

Hydrogen Distribution

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Transformation of the energy system
by which hydrogen is introduced as an energy carrier,
in particular for transport applications

- How and from what primary energies is the hydrogen produced ?
- How is the hydrogen taken to the vehicles ?

Various routes - all well known

Production	Transport	Refueling station	
		Storage	Dispensing
GH2	GH2 Pipe	-	GH2
	GH2 Trailer	Trailer swap OR GH2 storage	GH2
LH2	LH2 Trailer	LH2 storage	GH2 or/and LH2

Pipelines are used to network production

- Today H2 pipeline networks interconnect large GH2 sources
 - “Large capacity distributed H2 source”
 - ✓ High availability
 - ✓ High transmission capacity



Energy transmission capacity	
Oil pipeline (1 Mb/day)	73 GWh/h
NG pipeline (30 GNm ³ /y)	38 GWh/h
HVDC (53 TWh/y)	6 GWh/h
H2 pipeline (79 GNm ³ /y) (same diam as NG)	27 GWh/h

Source : Ludwig Bölkow Systemtechnik

- Tomorrow such networks could receive and make available green/carbon free H2 (certificates)

Road Transportation of hydrogen

Compressed Hydrogen



Container material	Pressure (bar)	Payload (kg H ₂)
Steel	200	370
Steel hoop wrapped	200	600
Carbon composite <i>In development</i>	500 +	1 300 +

Retail H₂ station consumption : 80 to 1000 kg/day

Liquid Hydrogen



Container type	Temp. (°C)	Payload (kg H ₂)
Steel - Vacuum insulated	-253°	3 800

- Current volumes for Germany (approx. 20 000 t/yr) would fuel more than 100 000 FCV's
- Liquid form provides flexibility wrt quantity&distance, Gaseous form wrt sources
- Use of composite material will greatly enhance efficiency of transport in gaseous form

Large capacity fuelling stations exist today

Whistler BC Transit bus refueling station

- 20 bus fleet
- 350 bar GH2 dispensing
- 45 kg in 10 min
- 2 400 kg/d theoretical refueling capacity
- 10 000 kg LH2 storage on site
- As of Sept 14th 2010 :
 - ✓ 2 854 fills
 - ✓ 66 947 kg dispensed



Passenger car H2 refueling infrastructure to be developed mostly by “retrofit” of existing stations

- Equipment to be inserted :
 - H2 storage (supply)
 - + Dispensing process skid
 - + H2 dispenser(s)

- Innovative solutions are under development to minimize foot-print :
 - ✓ Underground storage - Canopy storage
 - ✓ Storage at high pressure of H2 supplied

- Safety distance requirements are being standardized (ISO 20100), with aim of safely optimizing use of available space

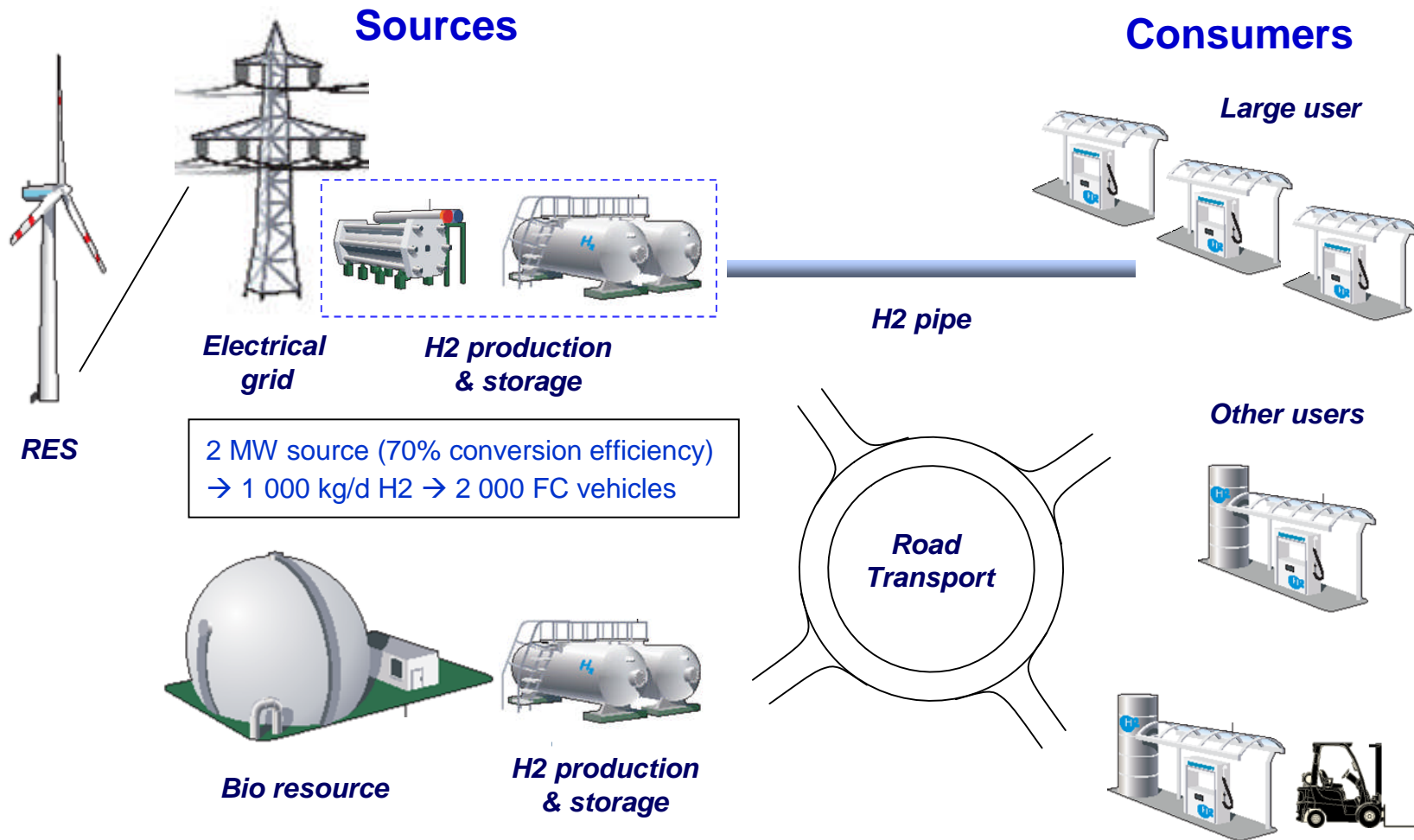


Standard today :
up to 6 kg @70 MPa*
in 3 minutes
(pre-cooling)

* 700 bar

Initiation of a local H2 infrastructure by linking local sources to local users

Potential local H2 energy infrastructure - example



Drawings by Enetrage

Conclusion

- A range of proven solutions are available for building up the Hydrogen distribution infrastructure for commercial startup in 2015
- Further pre-commercial deployments are needed for validation of optimized approaches
- It is critical to develop the RCS framework for optimized GH2 trailers and efficient permitting of fuelling stations
- Regional actors are key players for taking advantage of the best infrastructure build-up opportunities

Thank you
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