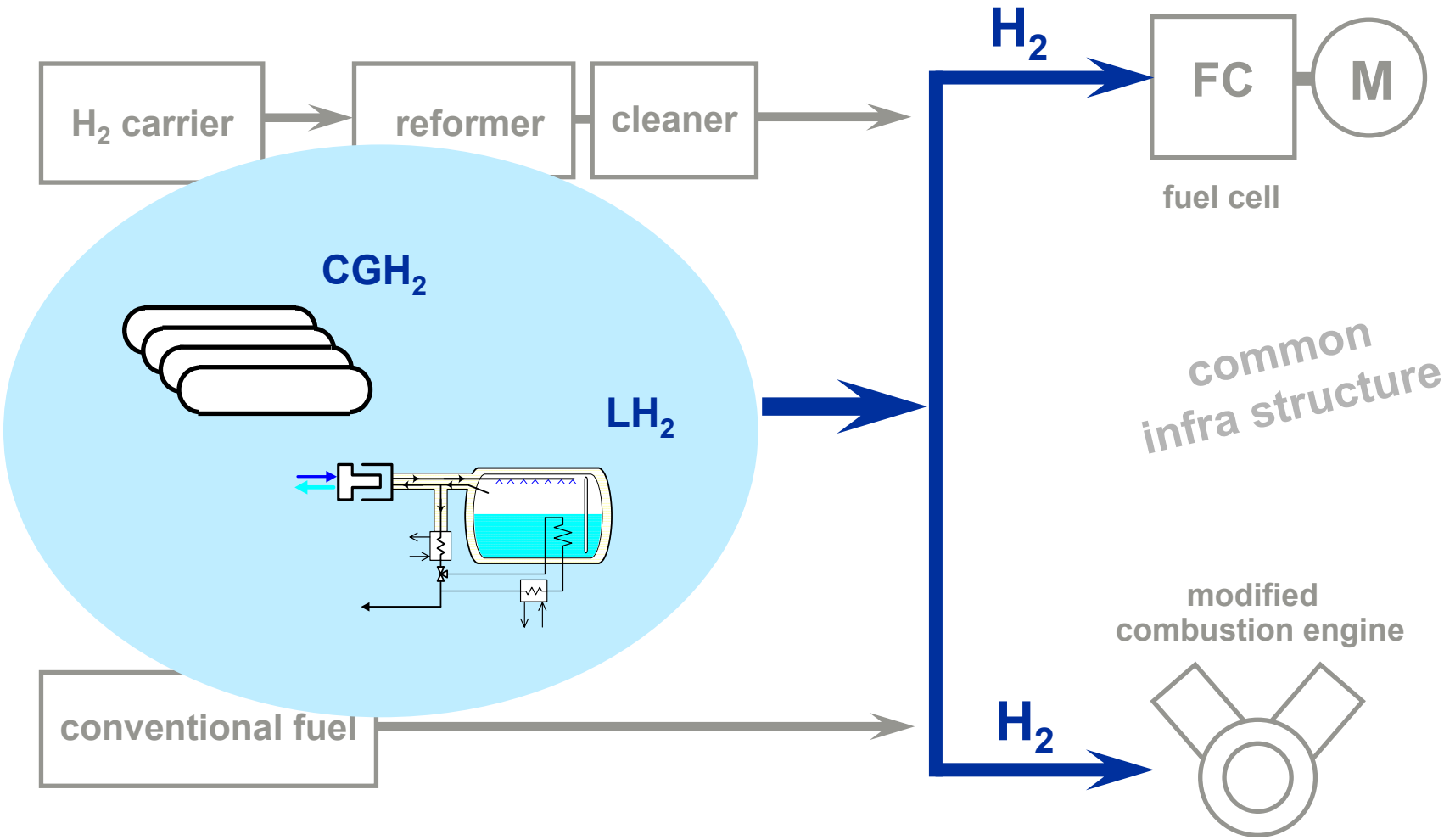
Shanghai Industrial Fair + Hydrogen and Fuel cells
Nov 3- 8, 2004, Shanghai, China

Linde Gas | Linde

Elements of a Hydrogen Infrastructure

Jaco Reijerkerk ***BEng (Hons) MSc*** Hydrogen Solutions

Introduction of hydrogen - by replacement of conventional fuel systems -



Hydrogen ...

... is more than a fuel.

hydrogen - the energy carrier -

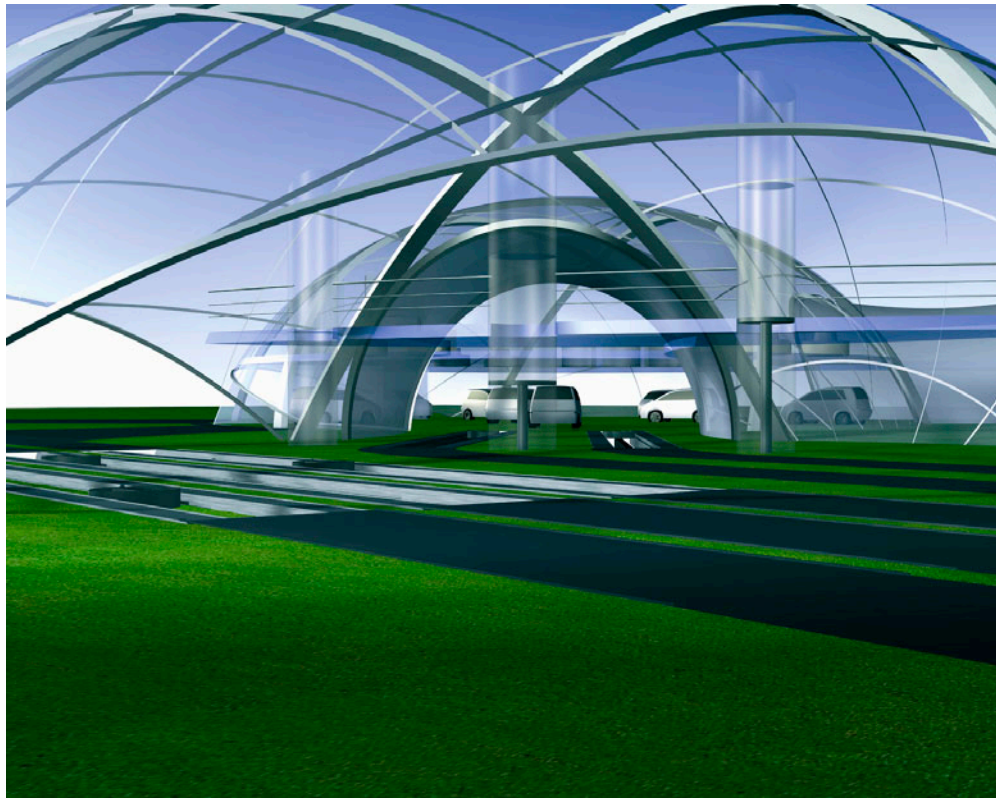
Hydrogen ...

... is storable electricity.

fuel stations - the new fuel offers new opportunities -

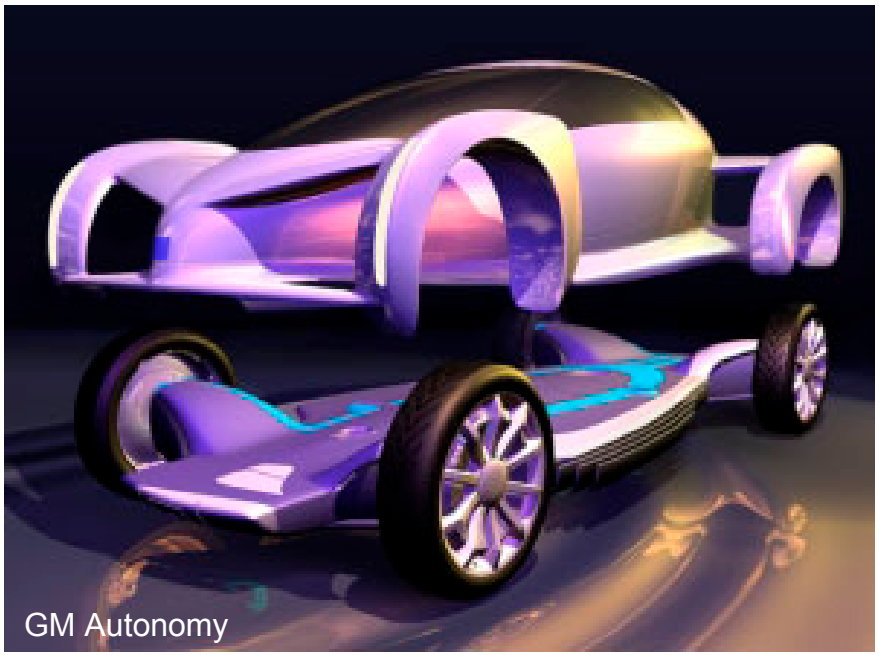
Instead of deserts …

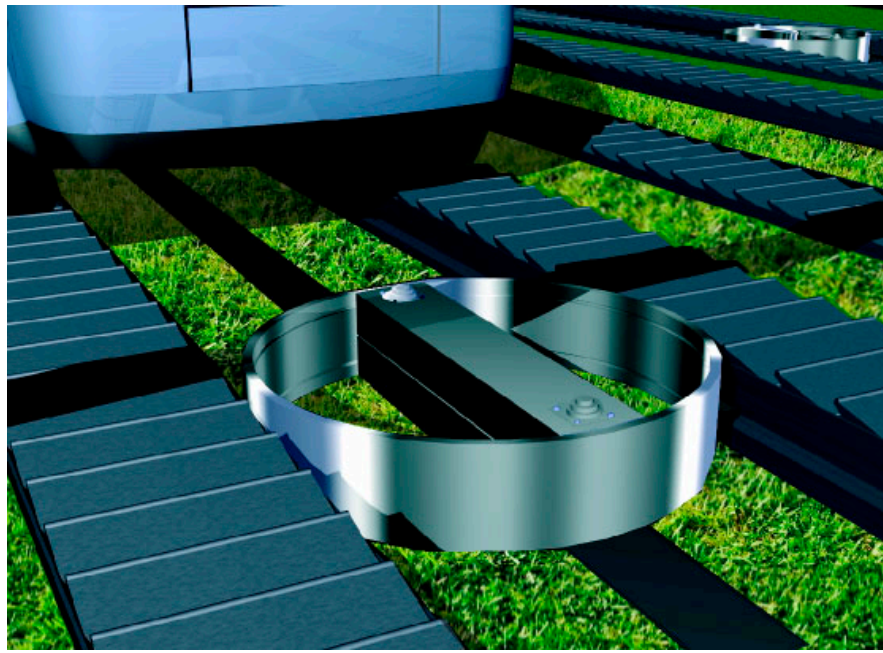
… green areas.



fuel stations - the new fuel offers new solutions -

For adaptation to future platform concepts suitable refuelling solutions are required.

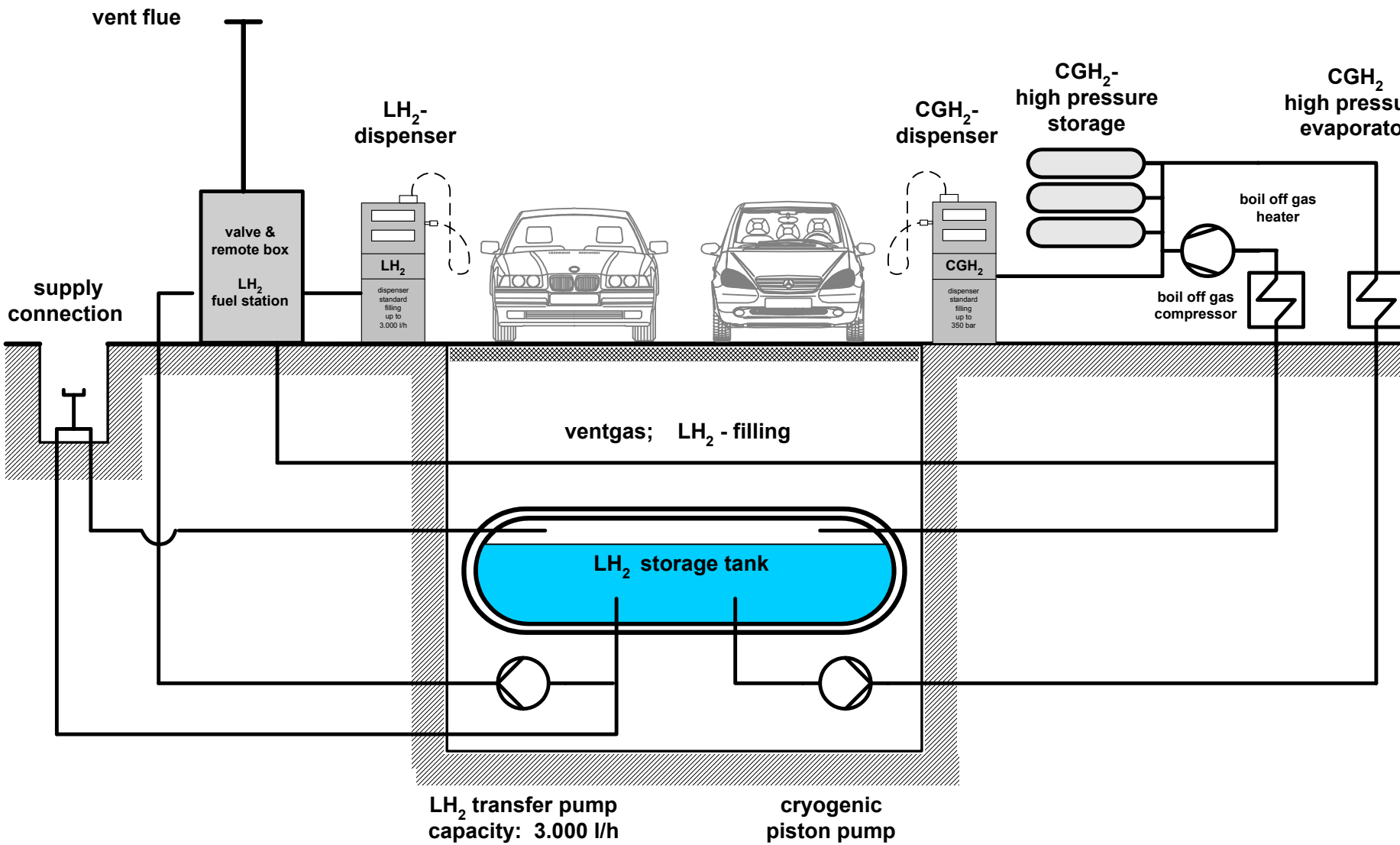




infrastructure & fuel stations - requirements -

- 24 hours available
- multiple customers simultaneously
- adaptable to current gas stations
- less than 3 minutes refuelling time
- dual configuration (liquid / gaseous)
- high purity Fuel Cell grade
- competitive costs

fuel stations - universal cryogenic fuel station, **principal scheme** -



- hydrogen?
- industrial infrastructure
  - production
  - distribution
- automotive infrastructure
  - actual existing elements
  - future elements
- outlook

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the actual

industrial infrastructure

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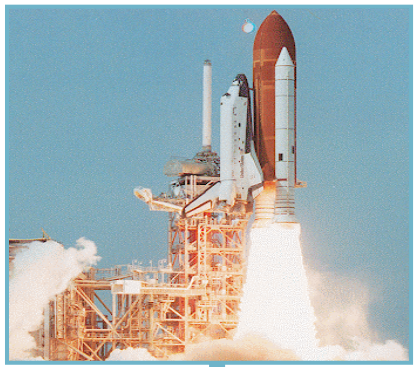
Use of Hydrogen

Target: Automobile Application

New Fields for Hydrogen



yesterday

- Ehemals treibende Kraft
- Stagnierender Markt

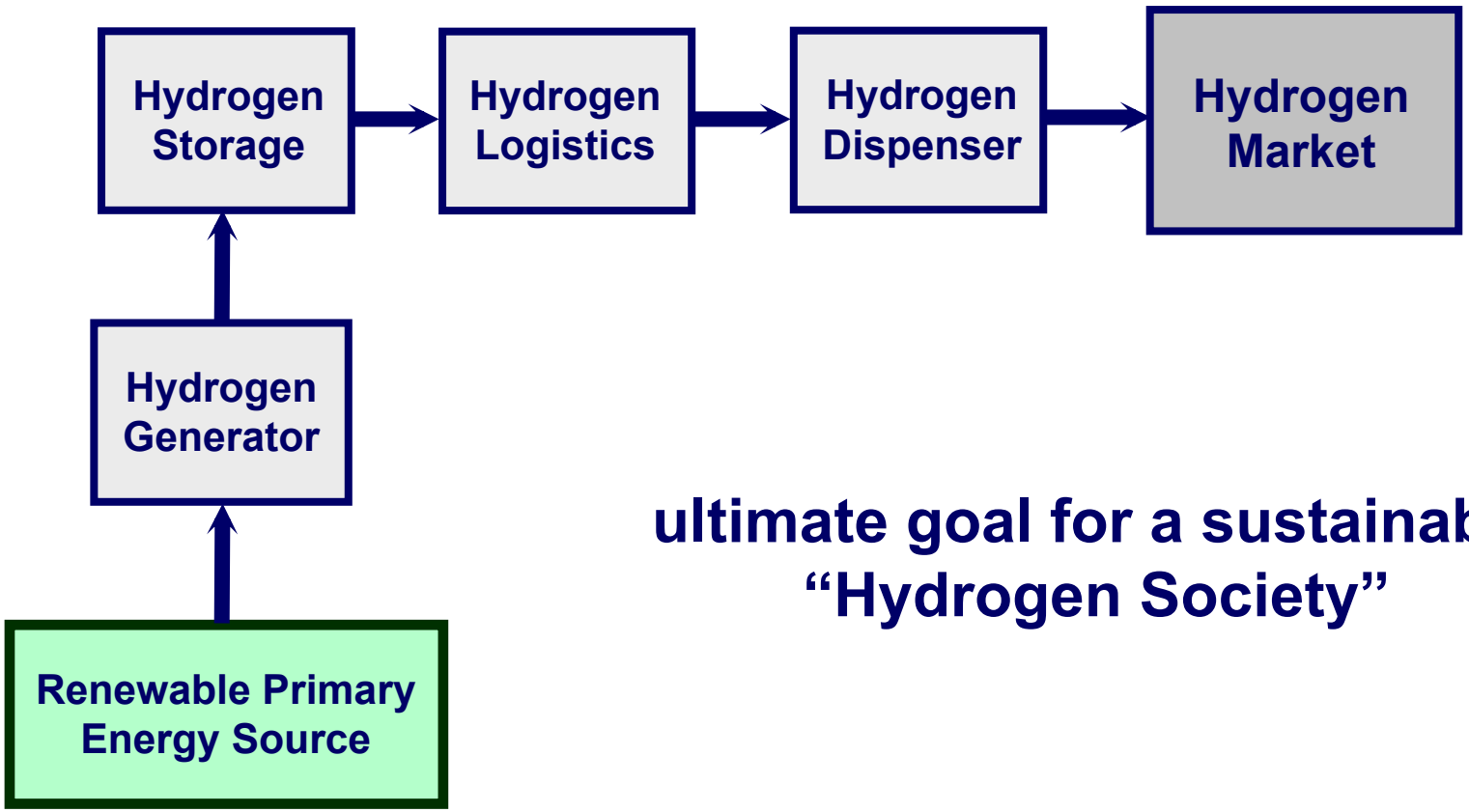
today

- Benzin, Fette, Dünger etc.
- Ca. 7-10% Wachstum pro Jahr

tomorrow

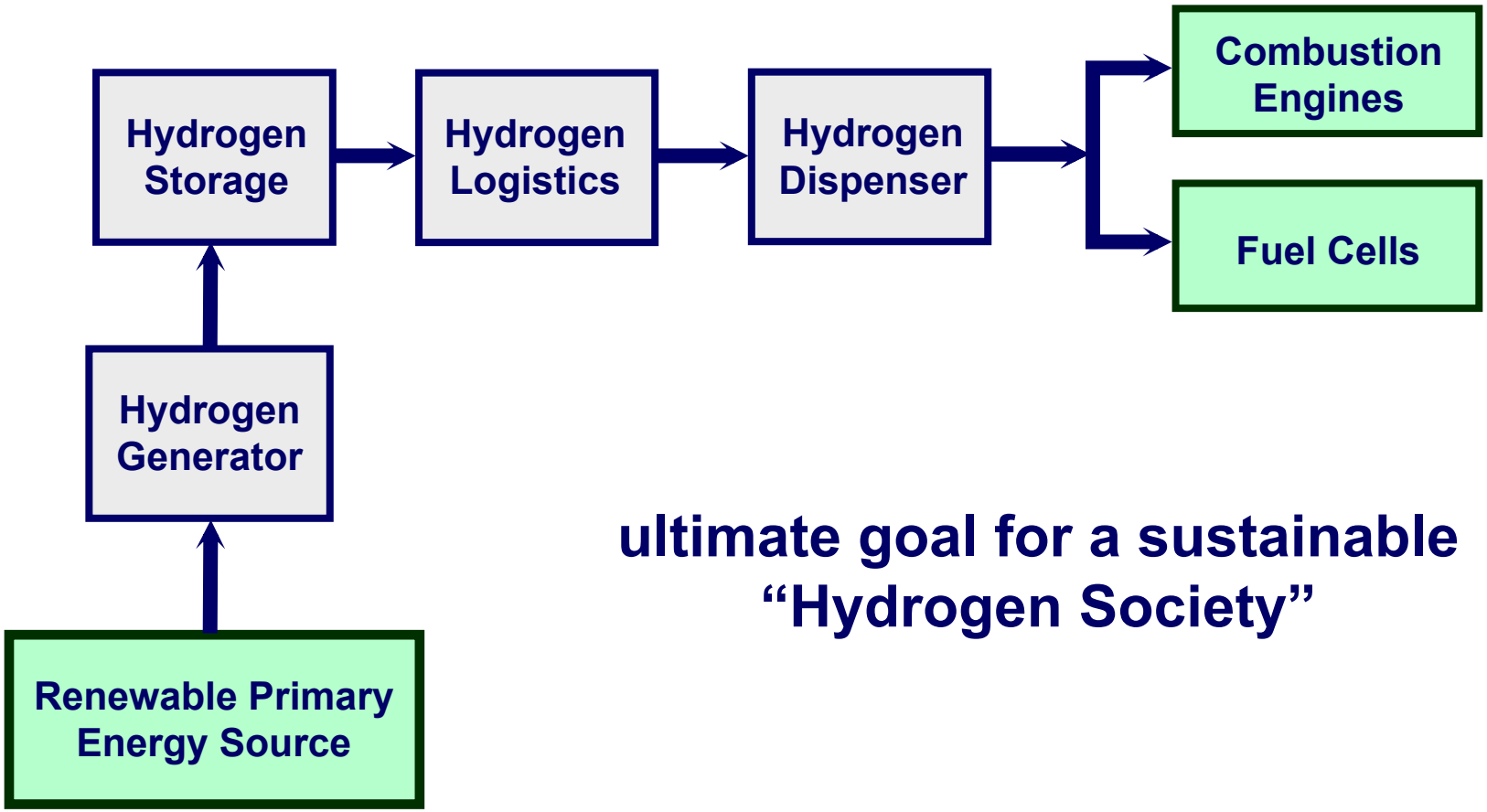
- Zentrale Technik Brennstoffzelle
- Großes Potenzial

Linde Group - hydrogen activities -



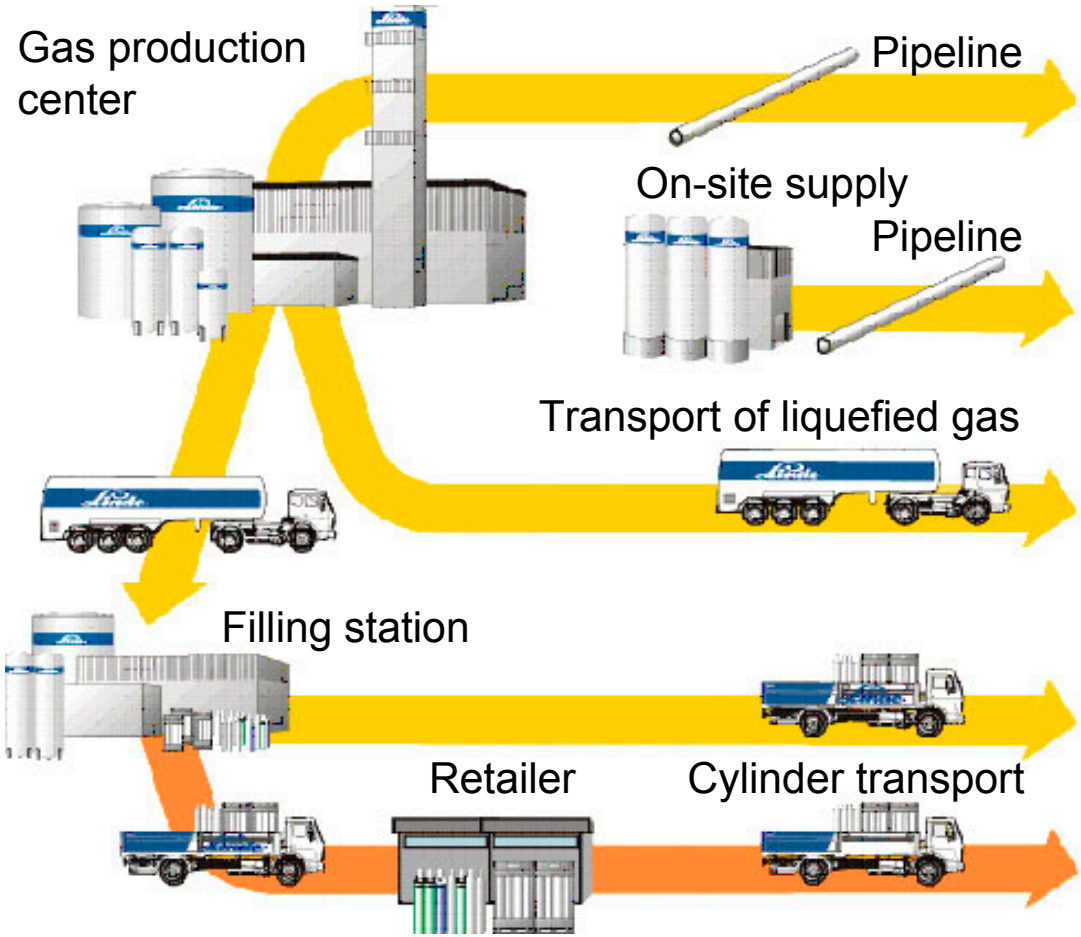
ultimate goal for a sustainable "Hydrogen Society"

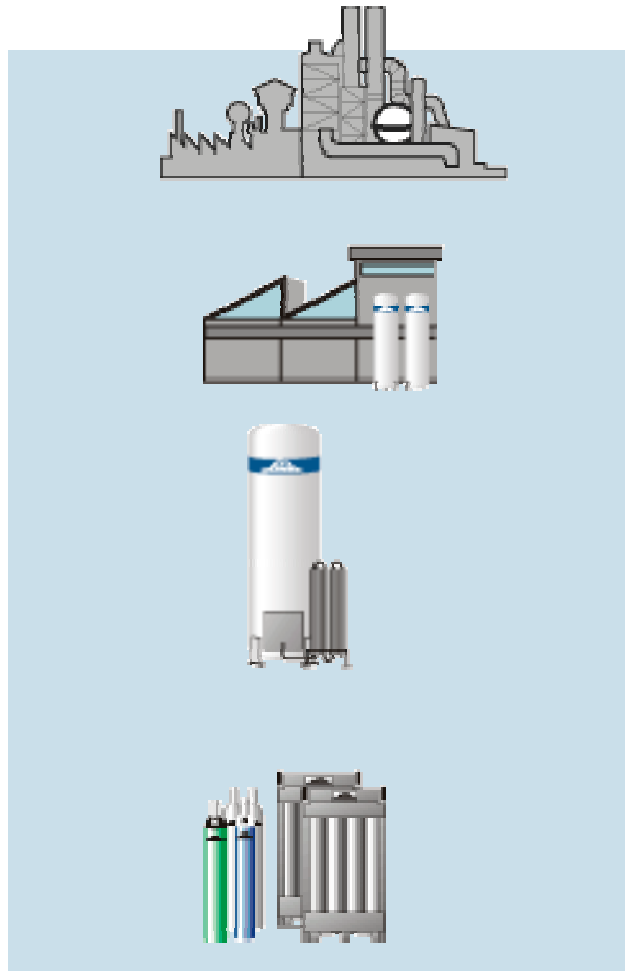
Linde Group - hydrogen activities -



ultimate goal for a sustainable "Hydrogen Society"

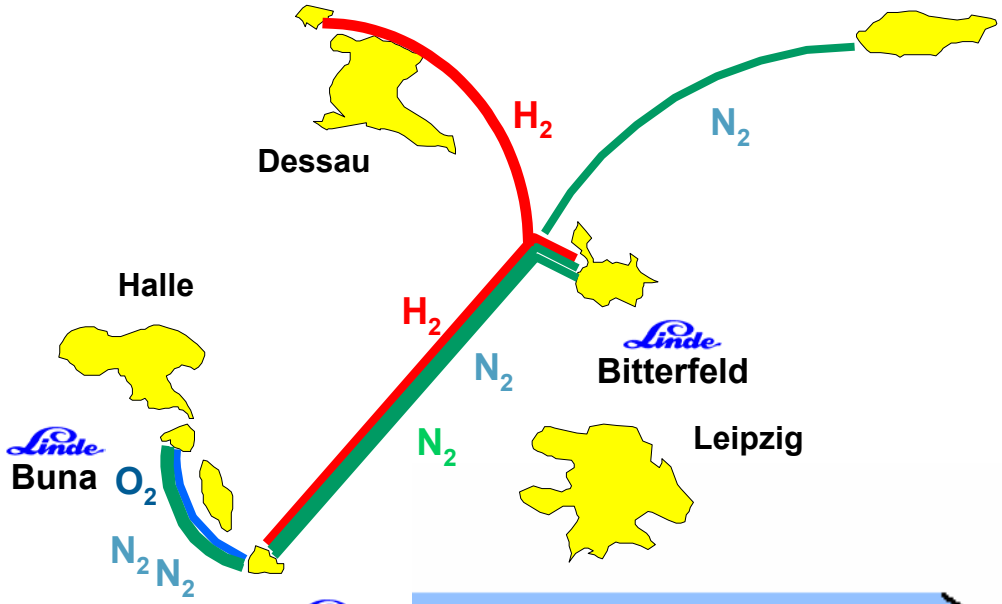
production & distribution - from the source to the customer -

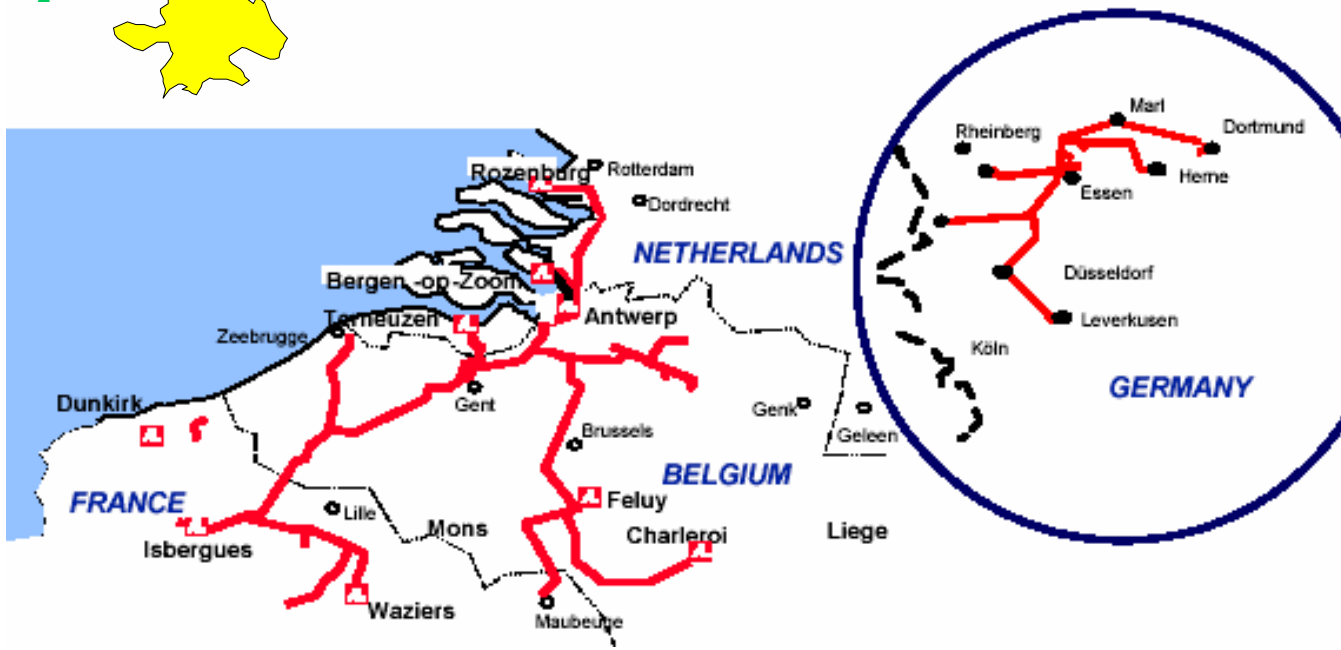




production & distribution - Linde steam reformer, Milazzo, Italy -

hydrogen pipelines in Europe - examples -





transport equipment - comparison for LH_2 and CGH_2 -

Trailer for
Compressed Gaseous Hydrogen
with
lightweight compound bottles

total weight:	**40 t**
Hydrogen load:	**530 kg**

Trailer for
Liquid Hydrogen
with
a super insulated cryostat

total weight:	**< 40t**
Hydrogen load:	**3.370 kg**

the actual

“automotive infrastructure”

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hydrogen projects - EXPO 2000, Berlin, BMW **2000** -

hydrogen projects - NECAR 4 (FC) with LH_2 supply, DaimlerChrysler **2000** -

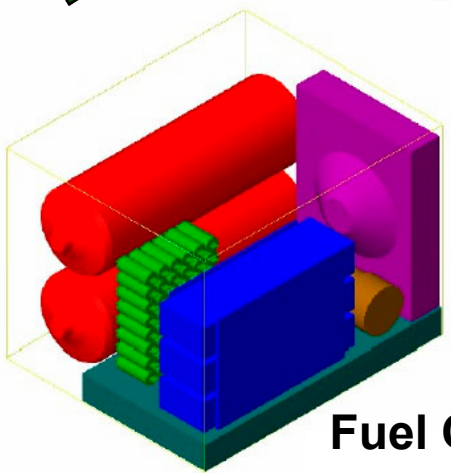
hydrogen projects - ZAFIRA (FC) with LH_2 supply, General Motors **2000** -

European Hydrogen Initiatives - **CUTE** **C**lean **U**rban **T**ransport **E**urope, **2002** -

FC-CITARO bus, DaimlerChrysler 2002

30 FC-city-busses running for 2 years in 9 European cities.

hydrogen projects - hydrogen powered FC-forklift, Linde **2003** -



Fuel Cell

Battery

STILL
member of the Linde Group

fuel stations - provisional LH_2 filling equipment, California, **2000** -

fuel stations - manual operated LH_2 fuel station, Hanover **2000** -

The manual fuel station …

… and the filling process.

fuel stations - CGH_2 fuel station, **700 bar technology**, GM **2002** -

fuel stations - Hydrogen Fuel Station, Tokyo **2003** -

fuel stations - the ROBOT application on Airport Munich, **2000** -

the future

automotive infrastructure

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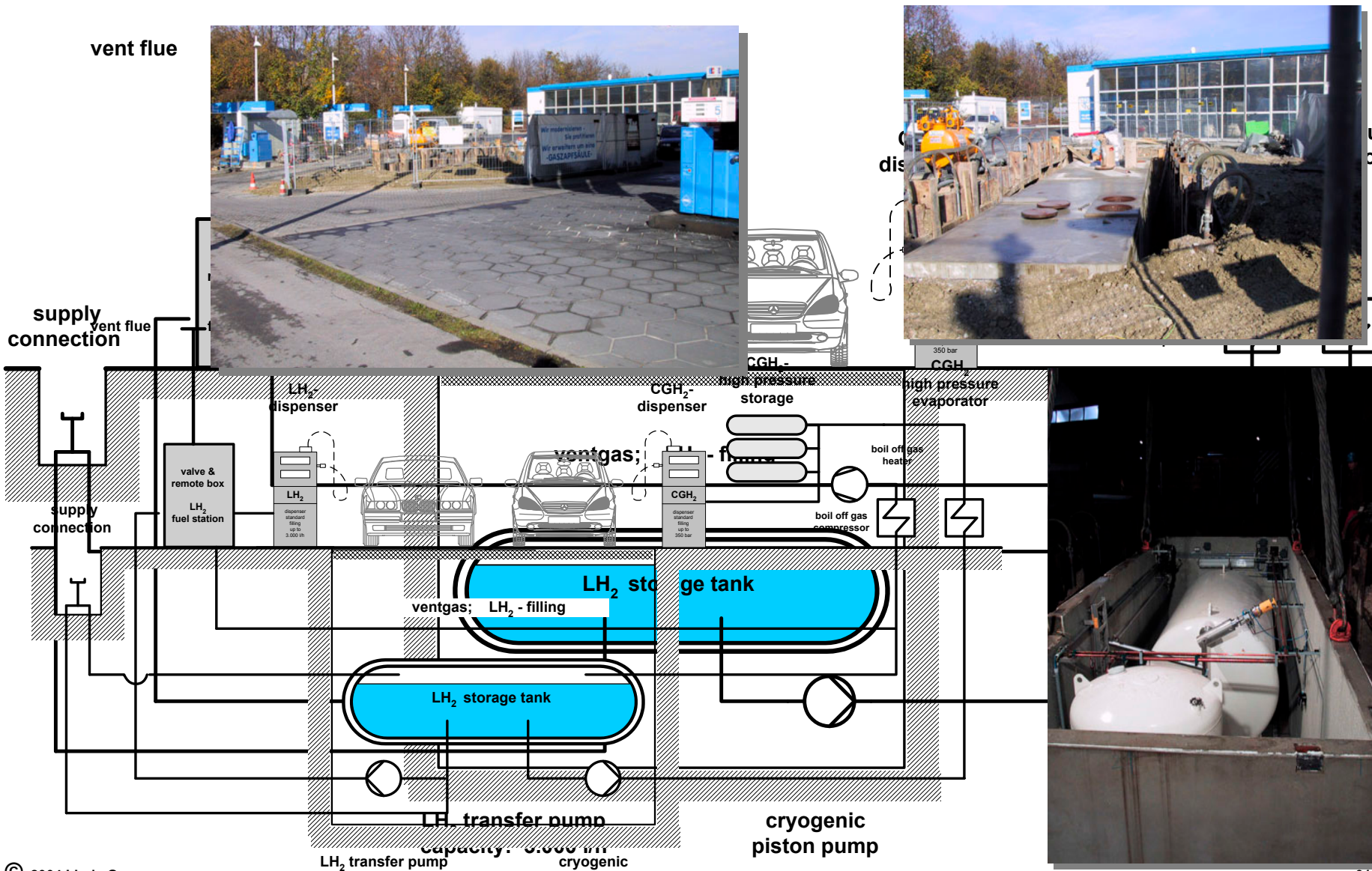
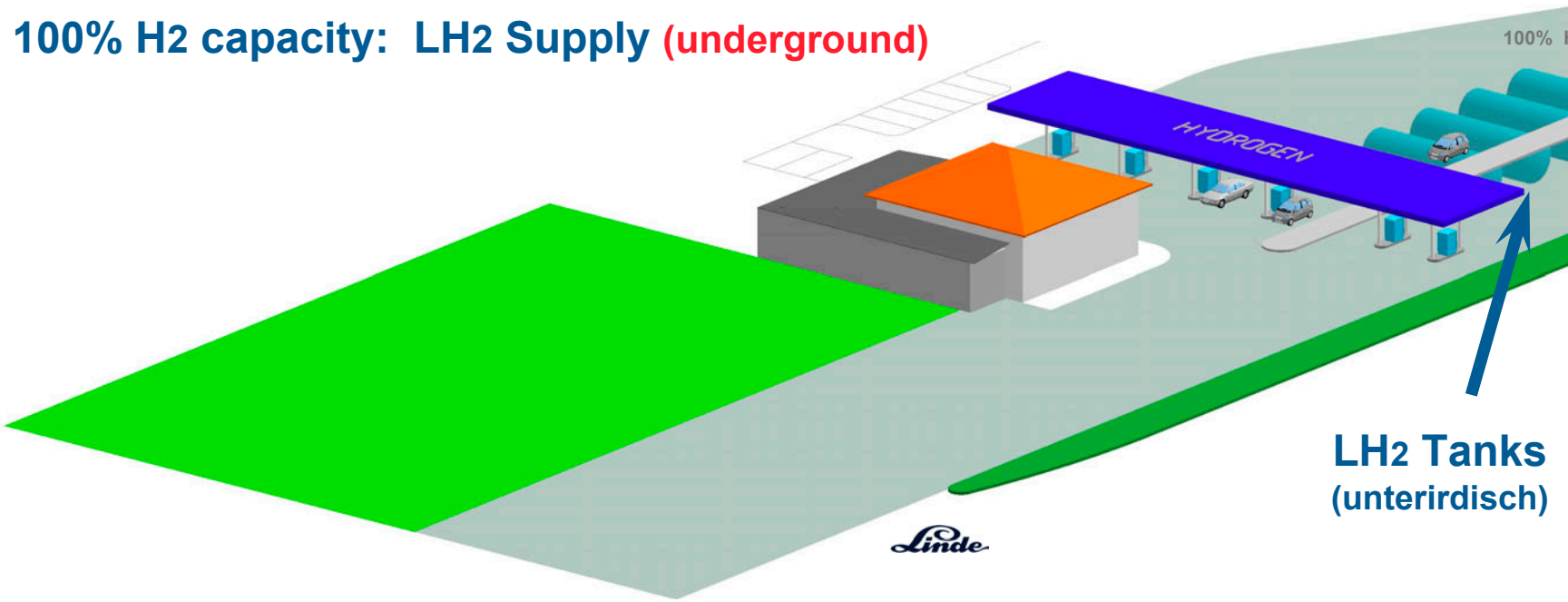


fuel stations - universal cryogenic fuel station, **after completion** -

Footprint of a conventional Fuelling Station

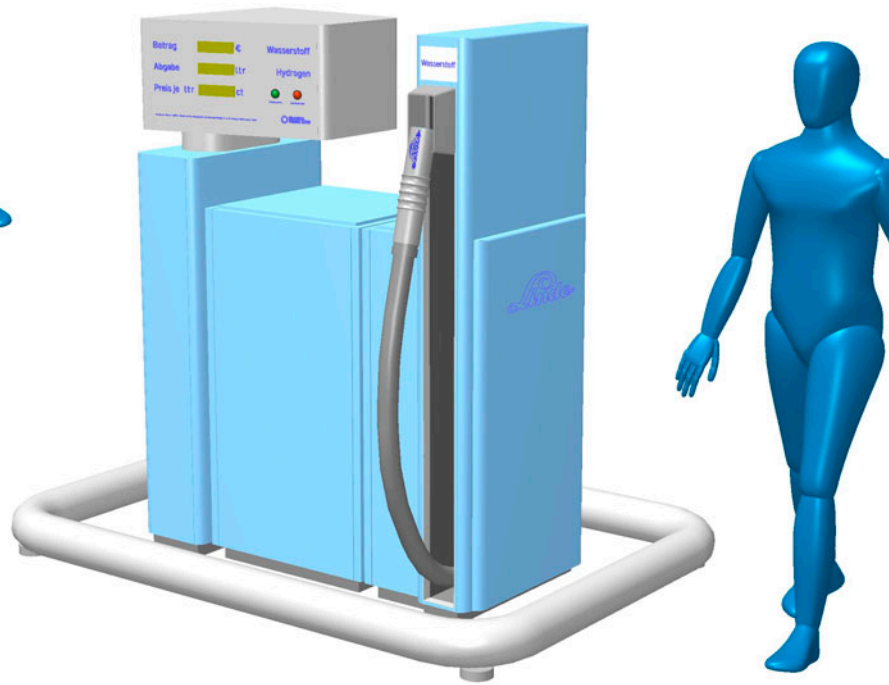
- 10% H_2 capacity: Test Operation with LH_2 Supply (above ground)
- 10% H_2 capacity: on-site Electrolysis with Liquefaction
- 10% H_2 capacity: on-site Steam Reforming with Liquefaction
- 50% H_2 capacity: on-site Steam Reforming with Liquefaction
- 50% H_2 capacity: on-site Electrolysis with Liquefaction
- **100% H_2 capacity: LH_2 Supply (underground)**



LH_2 Tanks
(unterirdisch)

fuel stations - development & integration of an automotive LH_2 coupling -

Integration



Linde Gas

Thank you.