



## FUEL CELLS AND HYDROGEN JOINT UNDERTAKING



# HYDROGENICS

SHIFT POWER | ENERGIZE YOUR WORLD

HARNESSING RENEWABLE ENERGY STORAGE  
AND POWERING HEAVY MOBILITY



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Business Development Manager  
Hydrogenics GmbH

FCH 2 JU  
HYDROGEN MARITIME WORKSHOP  
Valencia, 2017-06-15

# Shifting Power Across Industries Around the World



Our raw materials,  
water & renewable power are

infinite!

2,000+  
fuel cell sites

## HYDROG(E)NICS

Publicly  
traded

NASDAQ (HYGS) and  
TSX (HYG) since 1995

65+  
years  
of experience

> 55 H2  
Fueling  
Stations with  
Hydrogenics  
electrolysers  
worldwide

> \$50 M USD  
multi-year  
fuel cell  
contract with  
leading rail  
OEM

> \$90M USD  
multi-year  
fuel cell  
contract with  
hi-tech  
mobility OEM

1 single focus:  
hydrogen solutions

> \$100 M USD  
order  
backlog  
(YE 2016)

500+  
electrolysis plants  
in operation

Global leader

in 2 main hydrogen technologies:  
electrolysis and fuel cells

1,500+  
electrolysis plants  
sold since 1948

Leading PEM  
Stack &  
System  
Technology  
Innovator

# Our Principal Product Lines

## HyPM™ and CELERITY™ PEM Fuel Cell Power Modules and Systems for Mobility

- World leading feature list, innovation and product line maturity
- Variants customized to any requirements



## HyPM™ Fuel Cell Power Modules and HyPM™-R FC Racks Systems for Critical Power

- World leading feature list, innovation and product line maturity
- Unlimited scalability



## HySTAT™ Alkaline Electrolyzer Plants for Industrial, Hydrogen, Energy Storage and Fueling

- World leading market share
- The industrial standard



## HyLYZER™ PEM Electrolyzer Plants for Energy Storage and Fueling

- 3 MW in a single stack
- World leading power density
- Scalable to 50 MW, 100 MW



# Established Leader, Established Technology

## Alstom, Germany

- World's first commercial contract for hydrogen fuel cell trains
- 10-year agreement, contract value > €50M



ALSTOM

## Kolon, S. Korea

- Providing > 1 MW power using excess hydrogen
- 50% LHV electrical efficiency



KOLON

## Uniper (e-on), Germany

- MW-scale Power to Gas facilities in Germany
- Wind power and Hydrogenics' electrolysis equipment to transform water into hydrogen



## Fuel Cell Buses, China

- Certified Integration Partner Program
- Agreements with multiple strategic partners for thousands of fuel cell buses throughout China



亿华通  
Sinohytec



# Established Leader, Established Technology

## CEC Heavy Duty Fuel Cell Vehicle Projects, California

- New Flyer fuel cell bus and Freightliner fuel cell truck, with Hydrogenics' Celerity bundled with Siemens ELFA drive



## Palm Springs, California

- Supply CelerityPlus for (5) NewFlyer buses to SunLine Transit Agency
- 1.5 MW PEM Electrolyser Renewable Hydrogen Fueling Station (400 kg/d)
- Will be the largest Electrolyser HRS in North America



## ASKO, Trondheim, Norway

- Norway's largest grocery wholesaler
- Trucks of 27 tons
- Supplying **four (4) complete** HyPM™ HD90-based fuel cell power **systems including H2 storage, power electronics and controls**



## Blue-G New Energy Science and Technology Corporation, China

- **\$50M USD** contract for **1000 Fuel Cell Bus Power Modules**
- Delivery over next 2-3 years, plus additional revenues expected over 10 years





# Hydrogenics Production & Service Centers



**Mississauga, Ontario, Canada**  
PEM Technologies R&D and Production

**Gladbeck, NRW, Germany**  
PEM Technologies Integration & Support

**Oevel, Flanders, Belgium**  
Alkaline Tech. R&D and Production



*Saint Gobain, Colombia*



*Elemash, Russia*



*Bushan, India*

# Onsite Hydrogen Generation - Industrial



*Camao, Brazil*



*Nyagan, Russia*



*Kirovgrad, Russia*





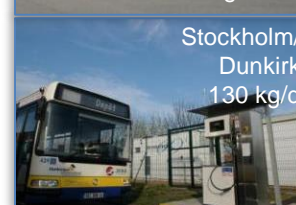
# Renewable Hydrogen & Energy Storage





# Hydrogen Fueling for European FC Bus Fleets

11 of 13 electrolyzer FC Bus fueling stations with HySTAT by Hydrogenics



CUTE	HYFLEET	CHIC	HiVLOCity	HyTransit
 <u>Reykjavik</u> -- --> <u>Reykjavik</u> <u>Amsterdam</u> -- --> <u>Amsterdam</u> <u>Porto</u> <u>Barcelona</u> -- --> <u>Barcelona</u> <u>Hamburg</u> -- --> <u>Hamburg</u> <u>Stockholm</u>	 <u>Reykjavik</u> <u>Amsterdam</u> <u>Barcelona</u> <u>Hamburg</u>	 <u>Bolzano</u> <u>Aargau</u> <u>Hamburg</u> <u>Oslo</u>	 <u>Aberdeen</u> <u>San Remo*</u> <u>* delivered</u>	 <u>Aberdeen 2</u>

2001

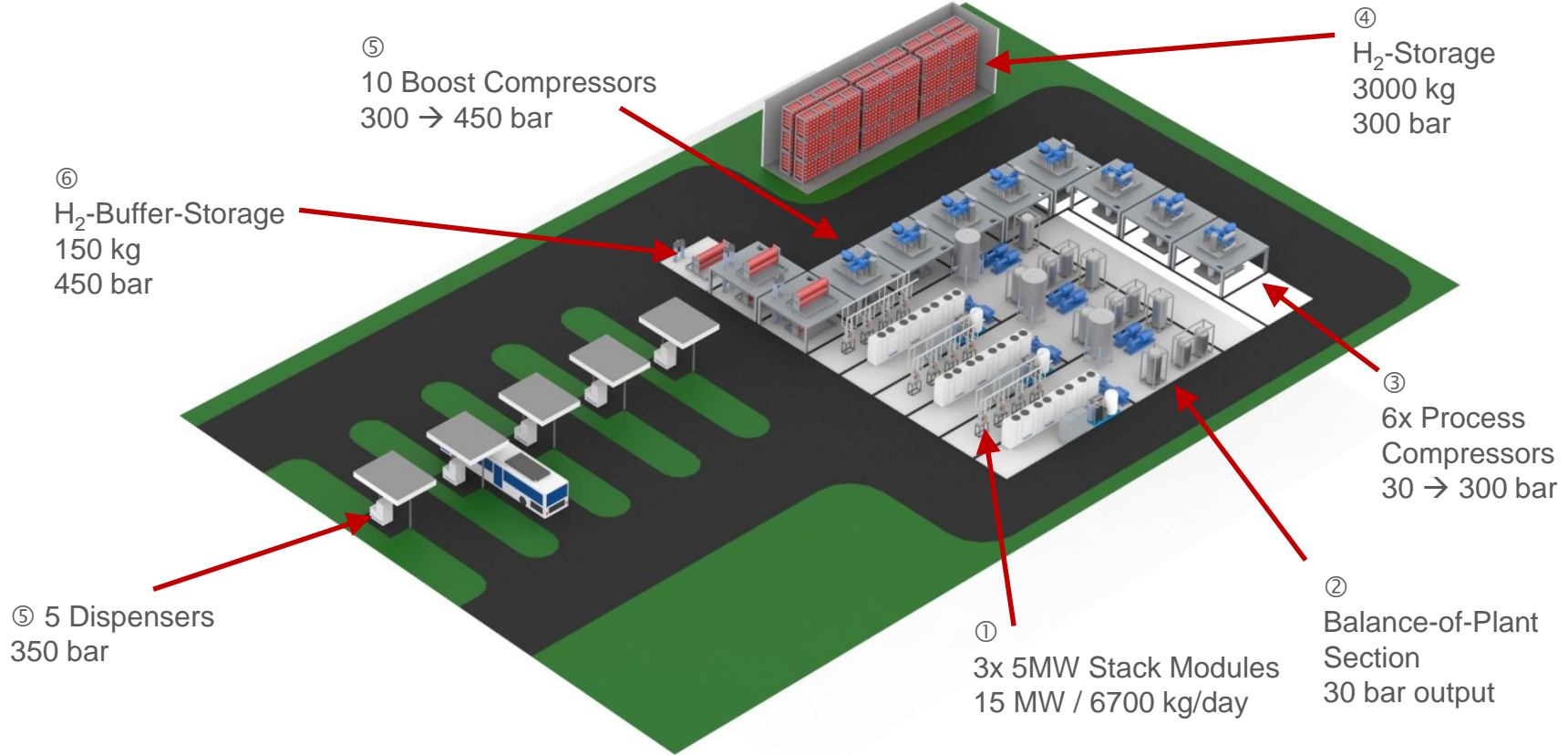
2017

# Electrolyzer Hydrogen Refueling Station

15 MW = 3 100 Nm<sup>3</sup>/h = **280 kg/h**  
**= 6 700 kg/24h**  
= 300 FC Buses/day  
= 30...45 FC Trains/day



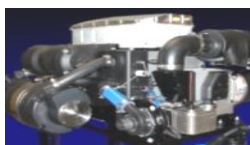
# PEM Electrolysis HRS – Capacity for 300 Buses or > 30 Trains







# FC Development History – Hydrogenics Gen2.0 HyPM™ Power Module

Hydrogenics  
HyPM Power  
Modules (mobility)



Gen2.0

	2001	2002	2003	2009	2011
<b>Stack Pressure</b>	High	High	Low	Low	Low
<b>Power</b>	25 kW	25 kW	20 kW	16.5 kW	33 kW
<b>System Mass</b>	290 kg	200 kg	170 kg	92 kg	75 kg
<b>Power Density</b>	<b>86 W/kg</b>	<b>125 W/kg</b>	<b>117 W/kg</b>	<b>180 W/kg</b> 	<b>440 W/kg</b>
<b>System Volume</b>	365 L	340 L	180 L	133 L	125 L
<b>Power Density</b>	<b>68 W/L</b>	<b>73 W/L</b>	<b>111 W/L</b>	<b>124 W/L</b> 	<b>264 W/L</b>
<b>System Efficiency</b>	45...38%	45...38%	54...40%	<b>54...48%</b>	<b>55...48%</b>
<b>Major Components</b>	25	19	8	6	6
<b>Onboard water</b>	Required	Required	Not required. With Ca and An saturators.	<b>Not required</b> <b>No saturators</b>	<b>Not required</b> <b>No saturators</b>

# Product Options for Heavy Duty Vehicles



5-30 kW

- PEM FC Power Module
- Freeze-protected
- Integral Balance of Plant
- Ease of Integration



60 kW

- „CELERITY“ designed for connection with Siemens ELFA electric drive
- Full feature set, including Pre-charge, Load contactor, Reverse current protection, IP rated enclosure



90, 120, 150+ kW

- Multiple HD30 FC modules plus:
- Frame and enclosure
- Manifolding
- Single interface set
- 120/150/180/240kW+ variants

# HyPM™ in Urban Transit Applications





# Alstom: Zero-emission hydrogen fuel cell regional trains



- ~ 40% of rail network in Germany is not electrified (operated with diesel)
- Too expensive to electrify all routes
- Increasingly stringent regulations (exhaust emission, noise)
- Expected price increase for diesel
- LOI from 4 German States zero emission passenger trains signed in 2014
- 1<sup>st</sup> integration unveiled at the Innotrans 2016 in Berlin

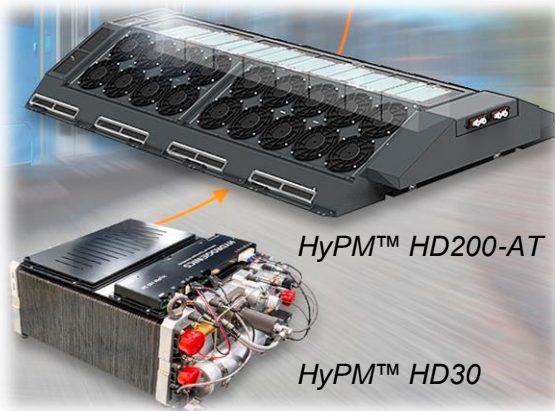


# Design and Testing Schedule

- 2015/2016 - Prototype bench testing in France
- 2016 - Fuel cells for first 2 trains tested and delivered
- 2017 - Integration into the first trains
- 2017 March 14 - First operation on the test track
- 2017 - Validation in Germany and Czech Republic
- 2017 – Certification by the EBA
- 2018 - First operation with passengers
- 2019/2020 – delivery to operators in the 4 States



Fuel cell  
production and  
testing for  
Alstom's Coradia  
iLint





# Hydrogenics in Maritime Applications





# 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
- Unveiled at the INTERBOOT Sept 2007
- Top speed of 40 km/h



zebotec   
ZERO EMISSION TECHNOLOGY



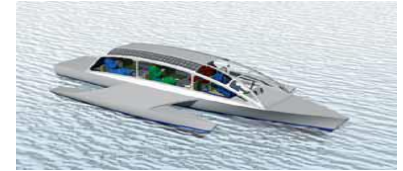
# UNIDO-ICHET Water Taxi Project



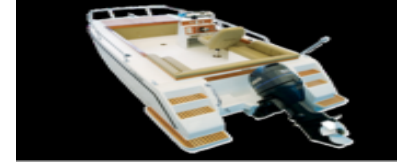
- 6 FC System Kits supplied through UNIDO (Vienna)
- Coordination: ICHET, Istanbul (International Center for Hydrogen Energy Technology)
- 4 sets to Universities for FC Boats
- Other 2 Kits:
  - Hybrid EV (minibus) (ITU)
  - Remaining with ICHET (spare)
- Supplied Kit:
  - HyPM™ HD 8-500
  - Dynetek H2 Tanks (200 bar)
  - DC-DC and controller



Istanbul Technical University



Yildiz Technical University



Sakarya University



Dokuz Eylul University



# Solo Racing Yacht Project



HyPM™ HD8 (8 kW)  
Delivered 2016  
Integration 2017/2018  
Circumnavigation race  
planned 2018



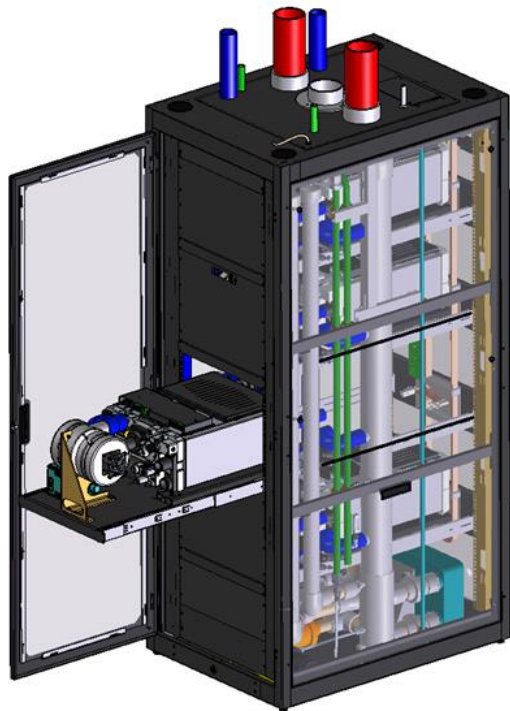
# HyPM™-R120

30 kW

30 kW

30 kW

30 kW



120 kW



240 kW

# HyPM™ 100 kW+ FC Rack Applications



Sandia National Labs Maritime Hydrogen Fuel Cell Project  
(Honolulu, Hawaii, USA)



Project “Don Quichote” at Colruyt Distribution Center  
(Halle, Belgium)



KOLON Water & Energy, HyPM™-R1000 (1 MW)  
(South Korea)



Energy Storage Project at the Glencore Mine (Raglan, Quebec)

# Sandia National Labs Maritime Hydrogen Fuel Cell Project



HyPM-R120 FC Rack

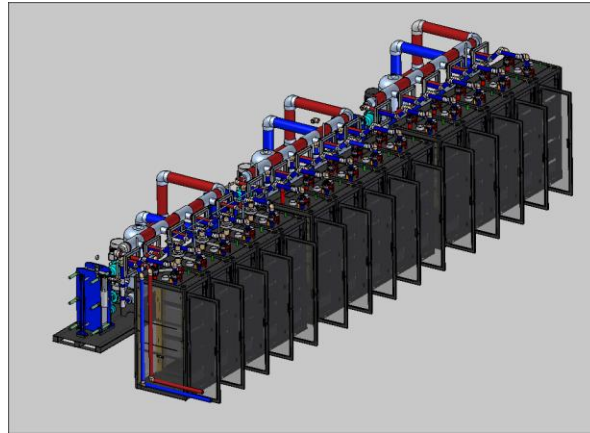
## • Port of Honolulu, Hawaii

- U.S. DOE's FC Office and the U.S. DOT's Maritime Administration funded six-month deployment
- FC Unit replaces diesel generators providing auxiliary power on board to ships at berth
- Four 30-kW fuel cells (Total 100 kWnet), power-conversion equipment (10 plugs) and H<sub>2</sub> storage
- 20 foot ISO container, 75 kg of on-board hydrogen storage, enough energy for 1000 continuous hours of operation

<http://www.hydrogenics.com/about-the-company/news-updates/2015/09/01/nothing-but-water-hydrogen-fuel-cell-unit-to-provide-renewable-power-to-honolulu-port>

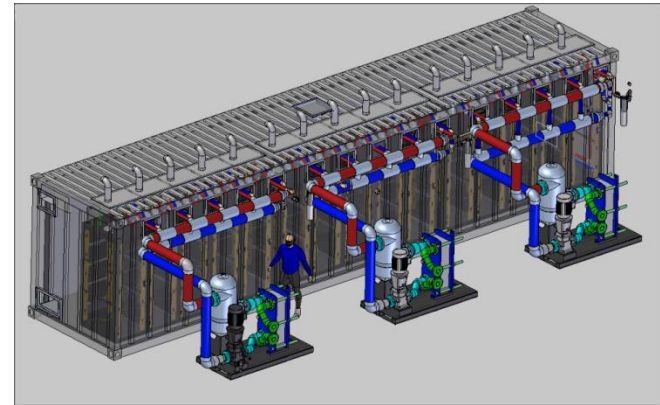
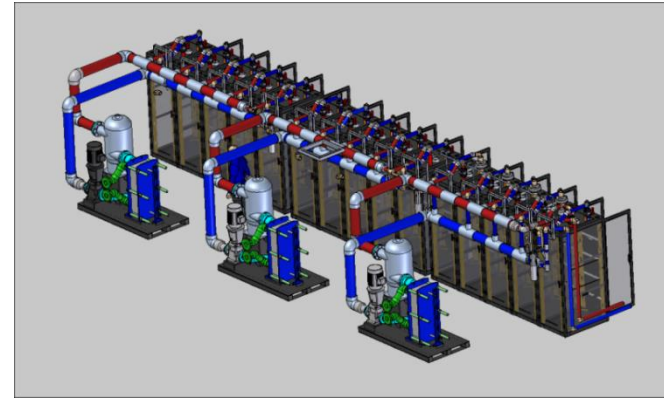


# 1.8 MW PEM Fuel Cell Plant - 40 foot ISO container



- 15x 120kW FC Racks
- 1.8 MW gross power\*

\* before power electronics, ventilation and secondary cooling loop



# 10 MW PEM Fuel Cell Plant including inverters



# Hydrogen is the Renewable Energy Enabler



Offgrid:  
Fixed fuel  
price for the  
operating life  
of the  
equipment!

**100% Fossil Fuel:**  
Imported energy  
Polluting emissions  
Fuel expense dictates cost

**Uncontrollable**

**100% Renewable:**  
Fully self-sufficient  
Zero-emissions  
CapEx defines cost

**Bankable**



