HYDROGENICS

SHIFT **POWER** | **ENERGIZE** YOUR WORLD

Hydrogenics Marine Applications

Electrolysers and Fuel Cell Power Modules & Systems

2013-05

EC FCH JU Marine Fuel Cell Workshop
Porto Marghera, Italy

Hydrogenics in Brief:

- Designer and manufacturer of advanced Water Electrolysis Equipment, Fuel Cells and Systems
- Headquartered in Canada with European facilities in Germany and Belgium
- Incorporated in 1995 [NASDAQ: HYGS; TSX: HYG].
- Experience in Hydrogen generation since 1948
- More than 2000 products deployed in 100 countries worldwide
- Commercial product manufacture ISO 9001 audited

OPERATING SEGMENTS

OnSite Hydrogen Generation
PEM and Alkaline Electrolyzers

Power Systems
PEM Fuel Cells

TODAY'S MARKETS


Industrial Hydrogen


Energy Storage & Fueling


Stationary Power


Mobility Power

PRODUCT LINES


HySTAT™ S15


HySTAT™ D30


HySTAT™ Q60




HyPM™
HyPM™-R





HyPM™+Systems, HyPX™

MAJOR RELATIONSHIPS

Linde Gas
AIR LIQUIDE
Iwatani
Chevron
e·on
ENBRIDGE
COMMSCOPE®
ANDREW
GM
KION GROUP
DLR
PROTERRA
BAE SYSTEMS
ZEV
Linde
STILL
AIRBUS
CSA ASC

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45+ Fueling Stations Worldwide


Southfield, MI, USA


Toronto, ON, CA


Dunkirk, FR


Halle, BE


Amsterdam, NL


Minot, ND, USA


Oslo, NO


Richmond, CA, USA


Stockholm, SE


Oakland, CA, USA


Malmø, SE


Chino, CA, USA


Hamburg, DE


Santa Monica, CA, USA

Stuttgart, DE

Hydrogenics Headquarters: Toronto, Canada
Hydrogenics Offices
Hydrogenics Installed Fuelling and Power Systems
Hydrogenics Installed Industrial Systems


Torrance, CA, USA


Los Angeles, CA, USA


São Paulo, BR


Barcelona, ES


Brugg, CH


Istanbul, Turkey

Haliç (Golden Horn), Istanbul, Turkey

65kg/day, 220/350bar dispensing

Located at historic site of the Golden Horn at the Bosphorus, the station can refuel boats at 220bar and vehicles at 350bar. The station has a 30Nm³/h electrolyser, 135kg storage and a -20°chiller to meet the customer's SAEJ 2601 refueling sequence.

Hamburg, Germany

780kg/day
350/700 bar dispensing

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Fuel Cell Value Chain "2.0":

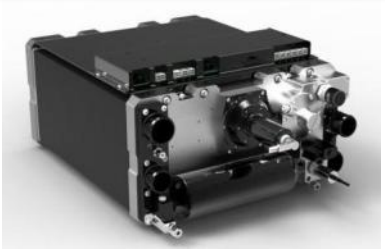
Integrators, OEMs

OEMs, Fleet Owners

PEM Single Cell

Single cell
Proton Exchange Membrane
- MEA - Membrane Electrolyte Assembly
- Bipolar plates
- Gas Diffusion layer
- Gaskets

Fuel Cell Power Module 2.0
Stack with integrated Balance of Plant



Stack with integral Balance of Plant

Multiple cells layered into a stack, including:
- End plates
- Tie rods
- Spring washers
- Bus bar interfaces
- Fuel cell voltage monitor

Stack and Balance Of Plant, includes:
- Fuel management
- Air management
- Water management
- Coolant pump and Control
- Control hardware and software

The Hybrid System

Hybrid forklift Power Pack

Hybrid Fuel Cell System on Transit Bus

Power Module with:
- Power conditioning
- Hybrid energy storage
- Hybrid control hardware and software
- Cooling rad or heat exchanger (or CHP)
- H_2 storage

Hydrogenics Marketed Products

Hydrogenics Core Competence

Hydrogenics HyPM™ Fuel Cell Power Modules

- *Advanced onboard controls and diagnostics*
- *Integral Balance of Plant*
- *Rapid start-up and dynamic response*
- *Liquid-cooled advanced-MEA PEM stack*
- *Complete with Cathode Air delivery unit*
- *-46°C sub-zero shutdown capability*
- *No water for humidification required*

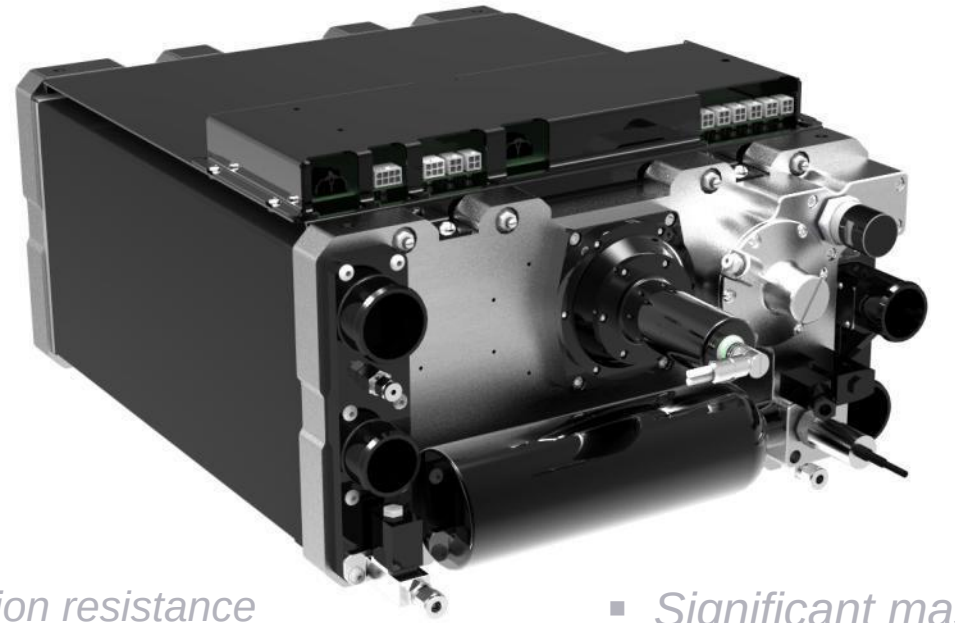
HyPM™ HD
Heavy Duty – High Durability

- *Unlimited start-stop cycling*
- *No nitrogen required for shutdown*

HyPM™ Next Generation Platform

- *Multi-function stack end plate (patent pending)*
  - *Integrated manifold*
  - *Integrated electronics and controls*
  - *Integrated wiring*

- *Reduced part count*
- *Eliminated piping and fittings*
- *Eliminated wiring harnesses*



HyPM HD30
(33 kW)

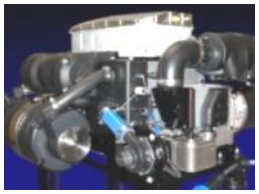
- *Enhanced vibration resistance*
- *Easier and faster part inspection and replacement*

- *Significant mass reduction*
- *Significant volume reduction*

Development History – Fuel Cell Power Module

Hydrogenics HyPM™ Power Modules (mobility)

Gen0.0 Gen1.0 Gen2.0



	2001	2002	2003	2009	2011
Stack Pressure	High	High	Low	Low	Low
Power	25 kW	25 kW	20 kW	16.5 kW	33 kW
System Mass **Power Density**	290 kg **86 W/kg**	200 kg **125 W/kg**	170 kg **117 W/kg**	92 kg **180 W/kg** >2x	65 kg **507 W/kg**
System Volume **Power Density**	365 L **68 W/L**	340 L **73 W/L**	180 L **111 W/L**	133 L **124 W/L** >2x	125 L **264 W/L**
System Efficiency	45…38%	45…38%	54…40%	**54…48%**	**55…48%**
Major Components	25	19	8	6	6
Onboard water	Required	Required	Not required. With Ca and An saturators.	**Not required** **No saturators**	**Not required** **No saturators**

Power density increase by 5.9x by mass and by 3.8x by volume in 10 years

2010 HyPM™ (Gen 1.6) Line-up

Stationary

Technical Data	Unit	XR 4	XR 8	XR 12	XRL 4	XRL 8	XRL 12
Continuous Power	kW	4.5	8.5	12.5	4.5	8.5	12.5

Mobility

Technical Data	Unit	HD 4-200	HD 8-200	HD 4	HD 8	HD 12	HD 16
Continuous Power	kW	4.5	8.5	4.5	8.5	12.5	16.5

All still available for ordering (2012)

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November 2012
The HyPM™ Gen 2.0 "*Next Gen*" G2 Line-up

Stationary






HyPM™		XR 2.5-200	XR 5	XR 8	XR 12	XRL 8	XRL 12
Continuous Power	[kW]	2.5	5.5	8.5	12.5	8.5	12.5

Mobility






HyPM™		HD 5	HD 8	HD 10-200	HD 12	HD 16	HD 30
Continuous Power	[kW]	5	8.5	10	12.5	16.5	33

Packages

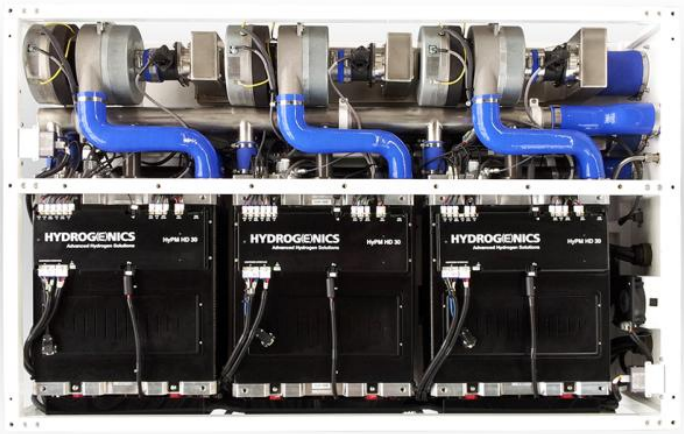

Coming Soon…

Future…

HyPM™		HD 90	HD 120	HD 150	HD 180		
Continuous Power	[kW]	99	132	165	198		

Hydrogenics‘ supply – the HyPM Series Power Module

HD 90 (99 kW) „Engine“- integrated package, single interface set



Hydrogenics Power Modules in Mobile Applications

HyPM™ in Boats – Supplied projects

VENEZIA TECNOLOGIE, VEGA, ENI, Venice, Italy

Pilot Vaporetto

12 kW FC Power

ZEBOTEC
Konstanz, Germany

Cobalt 233-ZET Sport Boat

24 kW FC Power

HORNBLOWER
Statue of Liberty Cruises, NYC

Compound Hybrid Passenger Ferry

32 kW FC Power

BELBIM
Istanbul, Turkey

Municipal Transit Passenger Ferry

48 kW FC power

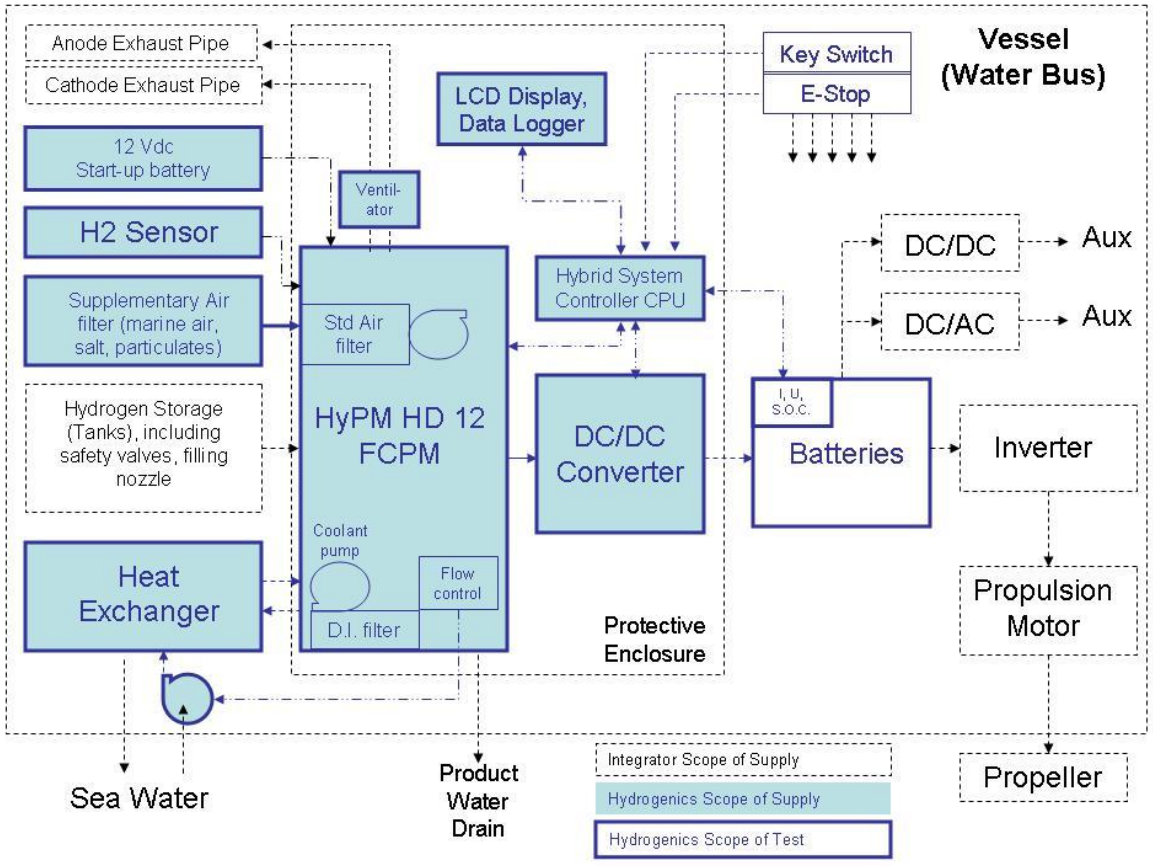
Yıldız Tech. University

Dokuz Eylul University

Istanbul Tech. University

Sakarya University

Venezia Tecnologie/VEGA Project (2005/2006)



HyPM™ HD 12
(12.5 kW peak Gross)

Selected and optimized for the ANTIUM Nautica s.r.l. ANTIUM 750

24 kW FC Speedboat Propulsion

- zebotec GmbH (Konstanz, Germany) in partnership with
- Brunnert-Grimm AG (Gottlieben, Switzerland)
- Cobalt 233 ZET Boat with Electric motor drive capacity of 50kW
- Originally energy entirely from onboard batteries
- display for the first time with fuel cells at the INTERBOOT Sept 2007 in Friedrichshafen
- Top speed of 40 km/h
- Operated like any “normal“ runabout
- goal of project was to show that an innovative product can get off the drawing board and spark the interest in a new future of boating

zebotec
ZERO EMISSION TECHNOLOGY

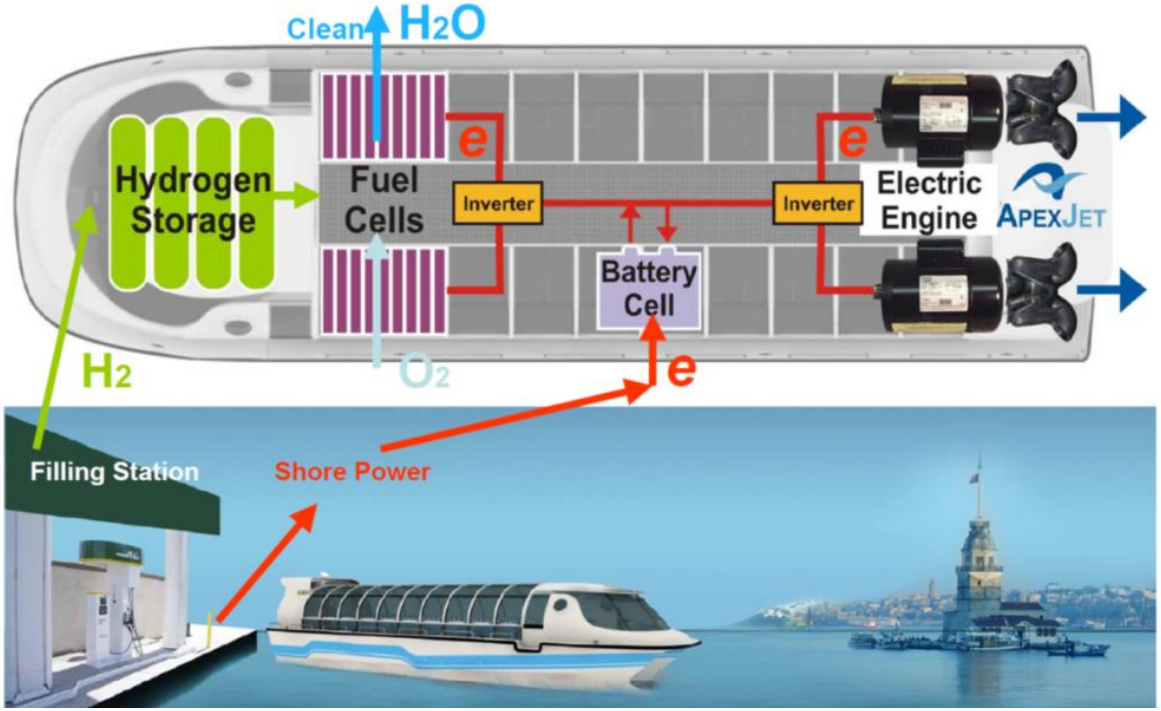
Istanbul Fuel Cell Passenger Ferry Project Partners

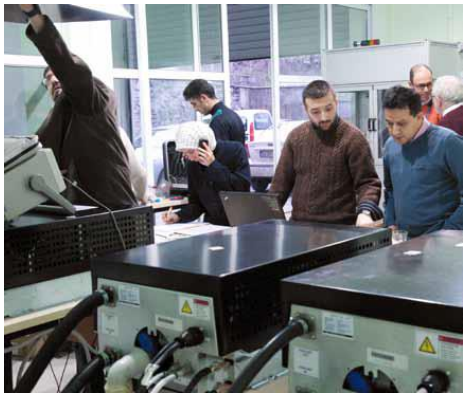
- BELBİM A.Ş. The Municipal Information & Electronic Systems Corporation
- İSTANBUL METROPOLITAN MUNICIPALITY (IBB)
- İDO A.Ş. İstanbul Fast Ferries Corporation
- İSTANBUL ENERJİ A.Ş. İstanbul Energy Corporation
- TUBİTAK – TÜSSİDE An Institute of Scientific & Tech. Research Council of Turkey

Istanbul H2 FC Ferry Bus Model

Istanbul H2 FC Ferry Architecture

4 x HyPM HD12





Lab test in Istanbul

UNIDO Water Taxi Project

- 6 kits supplied through UNIDO (Vienna)
- Coordination: ICHET, Istanbul
- 4 sets to Universities for FC Boat:s
  - Istanbul Technical University (**ITU**)
  - Yildiz Technical University (**YTU**)
  - Sakarya University
  - Dokuz Eylul University (DEU)
- Other 2 Kits:
  - Hybrid EV (minibus) (ITU)
  - Remaining with ICHET (spare)
- Supplied Kit:
  - HyPM HD 8-500, Dynetek H2 Tanks (200 bar), DC-DC, controller

ITU

YTU

Sakarya

DEU

Hornblower's Statue Cruises

- Compound Hybrid 600 passenger ferry
- Diesel, Wind, Solar, Battery, H_2 Fuel Cell (32 kW)

2 x HyPM HD16

sightseeing, dinner and special event cruises.

What is holding H2 PEM FC back in the marine surface vessel sectors?

- …Not technology !!!
  - PEM-FC functionally proven in 100's of land and air applications
  - FC Submarine programs are commercial and sustainable
  - Marine Proven: LT-PEM suitable for < 10^1 kW, < 10^2 kW, < 10^3 kW
  - Several marine sectors are not cost-sensitive (superyacht)

- Still, marine surface vessel market has much slower growth than other H2 FC application sectors

Marine Classification Challenges

- Classified Zones
  - Welding of all tube-fittings
  - Ex d (explosion proof by containment) components ($$$)
- Can Safety be assured as in FC road vehicles?
  - No Ex-Zone when handled innovatively
  - Safety through adequate ventilation
  - Avoid Nitrogen purge
  - H2 sensors unnecessary
- Example Optimized Certification Guidelines:
  - TÜV-Rheinland for FC Buses
  - UL for indoor stationary FCs

Hamburg Harbour & Logistics demos (2006-2007)

STILL R60-25
2.5 metric tonnes

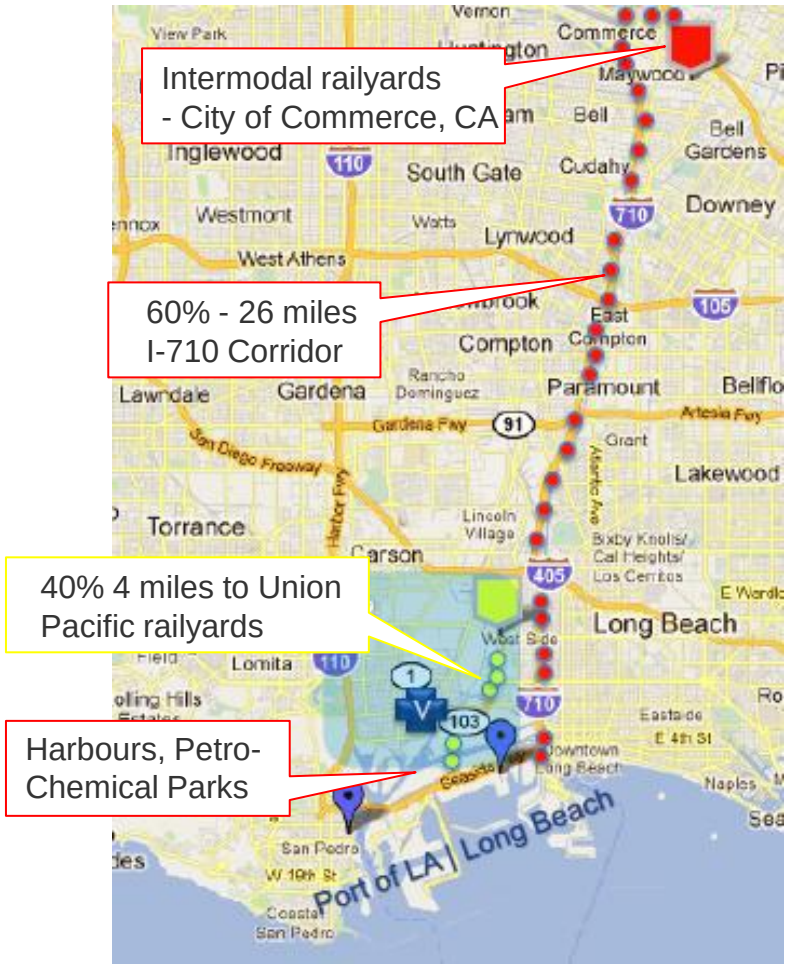
STILL RX60-45
4.5 metric tonnes

HyPX™ 1-855

Demo site: Hamburg Hafen & Logistik AG

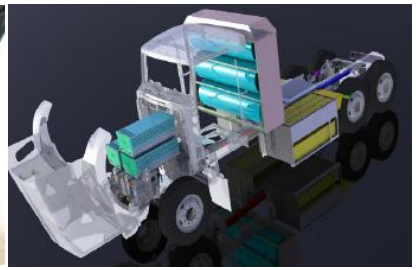
LA/Long Beach Ports

- 16,00 Truck trips per day
- H2 FC Truck comparable price to Diesel Truck with California State incentives (Clean Trucks Program)
- Existing Hydrogen Pipeline for 8 neighboring Petro-Refineries and
- H2 Fuel cost less than Diesel Fuel Costs
- Overall net savings verses Diesel could be possible



Range Extender for Short Haul Truck

Technical Data	
Vehicle	Freightliner „Tyrano“ Class 8
GCVWR*	80,000 lbs loaded w/ trailer
Fuel cell	33 kW (2 x 16.5 kW_{el})
Motor power	170 kW continuous 288 kW peak
Energy storage	Lithium Iron Phosphate batteries 73 kWh useable
Application	Zero emission range extension
Fuel	Hydrogen (99.99%) 20 to 40 kg (depending of configuration)
Testing and Demonstration	Ports of Los Angeles and Long Beach



VISION motor corp

Port of LONG BEACH The Green Port

THE PORT OF LOS ANGELES

TTSI

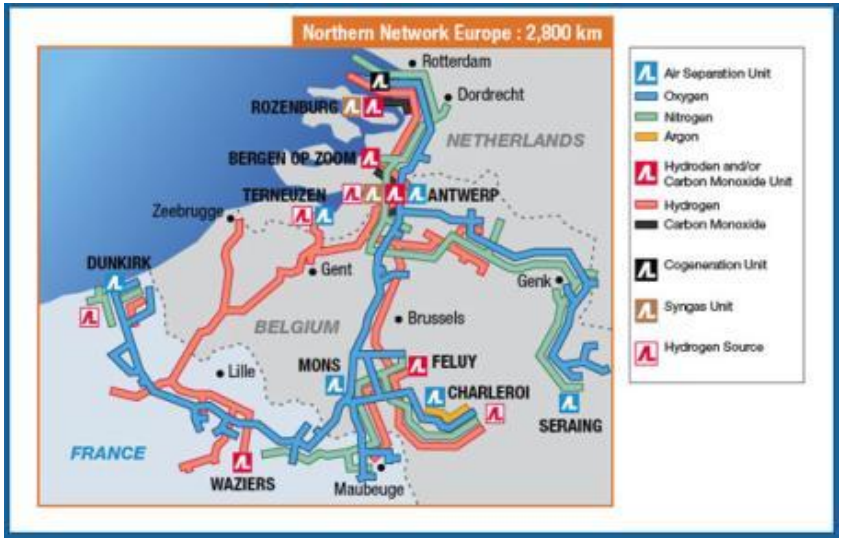
* Gross Combination Vehicle Weight Rating (including container trailer)

Houston-Galveston Port Drayage Trucks

- Demo Fleet: **20** Tyrano™ Class 8 Trucks
- Support: US Department of Energy (DOE)
- Location: Port of Houston Authority (PHA)
- Hydrogen source: local natural gas
- Project Partners:
  - Houston Galveston Area Council (HGAC)
  - Environmental Defense Fund (EDF)
  - Vision Industries Corp.,
  - Total Transportation Services Inc. (TTSI), and
  - Air Products
- Expected benefits:
  - Measure the operational cost effectiveness
  - Emissions reductions
  - Displacing diesel per
  - Assist region in achieving its national ambient air quality standards (NAAQS)

Hydrogen Pipelines near Shipping Ports

- Harbours/Ports will come first in line
- Fueling Stations must come first
- Early targets Ports with pipelines, nearby Hydrogen Industry
- Key for H2 from pipelines is filtration of S, CO, VOC and HC's.



What is holding H2 PEM FC back in the marine surface vessel sectors?

- Commercialization is happening first with land/road vehicles, where certification is more established and much simpler

- Bad news:
  - Integrators have an unattractive market
  - Without the demand “pull”, Fuel Cell Manufacturers are not tailoring their systems for marine sector requirements in the near term.

- Good news:
  - Commercialization is happening in ports, where hydrogen is readily and economically available

- However: the marine sector cannot wait – development takes time - standing still means future unpreparedness


We're Ready.