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 Chemical Processes, Chemicals, Chemical Products and Materials 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.

CH.3.3: Processes for the cost-efficient utilization of CO2 or CO as C1-synthetic building blocks

Scope:

As the result of carbon capture technologies, carbon dioxide (CO_2) is increasingly becoming available in vast quantities and in high purity as an economically attractive resource for chemical syntheses, new routes and processes (e.g. based on incorporation of CO_2 in polymers, hydrogenation of CO_2, as well as catalytic, organo-catalytic, photo-catalytic, electro-catalytic, etc., activation processes) are needed for the utilisation of CO_2 as C1-synthetic building block. Furthermore, utilisation of carbon monoxide (CO) as C1-synthetic building block can also be an opportunity.

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

- Tackle the “climate action, resource efficiency and raw materials” challenge, indirectly also contributing to address challenges such as “smart, green and integrated transport” and “secure, clean and efficient energy”

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

- Reduce dependency on hydrocarbon-based chemicals as well as materials production, subject to a long-term price increase tendency, and related operational costs
- Decrease dependency of chemical production from oil by shifting the feedstock base towards alternative feedstocks

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

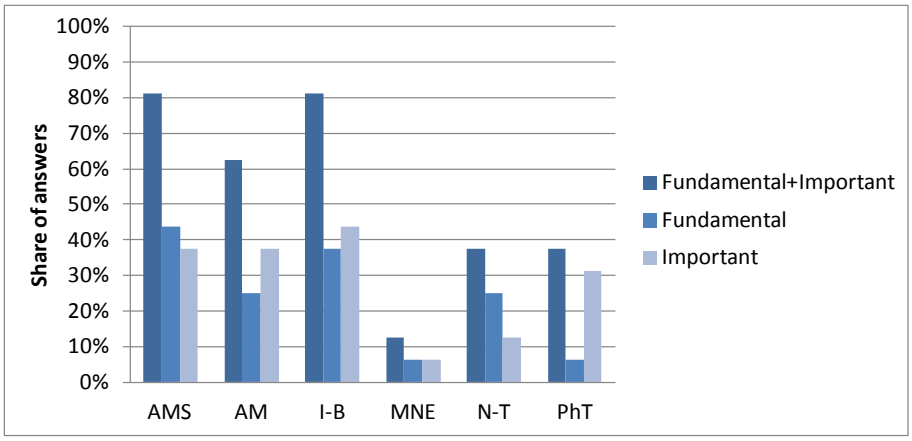
- Investigation and refinement of potential routes for CO_2 activation through catalytic processes as well as CO_2 incorporation in polymers, CO_2 hydrogenation, etc.
- Evaluation of the upstream and downstream processes, e.g. the intelligent production of reactants with high-energy content
- Development of efficient, robust catalysts that are less susceptible to catalyst poisoning to boost the chemical use even of less pure CO_2
- Development of novel organo-catalysts and cooperative catalytic procedures for the utilization of CO_2 and CO as synthetic building blocks
- Combination of catalytic pathways with the selective and local application of alternative energy options (e.g. photons, electrons, microwaves, ultrasound) to yield highest energy efficiency

Contribution by cross-cutting Key Enabling Technologies:

In respect to this Innovation Field, the integration of KETs could contribute to the development of processes for the cost-efficient utilization of carbon dioxide (CO_2) or carbon monoxide (CO) as C1-synthetic building block, by the development of new routes and processes (e.g. based on incorporation of CO_2 in polymers, hydrogenation of CO_2, as well as catalytic, organo-catalytic, photo-catalytic, electro-catalytic, etc., activation processes). The integration of KETs could moreover contribute to develop combinations of catalytic pathways with the selective and local application of alternative energy options (e.g. photons, electrons, microwaves, ultrasound) to yield highest energy efficiency during processing.

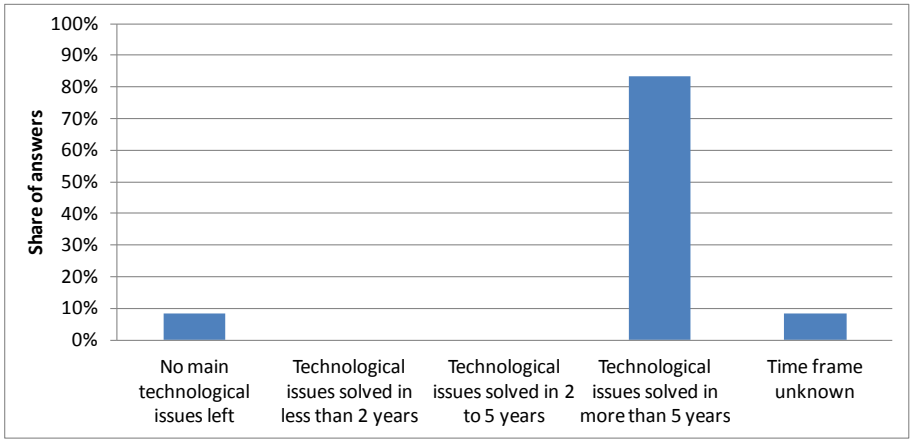
To this aim, the combination of KETs experts’ opinions collected through the dedicated survey (whose result is depicted in the below bar chart), the examination of KETs-related patenting activity in respect to this Innovation Field, and desk research activities, have allowed identifying a rather strong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

- Advanced Manufacturing Systems (AMS)
- Industrial Biotechnology (I-B)
- Advanced Materials (AM)



Timing for implementation:

A 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:



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 medium to medium term should be taken into consideration within this framework.

Additional information according to results of assessment:

- ***Impact assessment:***
  - The possibility to use carbon dioxide (CO_2) or its reduced forms as C1-synthetic building block to produce industrially useful chemicals and materials has been proven over several years. By coupling chemistry with biotechnology new routes (e.g. based on incorporation of CO_2 in polymers, hydrogenation of CO_2, as well as catalytic, organocatalytic, photocatalytic, electrocatalytic, etc., activation processes) have been demonstrated on a reduced scale. In several cases quite interesting results have been obtained that make this way promising.
  - Actually, CO_2 is already used by the chemical industry. The use of supercritical CO_2 as a solvent is a first example of exploitation by industry. Moreover, the synthesis of urea and the production of salicylic acid are examples of the synthesis of organic molecules using CO_2 as a reagent. Inorganic carbonates are also obtained using CO_2. While these reactions make no use of catalysts, many other reactions based on CO_2 for the production of chemicals are known that require catalysis. This has expanded in the last years the investigation of several catalytic, organocatalytic, photocatalytic, electrocatalytic, etc., pathways to provide for the chemical synthesis of various molecules starting from CO_2 besides of other processes such as based on incorporation of CO_2 in polymers, hydrogenation or activation of CO_2.

- ***Results of patents scenario analysis:***
  - No significant patent-related indicators can be reported in this field