

STORHY FINAL EVENT HYDROGEN STORAGE SYSTEMS FOR AUTOMOTIVE APPLICATION

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Overall Evaluation: Technical performance

Automotive requirements

- Hydrogen storage systems have to meet car manufacturers' requirements for transport application. Within StorHy, five evaluation criteria for the evaluation of the technical feasibility of automotive hydrogen storage systems have been considered: **gravimetric energy density, volumetric energy density, refuelling rate, hydrogen loss rate and conformability**.

StorHy Evaluation

	Volumetric energy density (kWh/l)	Gravimetric energy density (kWh/kg)	Refuelling rate (kWh/min)	Hydrogen loss rate (g/h/kg)	Conformability 1 = cylindrical 5 = complex
C-H ₂ 350 bar storage system	0.5	1.3	50	0	2
StorHy C-H ₂ 700 bar storage systems Type III ⁽¹⁾	0.8	1.3	50	0	2
StorHy C-H ₂ 700 bar storage system Type IV ⁽¹⁾	0.8	1.5	50	0.002	2
L-H ₂ conventional	1.2	2	100	1.3	1
StorHy L-H ₂ cylindrical ⁽²⁾	1.3	5.0	100	1	1
StorHy L-H ₂ Free-form demonstrator ⁽²⁾	1.2	5.9	100	0.8	4
SOLID storage Low temp. hydrides ⁽³⁾	0.8	0.4	13	0	3
StorHy SOLID storage NaAlH ₄ Pilot tank ⁽⁴⁾	0.7	0.3	25	0	3
StorHy SOLID storage NaAlH ₄ Forecast ⁽⁵⁾	1.2	0.7	25	0	3
Li Ion Battery ⁽⁶⁾	0.2	0.1	0.5 ⁽⁷⁾	0	4
Gasoline Tank ⁽⁸⁾	7	8	>200	0	5

Strong R&D efforts recommended
Still remaining R&D efforts
Slight/No more R&D efforts necessary


- ⁽¹⁾ Source: SP Pressure/Evaluation: Experimental data. extrapolation of a 5kg H₂ storage system
⁽²⁾ Source: SP Cryo: Experimental data; hydrogen loss rate: thermal simulation results (extrapolation from tests)
⁽³⁾ Source: Daimler
⁽⁴⁾ Source: SP Solid: Experimental data; extrapolation of a 5kg H₂ alanate storage system
⁽⁵⁾ Source: SP Solid: Forecast of an improved 5kg H₂ alanate storage system
⁽⁶⁾ Source: Battery Pack for Mitsubishi's i MiEV (cell level)
<http://www.greencarcongress.com/2008/05/the-battery-pac.html#more>
⁽⁷⁾ Calculated for quick charge to 80% state of charge
⁽⁸⁾ Source: BMW Group, gasoline tank system with auxiliaries (activated carbon filter, pump)

- In general:** The investigated storage technologies have achieved remarkable progress, but none of them entirely fulfils StorHy targets yet. A breakthrough beyond StorHy targets is limited by physics, safety and cost constraints. In future, hydrogen storage systems will have a significant impact on vehicle design, weight, and costs. New vehicle architectures will therefore be required to facilitate car integration.
- C-H₂:** 700 bar storage systems led to the improvement of the volumetric energy density in comparison with 350 bar technology and the gravimetric energy density by using Type IV vessels. The technical feasibility of advanced 700 bar pressure vessels, filling and recycling processes has been demonstrated; filling components are already certified. The fundamental understanding of failure mechanisms of high pressure vessels will help define new safety regulations and standards towards more design flexibility for further improvement of gravimetric and volumetric energy densities.
- L-H₂:** The technical feasibility, a remarkable increase of storage density by factor three and an improved conformability have been demonstrated by using the carbon fibre composite design. Nevertheless, additional R&D will be necessary to improve the permeation barrier, boil-off and dormancy time as well as long term reliability and stability of these systems.
- Solid:** StorHy investigations on system level showed the perspectives and constraints for solid storage systems. The feasibility of complex alanate based hydrogen storage systems could not be demonstrated for automotive use. Further R&D is required to improve the storage density on material level. StorHy results clearly outline that the fundamental material research must be accompanied by system engineering to ensure future automotive application.

Partners

- CEA – Commissariat à l'Energie Atomique (SP Evaluation Leader)
- StorHy car manufacturers Daimler, BMW, Ford, PSA, Volvo supported by MAGNA STEYR

Website www.storhy.net

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