Mega-Scale Liquid H2 Storage with Super-Insulated Full-Containment and Zero Boil-Off

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Abstract

This project focuses on developing the world's first mega-scale Liquid Hydrogen (LH2) storage solution, up to 200,000 m^3, with zero-boil off and full containment safety features for energy export and import terminals. The proposed commercial-scale storage system uses a novel super-insulated full-containment that significantly reduces the boil-off and risk, enabling material recovery during tank or vacuum failure. Moreover, Active Magnetic Refrigeration (AMR) technology with new magnetocaloric materials and ortho-para conversion that suits cryogenic boil-off gas will be developed and integrated into the tank, leading to a zero-boil-off solution. The mega-scale storage solution significantly lowers capital costs for storage, reduces the cost of boil-off gas, and minimises the risk and expense of material loss in case of leaks or vacuum failures. Furthermore, the project aims to develop cryogenic testing (<20K/-253^{0}C) capabilities with a set of advanced cryostats and a prototype storage tank (1:200,000) with an AMR unit to accelerate LH2 commercialisation.

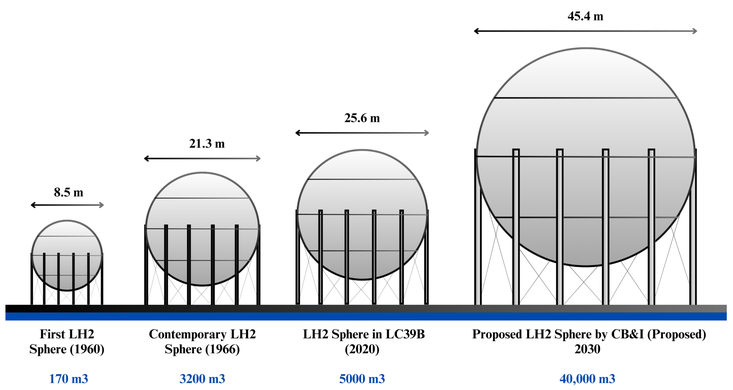


Fig 1: Growth of LH2 storage tank sizes over the years

Technical Activities

Year 0 – Core Research Stage

- Development of comprehensive mega-scale numerical models to simulate structural stability and thermal performances
- Synthesising novel materials for the inner lining of the primary LH2 compartment
- Extensive mechanical testing of structural materials and connection mechanisms using 20K mechanical testing cryostat
- Design and development of an apparatus to test the performance of the interior compartment material of the storage structure at 20K against leakages.
- Designing and developing the new 20K electrically operated insulation testing cryostat
- Developing new composite magneto caloric materials based on Er(Ho)Co2 compounds
- Designing and developing a lab-scale magnetic refrigeration system integrated with the ortho-para conversion process

Year 3 – Commercialisation Stage – Year 5

- Development of a lab-scale prototype and demonstration of the overall performance of the storage system
- Following suitable commercialisation pathways and developing a business model to transfer the newly developed technologies to the market

Cryostat for Mechanical Testing (20K)

CS500 Cryostat by GenH2

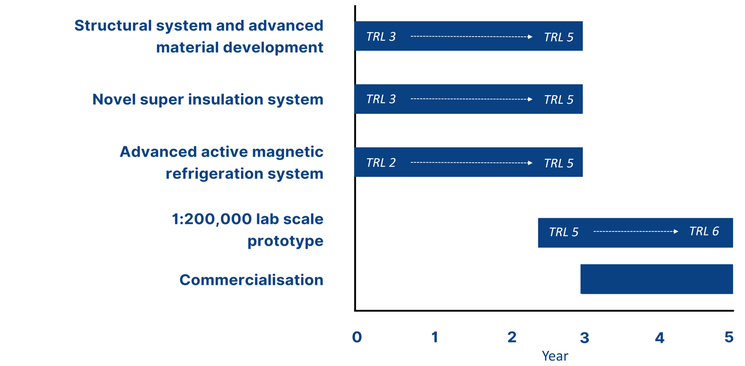
Objectives

- Development of a novel high-performing structural system with innovative configurations for LH2 storage
- Proposing a state-of-the-art Super Insulation System (SIS) and verifying the performance through comprehensive insulation material testing at cryogenic temperatures and thermal simulations.
- Research and development of an AMR system with integrated magnetic para conversion to reduce boil-off
- Fabricate a lab-scale prototype of the mega-scale storage system combining the developed technologies and commercialize Intellectual Properties

Outcomes

- A novel structural system for mega-scale LH2 storage including components such as innovative mounting system and inner lining with novel synthesised materials
- A novel superinsulation system capable of limiting daily boil-off rate to 0.1% while offering full containment
- An active magnetic refrigeration system based on newly developed Holmium-based compounds to achieve zero boil-off
- A lab-scale 1:200,000 prototype demonstrating the overall performance of the novel storage system
- Multiple Intellectual Properties based on the developed technologies

Research Plan



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Project Partners