



Welcome

to the 6th National Hydrogen Conference

*Hydrogen and Fuel Cells:
Inspiration by Demonstration*

11 December 2008

A group of diverse children are shown from a high angle, holding a globe of the Earth. They are all smiling and looking towards the camera. The background is a solid blue color. The text is overlaid on the image in white.

Latest Developments in Hydrogen Fuelling Infrastructure

**Ian Williamson
Air Products
December 2008**

**Dutch Hydrogen Association
Congress**

Today's Presentation

- **Who are Air Products**
- **Transition to Hydrogen**
- **Central vs Local**
- **Urban Scenario's**
- **Other Parameters**
- **Short Term Demonstration Examples**
 - **UK forging ahead**
- **Summary**

Leadership in Hydrogen Fuel Infrastructure

- **Worlds largest producer of merchant hydrogen ~50% share**
- **Our capacity ~1.75 million TPY
Could support 7-8 million vehicles**
- **Active since 1993**
 - **Built over 100 hydrogen station projects**
 - **Over 85,000 fuellings**
 - **in 14 countries**
- **Strong and broad IP position.**

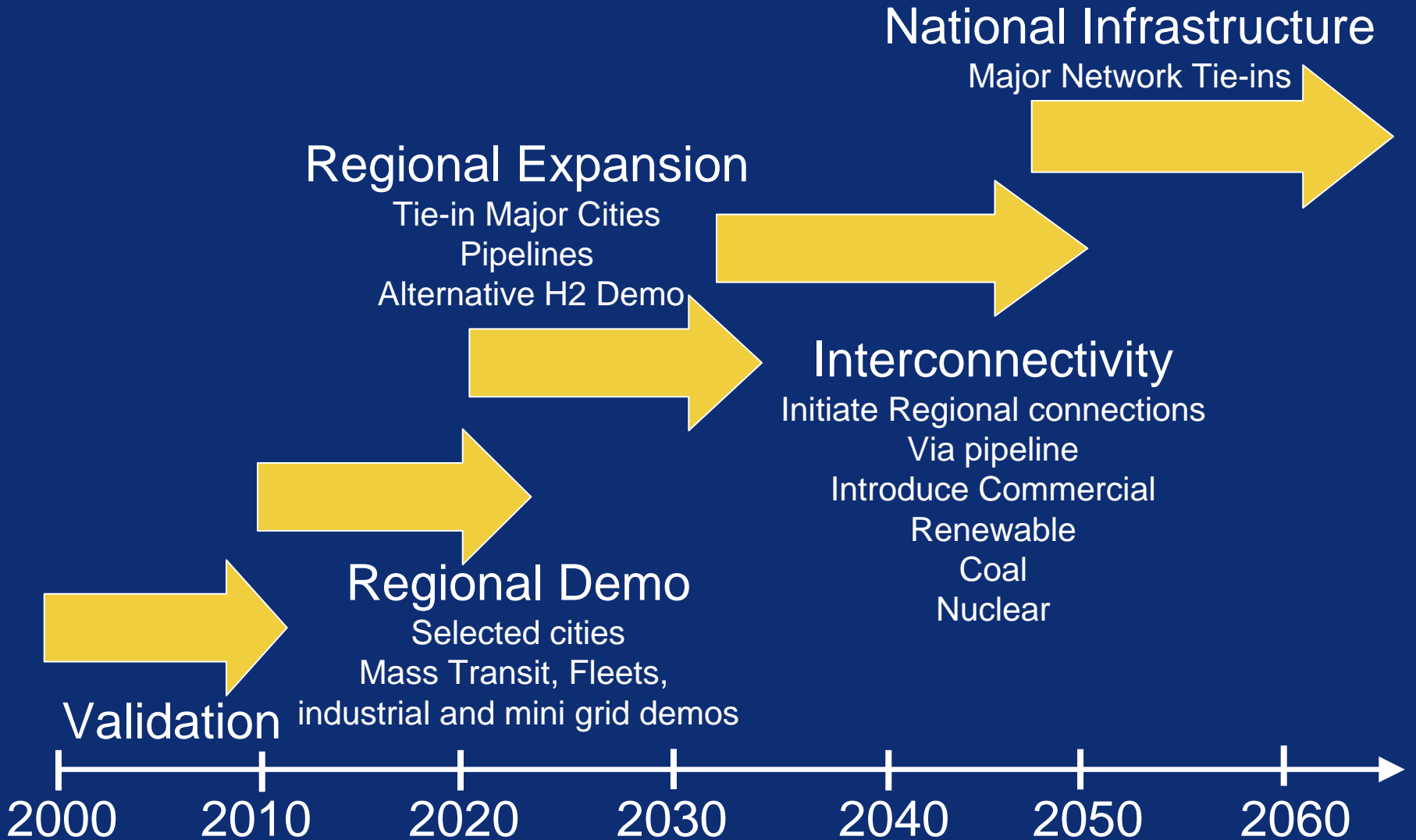


Infrastructure Transition

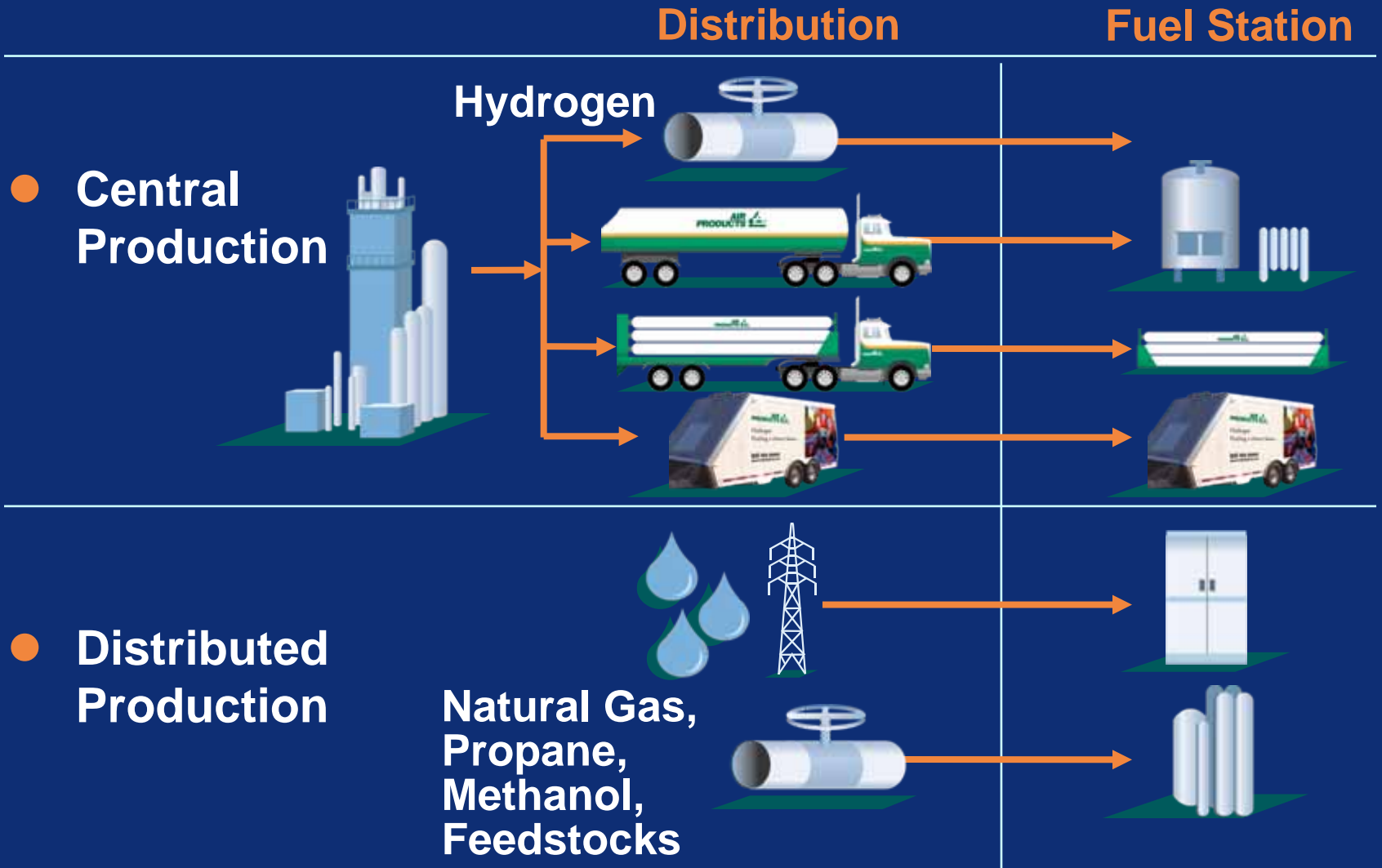
- Provide technologies which have utility today while positioning for the future
- Focus on a regional model with abundant H2 and population.
- Focus on mass transit in other urban areas.
- ☆ *Future Hydrogen Infrastructure will include:*
 - *Pipeline delivered hydrogen similar to NG*
 - *Multiple feed sources of hydrogen from:*
 - *Biomass*
 - *Geothermal*
 - *Wind*
 - *Solar*
 - *Nuclear*
 - *Coal*
 - *Methane reforming*
 - *Delivered or distributed product in the outlying areas*



Timeline for Transition



Hydrogen Sourcing



H2 Fueling Station Requirements

- **Safety**
- **Capacity per DOE H2A Model**
 - 1500 kg/day
 - Utilization 70%
 - Flexibility to meet daily, weekly, seasonal, and growing demand
- **Dispensing Capability**
 - 350 Bar and 700 Bar
 - Fill time 3-7 minutes
- **Reliability**
 - 99.9+%
- **Location**
 - Urban
- **Small Footprint**
- ☆ **Transparent Operation to the consumer**

Distributed Reformer

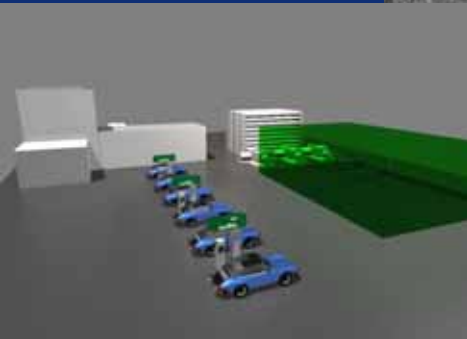
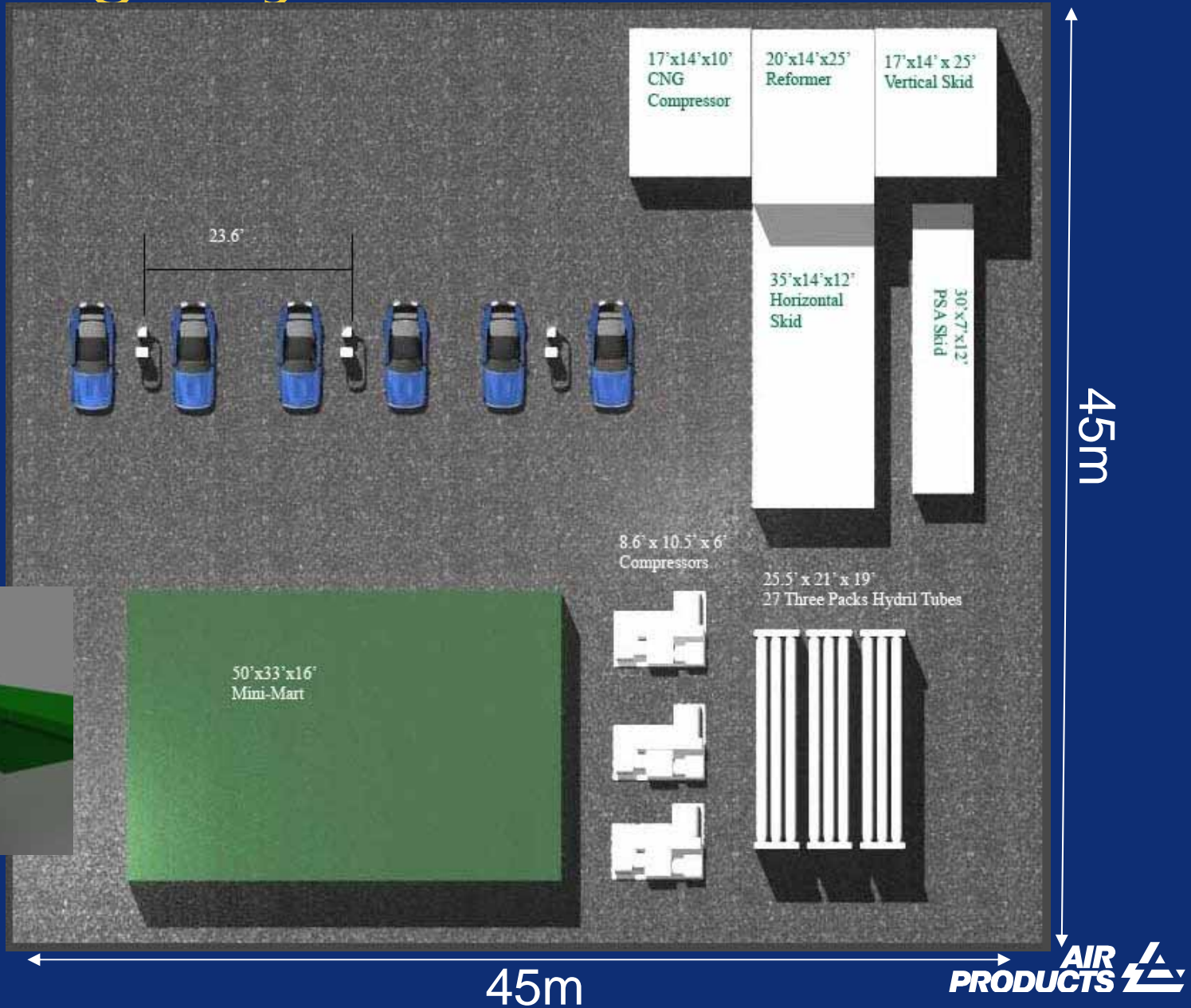
- 5 – 250nm³
- Currently only short operating history
- Product Purity and analysis issues for FC supply
- Good for some applications



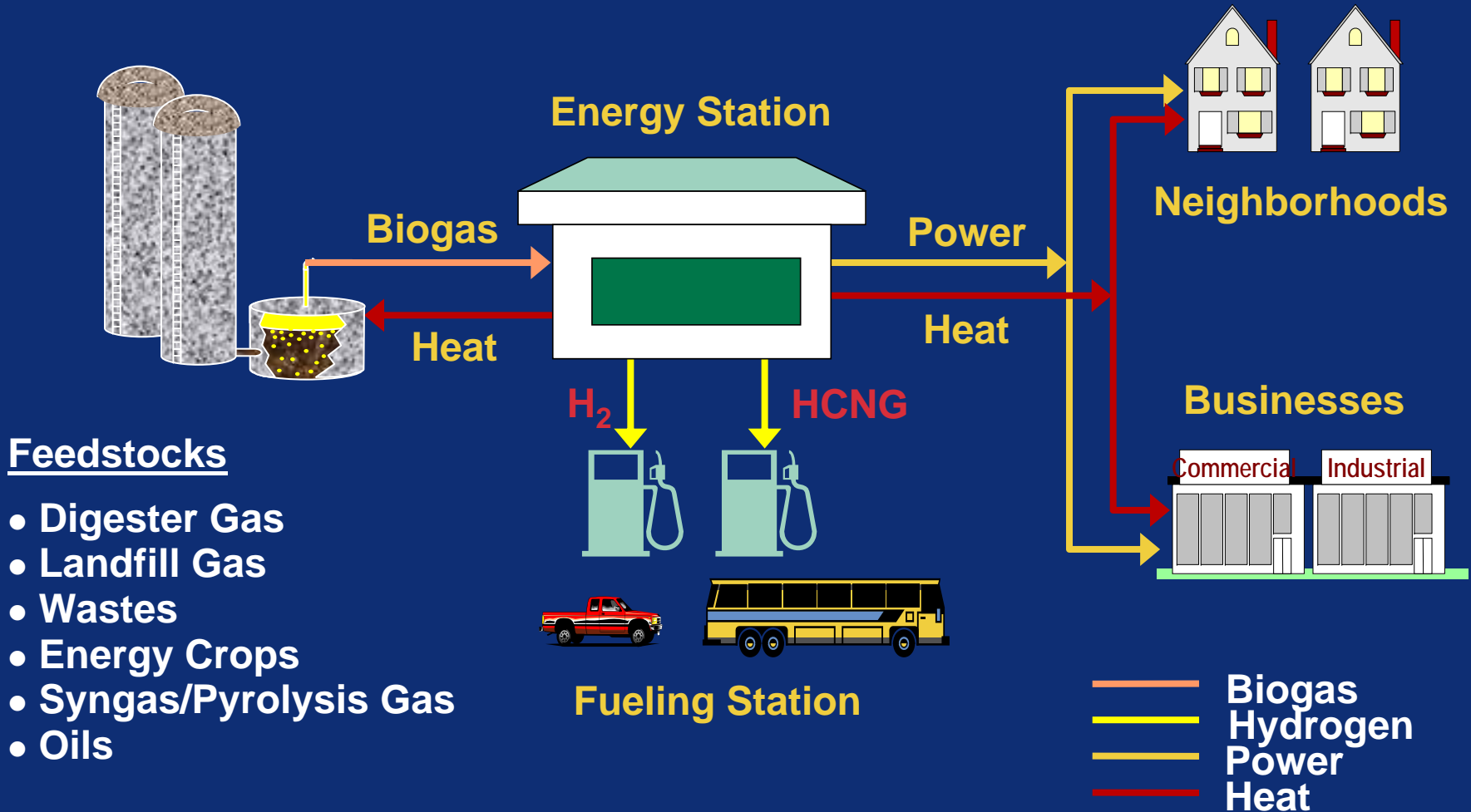
AP H2 Generator at PSU



1500 kg/day SMR Station



Renewable H2 Energy Station



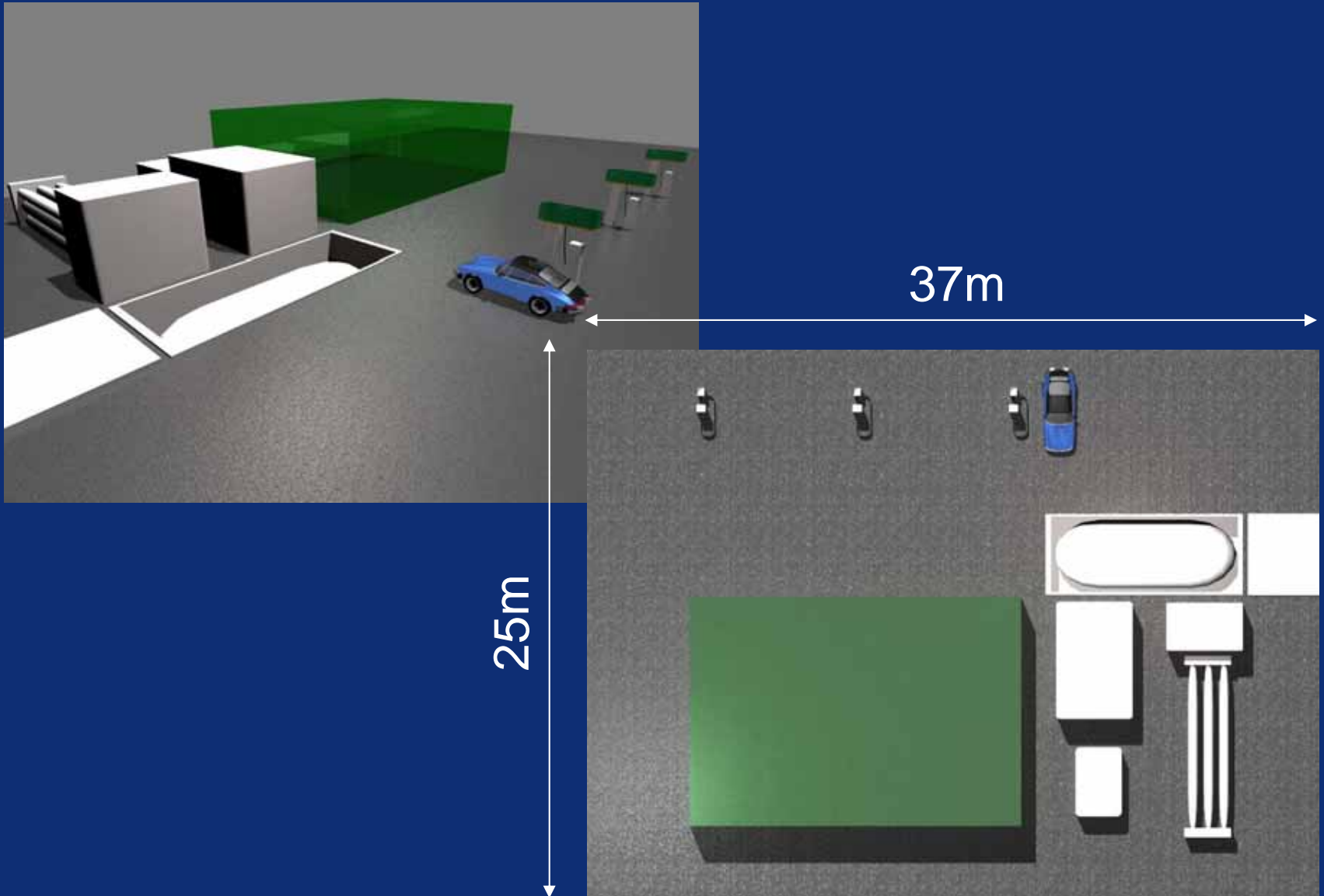
Liquid Hydrogen Tanker Capacity 3600 kg liq H₂



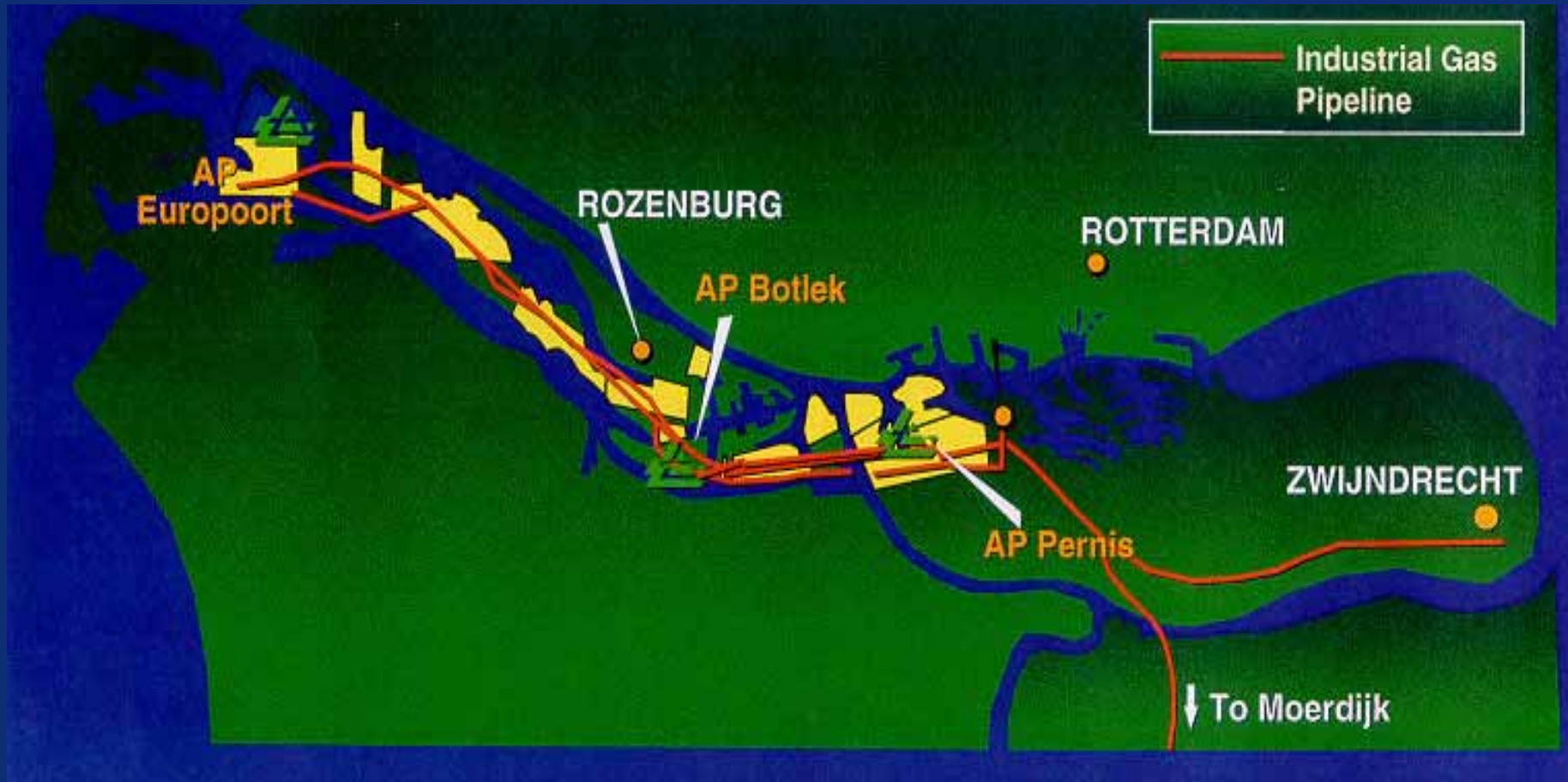
Underground LHY Tanks: Station storage of the future?



LHY Forecourt Illustration-1500kg/d

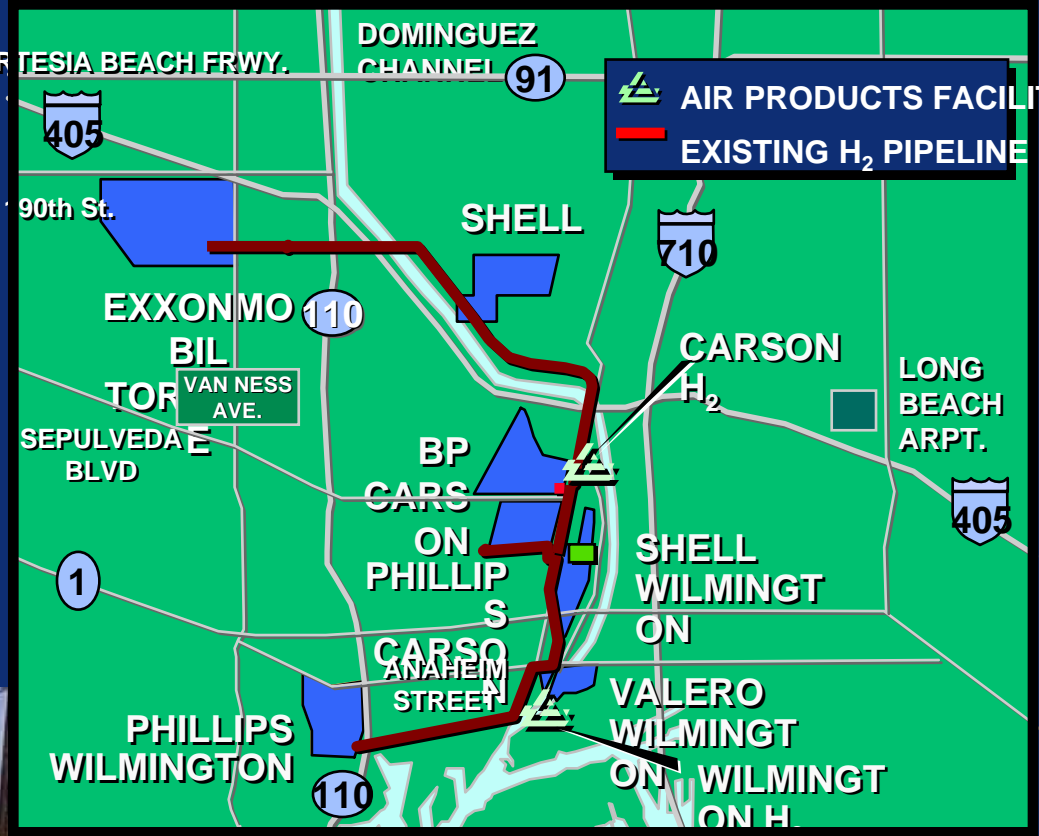


Rotterdam Gaseous H₂ Pipeline System

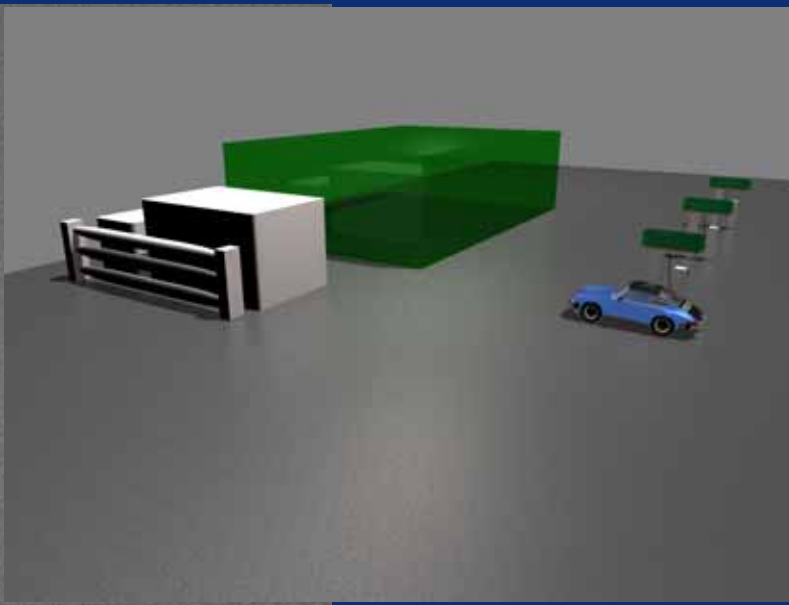
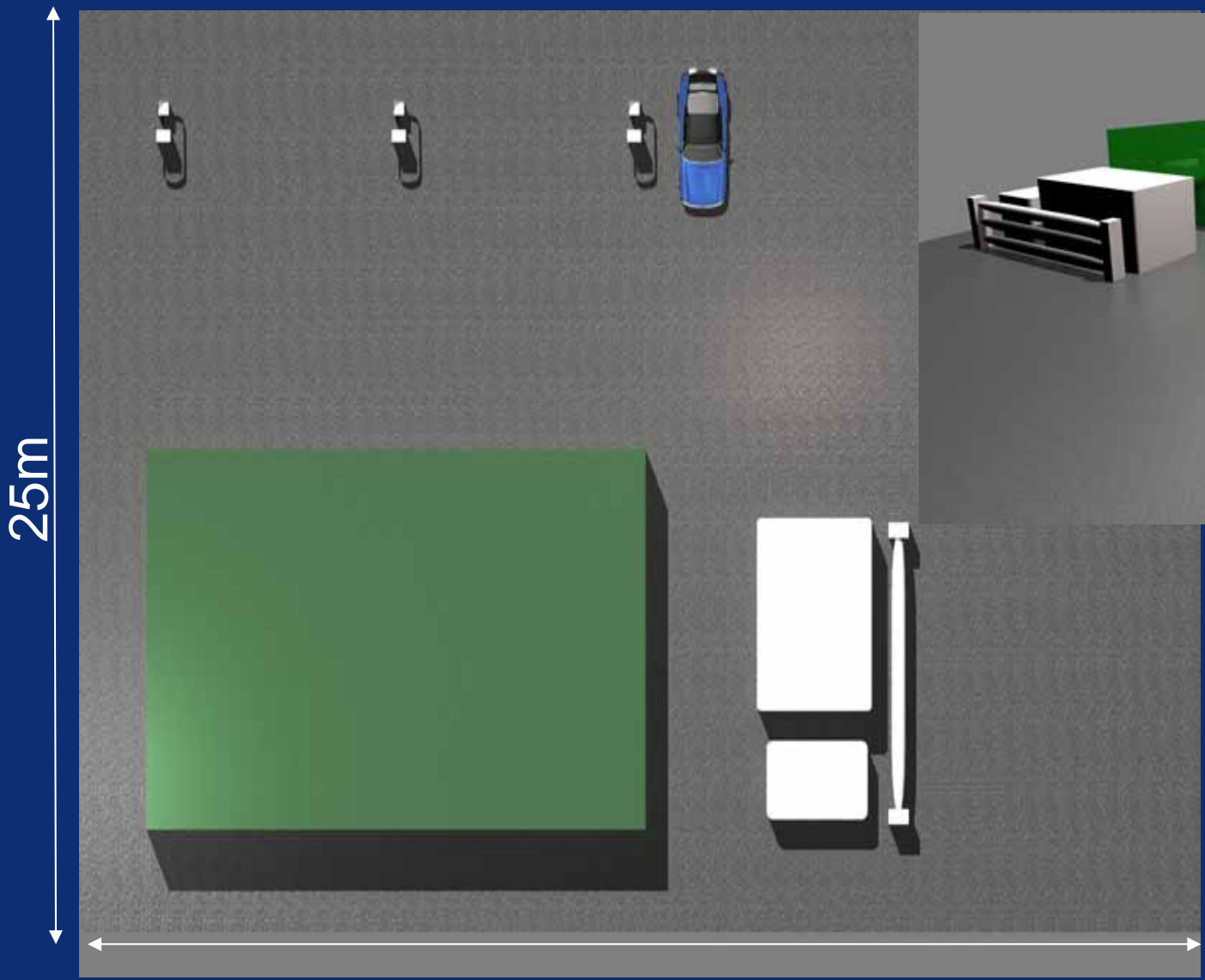


Air Products LA Basin Hydrogen Pipeline

- ~17 miles through urban area
- operate ~500 miles of H2 pipeline worldwide



Pipeline Forecourt Illustration-1500kg/d



Safe Accurate Fill Development

- **Nozzle**
- **Fueling protocol**
- **Comm. vs. Non-Comm.**
- **Purity**
- **Cooling**
- **Speed of fill**
- **Optimum Pressure**
- **Metering**
- **Hydrogen Detection**

Purity

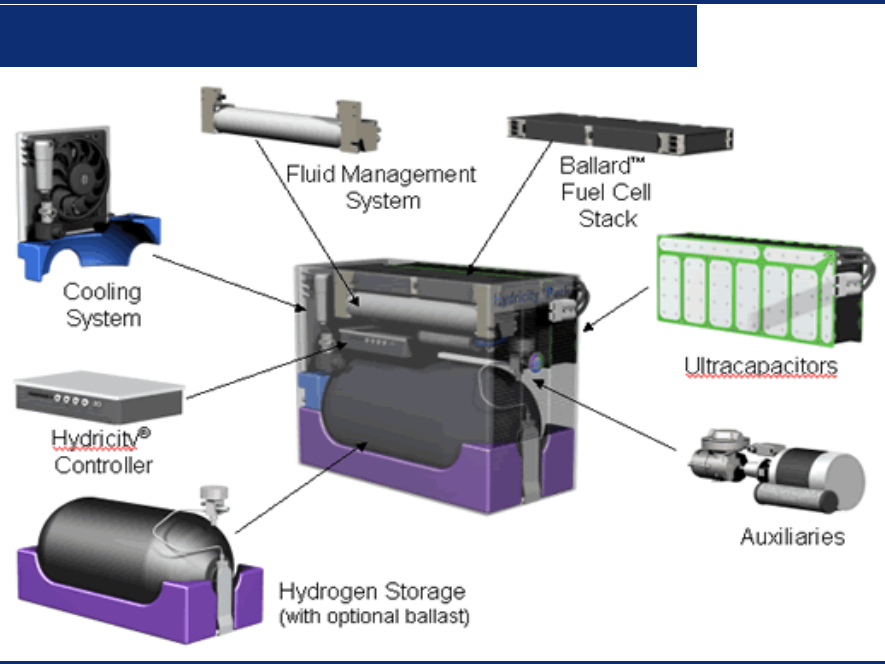
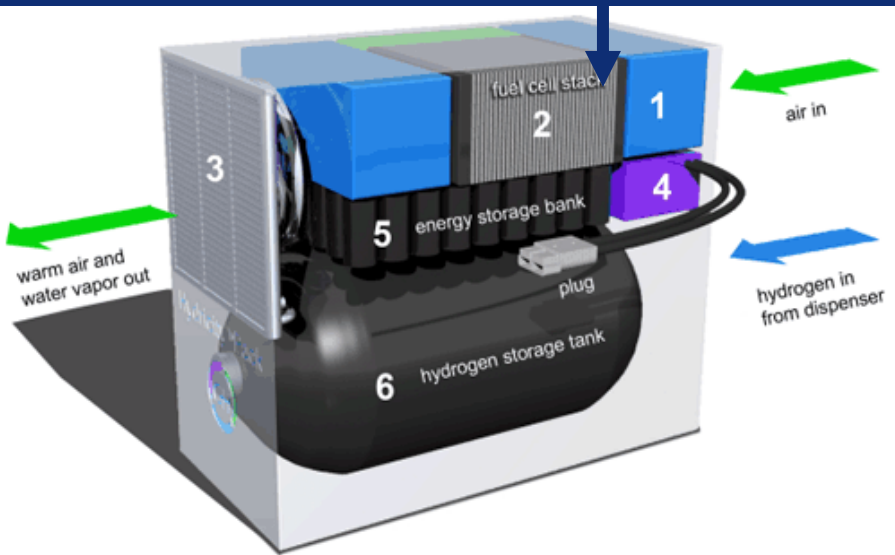
- **FC manufacturers continue to ask for higher purity gases**
- **Impurity levels now at ppb levels**
- **Liability for offspec product is an issue**
 - Pathways pre defined
 - Analysis is not accounted for
- **Significant driver towards cryogenic production methods**

Hydrogen Fueling Industry

- **Significant light duty vehicle deployments are forecast for 2015 and beyond**
- **Several markets have near term commercial potential**
 - Material handling market
 - Mass Transit
 - Back-up power generation

Fuel Cell Packs for Electric MHE

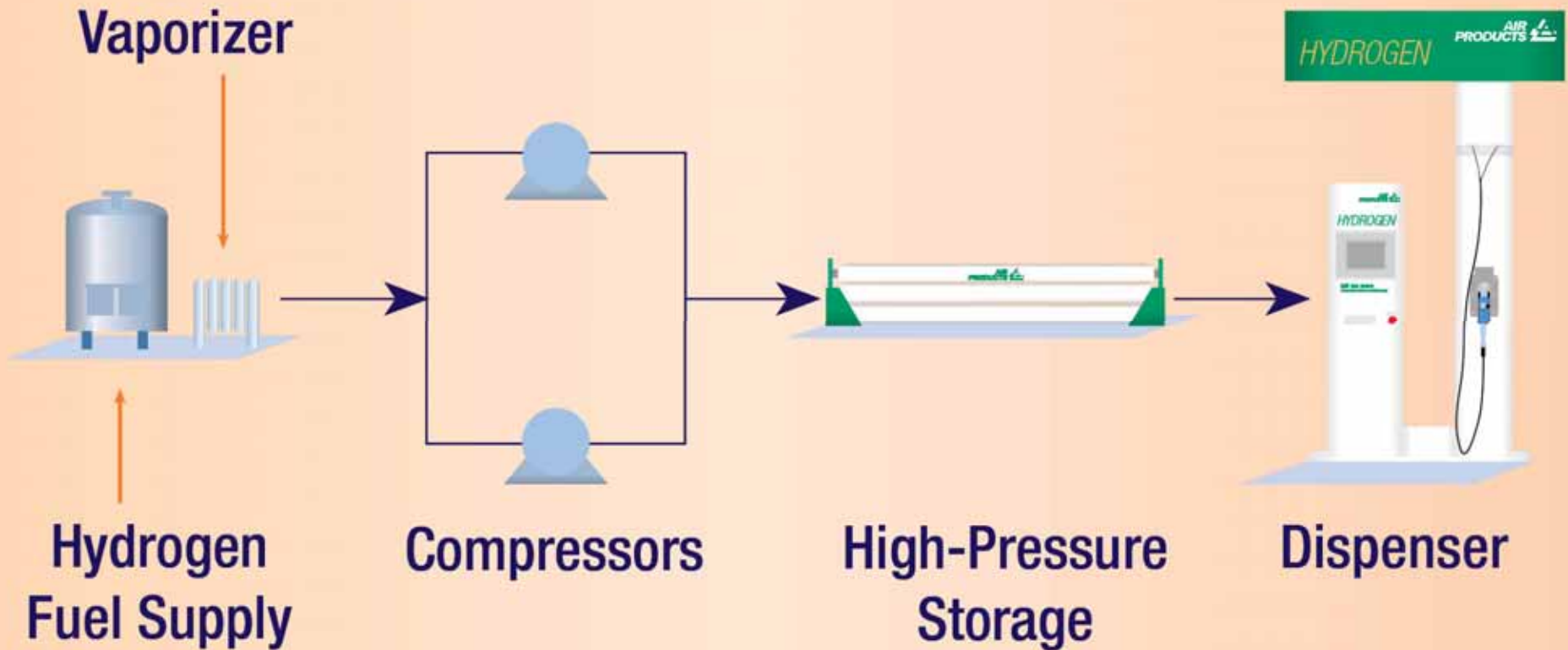
Form, Fit and Function Battery Replacement



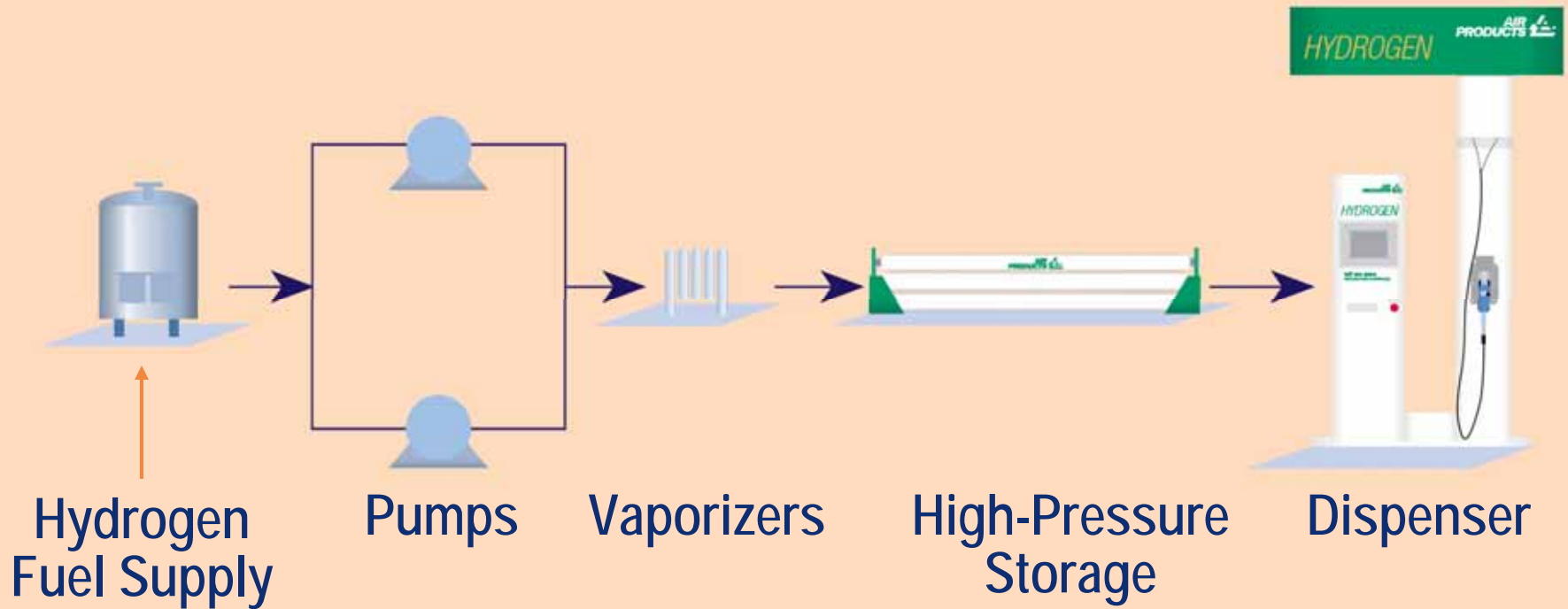
Courtesy of Ballard Power Systems






Fueling Infrastructure for MH market < 80 kg/day






Fueling Infrastructure for MH Market > 80 kg/day



AP's Product Offerings for MH Market

Product	Product Name	Typical Usage	Fueling Requirement (kg/day)
	Mobile Fueler	<ul style="list-style-type: none"> ● Demonstrations ● Fuel 2 to 5 units ● Outdoor Fueling 	<p style="text-align: center;">< 12</p>
	Series 100	<ul style="list-style-type: none"> ● Technology Assessment ● Fuel 4 to 10 units ● Tube trailer supply ● Outdoor Fueling 	<p style="text-align: center;"><20</p>
	Series 150	<ul style="list-style-type: none"> ● Technology Assessment and Deployment ● Fuel 4 to 20 units ● Indoor or outdoor fueling ● Tube trailer or liquid supply 	<p style="text-align: center;"><40</p>

AP's Product Offerings for MH Market

Product	Product Name	Typical Usage	Fueling Requirement (kg/day)
	CHC 7000	<ul style="list-style-type: none"> ● Full deployment ● Fuel >30 units ● Indoor Fueling 	<p style="text-align: center;">> 100</p>
	Indoor Stand Alone Dispenser	<ul style="list-style-type: none"> ● Technology Assessment and deployment ● Fuel 4 to 100 units ● Tube trailer or liquid supply 	<p style="text-align: center;">10 to 200+ kg/day</p>
	Indoor Wall Mounted Dispenser	<ul style="list-style-type: none"> ● Technology Assessment and Deployment (6 months +) ● Fuel 4 to 100 units ● Tube trailer or liquid supply 	<p style="text-align: center;">10 to 200+ kg/day</p>

MH Customer Activities



MH Customer Activities



Mass Transit Opportunities

- **Bus fleets around the world are striving to reduce emissions**
- **Various technologies are being evaluated, including:**
 - “Clean Diesel”
 - Fuel Cells
 - CNG
 - HCNG
 - HICE
- **Bus fleets are convenient from an infrastructure standpoint, as all buses fuel at the same location.**
 - One fueling station required. Significant throughput possible

Mass Transit Applications

- Pure Hydrogen
- Hydrogen / CNG blends



Hydrogen Bus Alliance



The Alliance includes the public transit agencies from:

- Amsterdam (GVB)
- Barcelona (TMB)
- Berlin (BVG)
- British Columbia (BC Transit)
- Cologne (Regionalverkehr Köln)
- Hamburg (Hamburger Hochbahn)
- London (Transport for London)
- Madrid (EMT)
- South Tyrol
- Western Australia – (Public Transport Authority of Western Australia)

Goal

To achieve bus commercialisation by 2015
by developing routes to hydrogen bus lower prices

TfL Bus Supply



- Air Products awarded a couple of weeks ago
- Fuelling of 10 buses for 5 years in London
- LHY supply via a novel supply concept trailer

Introducing HYDRA

- Liquid hydrogen tanker with capability to deliver liquid or high pressure gas
- Distribution & cost benefits of transporting large quantities of hydrogen



Other opportunities

- Utilisation of Hydra to replenish other hydrogen fuelling stations
- Hydra enables **lower cost** infrastructure as less equipment needed on the ground

Air Products Series 100 Fuelling Station

- **Series 100 is optimised to meet the needs of small fleets/early adopters**
- **Low cost - simple to install, minimal utilities**
- **Compact, relocatable**
- **Integrated system, modular**
- **Easy to operate**
- **Quick – capable of fast fill**
- **Integral safety features**



Birmingham University

- March 2008 Launch of Hydrogen Fuelling station at University of Birmingham
- Funded by AWM as part of Energy Futures Program
- Air Products S100 Fuelling station, fuelling 5 hydrogen microcabs operating on campus



Loughborough University

- September 2008 Launch of Hydrogen Fuelling station at Loughborough University
- Funded by EMDA
- Air Products S100 Hydrogen Fuelling station, pictured filling the Envbike



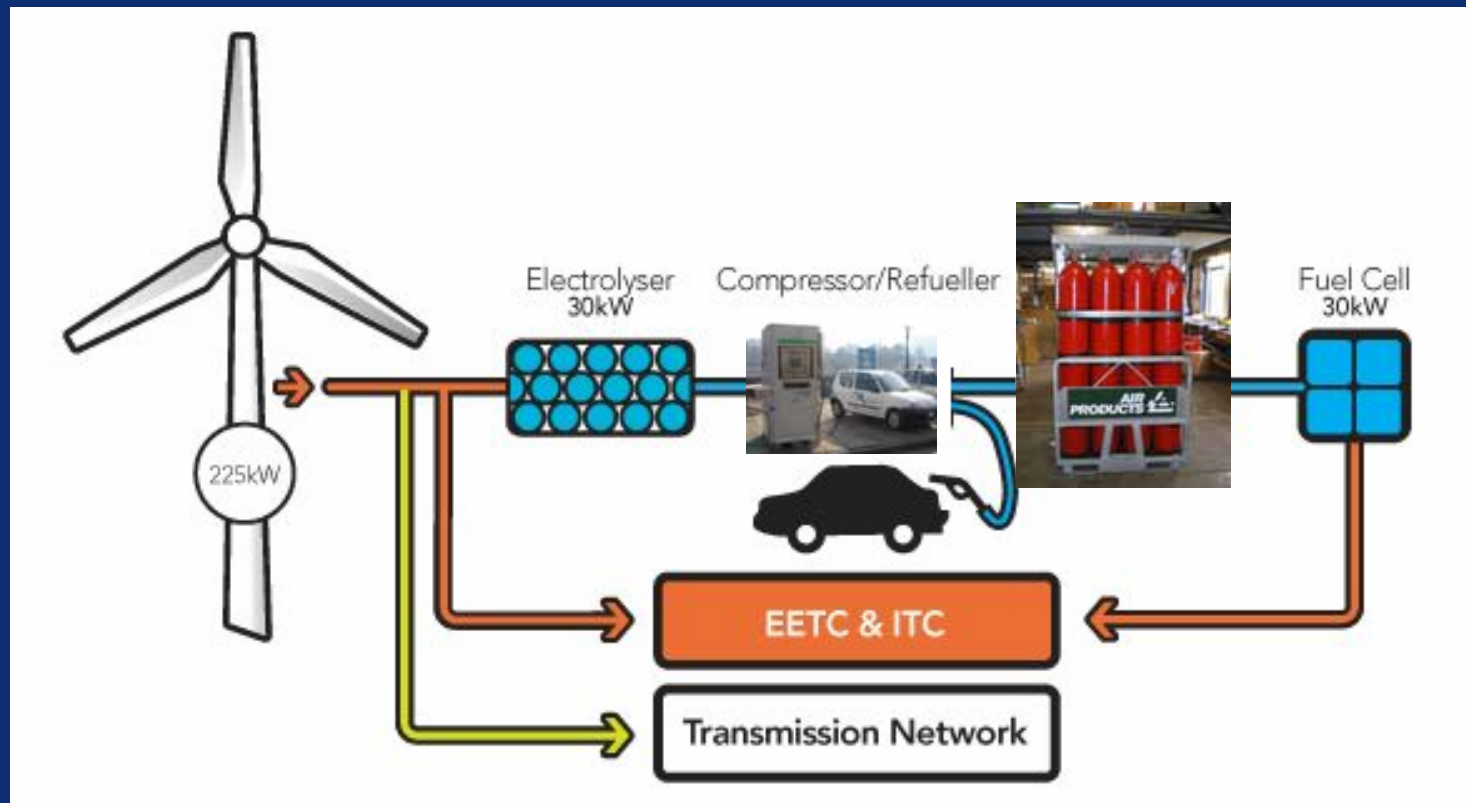
Hebridean Hydrogen Park Phase 2: Infrastructure - H2seed

- **May 2008 Announcement that AP will supply hydrogen fuelling station to CnEs – Western Isles Council**
- **Vehicle fuelling and cylinder filling capability**
- **System operational early 2008**



Hydrogen Mini Grid Rotherham

- October 2008 Announcement that AP will supply S100 hydrogen fuelling system + green hydrogen store for Hydrogen Mini Grid
- Funded by Yorkshire Forward as part of the Objective 1 investment programme
- Installation complete early 2008



Submarine Fuelling

- Fuelling large volume fast fuelling experience



BP – Next Energy, Detroit



BP - Beijing



Mobile Fueler, Los Angeles DWP



Sapio - Series 100 at 2006 Winter Olympics



Penn State – H2 and HCNG Fueling



Chevron Orlando, FL and Selfridge, MI – Under Construction



Proton, UNLV



Summary

- **Government policy and public acceptance will drive the fuelling station type we see in the future**
- **Initial niche applications will drive fuelling infrastructure before vehicles**
- **If an infrastructure route gains precedence it may preclude the development of an alternative despite lower energy considerations**
- **Distributed SMRs will reduce in cost to become cost competitive with centralised production but issues will remain**
- **Fuelling station storage will be governed not only by demand but also the need for fast fill, footprint, purity and reliability**
- **Existing industrial infrastructure holds the key to initial hydrogen economy roll out**

Tell me more !

www.airproducts.com/H2energy