Safety aspects of hydrogen as an energy carrier

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1st European Hydrogen Energy Conference Grenoble, France, 2 to 5 September 2003

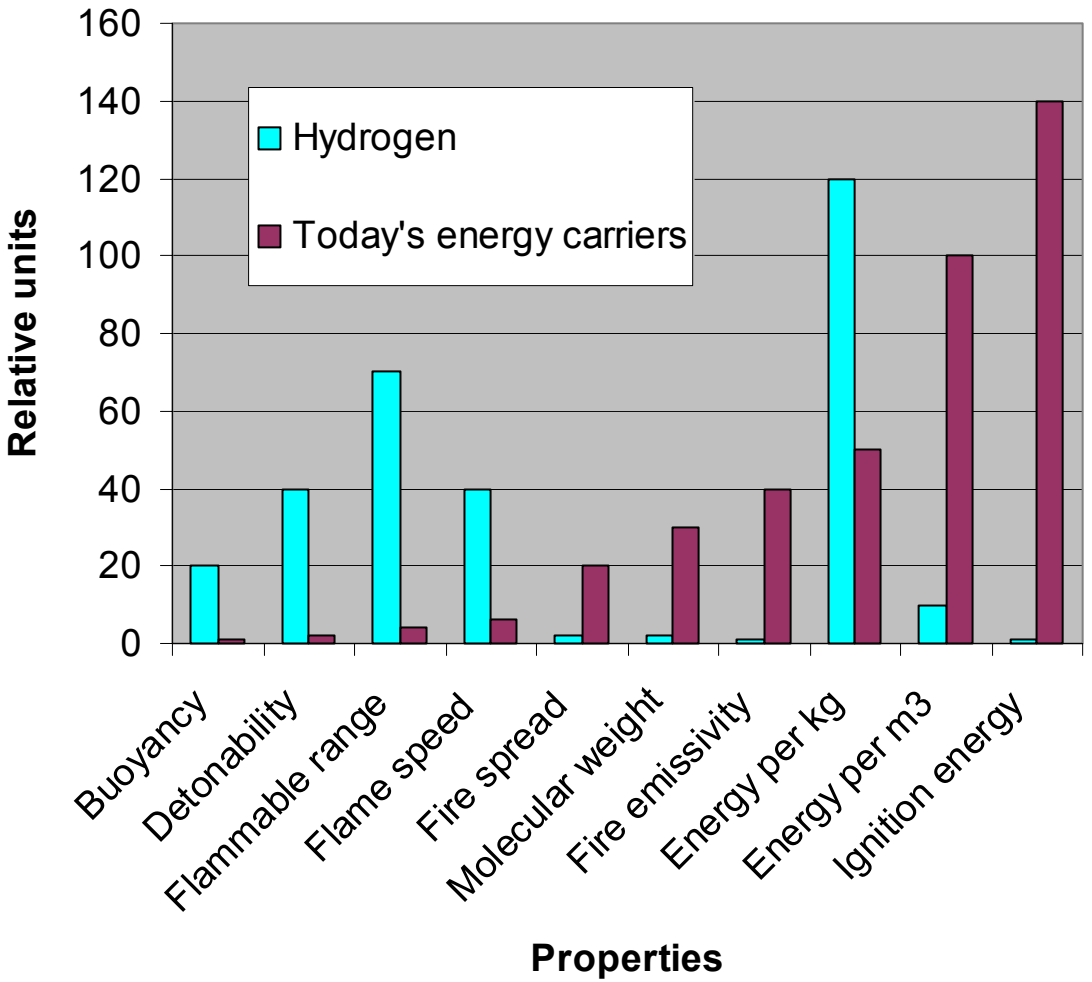
Roundtable "Daily use of hydrogen: safety, codes and regulations", September 3, 2003

Problems and goals

- Introduction of hydrogen as an energy carrier requires significant efforts in the field of safety
  - Hydrogen has been extensively used in many industrial applications, but not at the scale and not in public domain as an energy carrier should be
  - Hydrogen safety has been a subject of numerous research efforts, but no solutions are available in terms of widely accepted standards, methodologies, mitigation techniques, and regulations
- The central safety goal is that H_2-technologies should provide at least the same level of safety, reliability, and comfort as today's fossil energy carriers
- Public acceptance of H_2-technologies should be reached

Hydrogen and today's fuels

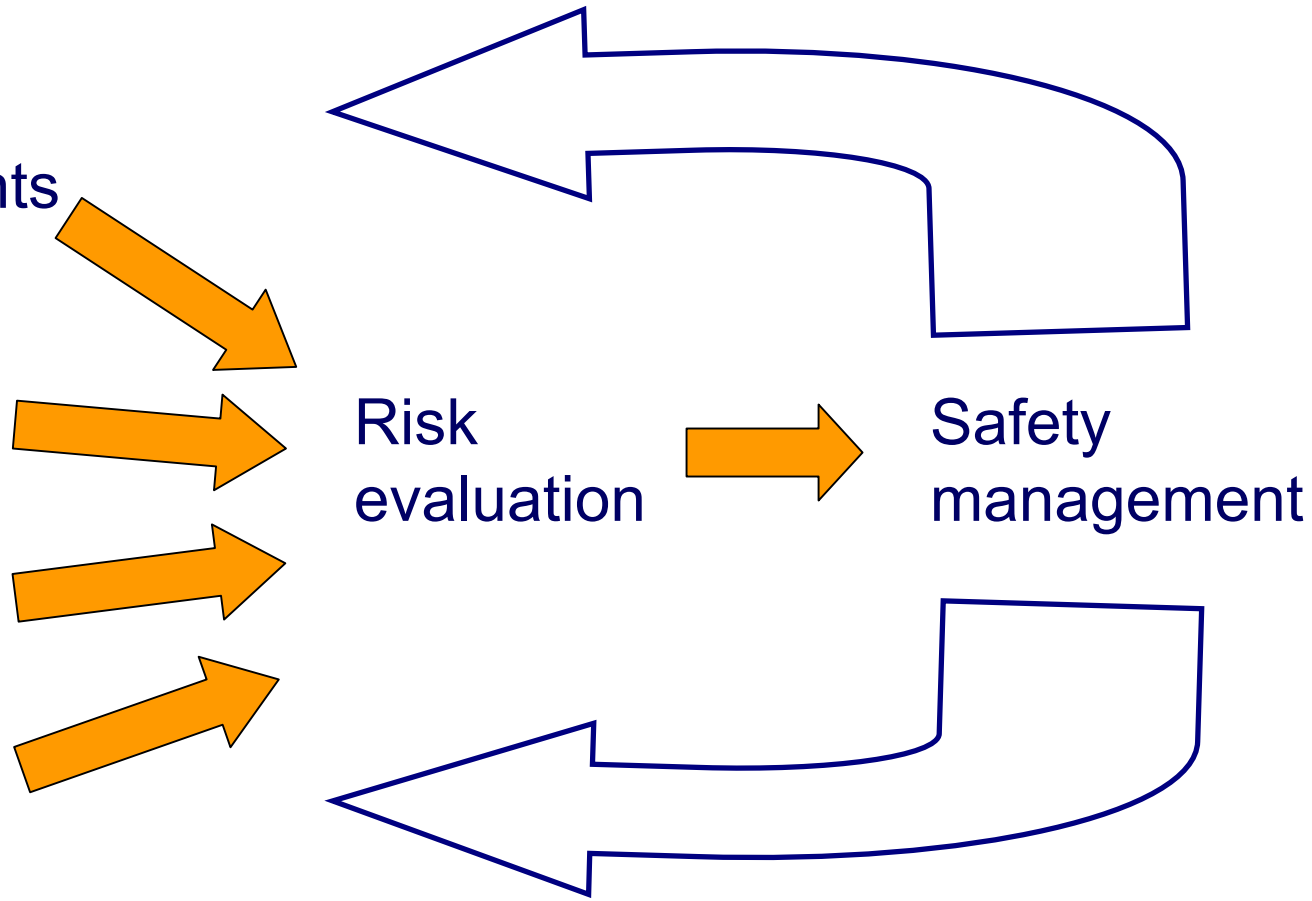
- Qualitative comparison of "Safety profiles"
- Properties of hydrogen are different from today's fuels
  - H_2 is less dangerous in terms of thermal and fire hazards,
  - H_2 may be responsible for stronger pressure effects



Safety aspects of hydrogen

What is necessary to provide safety?

- Reliability and frequencies of unfortunate events
- Hazard potential
- Consequences
- Mitigation measures



Applications

- Accident scenarios, initial conditions, hazard potential, and risk depend on the particular application of hydrogen as an energy carrier
- Blocks of applications :
  - Hydrogen production
  - Infrastructure (transport and distribution, refueling stations)
  - Storage (LH2, CGH2)
  - Vehicles powered with H_2 (passenger cars, trucks, repair shops)
  - Tunnels, public parking, and private garage
  - Utilization, portable or stationary H_2 based applications

Issues

- To evaluate hydrogen safety the following set of issues should be addressed for each of the applications
  - Hydrogen release, mixing, and distribution
  - Thermal, pressure, and missile effects from H_2 fires and H_2-air cloud explosions
  - Mitigation techniques for detection, dilution, and removal of hydrogen
  - Risk evaluation, both specific and in comparison with today's fossil energy carriers
  - Standardization, and regulatory issues

Safety aspects of hydrogen

Map to address hydrogen safety problems

	V1.Hydrogen release, mixing, and distribution	V2. Thermal and pressure effects from H_2 fires and explosions	V3. Development of hydrogen mitigation techniques	V4. Safety and risk studies	V5. Standardization, regulatory issues, and dissemination
H1.Production	→	↓	↓	↓	↓
H2. Transport and distribution, refueling stations	→				
H3. Storing H2 (LH2, CGH2)	→				
H4. Vehicles powered with H2	→				
H5. Tunnels, parking and garage	→				
H6. Utilisation, H_2 applications	→				

Outcome:

- Experimental databases for hydrogen safety analyses for different applications
- Validated analytical and numerical tools for assessment of safety for different applications
- Experimentally validated mitigation techniques and safety devices
- Innovative hydrogen mitigation technologies
- Methodologies for risk evaluation, both specific and in comparison with today's fuels
- Improved technical culture to handle hydrogen as an energy carrier
- Inputs to European/global regulatory and standardization activities

HySafe objectives

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

Look ahead

Hydrogen safety problems are to be addressed by:

- Developing and validating methodologies for safety assessments
- Undertaking safety and risk studies both by industry and by public bodies!
- R&D to create data, models and facilities that can be used for safety studies
- Promoting fundamental research necessary to address hydrogen safety issues
- Extracting net outcomes from safety and risk assessment studies as input to EU-legal requirements, standards and codes of practice
- Organizing training and educational programmes on hydrogen safety