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## Keynotes

### Ammonia MILD Combustion

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### Abstract

There are no doubts that the energy transition, in need to meet the challenge of climate change mitigation, asks for a serious reconsideration of the different aspects of energy supply systems, from the energy sources to transformation technologies. Though renewable energies have to play a primary role in the net zero $CO_2$ emission scenario, they are not free from countereffects. One of the most serious is their relying on the so called "critical metals", key enablers for the penetration of renewable energy sources. The scarce availability and very low recycle rates of numbers of them make clear that renewable cannot be the sole energy sources that can be considered in the next future. On the other hand, these bottlenecks impose the maximization of the renewable sources utilization by means of energy storage. The coupling of energy carriers as an effective vehicle of renewable energy with advanced combustion technologies is among the best solution to maximize the deployment of renewables keeping the efficiency of the energy grid. In this scenario, many energy carriers have been considered so far, one among others ammonia as a very effective hydrogen carrier. In this general framework, the combustion technologies that meet the energy transition requests have to be fuel flexible, clean and efficient. MILD combustion satisfies all these requirements and represents a paradigm shift in the panorama of standard combustion processes. Indeed, at local scale, it evolves from very diluted and preheated reactants through "ignidiffusion" without the stabilization of the typical deflagrative or diffusion flame structures, thus overcoming issues related to low burning velocities and narrow flammability limits. Due to dilution, the temperature increase is very limited thus avoiding or significantly reducing the formation of pollutants. MILD combustion is particular effective in case of ammonia, being the only process that is able to stabilize pure ammonia combustion with very low NOx emission in stoichiometric condition. Indeed, MILD combustion of ammonia occurs in a temperature range below the temperature threshold for thermal NOx formation. NOx level can be further decreased with the addition of water without altering the process stability while increasing the emissivity in the reaction volume, improving the radiative heat transfer. Though the use of enhancers in ammonia MILD combustion is not mandatory, its mixtures with alcohols, methane and hydrogen have been deeply characterized in these conditions. It was shown that the addition of species increases the OH radical concentration during combustion and enhances the stability of the process but, in turn, NOx emission increases. The well assessed fuel flexibility of MILD combustion is also associated to its robustness in term of operational flexibility. In conclusion, MILD combustion technology can be

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numbered among the main key enablers of the energy transition as it effectively supports the utilization of energy carriers as ammonia.

### Ammonia Emission Measurements

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### Abstract

More recently, the first multiyear time series of atmospheric ammonia (NH3-OASIS) from ground-based remote sensing in the Paris region was retrieved (Tournadre et al., 2020) since NH3 is known as a precursor of ammonium salts, which are responsible for the serious springtime pollution episodes involving fine particles in the Ile-de-France region (Kutzner et al., 2021) and across Europe. Despite its major scientific and societal role, and the reduction targets, there is yet no binding regulation of ammonia emissions, but it will become compulsory in the near future since the proposal of revised directive include NH3. But measuring ammonia remains very challenging for several reasons: sticky, volatile and reactive nature, very high spatially and temporally variable, gas/particle inter-conversion, resulting in strong interactions with sampling systems. With the lead of Pascale Chelin, a research consortium, called AMICA (Analysis of Multi-Instrumental Concentrations of Ammonia), strongly emphasizes NH3 observations challenges with a complementary range of experts in NH3 measurement (metrology, agriculture, remote sensing, embedded systems, and low-cost sensors), for example during a 2-month inter-comparison field campaign in 2021 in France (Caville et al., 2024).

Caville S., et al., Sensors, 2024, in prep.
Kutzner, R. D. et al., https://doi.org/10.5194/acp-21-12091-2021.
Tournadre, B., et al. https://doi.org/10.5194/amt-13-3923-2020.
Viatte, C., et al., https://doi.org/10.5194/amt-4-2323-2011.