SMART FUELS FOR AVIATION: THE SMARTCATS COST ACTION

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Abstract. The successful introduction of sustainable alternative fuels (including biofuels and synthetic fuels) in the aviation sector requires a thorough collaboration of academic, industrial and policy actors covering all aspects of fuel production, distribution and utilization. The SMARTCATs COST Action (Chemistry of Smart Energy Carriers and Technologies, CM1404, www.smartcats.eu), aims to create a Europe-wide network of world leading academic and research institutions and key industries to promote the use of Smart Energy Carriers, SECs (fossil, unconventional and renewable) on a large scale in order to increase fuel flexibility and carbon efficiency of energy production and to support distributed energy generation strategies. The approach to accomplish this aim is twofold. On the one hand, academic/research organizations will devote strong efforts to bring together fundamental/advanced numerical and diagnostic tools to improve the understanding of combustion kinetics and by-products formation of SECs at micro/meso-scale levels. On the other hand, the intended exchange between academic and industrial partners will support the optimization of tools developed in the Action exploiting the way that SECs could be utilised at the macro-scale in advanced combustion technology devices. This interaction will lead to the identification of standards and criteria for the development of a searchable database and internet tool devoted to integration of experimental and numerical combustion chemical/physical data which will provide easy access to information relevant to SECs components. The current paper provides a detailed description of SMARTCATS work programme and illustrates examples of its application to the development and utilization of alternative aviation fuels.

Keywords: Smart energy carriers, Alternative aviation fuels, Academia/Industry Symbiosis

INTRODUCTION

A safe, secure and environmentally-friendly energy supply is among the highest priorities and concerns of contemporary society. Currently, combustion of conventional and alternative fuels accounts for about 80% of total gross energy production in Europe. The greatest challenge that the combustion community has to face in the coming years is the urgent need for maximum fuel flexibility of combustion technologies, the minimization of greenhouse gas (GHG) emissions and the adjustment of distributed energy production, the so called Combustion Trilemma, Fig. 1. Fuel flexibility is a prerequisite to exploit a fast changing fuel market and an increasing number of energy carriers available. Mitigation of GHG emissions is a central priority of the EU Framework Programme for Research and Innovation Horizon 2020 and it is clear that a multifaceted approach, encompassing highly efficient low- carbon technologies coupled with medium-term emission containment (e.g. Carbon Capture and Storage/Utilization), will have to be pursued in order to avoid potentially catastrophic climatic consequences. The realization of a new energy production and distribution system based on smart grid concepts is often seen as a possible straightforward option for developed countries.

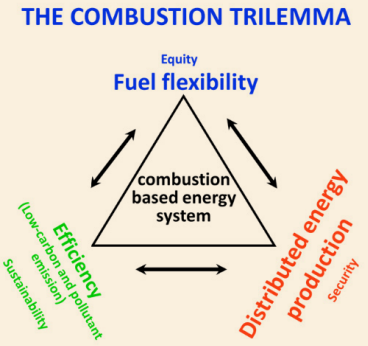

Figure 1. The Combustion Trilemma

These three needs derive from a complex geo-political situation with multiple influences on fuel availability and perspectives as well as from the long term objective of build up a low carbon society in the EU, the opportunity offered by the growing of cyber-physical applications and their reflection on smart energy distribution and utilization grids and the ecological drives.

The scope, objectives and outcomes of the Action are of primary relevance to the aviation sector. Aviation is one of the strongest growing transport sectors and this trend is expected to continue. Advanced biofuels constitute the only viable and sustainable alternative to kerosene. The comprehensive assessment of alternative biofuels properties and their integration with propulsion devices are crucial issues for the aviation industry and can be addressed in the context of SMARTCATs.

DEFINITION OF SMART ENERGY CARRIERS

All these factors call for the characterization, specification and proper utilization of new Smart Energy Carriers (SECs). This category includes conventional and novel energetic molecules from alternative or conventional (re)sources, selected on the basis of their best available production and/or utilization technologies. Accordingly, to be considered "smart" an energy carrier and related technologies must be energetically and CO_2 efficient and able to provide the most suitable energy mix to exploit varying and locally diverse sources and to satisfy the requirements for eco-compatibility and sustainability. SECs are strong candidates as possible solutions for energy storage, transfer and transformation from renewable (wind, solar, biomass, wastes) and unconventional sources (e.g. shale gas). SECs include a wide range of compounds like aliphatics, oxygenates (alcohols, esters, ethers) as well as olefins, naphthenes and their mixtures with diluents (CO_2 and H_2O). As a consequence, energy conversion systems have to face an increasing variety of smart carriers that change their characteristics depending on the available source. Even though tailor-made fuel technologies are under development, feedstock and fuel processing variability influences fuel properties in a complex and sometimes unpredictable way. To meet these needs, advanced combustion technologies for energy and power generation in the industrial, domestic and transport sectors are required. Such technologies have to be fuel-flexible and able to achieve high efficiencies, often operating under conditions that are significantly different from those of conventional combustion modes. A new knowledge has to be built to make SECs and new combustion technologies usable in an efficient and sustainable way.

THE SMARTCATS COST ACTION

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According to this methodology the SMARTCATs work programme is structured in five Working Groups (WG), as outlined in Fig. 2.

WG1. Smart Energy Carriers gas phase chemistry: from experiments to kinetic models that aims to improve the knowledge on detailed chemistry and thermochemistry for the combustion, pyrolysis, and oxidation of fuels, such as natural gas mixtures (compressed natural gas, liquefied natural gas, syngas natural gas, bio- methane), simple molecules (large normal and iso-paraffins, alcohols, esters, saturated and unsaturated cyclic ethers) that can be present in 1st and 2nd generation biofuels and complex mixtures of molecules actually found in 1st and 2nd generation biofuels or in the proposed surrogates.

WG2: Chemistry for control of by-products in Smart Energy Carrier conversion that aims to increase knowledge on the formation of organic and inorganic combustion by-products. The pollutant tendency of smart energy carriers will be studied by tracing pollutant species typically formed in combustion (carbon monoxide, unburned hydrocarbons (UHC), polycyclic aromatic hydrocarbons (PAH), aldehydes, NOx soot and nano-particles) as well as other classes of pollutants possibly originating from SECs.

WG3: Chemical and optical advanced diagnostics for Smart Energy Carriers conversion monitoring that aims to improve the knowledge on advanced combustion diagnostics, with a strong focus on technology transfer from fundamental to complex systems, and focuses on advanced sampling and chemical analysis diagnostics, laser-based and mass-spectrometric diagnostics in fundamental combustion devices and chemical kinetics experiments, elementary reaction rate measurements, chemical markers for combustion performance characterization, combustion and emission measurements in complex systems (engines, furnaces, household applications, etc).

WG4: Standard definition for data collection and mining toward a virtual chemistry of Smart Energy Carriers that aims towards the identification of the main requirements and tools for the development of databases, software and mathematical tools for data collection and handling as well as chemistry optimization using data mining techniques. Definition of "crucial" experiments and simulations, uncertainty and sensitivity analysis in combustion modelling will be key issues to be considered.

WG5: Integration of fundamental knowledge towards technology application for Smart Energy Carriers exploitation that is to apply/integrate the knowledge tools developed in WG1-WG4. This will provide optimized ready to use tools and techniques for an effective use of SECs on large scale. The research activities of the WG will be driven by the identification of validation test cases, identified in collaboration with the industrial partners to provide scale-bridging information from the laboratory units to the real applications by means of integration of detailed kinetic mechanisms in large scale numerical simulations, and assessment of the uncertainty related to numerical predictions for their use in new design and regulation.

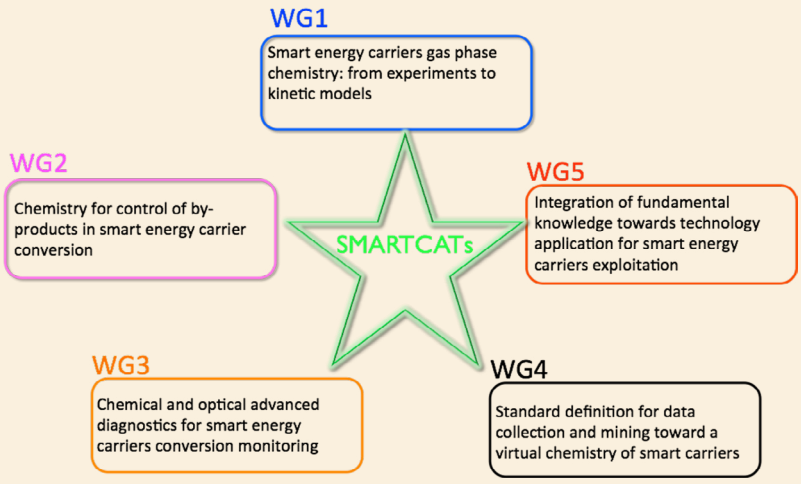

Figure 2. The SMARTCATs workgroups

A total of 75 organizations from 25 countries participate in the SMARTCATs COST Action. There is a strong participation from the industrial sector (more than 20 large companies and SMEs) and particularly from industries strongly related to the aviation sector (gas turbine manufacturers, fuel providers, engineering consulting companies).

CONCLUSIONS

Europe has a highly productive and scientifically visible fuels and combustion community, encompassing several groups with strong expertise in experimental, theoretical, and numerical simulation approaches. The SMARTCATs Action is building an effective network academic/research and industrial players aimed at addressing the "grand challenge" of matching the most promising SECs with the advanced energy conversion technologies for the 21st century. This is of particular importance to the aviation sector where extensive assessment of potential alternative fuels is crucial.

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