European Commission

This fiche is part of the wider roadmap for cross-cutting KETs activities

'Cross-cutting KETs' activities bring together and integrate different KETs and reflect the interdisciplinary nature of technological development. They have the potential to lead to unforeseen advances and new markets, and are important contributors to new technological components or products.

The complete roadmap for cross-cutting KETs activities can be downloaded from:

http://ec.europa.eu/growth/industry/key-enabling-technologies/eu-actions/ro-ckets

Potential areas of industrial interest relevant for cross-cutting KETs in the Energy domain

This innovation field is part of the wider roadmap for cross-cutting KETs activities developed within the framework of the RO-cKETs study. The roadmap for cross-cutting KETs activities identifies the potential innovation fields of industrial interest relevant for cross-cutting KETs in a broad range of industrial sectors relevant for the European economy.

The roadmap has been developed starting from actual market needs and industrial challenges in a broad range of industrial sectors relevant for the European economy. The roadmapping activity has focused on exploring potential innovation areas in terms of products, processes or services with respect to which the cross-fertilization between KETs can provide an added value, taking into account the main market drivers for each of those innovation areas as well as the societal and economic context in which they locate.

Taking the demand side as a starting point, cross-cutting KETs activities will in general include activities closer to market and applications. The study focused on identifying potential innovation areas of industrial interest implying Technology Readiness Levels of between 4 and 8.

E.4.3: Systems for hydrogen storage for fuel cells transport as well as portable and consumer applications

Scope:

To develop systems for hydrogen storage for fuel cells transport as well as portable and consumer applications (e.g. hydrogen cylinders, metal-hydride tanks, chemical-hydride tanks, methanol cartridges (for direct methanol fuel cells, DMFCs).

Demand-side requirements (stemming from Societal Challenges) addressed:

- Contribute to achieving competitive, sustainable and secure energy

Demand-side requirements (stemming from market needs) addressed:

- Enable more efficient power storage in order to guarantee power supply to mobile, portable and consumer products
- Larger supply availability of more reliable as well as small-sized / low-weight systems for power supply
- Increase power to weight ratio of storage systems in order to maximize yield at overall system level

Specific technical/industrial challenges (mainly resulting from gaps in technological capacities):

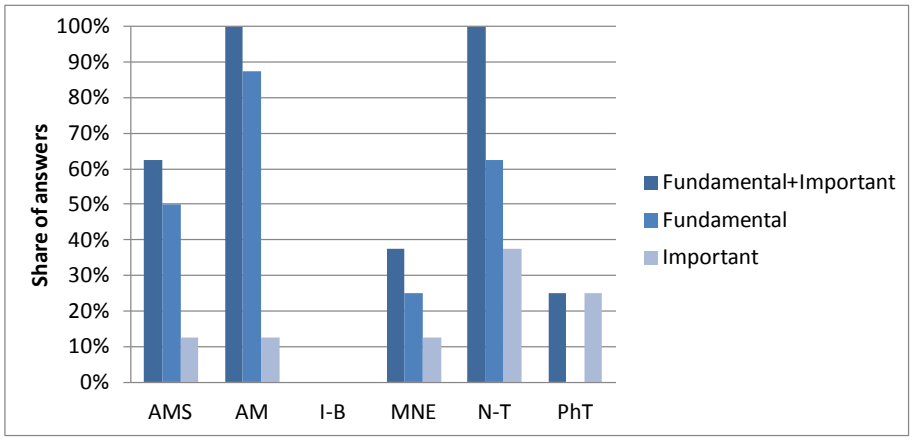
- Development of safe and effective reversible and non-reversible hydrogen storage solutions for portable applications (non-reversible chemical storage, compressed hydrogen, metal hydrides): components, infrastructures, supply management
- Investigation of methanol as an high energy density (compared to hydrogen) energy carrier (e.g. for portable direct methanol fuel cells (DMFCs) applications)
- Developments in basic research for safe, reliable and cost effective hydrogen storage and distribution: new materials for hydrogen storage and storage containers (e.g. alanates, aminoboranes, porous materials, high surface materials): investigation of failure mechanisms including through modelling; development of standardized material screening and testing procedures, understanding of absorption and adsorption mechanisms
- Development of cost-efficient manufacturing

Contribution by cross-cutting Key Enabling Technologies:

In respect to this Innovation Field, the integration of KETs could contribute to the development of safe, reliable and cost-effective reversible and non-reversible hydrogen storage solutions for transport and portable applications, encompassing components, infrastructures, and supply/distribution management. The integration of KETs could particularly contribute to the development of new materials for hydrogen storage and storage containers, and to the development of integrated systems, including electronic equipment and components for the reliable and safe management of the supply/distribution. The integration of KETs could finally contribute to render manufacturing of storage systems and equipment more cost-efficient.

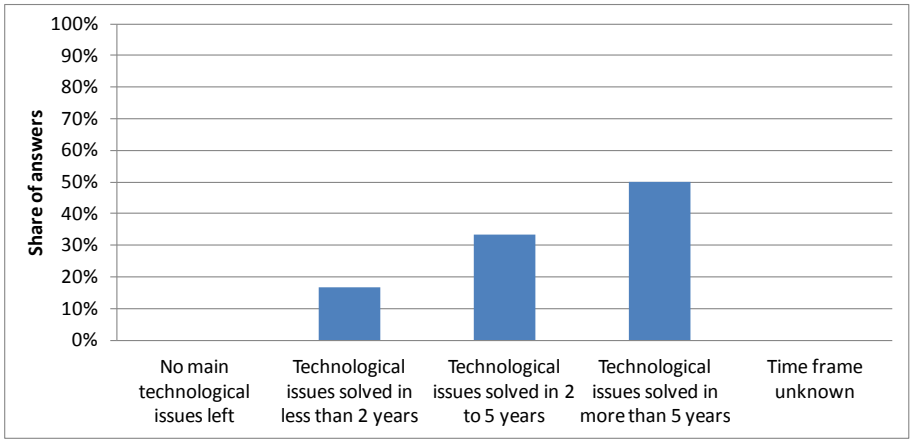
To this aim, the combination of KETs experts' opinions collected through the dedicated survey (whose result is depicted in the below bar chart), the examination of KETs-related patenting activity in respect to this Innovation Field, and desk research activities, have allowed identifying a rather strong interaction of KETs with respect to this Innovation Field, with either fundamental or important contribution mainly by the following KETs:

- Advanced Materials (AM)
- Nanotechnologies (N-T)
- Advanced Manufacturing Systems (AMS)



Timing for implementation:

According to the majority of KETs experts' opinions (whose result is depicted in the below bar chart), desk research, and in line with the KETs-related patenting activity in this field, it is considered that the main technological issues holding back the achievement of cross-cutting KETs based products related to this Innovation Field could be solved in a time frame of more than 5 years, yet significant consensus indicates also shorter periods being necessary, which depends from the type of storage solution being considered:



Hence, depending on the specific technical and/or industrial challenges holding back the achievement of cross-cutting KETs based products related to this Innovation Field, the provision of support in the short to medium term should be taken into consideration within this framework.

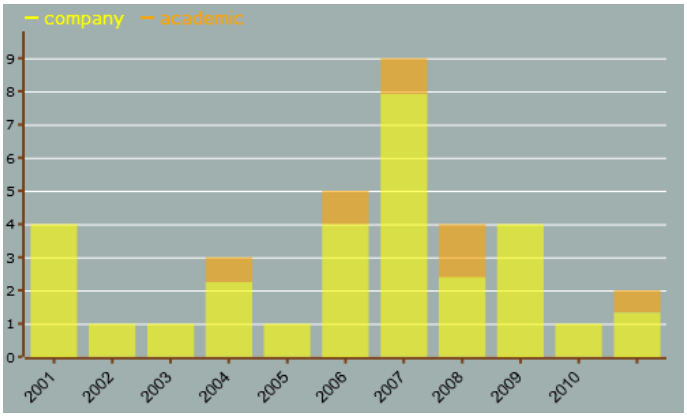
Additional information according to results of assessment:

- ***Impact assessment:***
  - Along with fuel cell systems, hydrogen storage systems need to be deployed in order to provide for fuelling of the fuel cells. Applications and markets for hydrogen storage technologies therefore strictly relate to the fuel cell technology applications and markets. At the same instance, systems for the generation of hydrogen need to be deployed as well in order to feed storage capacity (with except from the case of non-reversible chemical storage).
  - While the focus for hydrogen generation technologies' development is on enabling renewable energy to be exploited for the purpose of producing hydrogen, the focus for hydrogen storage technologies' development is instead enabling the highest volume of hydrogen to be stored at the lowest weight while guaranteeing safety as well as a high number of charging and discharging cycles in the case of reversible hydrogen storage solutions (which are the focus especially in the transportation market segment). Within this framework, hydrogen storage technologies that have near-term potential to be readily available, reliable, and capable of satisfying the demanding operation environment are necessary for market acceptance.

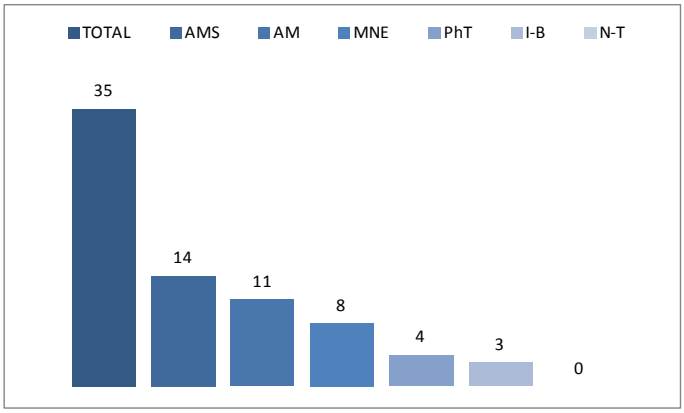
- While compressed hydrogen tanks are the most common hydrogen storage technology implemented and capable of satisfying many of the performance needs for early markets, there is potential for performance gains by developing alternative hydrogen storage technologies for the future.
- In the defence sector, hydrogen storage technologies have been used and developed. In order to support the building and operation of systems that integrate multiple fuel cell and hydrogen technologies to demonstrate and enhance their long-term potential. This background knowledge would be useful for potential dual use applications in the civilian field.
- Source: NREL Technical Report, Hydrogen Storage Needs for Early Motive Fuel Cell Markets, November 2012

➢ ***Results of patents scenario analysis:***

- 35 exclusively KETs-related patents identified in the period 2001-2011 for the specific Innovation Field
- Scattered trend curve (number of patents per year)
- Highest share of industrial applicants with intermittent relevant patenting activity by academic applicants, most probably standing for new technologies having been patented in the corresponding periods:



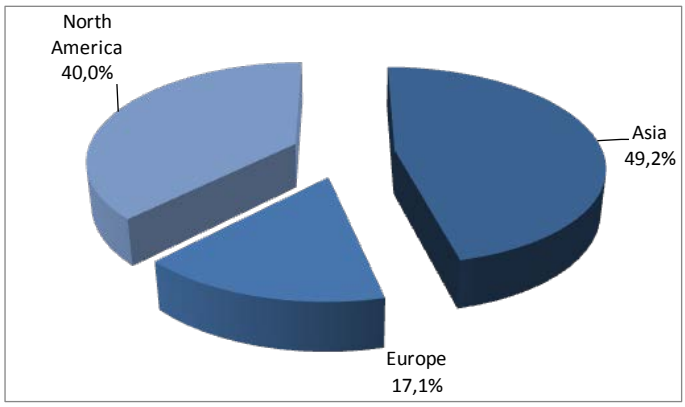
- Patents by KET(s):



- Patents by KET(s) and relevant combinations of KETs:

KET(s)	*Number of patents*
AM	11
AMS	14
AMS / AM	1
IBT	3
MNE	8
MNE / PhT	4
PhT	4

- Patent distribution by (Applicant) organization geographical zone:



- Patent distribution by geographical zone of priority protection: