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Cryogenic H2 for heavy-duty trucks: applying fundamental thermodynamics to solve clean transportation challenges

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Over the last few years, a number of projects dedicated to the full scale demonstration of cryogenic H2 systems for clean mobility have been successfully carried out at Air Liquide's Campus Technologies Grenoble (ex-ALaT), in Sassenage (France). Those pioneering prototypes have been designed and operated together with world class industry leaders, and pave the way towards a realistic, cost effective, rapidly refueling and safe clean transportation future. In this paper, we present the challenges associated with heavy duty truck transportation, the unique cryogenic designs that were developed to address that market, and the major results obtained thus far.

LH2 has many merits when considering volume and mass limited, and also refueling time sensitive, near zero emission large transportation applications ranging from aircrafts, boats, rails to trucks. Indeed, its high (volumetric) energy density enables to drastically reduce the gravimetric and volumetric footprint of benchmark 350 to 700 bar gaseous H2 storage, while also providing much more easily scalable transfer solutions. The sensitivity of LH2 to heat ingress remains its main challenges, and transitioning the use of the molecule from industrial applications (mostly, distribution) to a near zero emission transportation fuel commodity necessitates to develop new cryogenic system and process architectures capable of optimizing performances (cost, safety, footprint) along the entire supply chain, up to onboard the vehicle.

Thanks to detailed functional and engineering analyses, engineers at Campus Technologies Grenoble (ex-ALaT) have been developing a complete mobile solution, comprising the bulk supply of LH2, the refueling system and the storage onboard the vehicle for the heavy-duty applications and relying on the so-called "sLH2" (for "sub-cooled LH2") approach.

The sLH2 standard represents a great compromise between low pressure LH2 and high-pressure CcH2 (for "cryo-compressed H2") standards: it offers single flow refueling (no need for communication), reasonable cost (no expensive materials for the storage, low CAPEX and OPEX at refueling station), holding times of a few days (compatible with the application), and high technological maturity (well known components and processes).

This presentation will cover key features of sLH2 refueling and storage, from fundamental thermodynamics understanding of critical performance indicators such as dormancy, state of charge, pressure boundaries, 2 phase to supercritical transitions; to full scale implementations into systems developed together with global industry leaders.

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