IEA HIA Task 28:

Large scale Hydrogen Delivery Infrastructure

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Background of Task 28

- **Fuel cell electric vehicles are close to commercialization and market introduction**
- **The first initiatives for build-up of hydrogen refueling infrastructure are emerging**
- **Worldwide there have been, and still are many HRS demonstration projects; what are the lessons learned?**
- **Next step: What is needed, when, where, and how much?**
- **International cooperation and information exchange needed to foster effective and cost-efficient HRS network build-up**

Goals and objectives

- **Comprehensive analysis of knowlegde on hydrogen delivery infrastructures :**
  - **Focus on mobility**
  - Touch upon hydrogen for integration of RES
- **State-of-the-art overview and evaluation of infrastructure options for delivery of hydrogen**
  - Insight in achievements and remaining challenges
  - support for policymaking and planning
- **Inform a wide range of stakeholders (policy, research, industry, business) about the findings**

Task participation

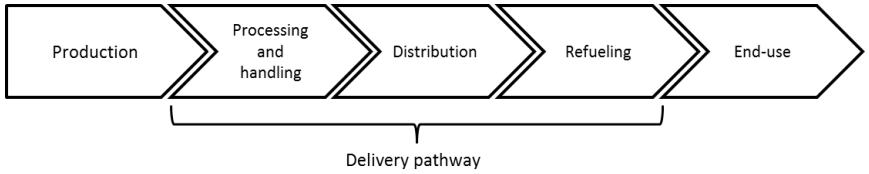
- **Current team:**
  - Netherlands: ECN(Operating Agent), Shell
  - USA: ANL and Proton OnSite
  - Japan: Tokyo Gas and Nissan
  - Denmark: DGC and H_2Logic
  - Australia: H2U / AAHE
  - France: GdF-SUEZ, TOTAL and Air Liquide
  - Germany: NOW
  - Norway: HYOP

- **Links with all European H_2 Mobility initiatives, the Scandinavian initiatives, CaFCP and the Japanese initiative HySUT**

Time schedule, Scope and Activities

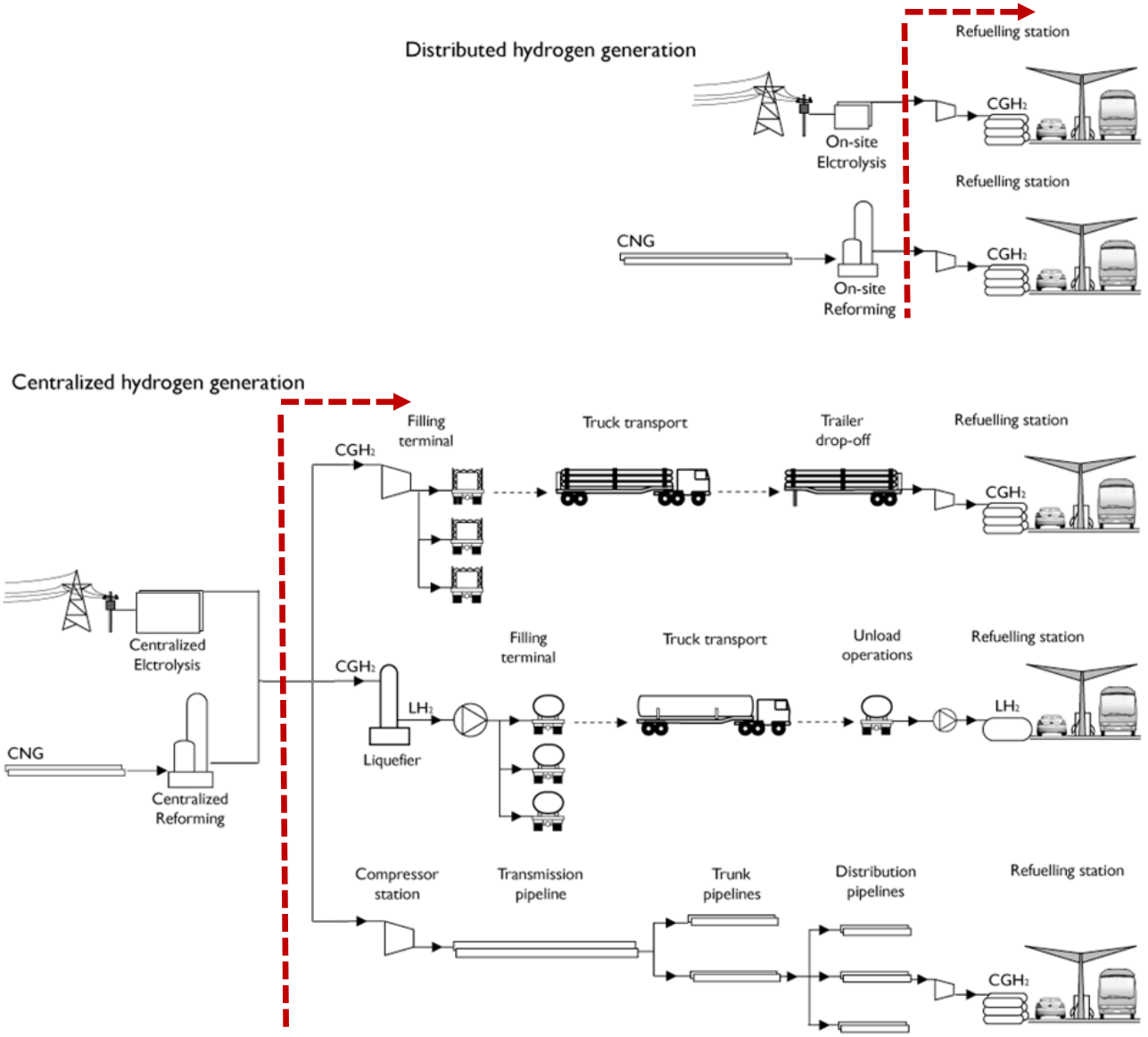
- **Time schedule**
  - Task started June 2010
  - Final report will soon be published

- **Scope**
  - From production to the end user (the tank in the car)



- **Focus and activities:**
  A. Initiatives for infrastructure development
  B. Evaluation of hydrogen delivery pathways
  C. Analysis of the economics of hydrogen refueling stations
  D. Hydrogen for integration of intermittent RES

Scope



Source: Hydrogen Delivery Roadmap Australia, 2009

Conclusions: achievements and status

- **FCEVs, in particular cars are technically ready; most major car OEMs have FCEV commercialization plans**

- **Major progress has been made in the field of technology for hydrogen delivery, especially refueling:**
  - Fast refueling at 700 bar
  - SAE J2601 (fueling protcol), SAE J2799 (Connection and communications)
  - Ionic compressor, liquid hydrogen pump
  - Truck delivery at 500 bar (about 1000 kg)

- **Technical feasibility of H_2 delivery pathways have been demonstrated; ready for scale-up to build initial networks**
  - CaFCP, CEP and JHFC1/2/3
  - Standardization of functional specifications and capacities

Conclusions: Main insights

- **Market development rather than technology development is currently the main barrier for (large-scale) introduction of hydrogen and FCEVs**
  - Concerted effort/action of all involved stakeholders needed!!

- **Initiatives for infrastructure and market development are spreading in Asia, Europe, and the USA**
  - Europe: Germany, UK, Scandinavia and now also France, Netherlands, …
  - Asia: Japan, South-Korea
  - USA: California, H2USA

- **There is no single blueprint for the type of hydrogen delivery infrastructure that needs to be rolled out**
  - Depends on specific national, regional and local resources, conditions and priorities

Evaluation of hydrogen delivery pathways

- **Important assessment criteria: Investment and O&M costs; space requirement (footprint); safety and hydrogen quality characteristics; flexibility (3x!)**

Distribution option \ HRS size	Very small ≤ 80 kg/day	Small ~ 200 kg/day	Medium ~ 400 kg day	Large ~1000 kg/day	Very large ≥ 1000 kg/day
On-site electrolysis			On-site space and power requirement may become an issue: 400 kg/day ≈ 1 MW		
On-site reforming		Costly to capture CO_2		Required footprint is an issue	
CGH2 truck		Delivery possible up to about 1000 kg per trailer		Required frequency of delivery at high throughput is an issue	
LH2 truck	Relatively large boil-off at low demand levels in early markets		Considerable investment in liquefaction capacity needed, and liquefaction is energy intensive		
CGH2 pipeline	Due to high investments pipelines are not likely in early markets unless already available				

Color coding: Suitable | Possible | Less likely

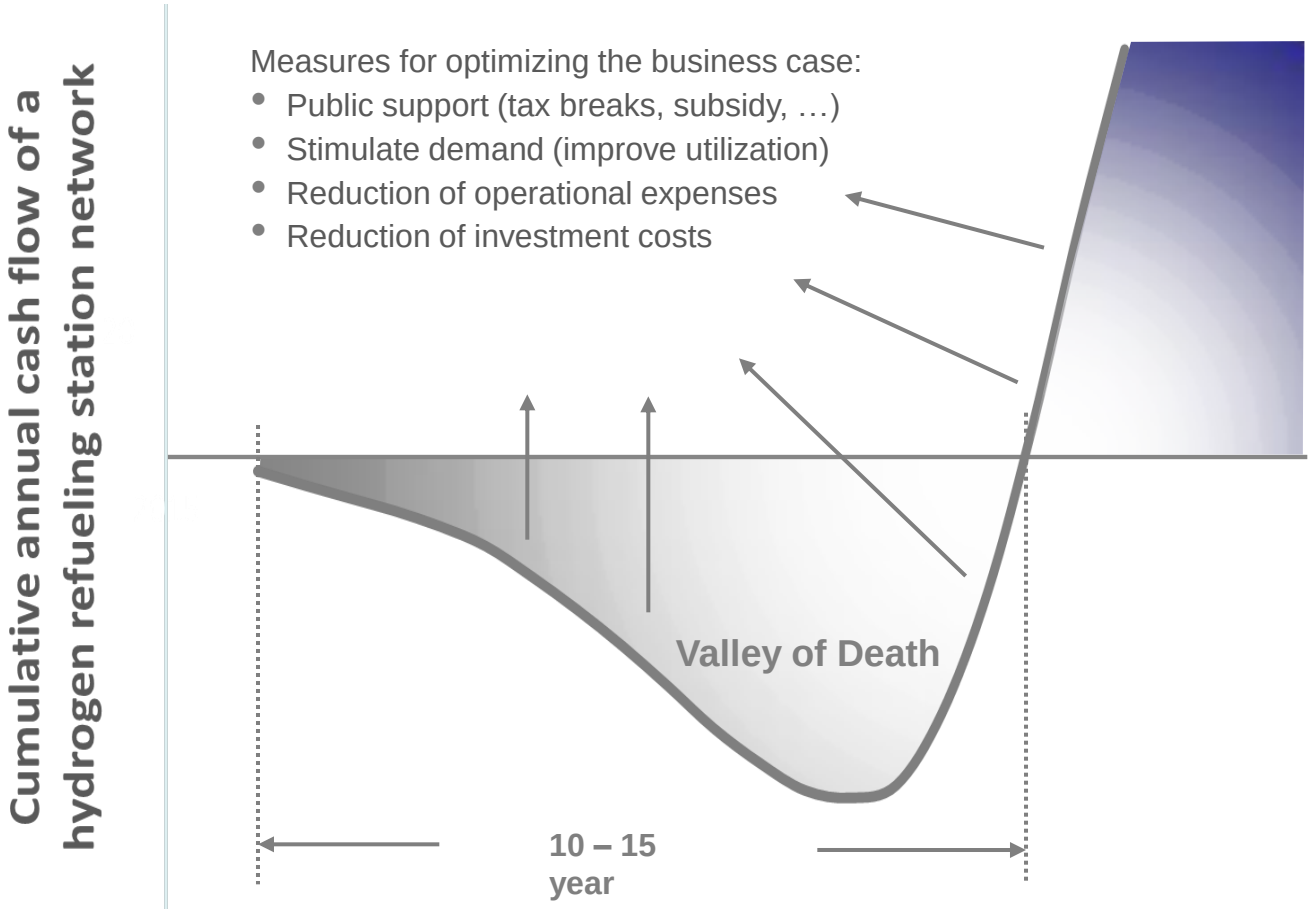
Selection of typical HRS capacities based on public document 'H2Mobility Germany 70 MPa HRS Standardisation – Functional description'

Conclusions: Remaining challenges

- **Development of an acceptable business case for initial HRS networks:**
  - Installation of station capacity needs to precede cars on the road which results in underutilization of initial HRS networks
  - Initially high investment cost; in addition high O&M costs
  - High risks: development of costs, variable public policies, rate of supply by OEMs, uptake by the market, changing regulations, ...

- **Remaining technological challenges:**
  - Improving system reliability; demanding conditions: 700^{+} bar, -40°C
  - Hydrogen metering: improving accuracy of meters, and standardized measuring method for certification of hydrogen meters
  - Practical hydrogen quality specifications, and efficient standardized methods and procedures for demonstrating compliance

The financial gap: “Valley of Death”



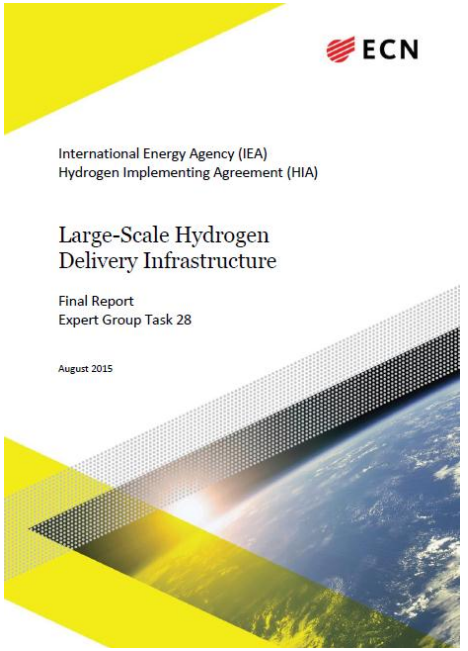
What are the Task 28 recommendations?

- Support formation of strong consortia and joint ventures by industry stakeholders
- Ensure establishing of a robust well-balanced framework of government interventions for HRS, FCEV and fuel
- Aim for obtaining of adequate commitment of all stakeholders regarding well-coordinated rollout
- Stimulate R&D to improve critical components
- Stimulate development of solutions for certification of hydrogen metering and hydrogen quality compliance
- Encourage the development and implementation of unambiguous and harmonized standards

… and finally

- **Strengthen international cooperation on, and coordination of HRS delivery infrastructure and FCEV rollout:**
  - Continue sharing lessons learned
  - Avoid counterproductive competition between rollout initiatives
  - Manage expectations … avoid hype creation!

- **For more details:**
  see Task 28 final report
  (to be published soon)



IEA HIA

A premier global resource for technical expertise in H2 RD&D

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Thank you very much!

Key elements of work plan - 1

- **Initiatives for development of hydrogen refuelling infrastructure:**
  - Map/list and compare main initiatives
  - Develop quantitative outlook based on existing projections

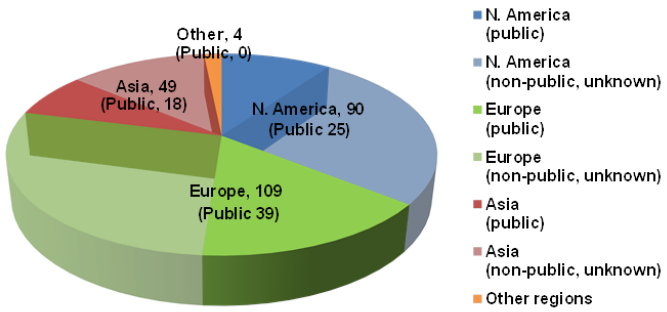
- **Evaluation of hydrogen delivery pathways:**
  - Description of hydrogen delivery options
  - Functional specifications and requirements of HRS
  - Evaluation HRS options in view of specifications and requirements
  - Mapping current public HRS

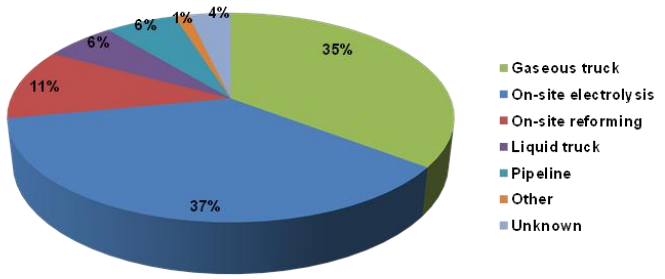
Key elements of work plan - 2

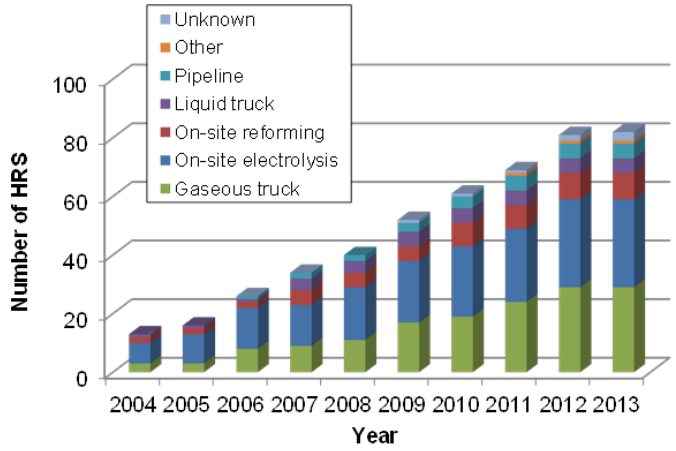
- **Analysis of the economics of HRS:**
  - Overview best publicly available technology cost data
  - Projections for future costs of technology
  - Cost of hydrogen: important cost factors

- **Hydrogen for integration of RES:**
  - Shared view on the usefulness and necessity
  - Associated hydrogen delivery infrastructure and current status
  - Research questions and challenges

Overview of current (public) HRS



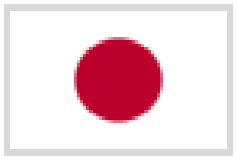
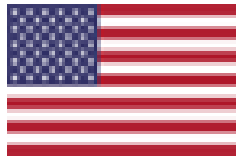
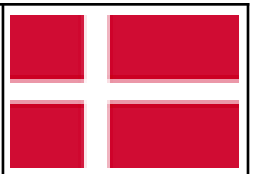




- **Currently, total 285 HRS of which 82 publicly accessible**
  - Significant differences in breakdown of delivery options: on-site reforming almost absent in Europe but large in Asia, and CGH2 relatively small in North-America

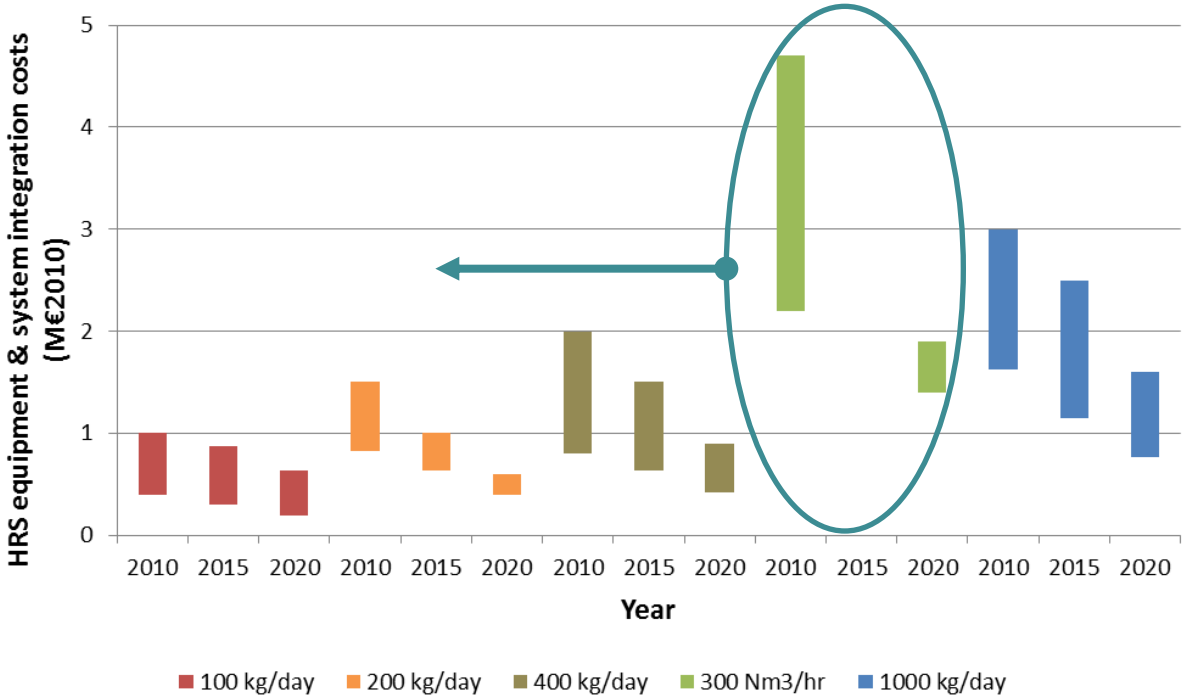
HRS projections in major H_2 infrastructure initiatives

- **Comprehensive overview of countries in conjunction with projections on FCEVs**

						
	Japan	S.Korea	USA California	Germany	UK	Denmark
2015-2020	100	10	68	100	65	15
2020-2025	1000	200	100	400	330	185
2025-2030				900	1150	>>185

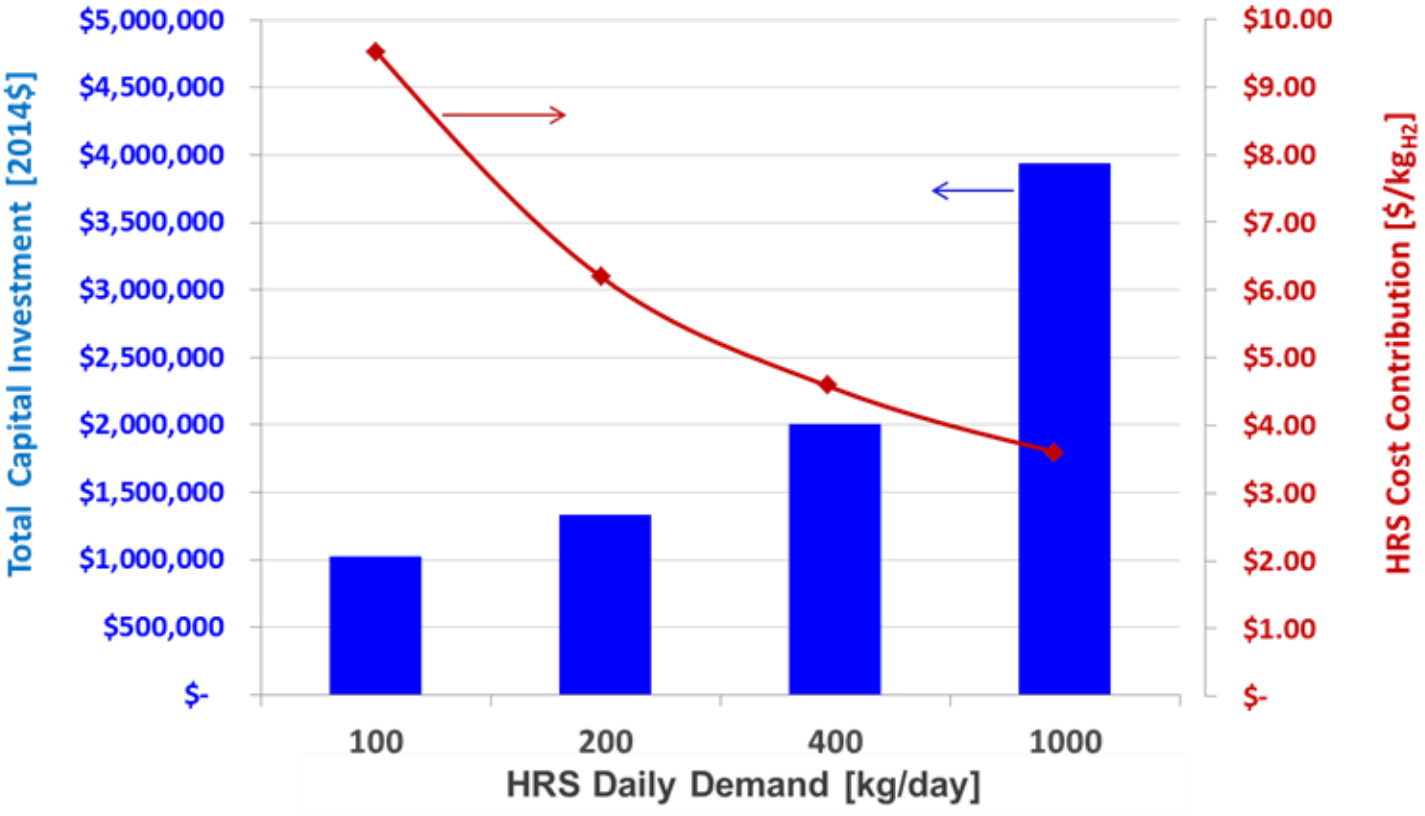
  - Overview of HRS projections in major initiatives on market development

Indicative HRS investment cost



- **Difficult to compare and interpret numbers due to lack of hamonization in definitions, cost factors and HRS cost breakdown**

HRS cost contribution to H_2 price



– Elgowainy, A, 2015, Hydrogen Refueling Station Analysis Model HRSAM – A Near-Term HRS Cost Model)