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Comment Received From: Patrick Donley
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Future-proofed HD Hydrogen Refueling Stations

Additional submitted attachment is included below.

June 5, 2024

Subject: Verne Response to RFI for California, Oregon, and Washington's Medium- and Heavy-Duty Joint Application for the U.S. Department of Transportation's Charging and Fueling Infrastructure Discretionary Grant Program

To whom it may concern:

On behalf of Verne, we would like to respond to the Request for Information regarding California, Oregon, and Washington's Medium- and Heavy-Duty Joint Application for the U.S. Department of Transportation's Charging and Fueling Infrastructure Discretionary Grant Program.

Verne is a for-profit startup based in San Francisco, CA. Verne is a manufacturer of cryo-compressed hydrogen (CcH_2) storage technology that maximizes the storage density of hydrogen for use in heavy-duty vehicles including Class 6 trucks and Class 8 trucks. Verne is financially supported by leading commercial entities, including Amazon's Climate Pledge Fund, Caterpillar VC, Newlab and Collaborative Fund. Verne is also supported by Breakthrough Energy Fellows, the Department of Energy's ARPA-E, and other agencies. Verne develops two main products: on-board hydrogen storage equipment used to store CcH_2 and station equipment used to cryo-compress hydrogen to be used in vehicle refueling.

Verne is responding to this RFI to inform station development and funding applications to ensure the most economical technologies are employed to optimize the transition to heavy-duty hydrogen vehicles today and in the future. Our responses inform question #9, regarding cost implications for MDHD refueling stations.

Required Hydrogen Fueling Equipment and Associated Technologies

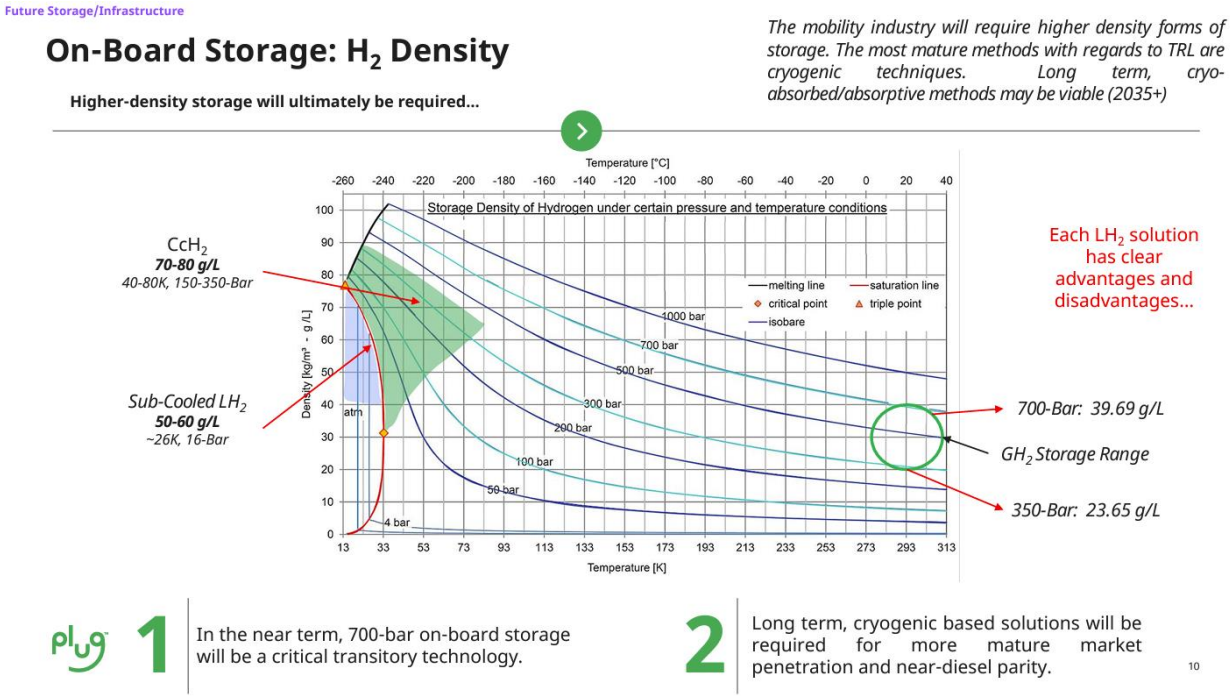
It is important that hydrogen stations developed today are prepared for future developments in hydrogen trucking technology: stations should not be designed just for current truck models, but should also contemplate truck manufacturers' technology roadmaps.

Initially, trucks will be refueled with compressed hydrogen at 700 bar pressure (e.g. Nikola, PACCAR). These early trucks fall short of providing diesel-parity performance, operating with ~50% the range vs. diesel (only ~400 miles per fueling). This performance shortfall is driven by the on-truck storage system: 700 bar compressed hydrogen is too low in density, limiting the amount of hydrogen that can be stored on-board.

Nearly all truck manufacturers are **evaluating future technology to replace 700 bar in order to increase performance.** This will require higher-density onboard storage. This adjustment will also impact fuel station technology: the fuel station must be capable of fueling the higher density 2nd generation hydrogen trucks.

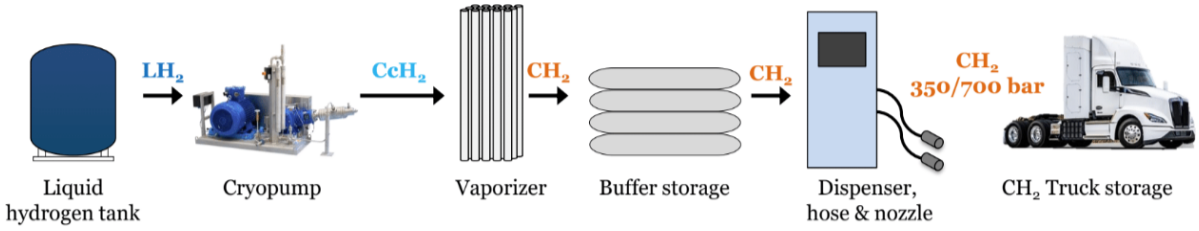
The two main options for storing hydrogen at higher density are liquid hydrogen (e.g. Air Liquide) or cryo-compressed hydrogen (e.g. Verne). Verne believes that CcH_2 storage is the optimal high-density hydrogen storage for heavy-duty trucks, due to both on-vehicle performance and refueling dynamics (more information on on-vehicle performance of CcH_2 can

be provided upon request). See the image below from a recent presentation to the DOE from Plug Power, highlighting the need for higher density storage and the benefits of CcH_2.



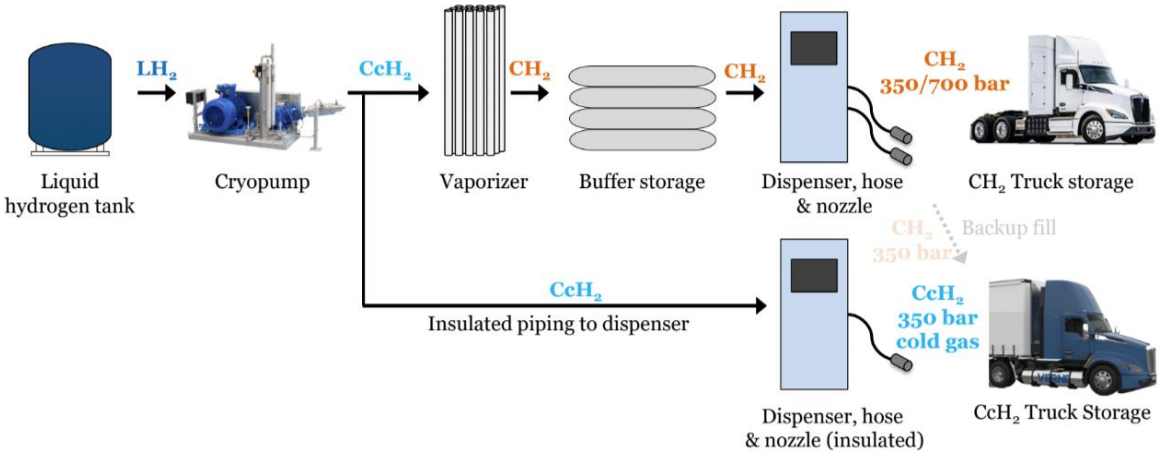
It is important for hydrogen refueling stations to consider future onboard hydrogen storage technologies such as CcH_2. **Hydrogen refueling stations should be future-proofed**, built to enable fueling of multiple hydrogen storage technologies: they should have the ability to conduct 700 bar refueling today and be setup to easily accommodate refueling of other, emerging hydrogen storage methods in the future (such as CcH_2).

Current hydrogen refueling stations can enable refueling of 700 bar (or 350 bar) hydrogen from a liquid hydrogen supply. These stations include a liquid hydrogen tank, cryopump, vaporizer, buffer storage, dispenser, hose & nozzle:



A small retrofit can be completed to enable refueling of CcH_2, by providing insulated piping to a second dispenser that can refuel trucks with CcH_2.This minor retrofit primarily uses

equipment already included in 700 bar stations, and enables higher density CcH_2 refueling:



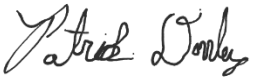
This highlights one of the greatest advantages to CcH_2 over LH_2: CcH_2 can use the same cryopump as H35 and H70. This is very different from trucks with onboard LH_2 storage, which require a distinct, separate fueling pump.

Verne recommends considering the potential need for CcH_2 refueling as hydrogen refueling stations are developed. This could include involving cryo-compression experts in station planning to design stations that can have minimal retrofit cost. This upfront planning adds no cost now and could meaningfully streamline retrofits for CcH_2 later. Given the simplicity of adding CcH_2 refueling capabilities, Verne supports refueling stations being developed with CcH_2 refueling capabilities whenever a station may service heavy-duty trucks.

Please reach out to Pat Donley (contact information included below) to discuss Verne's input on this RFI, as we would be happy to provide further context on Verne's technology or perspectives on the development of the hydrogen trucking market.

Thank you for your consideration.

Sincerely,



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