is expected that it will contribute to education and training e.g. by participation in European research and demonstration projects. Furthermore, it can be expected that industrial enterprises will contribute to the generation of an education and training infrastructure for hydrogen and fuel cell technologies.

**Individual Aspect**
Besides public and industrial sponsoring, it is expected that trainees or their parent companies will have their share.

The ETP is designed for the 7th FP. Therefore most of the support money is to be placed in the 7th FP. Nevertheless for a transitional period of one year till the beginning of the 7th FP, a sum of about 1 Mill EUR should be allocated to

- Summer schools 100, 000 €
- Young scientist award 25,000 €
- European H2&FC Education and Training Coordination Unit (HYFED6) 400,000 €
- Education materials 475,000 €.

In the moment is is very difficult to estimate the total sum to be allocated for education and training activities in the 7th FP, because the details are not clear enough for all WG activities. Nevertheless for a significant part of the measures proposed, approximations are given in the chapters of the WGs dedicated to financing.

An indicator for the finacial demand could be the present EC rule to use about 10% of the total RT&D budget of the commission contribution for dissemination and education&training.

In the 7th FP two ways of E&T funding are to be proposed:

a- E&T activities should be explicitly integrated into RT&D calls

b- Special E&T activities of Education and Training Program should be funded separately

The relatively costs distribution for the 4 WGs and the coordination should be as follows:

| | 2007-2010 | 2010-2013 |
|---|---|---|
| WG School | 20 % | 25 % |
| WG Academia&Research | 40 % | 35 % |
| WG Trade&Industry | 27,5 % | 27,5 % |
| WG Government | 10 % | 10 % |
| Coordination | 2,5 % | 2,5 % |

Additionally, funding from DG Education could support the proposed E&T activities. Furthermore, regional and infrastructure funds should be considered.

In parallel with the market introduction of the H2&FC technology most of the Trade & Industry E&T activities should became step by step self-financing after an initial financial support by the EU.

## 6 Proposition E&T Programme

The Education and Training Programme (ETP) in general should help to bring hydrogen and fuel cells to the market - exploiting their outstanding environmental and economical potential by educating the customers of the future and their families. In more specific terms, the Education and Training Programme provides an outline to stimulate a broad European education and training spanning primary schooling to world-class research.

The ETP is designed to provide guidance for H2&FC education and training measures for the different addressees (schools, universities, research centres, trade, industry, state and local governments) in order to make available people with in depth H2&FC knowledge on the different levels on the way to a H2&FC market to ensure that European competencies are at the forefront of science & technology worldwide.

Education efforts can achieve their maximum benefit if they crosscut all the HFP areas starting with the Strategic Research Agenda (SRA) until the Deployment Strategy (DS) – to leverage educational opportunities and materials in each area. The IG E&T will work with both the SRA and DS to ensure that education efforts are appropriately integrated across program areas.

The programme will cover the period until 2013, i.e. until the end of the FP 7 in detail

The following is proposed:

**Schools:**

- *Establishment of a European H2&FC Education and Training Coordination Unit (HYFED6)*
  to coordinate the different components of the European School Strategy on European and national levels and disseminate information on educational material and programmes

  *Timeline:* beginning now

- *National Curriculum Integration of Hydrogen and Fuel Cell topics as part of clean energy*

  *Timeline:* beginning now and to continue in the 7th FP

- *Develop permanent and portable exhibitions and programmes at local science museums, nature centres and learning centres*

  *Timeline:* beginning now and to continue in the 7th FP

- *Central Database and Website of Educational Material and Programmes,*
  *Timeline:* by the end of 2006

**Academia&Research**

- *Establishment of a European H2&FC Education and Training Coordination Unit (HYFED6)*
  to coordinate the different components of the European Academia&Research Strategy on European and national levels and disseminate information on educational material

  *Timeline:* Beginning now

- *Forming a H2&FC University and R&D Institute Network*
  to combine and to improve the experiences of the different universities. One important task of this network is to develop basic H2&FC teaching materials (software and cheap hardware).

  *Timeline:* Beginning now and to continue in the 7th FP.

- *Forming European H2&FC Education and Training Centres*
  at university and R&D Institute level to give selected members of the *H2&FC University Network* an experimental basic.

  *Timeline:* Beginning with the 7th FP

- *Establishment of a European Virtual H2&FC University*
  based on the *H2&FC University and R&D Institute Network* and *European H2&FC Education and Training Centres.*
  Later an extension to a *World Virtual H2&FC University* in cooperation with the IHPE, the IEA and the UNO is planed

  *Timeline:* Beginning with the 7th FP.

- Using the Marie Curie fellowships
  as a vehicle for effectively organising a new educational approach at the level of universities and research centers with the most widespread impact.

  *Timeline:* Beginning now.

- *European Young Scientists Competition*
  Should be offered awarding a special prize in the area of H2&FCs.

  *Timeline:* Beginning now

- *Training courses for young and high level/experienced researchers*
  in agreement with the demand of the SRA.

  *Timeline:* Beginning now and to continue in the 7th FP.

- *Establishment of a high level research oriented European H2&FC conference* in the style of the Gordon research conferences should be considered.

  *Timeline:* Beginning now, but realization in the beginning of the 7th FP.

- *Worldwide dissemination of H2&FC education materials*
  In cooperation with the IPHE, the IEA, the United Nations, and National H2&FC Organizations with special connections to non-European countries.

  *Timeline:* Beginning now

***Trade&Industry***

*Short Term E&T Recommendations*

Measures having implementaton time constants up to 3 years will be summarized in the following chapter,.

- *Establishment of a European H2&FC Education and Training Coordination Unit (HYFED6)*
  to coordinate the different components of the European Trade&Industry Strategy on European and national levels and disseminate information on educational material and programmes

  *Timeline:* Beginning now

- *Internet Portal*
  The Internet portal should give access to the following information

  - Information on current demonstrations
  - Reference to Codes and Standards
  - Basic distant learning modules
  - Best practices and implementation guidelines

  *Timeline:* Beginning now, extended in the 7th FP.

- *Written Information*
  The contents could be adapted from Internet portal. The translation into the different languages within the EU could be done by the Commission Services.

  *Timeline:* Beginning now, extended in the 7th FP.

- *Information tour*

Information on hydrogen and fuel cell technology should be disseminated via lecture tour through European facilities of vocational training giving presentations on:

- Properties and visions on hydrogen
- Fuel cell basics
- Reports from current RT&D projects
- Technical exhibit

*Timeline:* Beginning with the 7th FP

- *Information trailer*
  A prototype of an info trailer demonstration hydrogen and fuel cell technologies should be built. The trailer should demonstrate the best practice.

  *Timeline:* Beginning with the 7th FP

- *Workshops for Builders and Planners*
  Dedicated workshops on hydrogen and fuel cell technologies for builders, architects and planners should be carried out.

  *Timeline:* Beginning with the 7th FP

*Longer Term E&T Recommendations*

In the following chapters, measures having implementation time constants above 3 years will be summarized.

- *Socio Economic Studies*
  A - a comparative study on the state of the art of E&T activities in the field of hydrogen and fuel cell technologies within Europe summarizing the vocational training systems followed and the qualifications required.

  *Timeline:* Beginning with the 7th FP

  B - a study on the effects of distant learning in vocational training throughout Europe

  *Timeline:* Beginning with the 7th FP

- *Establishment of a knowledge data base*
  The Establishment of an easily accessible and searchable knowledge data as existing codes & standards and reference to best practice.

  *Timeline:* Beginning with the 7th FP

- *Definition of a curriculum*

  Education and training of people in trade and industry could start by "infiltration" of technical training of advanced technicials. This effort should be done in cooperation with the Grundvik and Leonardo program. The curriculum should be specific for the following target groups:

  - Industry
  - Trade
  - Builders, planners, architects

  *Timeline:* Beginning with the 7th FP

- *Walk in Info Center*

  Dedicated exhibitions should be available as "Walk in Info Centers" e.g. in the Innovation relay Centers of the EU. The exhibitions could be "poster type only".

  *Timeline:* Beginning with the 7th FP

- *Training Centers for vocational training*

  Approximately 5-10 vocational training centers focussing on hydrogen and fuel cell technologies should be established throughout Europe.

  *Timeline:* Beginning with the 7th FP

***Government***

- *Establishment of a European H2&FC Education and Training Coordination Unit (HYFED6)*

  to coordinate the different components of the European Strategy for Education of government and regulatory bodies on European and national levels.

  *Timeline:* Beginning now

- *Education and training of decision makers*

  as central and local government employees, regulatory organizations, members of parliament, other decision makers on the EU, national, state and local level, and end-users decision makers.

  In three phases:

  *A - Preparatory phase for the identification of needs and target groups*

  The results of the survey should be:

- § a database of potential interested bodies,
- § a priority list of needs of information in the field of hydrogen and fuel cells
- § a selection of preferred tools for education and training.

*Timeline:* Beginning now

*B - Evaluation phase for developing and testing educational tools* for a restricted reference group

*Timeline:* Beginning in 2006

*C - Regular phase with annual updates and continuous courses* for the defined target groups.

*Timeline:* Beginning with the 7th FP

For the European E&T work should be formed an *European H2&FC Education and Training Coordination Unit* (HYFED6) and *European H2&FC Education and Training Centers (EETCs).* They will be a effective umbrella for all E&T work. The HYFED6 and the EETCs have to coordinate their work carefully.

The European H2&FC Education and Training Coordination Unit (HYFED6) should be responsile for the ***coordination*** of the E&T activities in all fields.

The European H2&FC Education and Training Centers (EETCs) should be responsible for the actual ***E&T work.***

Because the HYFED6 and the EECTs are the central point for realizing the ETP, it is very important, that they shoud be started immediately. Otherwise the ongoing ET activities, initiated and driven by the IGE&T cannot be sustained.

Furthermore for a transitional period of one year till the beginning of the 7th FP, a sum of about 1 Mill EUR should be allocated to summer schools, young scientist award, formtion of an European H2&FC Education and Training Coordination Unit (HYFED6), and Education materials.

## 7 ANNEX (Editorial Commission of the Education and Training Programme)

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