EUROPEAN INTEGRATED HYDROGEN PROJECT [EIHP]

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1 EXECUTIVE SUMMARY

A significant reduction or even elimination of local greenhouse gas (GHG) emissions from vehicles can be achieved by the use of hydrogen as a vehicle fuel, particularly when it is produced from renewable energy sources. Fuel Cell Vehicles using hydrogen as a fuel provide a solution to improve energy efficiency and a reduction of local and global pollutants. With hydrogen optimised internal combustion engine concepts emissions characteristics can be achieved which may come very close to fuel cells. In urban and suburban driving patterns fuel cell electric drive trains will maintain their superior tank-to-wheel fuel efficiency. In order to introduce hydrogen successfully into the transport sector, the use of hydrogen must be at least as safe as conventional fuels and preferably safer.

To understand the motivation for the project, one has to realise that some 46 directives have to be applied in order to receive an approval for a road vehicle in Europe. If a vehicle fulfils the test requirements of these 46 directives it has to be approved. The result is a Whole Vehicle Type Approval. At present if approval for a hydrogen fuelled vehicle is applied for, tests required by directives relating to emissions, fuel consumption and engine power cannot be carried out because of the absence of a standardised reference fuel or a procedure for testing the engine power. Some other directives can be fulfilled formally, but from the technical point of view they should be revised for hydrogen vehicles. Some requirements regarding the safety of the hydrogen on-board storage systems are not included in the existing directives.

What needs to be done to approve a hydrogen vehicle in Europe? In this case the exception ruling for application of new technologies, as per Article 8(2)c of directive 70/156/EEC, has to be invoked. With respect to this, evidence has to be shown that equivalent safety and environmental protection is provided by the vehicles when compared to conventional vehicles. Within six months, the Commission should make a decision regarding the application.

The weaknesses of the process are:

1. Excessive amount of time required
2. Uncertainty of the outcome of the process up until the very end

It is evident that such an approval process cannot be used for hydrogen fuelled vehicles in the future.

In order to enhance the safety of hydrogen vehicles, and to facilitate the approval of hydrogen vehicles, the European Integrated Hydrogen Project (EIHP) was established. A main objective of the EIHP was the development of draft regulations for the use of hydrogen as a vehicle fuel. These documents will be presented to WP29 of the Economic Commission for Europe (ECE), a UN organisation in Geneva, in the second half of 2000. The EIHP aimed at creating the basis for the harmonisation of the necessary legislation in Europe for the use of hydrogen in road vehicles. The work has been undertaken by the partners in close co-operation with the licensing authorities and was based on a dual strategy: analysis of existing hydrogen related legislation in Europe, Japan and the USA, and analyses of existing hydrogen vehicles and infrastructure in Europe complemented by safety studies.

Proposals for improved safety concepts were developed as well as concepts for standardised vehicle and infrastructure components, and harmonised regulations. The new draft ECE regulations for hydrogen fuelled road vehicles were developed following the framework of existing regulations and standards for CNG and LPG, and were also based on the results of the EIHP safety studies.

Where necessary, proposals for further investigations were identified. Open questions regarding hydrogen fuelled vehicles were addressed and approval authorities were familiarised with

hydrogen technology. Applicable regulations for hydrogen related refuelling infrastructure were collected for Germany and France.

In a public mid-term workshop, held in Brussels in March 1999, project partners and interested European authorities and specialists exchanged views on the approach of the EIHP to safety, licensing and approval issues.

The EIHP project helped the partners from the automotive industry (BMW, RENAULT and VOLVO) to advance the regulatory situation of hydrogen fuelled road vehicles with respect to obtaining whole vehicle type approval for operation on public roads in Europe. Furthermore, the EIHP allowed the partners to progress the development of components and systems for hydrogen fuelled road vehicles (internal combustion engine or fuel cell propelled ones) and to develop the necessary knowledge and expertise necessary for the safe introduction of hydrogen as a vehicle fuel.

2 THE PARTNERSHIP

The EIHP consortium comprises some of the most experienced companies and institutions actively involved in the fields of hydrogen vehicle applications, hydrogen infrastructure and hydrogen safety in Europe. In alphabetical order the organisations are:

- Air Liquide S.A. (LAL), France, a company specialising in industrial gases and gas technology as well as cryogenic liquid hydrogen covering all aspects of storage, handling and safety of LH_2;
- Bayerische Motoren Werke AG (BMW), Germany, a manufacturer of high-performance vehicles and a specialist in LH_2 vehicle applications for almost 20 years;
- European Commission's Joint Research Centre (EC-JRC), Italy, a specialist in developing mathematical models of liquid gas spillages, evaporation and gaseous cloud formation, as well as fire and explosion propagation in confined and non-confined environments;
- Hamburgische Electricitäts-Werke AG (HEW), Germany, a utility active in several hydrogen projects, most recently participating in a small fleet demonstration of six vans converted to facilitate compressed hydrogen operation (W.E.I.T. project);
- Hydrogen Systems N.V. (HYDSYS), Belgium, a specialist in hydrogen technologies such as electrolysis equipment, hydrogen use in stationary CHP applications and especially conversion of vehicles and of internal combustion engines for the purpose of hydrogen operation;
- Instituto Nacional de Técnica Aeroespacial (INTA), Spain, the leading institute for the homologation of vehicles in Spain with experience in the approval of gas-operated vehicles as well as hydrogen expertise in stationary applications;
- Ludwig-Boelkow-Systemtechnik GmbH (LBST), Germany, an experienced co-ordinator of various national and international hydrogen-related projects of the last decade, and author of numerous hydrogen related system studies on hydrogen production from renewable and non-renewable sources, on hydrogen supply, handling and distribution, on hydrogen safety and on hydrogen use in stationary and mobile fuel cell applications;
- Messer-Griesheim GmbH (MESSER), Germany, a leading specialist in cryogenic liquid natural gas and liquid hydrogen technology for vehicle applications;

- Renault, the leading French vehicle manufacturer and recently engaged in the development of LNG propulsion technology and of a PEM fuel cell driven Renault Laguna with LH_2 fuel storage;
- AB Volvo, Sweden, the largest Swedish vehicle manufacturer is now one of the world's largest producers of transport equipment for commercial use, including trucks, buses and construction equipment, and holds a leading position in the fields of marine, industrial and aerospace engines. For many years Volvo has been actively involved in the development of alternative drive train concepts and more recently also engaged in the development of PEM fuel cell drive train systems.

3 OBJECTIVES OF THE PROJECT

Implementation of hydrogen vehicle and infrastructure technology can only succeed if the co-ordination of European R&D activities are intensified and technical progress is not hindered by differing regulations and licensing procedures within the EU member states. This project, which aimed at creating the basis for harmonisation of necessary legislation in Europe, was undertaken in close cooperation with licensing authorities in several EU member states (Belgium, France, Germany, Spain, Sweden).

The main objectives of this project were to: identify deficiencies impeding the harmonisation of guidelines, regulations etc., coordinate harmonisation in the approaches to standardisation; prepare a well-defined basis for discussion with relevant authorities; integrate the practical experience with hydrogen vehicles in the draft regulations; integrate existing ECE frameworks; and develop concepts for standardised vehicle components and infrastructure.

The particular objectives of the EIHP were:

1. To create a pan-European database of existing regulations and codes of practice applicable to the use of hydrogen in vehicles
2. To contact other pertinent authorities outside Europe (Japan, USA)
3. To identify weak spots in today's technology
4. To define the areas requiring regulation
5. To analyse, identify and propose safety concepts
6. To integrate ECE guidelines and create a basis of ECE regulation of hydrogen vehicles and the necessary infrastructure (replacing national legislation/ regulations)

As a result, proposals for further investigations and improved safety concepts were compiled, together with concepts for standardised vehicle components, infrastructure components and draft harmonised regulations.

4 SCIENTIFIC AND TECHNICAL DESCRIPTION OF THE PROJECT

4.1 Project overview

The project is based on a dual strategy.

One part of the project – a top down approach –focused on the existing hydrogen related vehicle legislation in European countries.

The other part of the project – a bottom up approach –focused on hydrogen vehicles and technology in Europe including safety issues and infrastructure supply technology.

A continuous exchange of the results between the two parts and a flexible approach to the various tasks assured the effectiveness of the project. The results of the technology and of the safety studies were integrated into the draft hydrogen regulations where appropriate.

Figure 4.1 depicts the two main paths of the 'top down approach' pursued in Tasks 1, 3, 4, and 6 (see Section 4.2) covering the regulatory situation, and the 'bottom up approach' worked on in Tasks 2, 5 and 7, covering safety aspects. The results from both lines of work, fine tuned in several iterations, have been fed into the two draft regulations developed during the course of the project within a redefined Task 8.

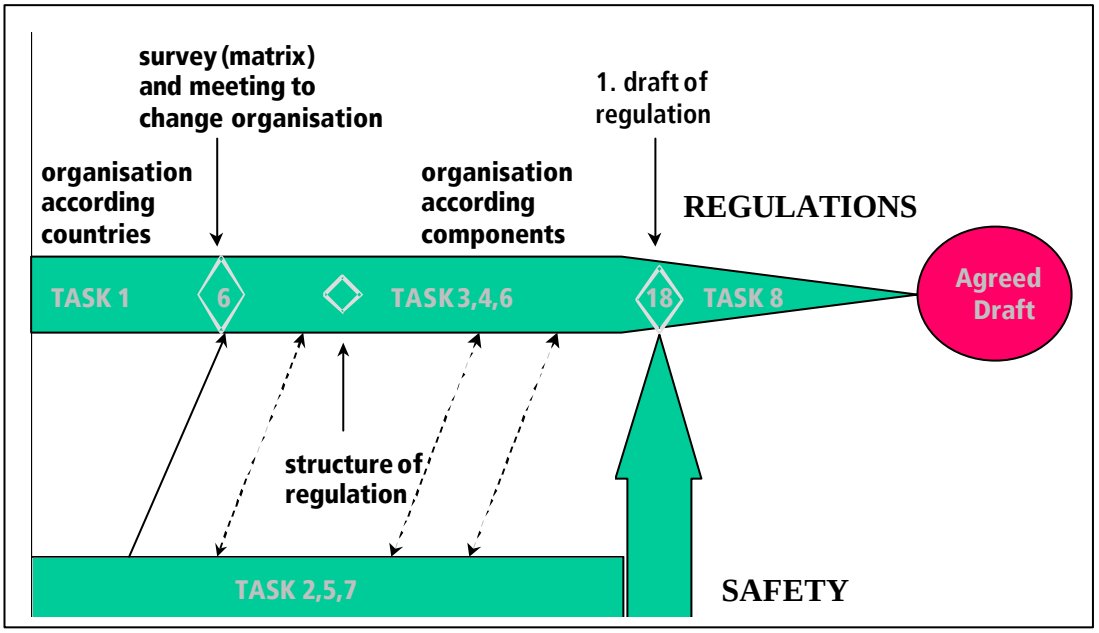


Figure 4.1: Strategy of Work Distribution

4.2 Description of the different tasks of the project

The following overview shows the description of the different tasks or work packages:

Task 1: Survey/ analysis of rules, regulations and licensing procedures

Task 2: Analysis of existing and planned hydrogen safety concepts and technologies

Task 3: Identification of rules and regulations ready for harmonisation

Task 4: Identification of deficiencies in existing rules and regulations

Task 5: Identification of deficiencies in safety concepts and technologies

Task 6: Proposal for investigations to create a basis for standardisation

Task 7: Proposal for safety concepts

Task 8: Proposal of Draft for Submission to ECE

Tasks 1,3,4,6 and 8 dealt with existing regulations and standards and with the development of a draft for a new regulation.

Tasks 2,5 and 7 focused on the assessing the safety of hydrogen vehicles and components.

4.3 Top down approach

The first step of the top down approach was the survey and the analysis of existing regulations and standards for the use of hydrogen in road vehicles. The survey was conducted for Belgium, France, Germany, Japan, Spain, Sweden and USA. The aim was not only to identify deficiencies in existing regulations but also to identify regulations which were already sufficiently comprehensive to use as the basis of a harmonised European draft. In many countries there are many regulations for the use of hydrogen in different applications but there are none specifically for hydrogen vehicles.

The survey was structured in order to identify the different categories of the regulations and the countries of origin.

The survey distinguished between 4 categories of regulations/standards:

1. Legal requirements
   These are the requirements that are directly applicable
2. Not directly valid regulations and standards etc. which should be applied analogously. An example for this is the ECE regulation R67 for LPG vehicles.
3. Peripheral requirements affecting the vehicle system. For example regulations for the use of garages or tunnels or sea transport by ship etc.
4. Requirements with potentially transferable safety targets. These are mainly standards which are not applicable for hydrogen vehicles or components but from which safety targets can be taken.

As an example, brief results of the survey for Germany and the USA are given below:

Germany:

Figure 4.2 shows the situation in Germany in a simplified form.

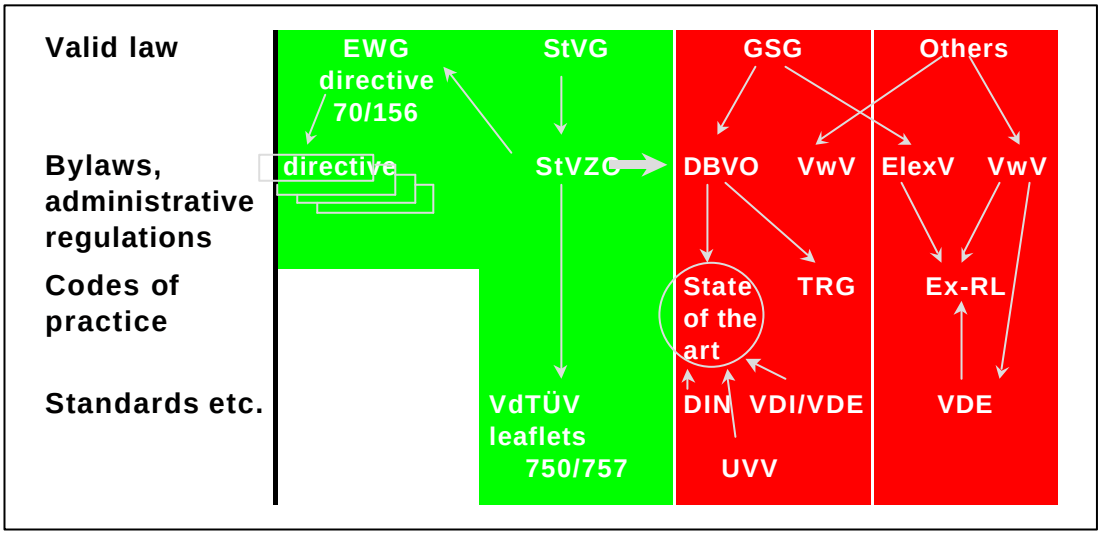


Figure 4.2: Legal situation in Germany for approving a hydrogen road vehicle

Usually all legal requirements for vehicles are described in StVG, which is the road transport law, or in the equivalent EC directives. In the above figure these laws and all the following

bylaws, codes of practice standards, etc. are highlighted in green (left two columns 'EWG', 'StVG'). They are well known and it is known how to apply them. In case of hydrogen vehicles there is a link in the StVZO to the law for pressure vessels which refers to many other bylaws, codes of practice standards etc. These additional requirements were not developed for vehicle applications and often they do not meet the requirements for vehicle applications. This leads to long discussions with the technical services and, depending on individuals, may result in different requirements. They are highlighted in red (right two columns 'GSG', 'Others').

Example: When the signal "engine speed 0" is used for closing the safety valve of the hydrogen supply line, and this signal is taken from the ECU [engine control unit] of the engine, the ECU requires additional testing, approval and marking according to VDE [Association of German Engineers] specifications. For this approval a different inspector is responsible tothe inspector responsible for the automotive application.

USA:

Figure 4.3 shows the relevant requirements for hydrogen-specific applications in the USA that are in addition to the usual requirements for road vehicles. This picture demonstrates the amount of different requirements.

Figure 4.3: US requirements for approving a hydrogen road vehicle

A similar picture can be taken in almost every European country.

It is very clear that it is impossible to meet all the requirements of each country with a single vehicle design. [Example: The automatic shut off valve for the BMW CNG vehicle was placed according to German law at the safest place in the vehicle, which is outside the passenger compartment, below the vehicle floor, but above the rear axle. This was not acceptable for the authorities of the Netherlands. They require the safety valve to be mounted directly onto the CNG container. A particular requirement for the crash protection of this important safety valve in the Netherlands however does not exist.]

4.4 Bottom up approach

This part of the project focused on existing and conceptual hydrogen vehicles in Europe and the fuel supply technology. The different partners conducted systematic analyses such as

Fault Tree Analysis (FTA) or Failure Mode and Effect Analysis (FMEA). The work was complemented by various safety studies including detailed modelling of worst case scenarios.

Additionally some components were subjected to certain tests developed for the new technology.

From the results of the systematic technology analyses and the safety studies, recommendations were made and where appropriate integrated into the draft hydrogen regulations. For example, the necessity of boil off management systems, ventilation, flow restrictors, shut off valves etc.

4.5 Critical appraisal of methodology adopted

The analysis of the existing standards, regulations and codes of practice in five member states of the European Union plus the USA and Japan (see Figures 4.4 & 4.5) indicated that an analysis of the applicable regulations in all European member states would have been a much too challenging effort within the resources of the EIHP with an uncertain chance of success.

To understand the motivation for the methodology adopted, one has to realise that some 46 directives have to be applied in order to receive an approval for a road vehicle in Europe. If a vehicle is satisfactorily tested in accordance with all these directives it has to be approved. The result is a Whole Vehicle Type Approval.

At present, if approval for a hydrogen fuelled vehicle is requested, the tests required by directives relating to emissions, fuel consumption and engine power cannot be carried out because of the absence of a standardised reference fuel or a procedure for testing the engine power. Some other directives can be fulfilled formally, but from the technical point of view should be revised for hydrogen vehicles. . Some requirements regarding the safety of the hydrogen on-board storage systems are not included in the existing directives.

Standards, Regulations and Codes for VEHICLES

	Infrastructure	Components	Regular Inspections
Category 1	3 D; 4 E; 2 F **2 EU**	6 D; 2 E; 1 F -	2 E; 1 F -
Category 2	3 D -	1 E 1 EU	1 E -
Category 3	2 B; 29 D	1 F -	- -
Category 4	4 B; 1 E -	- -	- -

(**B**: Belgium; **D**: Germany ; **E**: Spain; **EU**: Europe; **F**: France; **JP**: Japan; **SE**: Sweden; **USA**: United States)

Figure 4.4: Standards, Regulations and Codes for Vehicles

Standards, Regulations and Codes for INFRASTRUCTURE

	Infrastructure	Components	Regular In-spections
Category 1	3 D; 4 E; 2 F **2 EU**	6 D; 2 E; 1 F -	2 E; 1 F -
Category 2	3 D -	1 E 1 EU	1 E -
Category 3	2 B; 29 D	1 F -	- -
Category 4	4 B; 1 E -	- -	- -

(**B**: Belgium; **D**: Germany ; **E**: Spain; **EU**: Europe; **F**: France; **JP**: Japan; **SE**: Sweden; **USA**: United States)

Figure 4.5: Standards, Regulations and Codes for Infrastructure

The EC Directives that are either not applicable to hydrogen vehicles or may have to be modified for hydrogen vehicles are listed in the Figure 4.6.

	Subject	Directive
1.	Emissions	70/220/EEC, 77/102/EEC, 79/490/EEC, 88/76/EEC, 88/436/EEC, 91/441/EEC, 93/59/EEC, 94/12/EC, 96/44/EC, 96/69/EC, 98/69/EC, 98/77/EC
2.	Fuel tanks / rear protective device	70/221/EEC, 97/19/EC
3.	Diesel smoke	72/306/EEC, 97/20/EC
4.	Identification of controls	78/316/EEC, 93/91/EEC
5.	Fuel consumption	80/1268/EEC, 93/116/EC
6.	Engine power	80/1269/EEC, 88/195/EEC, 97/21/EC
7.	Diesel emissions	88/77/EEC
8.	Side impact	96/27/EC
9.	Frontal impact	96/79/EC
10.	Roadworthiness tests	96/96/EC

Figure 4.6: List of partial directives that are not applicable for hydrogen vehicles or which have to be modified for hydrogen vehicles:

What needs to be done to approve a hydrogen vehicle in Europe?

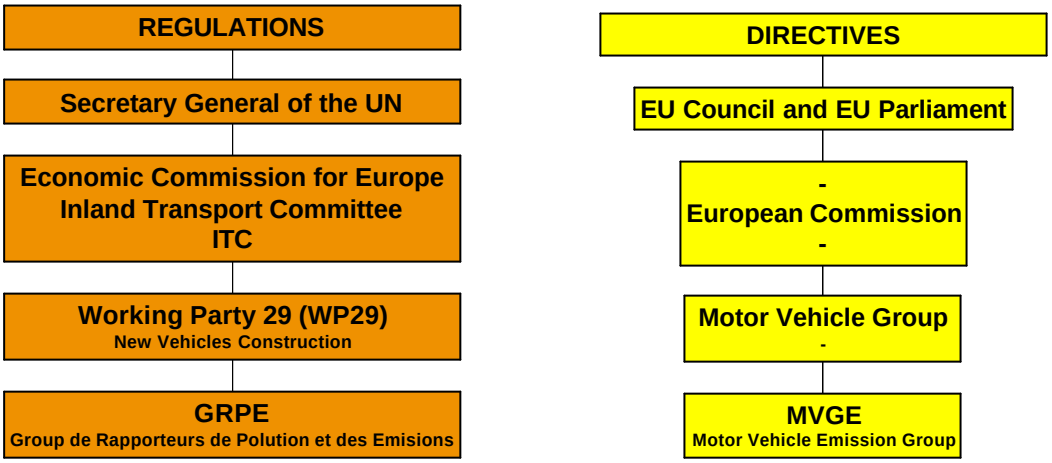
In this case the exception ruling for application of new technologies, as per Article 8(2)c of directive 70/156/EEC, has to be invoked. With respect to this, evidence has to be shown that equivalent safety and environmental protection is provided by the vehicles when compared to conventional vehicles. The use of Council Directive No 98/14/EC, article 8(2)c, to approve

hydrogen fuelled vehicles first of all requires an excessive amount of time and the outcome of the process up until the very end is uncertain.

Therefore, it was decided by the EIHP consortium to use the knowledge collected in the project activities from the ' top down' and 'bottom up' approach to develop a **new** draft regulation for hydrogen fuelled road vehicles.

The options within Europe for where to present the new draft regulations were identified as the Economic Commission for Europe (ECE) a United Nations Organisation body and the European Commission governed by the EU Council and EU Parliament. The preference for submitting the proposal to was given to ECE as it is considered to be the platform for the future global harmonisation for legal requirements for road vehicles by major automobile nations, such as the USA, Japan and Australia.

The organisational structures are given in Figure 4.7:



Fiugure 4.7: Alternative Routes To Introduction Of The Regulations

The development of the two draft documents, one for vehicles with LH_2 onboard storage and another for vehicles with CGH_2 onboard storage, required the creation of two working groups meet many times in order to develop, fine tune and discuss the proposed texts of the draft regulations, among themselves and later with the relevant national authorities.

In retrospective, the working process, although laborious and time consuming, was very efficient and successful for achieving the objectives of the project. It made maximum utilisation of the knowledge available in the partnership as well as from external experts approached by the partners.

4.6 Why an ECE regulation ?

Members of the ECE are not only European countries. The ECE is free for the accession of countries from other continents. For example Australia was the last country to join the ECE on 25.02.2000. The ECE is considered to be the platform for the future global harmonisation for legal requirements for vehicles (see Figure 4.8). Therefore the consortium decided to develop the drafts in the format of ECE regulations.

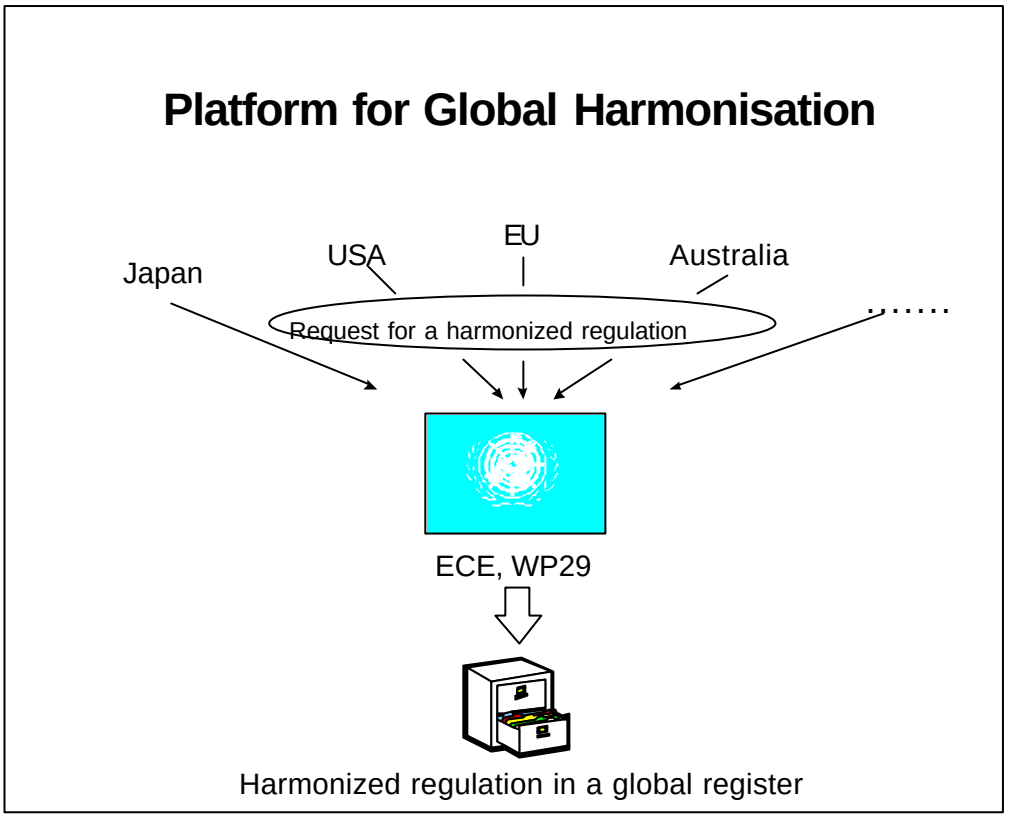


Figure 4.8: Platform for global harmonisation at ECE

4.7 The drafts

The EIHP partners finally developed 2 drafts for new ECE regulations (see Figures 4.9 & 4.10).

Figure 4.9:

Title of draft regulation document for LH_2 road vehicles

PROPOSAL FOR A NEW DRAFT REGULATION

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF:

I. SPECIFIC COMPONENTS OF MOTOR VEHICLES USING LIQUID HYDROGEN;

II. VEHICLES WITH REGARD TO THE INSTALLATION OF SPECIFIC COMPONENTS FOR THE USE OF LIQUID HYDROGEN

Figure 4.10:

Title of draft regulation document for CGH_2 road vehicles

PROPOSAL FOR A NEW DRAFT REGULATION

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF:

I. PECIFIC COMPONENTS OF MOTOR VEHICLES USING COMPRESSED GASEOUS HYDROGEN;

II. VEHICLES WITH REGARD TO THE INSTALLATION OF SPECIFIC COMPONENTS FOR THE USE OF COMPRESSED GASEOUS HYDROGEN;

One regulation was developed for the use of liquid hydrogen in vehicles and one regulation for the use of compressed gaseous hydrogen in vehicles.

The requirements of the drafts apply to hydrogen components and the installation of the hydrogen components in vehicles. Part I of each regulation is primarily relevant to component manufacturers and Part II is relevant to vehicle manufacturers. References were made to international standards whenever they were available. Beside the technical requirements, all procedures for granting a type approval are included as is usual in ECE Regulations.

4.8 Current status of the drafts

The drafts were finished in April 2000. Before finishing the drafts, several revisions were made by the working groups together with inputs from national authorities, technical services and other industrial and research organisations. The drafts were distributed to different industrial associations (CLEPA – European Association of Automotive Suppliers, ACEA - Association des Constructeurs Européens d' Automobiles/ European Automobile Manufacturers Association, OICA – Organisation International des Constructeurs d'Automobiles/ International Organization of Motor Vehicle Manufacturers, VDA – Verband der Automobilindustrie, ANFIA – Associazione Nazionale Fra Industrie Automobilistiche), from whom no comments were received. The drafts have now been presented to the German Ministry of Transport with the request that they are presented to WP29 of the ECE, where it is expected that they will follow the procedure shown in Figure 4.11.

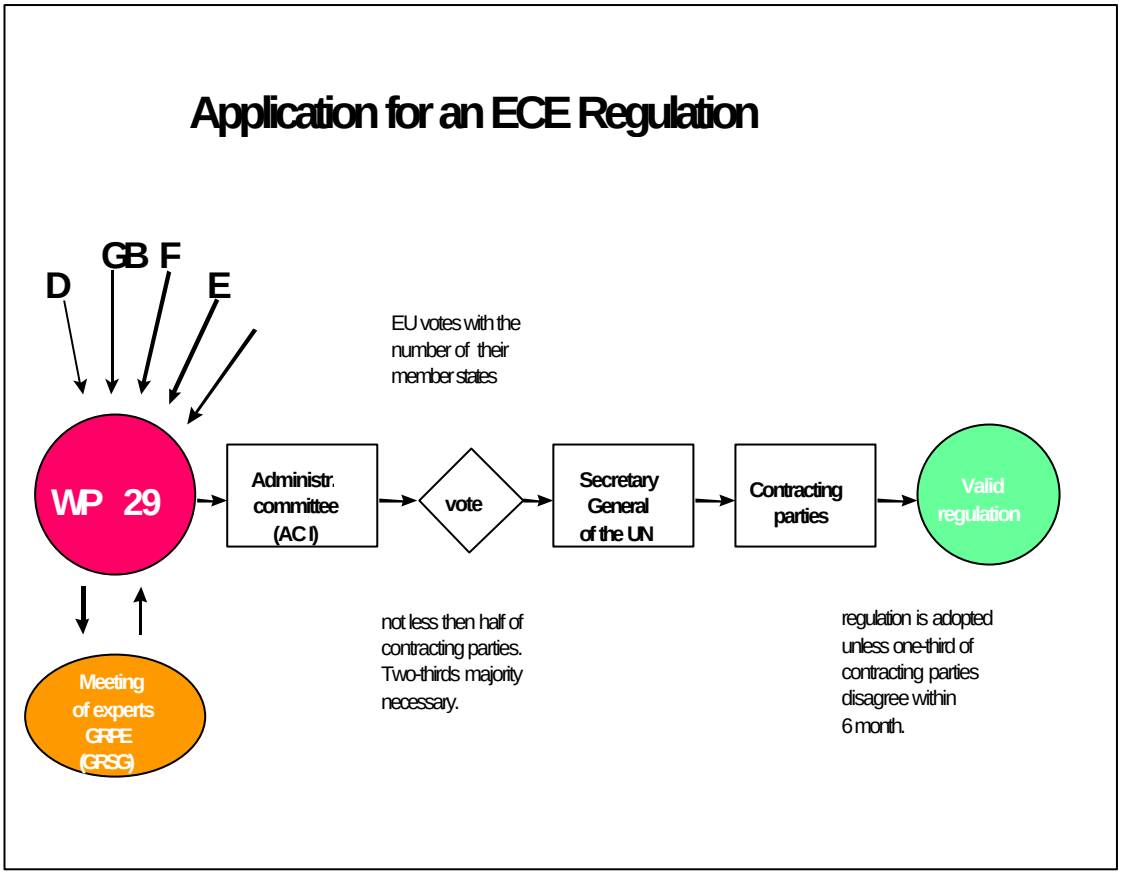


Figure 4.11: Application procedure for an ECE regulation

The typical process for further discussion of the submitted draft regulation documents is outlined in Figure4.12:

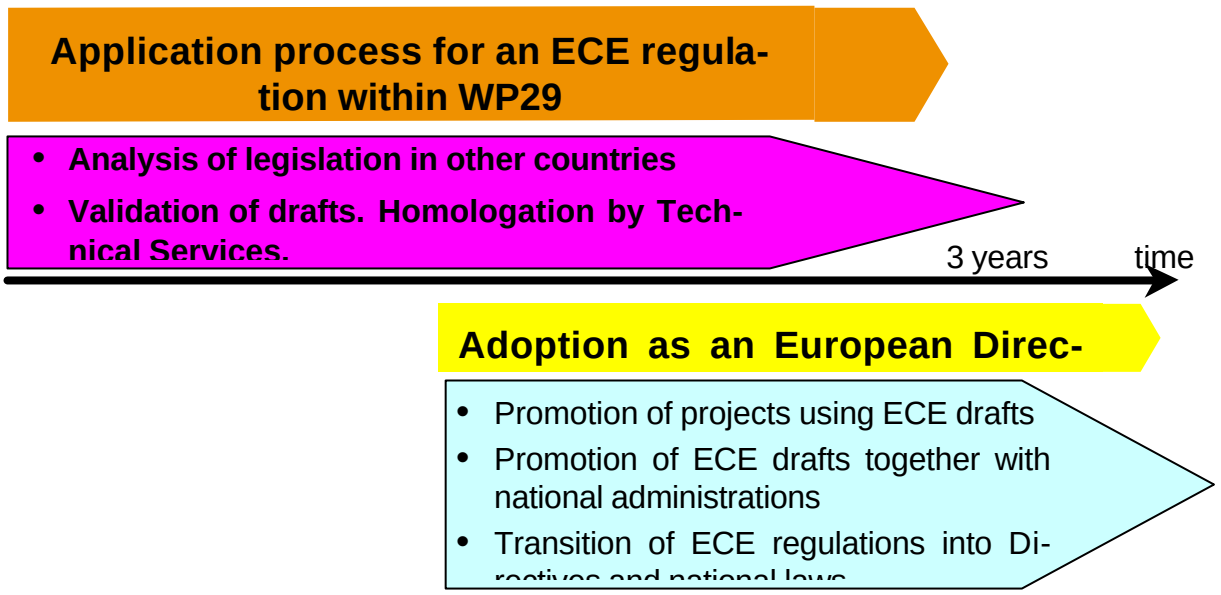


Figure 4.12: Anticipated Time Schedule for Discussion of Draft Regulation

4.9 Further regulation/ standardisation activities

To promote the safe and economic introduction of hydrogen vehicles the following regulation/standardisation activities should be undertaken:

- Development of a code of practice for refuelling stations

  To allow the installation of hydrogen refuelling stations throughout Europe. There is a similar problem as existed for vehicles with different requirements in different countries resulting in different designs required for refuelling stations.

  .

- Standardisation of the interface between the refuelling station and vehicle, including the refuelling procedure

  Currently almost every hydrogen on board storage system requires its own refuelling station

- Standardisation of the on-board storage pressure for CGH_2 systems

  Currently the CGH_2-on-board storage pressure is not standardised with potential safety and economic implications.

- Development of a world wide harmonised and accepted regulation for hydrogen vehicles

  All of these further steps are identified and currently a new partnership, called EIHP 2 is drafted.

5 ACHIEVEMENTS AND EXPECTED IMPACT

The EIHP was established to provide the basis for a harmonised approach to the introduction, standardisation and regulation of hydrogen powered vehicles and their supporting infrastructure within the European Union. Within this framework the partners of the consortium undertook the following activities:

i) Survey of existing regulations applicable to the use of hydrogen (also LNG) in Germany and the USA [BMW], of hydrogen (also CNG) in France [Air Liquide], of hydrogen (also LNG) in Belgium [Hydrogen Systems], of hydrogen (also CNG) in Spain [INTA], and of hydrogen (also CNG and LPG) in Sweden and Japan [VOLVO]

ii) Survey of existing regulations applicable to hydrogen refuelling infrastructure and identification of deficits in relevant regulations [HEW]

iii) Identification of deficits in regulations applicable to the use of hydrogen in vehicles and of harmonisable rules [INTA, Renault]

iv) Development of general safety principles for hydrogen fuelled vehicles [Air Liquide]

v) Development of a program for modelling of cryogenic tank systems [Air Liquide]

vi) Specification for a fuel tank and its equipment for LH_2 storage in road vehicles [Air Liquide]

vii) Definition of safety devices under 2 phase conditions [Air Liquide] and test program for 2 phase flow in a safety valve [Messer]

viii) Calculations and simulations of hydrogen release, dispersion and combustion/ explosion in unconfined and confined spaces for LH_2 and CGH_2 (20 and 70 MPa) storage [EC-JRC/ NCSRD]

ix) Safety study for the use of LH_2 in cars including proposals for improved safety concepts [BMW, Renault]

x) Safety study for the use of CGH_2 in cars including proposals for improved safety concepts [VOLVO]

xi) Definition of a test infrastructure for hydrogen vehicles [INTA]

xii) Development of draft regulations for the use of CGH_2 and LH_2 in road vehicles (coordination of LH_2 draft development by BMW and of CGH_2 draft development by VOLVO),

The safety studies undertaken by the consortium allowed the identification of the weak spots in present hydrogen vehicle design, the development of improved concepts for hydrogen components, and to use this updated state of technological knowledge as vital inputs to the development of the draft LH_2 and CGH_2 regulations. The safety studies provide a strong platform from which to develop safe LH_2 and CGH_2 systems in the future.

The main results of the overall project have been the development of the harmonised draft regulations for the use of hydrogen within vehicles and the investigation of a wide range of safety issues. The draft regulations will greatly assist the safe and economic introduction of hydrogen as a vehicle fuel within Europe in the future, and will also form the basis from which to develop a globally recognised regulation. To be accepted the regulations needed to be supported by comprehensive and in depth research particularly in relation to safety issues. The successful collaboration between the wide range of Partners within the EIHP has allowed a much greater breadth and depth of expertise to be directed towards the questions of safety than could be achieved by any Partner acting alone. Although the EIHP has not answered all questions, it has identified key areas where further work is required, including some safety issues and areas where standardisation and harmonisation of automotive hydrogen technology can lead to substantial safety and economic benefits.

The main potential application of such harmonised legislation is to provide a tool with which the international administration bodies can offer to society an improvement of the quality of life. Among others the following important benefits to the society can be achieved:

- Hydrogen vehicles with identical technical standards will become feasible throughout Europe as harmonised conditions for licensing will be created in Europe and the efforts (time and costs) for licensing and approval of hydrogen vehicles will be reduced in general.
- The authorities guarantee that a commercial product in the market, i.e.hydrogen fuelled vehicles, can be used safely by the citizens.
- A cleaner technology is promoted to substitute a polluting one (fossil fuels vehicle), improving the quality of air in cities and reducing the polluting emissions that cause the greenhouse effect.

The vehicle manufacturing industry will also benefit because administration barriers for marketing a technology that will soon be available can be removed. At the same time, the social acceptance of such a product will be advanced.

6 EUROPEAN ADDED VALUE

Approval of vehicles and vehicle related components is carried out mainly on a European level and no longer on a national level (according to EEC directive 70/156/EEC last amended by 98/91EC). Hence, alternative fuel related technologies, e.g. hydrogen, and new propulsion technologies, e.g. hydrogen internal combustion engine (ICE) and fuel cell drive trains, are not approved at a national level anymore.

In order to assist in preparing the grounds for a successful transition from national to European regulations and standards, a variety of qualifications and competencies was needed from the automotive, infrastructure technology, fuel supply and distribution industry as well as from research and approval organisations. The partnership of EIHP tried to reflect these requirements. Furthermore, these partners came from a minimum critical number of EU member states (five). They successfully established qualified links inside their respective member states, especially to the relevant authorities, in order to assist in spreading the knowledge and expertise, to serve as qualified contact and partner for discussion, and thus to prepare for a later EU -wide implementation of the harmonised regulations.

The outcome of the project assists Europe in taking a more coordinated and efficient approach to the introduction and approval of hydrogen ICE and fuel cell vehicles. This in turn would strengthen its competitive position against its major competitors from Japan and the USA.

7 CONCLUSIONS

In general, the Partners of the EIHP regard the project as being unique in its approach and achievements in the hydrogen field and as being very successful. The EIHP can only be regarded as a first step in a longer process as there is still a lot of work to be accomplished in order to promote the safe introduction of the hydrogen vehicle and the creation of a hydrogen energy supply chain.

The two draft regulations for the approval of hydrogen fuelled road vehicles are now finalised. During the application process for an ECE regulation within WP29, the analysis of legislation in other countries could become necessary in order to consolidate the draft. Based on the time needed for the discussion of the CNG draft within ECE, at least 3 years of discussions is expected. The European Commission should promote projects that agree to use these drafts as construction codes and promote these drafts together with national administrationsThe progress of the drafts should also be complemented with further technical development of LH_2 systems, including the design of safety valves and the design of a boil-off management system.

Further work is needed to identify the requirements regarding regular inspection of LH_2 and CGH_2 vehicles.

Final acceptance of the ECE regulation into EU-law and into national law of the member states has to be undertaken.

In order to develop the draft regulations into global regulations the support by the signatory states of ECE WP29 is needed. The relevant industrial companies must continue to support this important goal.

As the present EIHP covered hydrogen infrastructure related components on a very limited scale, such a work shall also be undertaken for refuelling infrastructure issues. First for refuelling stations (design rules and integration into urban environments), then for parking garages, tunnels, maintenance shops, and finally for on-site hydrogen production plants.

As most of the industrial organisations in the automotive and fuel supply business are international or multinational undertakings a harmonisation of standards, codes of practice and regulations on international level is indispensable. Harmonised regulations and approval procedures will drastically reduce the efforts (e.g. time, cost) for industry in bringing their products to the market. On the other hand, all citizens will benefit from more standardised products as they will be safer, more cost competitive, and easier to use.

The process started by the EIHP has to be pursued with increased efforts in order to maintain and improve the position of European industry in the competitive global economic environment, as the automotive industry is presently aiming for the commercialisation of minimum emission

vehicles over the next decade. Automotive and fuel supply industries face the difficult situation of

- a dramatically increasing demand in mobility (almost 1 billion new motorist in Asia and Latin America by 2040),
- the need to reduce CO_2 emissions by 25% before 2010 and for the industrial countries by 80% by 2050 in order to achieve an overall CO_2 reduction of in average 50% by 2050, the only way to stabilise ever growing human induced climate change effects
- peaking world petroleum production in the present decade and the initiation of an irreversible downward trend in oil production and thus increasing crude oil prices

The introduction of hydrogen and fuel cells to the transport sector seems to represent the most promising chance for a sustainable restructuring of the transport and fuel economy. Europe should make maximum use of its human and technological resources. The route to harmonised legislation which EIHP started deserves further coordinated support, morally and financially, from the involved stakeholders, i.e. industry, SMEs, regulatory authorities and governments.

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