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Integrated Design for Demonstration of Efficient Liquefaction of Hydrogen

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(Coordinator)

New Energy World JU

fuel cells & hydrogen for sustainability

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Project introduction

Scope: to develop a generic process design and plan for demonstration of efficient hydrogen liquefaction in the range of up to 200 tonnes per day

Objective: to reduce liquefaction energy consumption by 50% and simultaneously reduce investment cost

Timeline: November 2011 – October 2013

Information and results available at ***www.idealhy.eu***


Liquefaction offers advantages for distribution and storage of hydrogen

Supply to retail stations

Shell station in Berlin built by Linde

- Fewer distribution trucks on the road
- Lower cost storage & less storage space
- Lower cost compression to 700 bar

Transport of energy

LH2 ship impression by Kawasaki Heavy Industries

- Transport of CO_2-free energy to where it is needed

Fewer distribution trucks and lower cost storage and dispensing

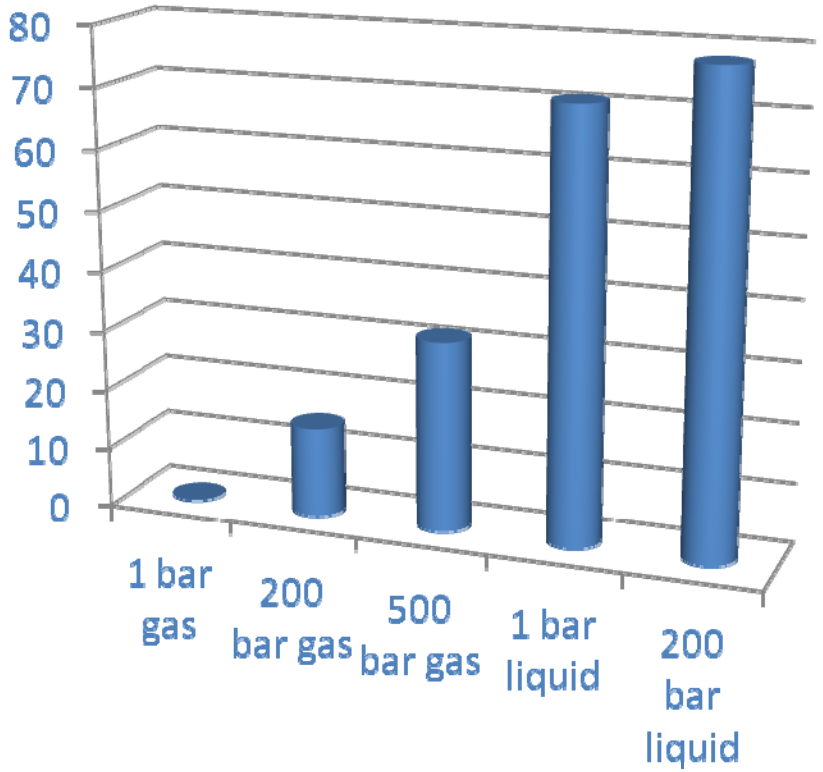
Hydrogen trucking capacities

- Liquid: ± 4000 kg
- 200 bar gas: ± 400 kg
- 500 bar gas: ± 900 kg

Hydrogen storage on large stations

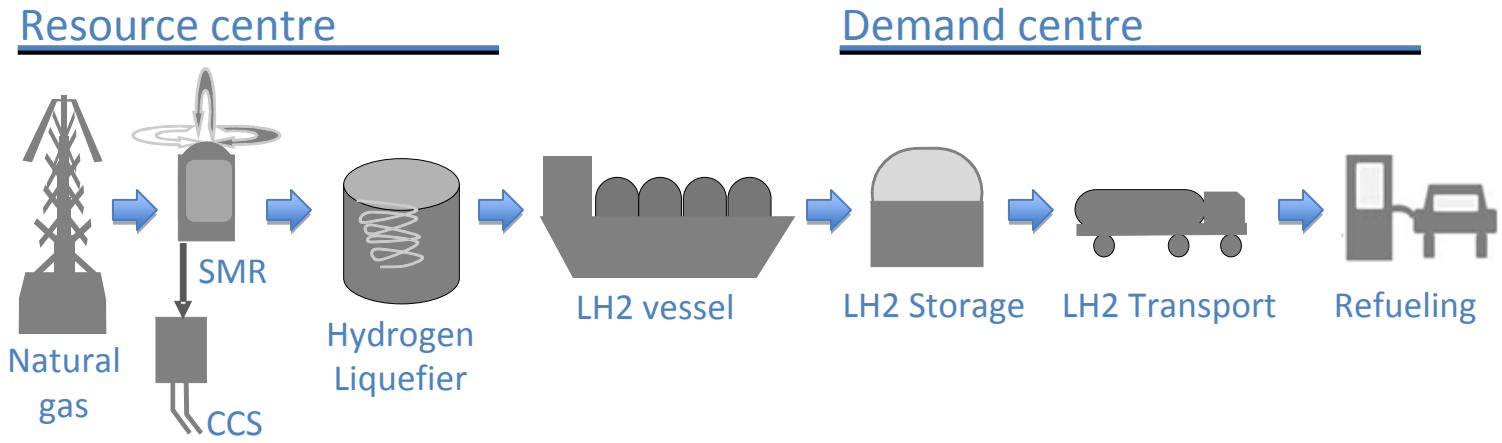
Shell station in Berlin built by Linde

Hydrogen density, kg/m^3



Import of CO2-free energy: energy security

- Production of low-CO_2 hydrogen at a resource centre
  - from natural gas or coal with carbon capture
  - wind/solar/hydro electricity or solar energy
- Liquefaction and transport of CO_2-free energy to demand areas
- Use of hydrogen
  - for mobility, industry and households via injection in the natural gas grid



Tackling the two main drawbacks of liquid hydrogen

1. Boil-off

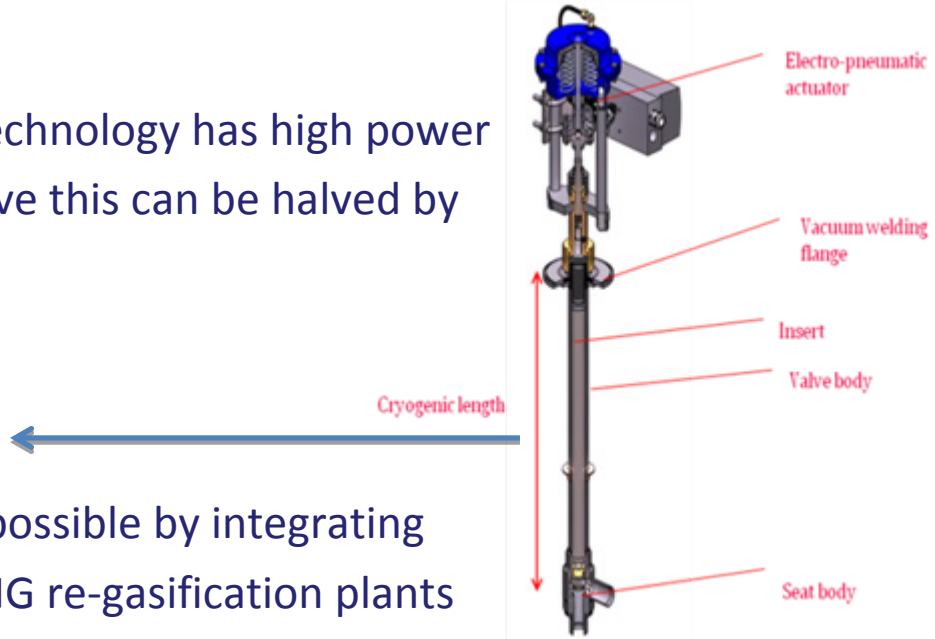
   Boil-off is a problem in vehicle tanks, but much less so in fully utilised distribution and retail equipment

2. Energy use for liquefaction

   State of the art hydrogen liquefaction technology has high power consumption. Partners in IDEALHY believe this can be halved by

   - Increasing plant scale
   - More efficient process design
   - Using more efficient components

Furthermore, efficiency improvements are possible by integrating liquefaction with other processes like LNG re-gasification plants



WEKA cryogenic valve

Energy use for liquefaction could approach that for compression

Energy use for liquefaction:

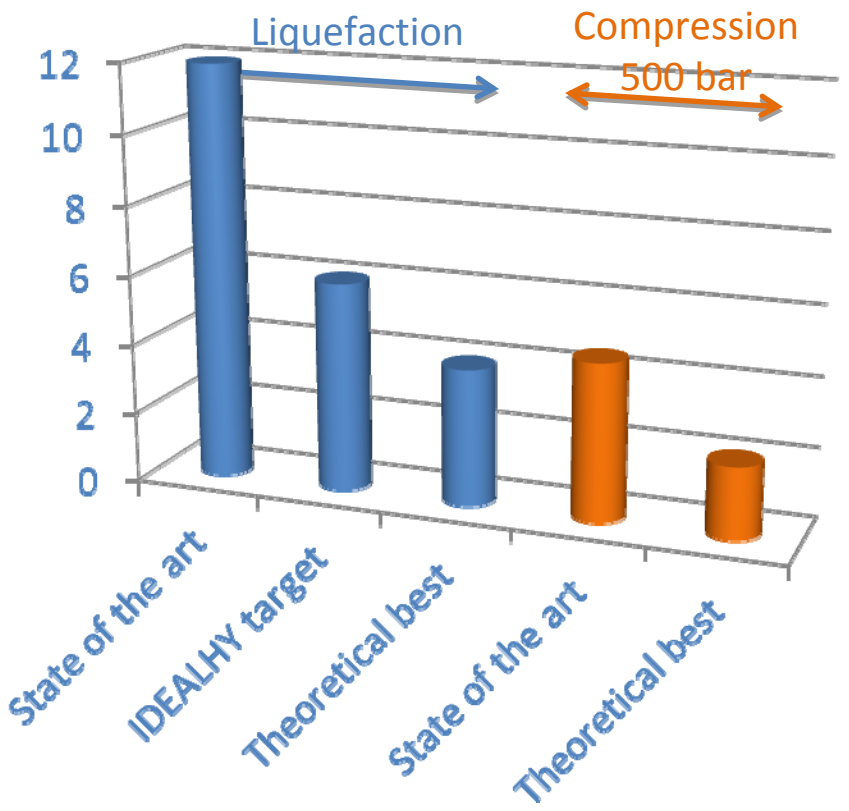
Discrepancy between study results and real plant experience

Plant	Energy use, kWh/kg real (theoretical)	
Linde Ingolstadt (1992)	13.6	(2.86)
Linde Leuna (2007)	11.9	(2.81)

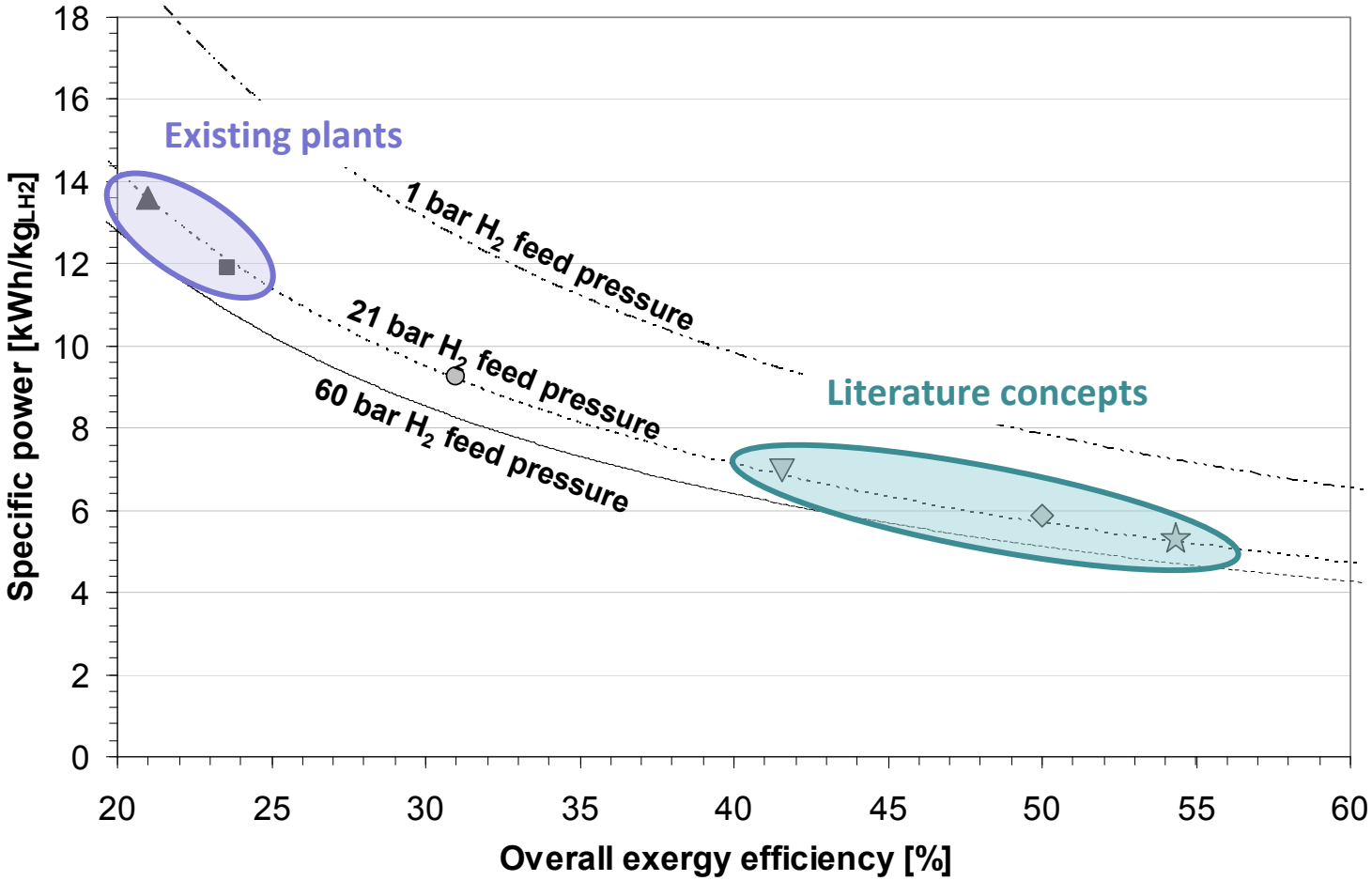
Study	Energy use, kWh/kg real (theoretical)	
WE-NET (1997)	8.53	(3.92)
Quack (2001)	6.93	(3.94)
Sintef (2010)	6.2 - 6.5	(2.90)

Theoretical energy use depends initial pressure

Energy use, kWh/kg H_2



The experts from academics and industry are united in IDEALHY to unlock the potential of hydrogen liquefaction technology



Source: Berstad D., Stang J. and Nekså P. *Comparison criteria for large-scale hydrogen liquefaction processes*. Int J Hydrogen Energy 34(3):1560–8, 2009

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Work done & next steps

1. Technology analysis & conceptual process assessment (presented at WHEC)
   - ➢ Functional schemes of efficient large-scale hydrogen liquefaction processes
   - ➢ Targets, criteria and boundary conditions
2. Process optimisation
   - ➢ Optimised process scheme and technical design of selected processes
3. Whole chain assessment: lifecycle, economic and safety assessment
   - ➢ Trade-off between plant efficiency and component cost
4. Planning and preparation of demonstration options