Pioneering fuel cell products and projects

UKHFCA, SW Environmental iNet

Bristol

20 May 2015

The drivers

- **Concern on Climate Change**
- **Levels of toxic pollution**
- **Ever increasing demand for energy**
- **Dependence on imported energy supply**
  - Price of oil & gas
- **Numerous governmental initiatives**
  - EU launched “post-industrial revolution” Jan 07
  - UK Climate Change Act 2008
    - Reduce carbon emissions by >80% by 2050
    - *BCC to reduce by 3% per year to 2020 (→40%)*
    - *London to reduce by 60% by 2025*

NOX and particulate targets needed

Targets don’t stop in 2020

Products for global market

- **Auriga Energy modular hydrogen fuel cell systems applications:**
  - Ferries/water taxis, canal boats
  - UPS/back-up power
  - Electric fork lifts
  - Others to come

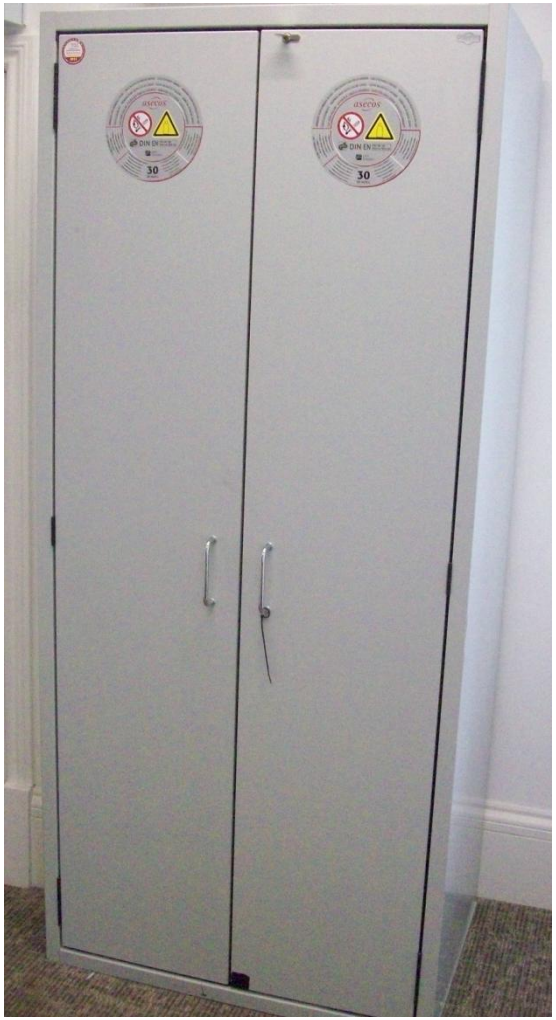
UPS/Backup Power

- **A single solution providing both UPS and backup generator**
- **Modular to allow growth**
- **Up to 10,000 hours operational time**
- **Operational runtime virtually unlimited**
  - Can be primary generator
- **Clean, quiet operation indoors or outside**
- **Remote monitoring capability**
- **Wide operational temperature tolerance -20ºC to 50ºC**
- **Low Through Life Cost**
- **Compliance to EMC standards EN620420-2 and safety standards EN62040-1**

Potential backup power applications

- **Battery UPS replacement**
  - for longer running times
- **Diesel generator replacement**
  - Reliable, clean, quiet, long run times
- **Support Comms, IT networks, Data Centres, Health Clinics**
  - “How long can your business survive without power”?
- **Operate safety critical valves, switches, pumps .....**

Glasgow city centre installation



Gas
Cabinet

Linnet Technology

AurigaGen
UPS

AURIGA energy

Linnet Technology

Award winning

- Select Electrotechnical Awards 2012: **Best New Product for UPS/backup power system**

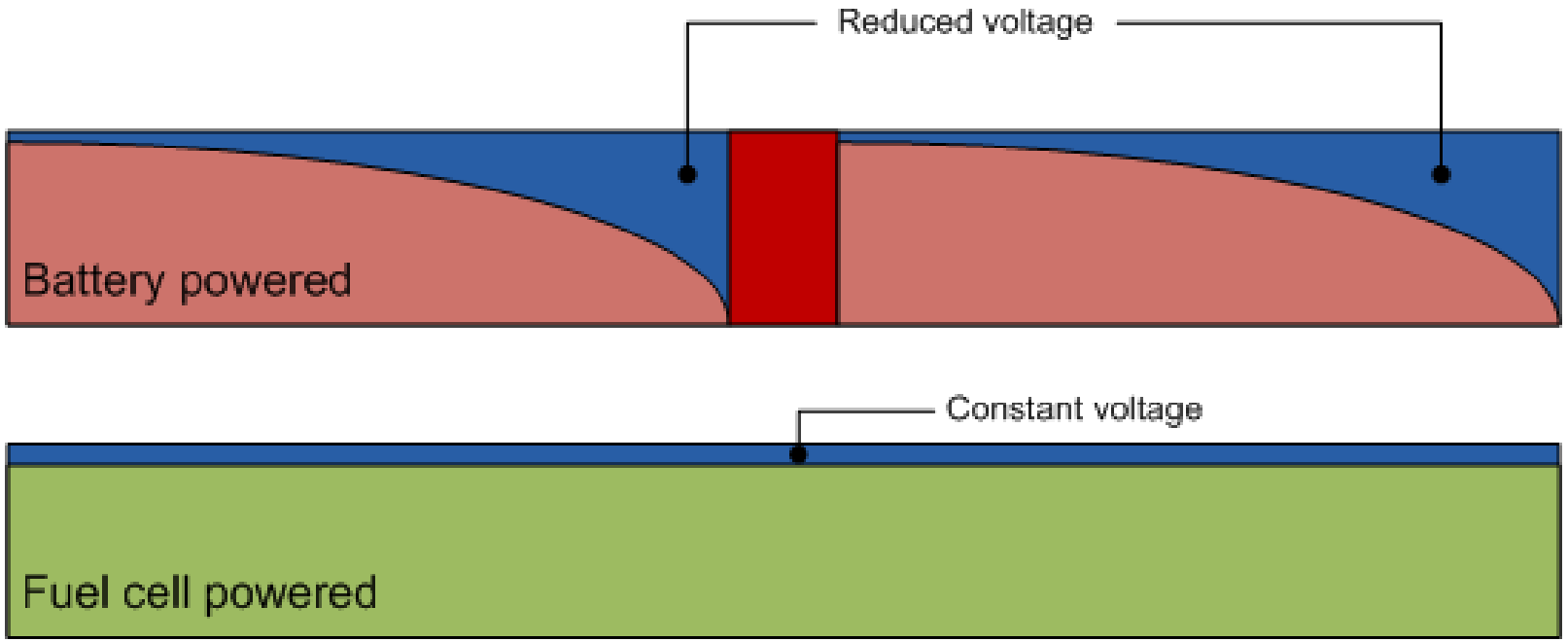
London city centre installation

Fuel Cells in Materials Handling

- **Increased lift truck operation time**
  - Eliminate need to maintain and change batteries
  - Quick refuelling vs. long battery charging
  - Extended runtime
- **Consistent power**
- **More productive warehouse floor space**
  - Eliminate need for battery room
  - Eliminate spare battery requirement
- **Environmental benefits**
  - Zero emissions
  - Eliminate need to handle, store, and dispose of lead & acid

Fuel Cell benefits

- **Elimination of battery droop**

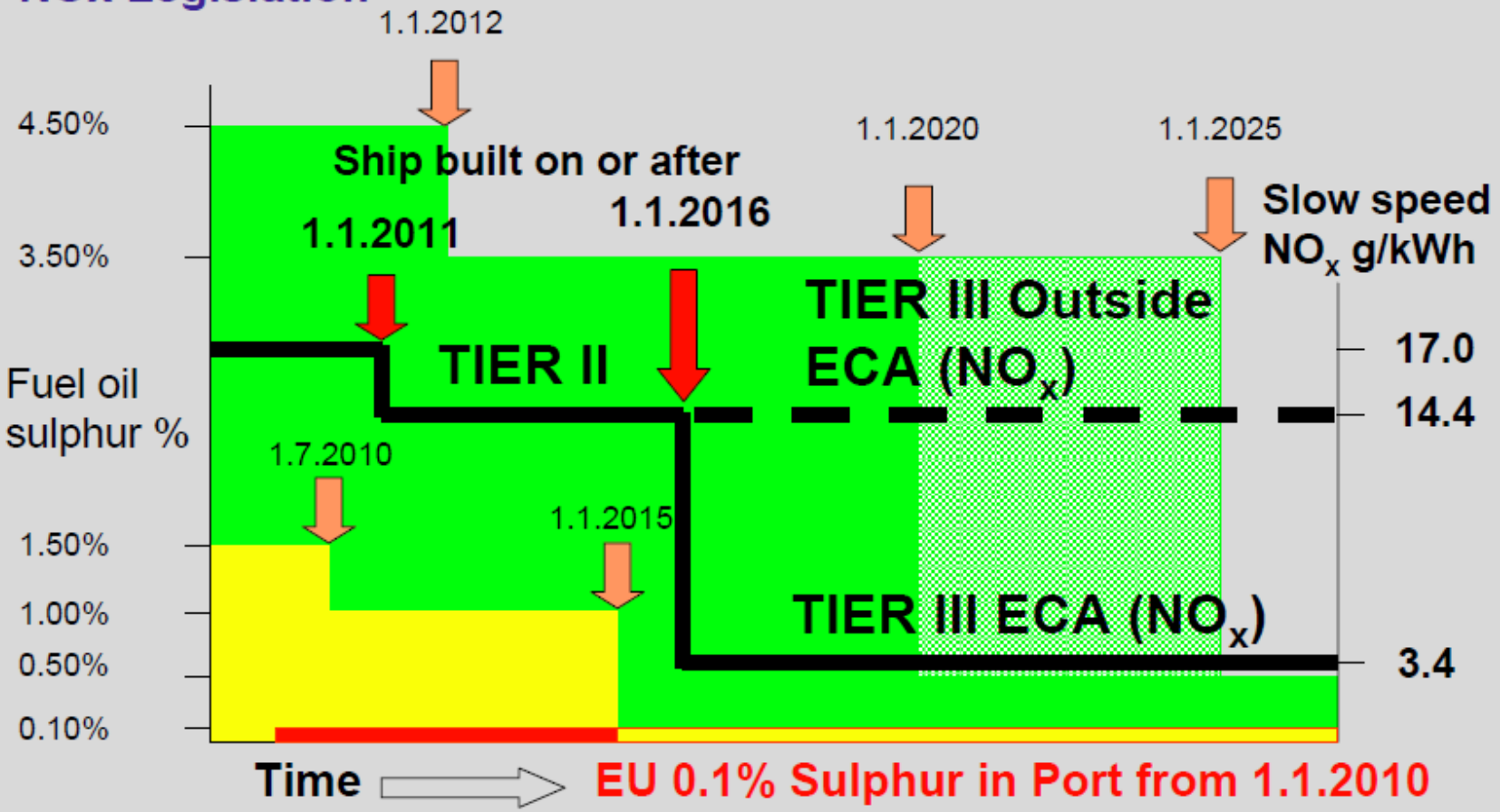


Innovative forklift fuel cell project

- **Progressing**

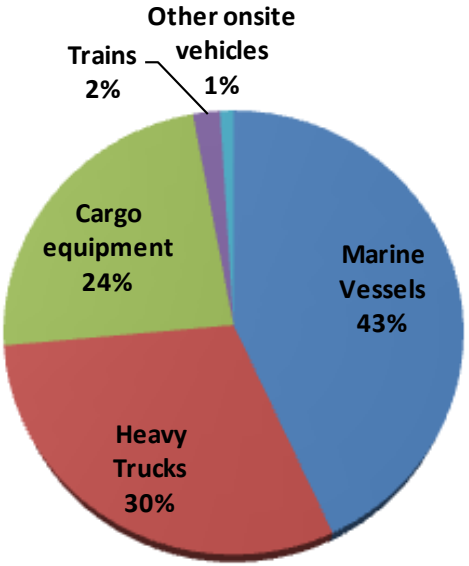
Exhaust Emissions NOx Legislation

MARPOL Annex VI SOx Certification

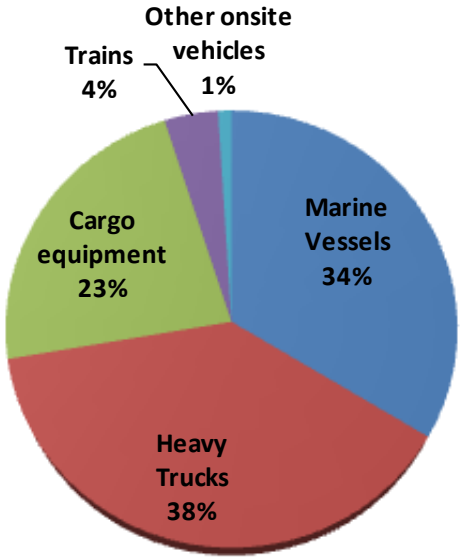


MARINE SERVICES
LLOYD'S REGISTER

Port & waterway pollution



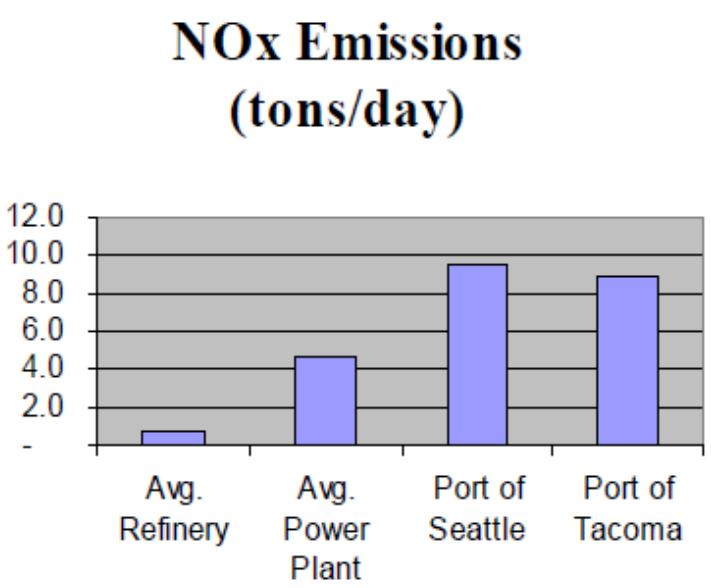
Particulate Emissions

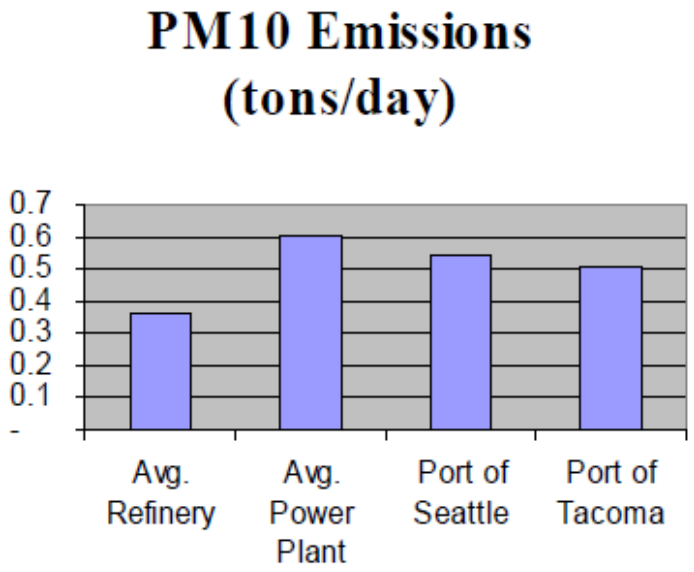


NOx Emissions

Source: NRDC

Port & waterway pollution





- **The 10 largest US container ports pollute the same as:**
  - 3.2 million cars worth of NOx
  - 8.1 million cars worth of PM_{10}
  - 18.5 million cars worth of SOx
  - 182 thousand cars worth of VOC
  - 80 thousand cars worth of CO

Source: NRDC

Bristol Hydrogen Ferry

- **Demonstrate the viability of hydrogen fuel cell technologies in ferry operations**
- **Help quantify potential CO_2 reductions**
- **De-risk the installation and operation of fuelling infrastructure**
- **Resolve certification and insurance issues**
- **Inform and educate the public**
- **Evaluate the commercial case for hydrogen ferry operations**

BRISTOL HYDROGEN BOATS

A strong team

- **Consortium of Auriga Energy, Bristol Packet Boat Trips and No 7 Boat Trips**
- **Air Products supply the hydrogen and refueller**

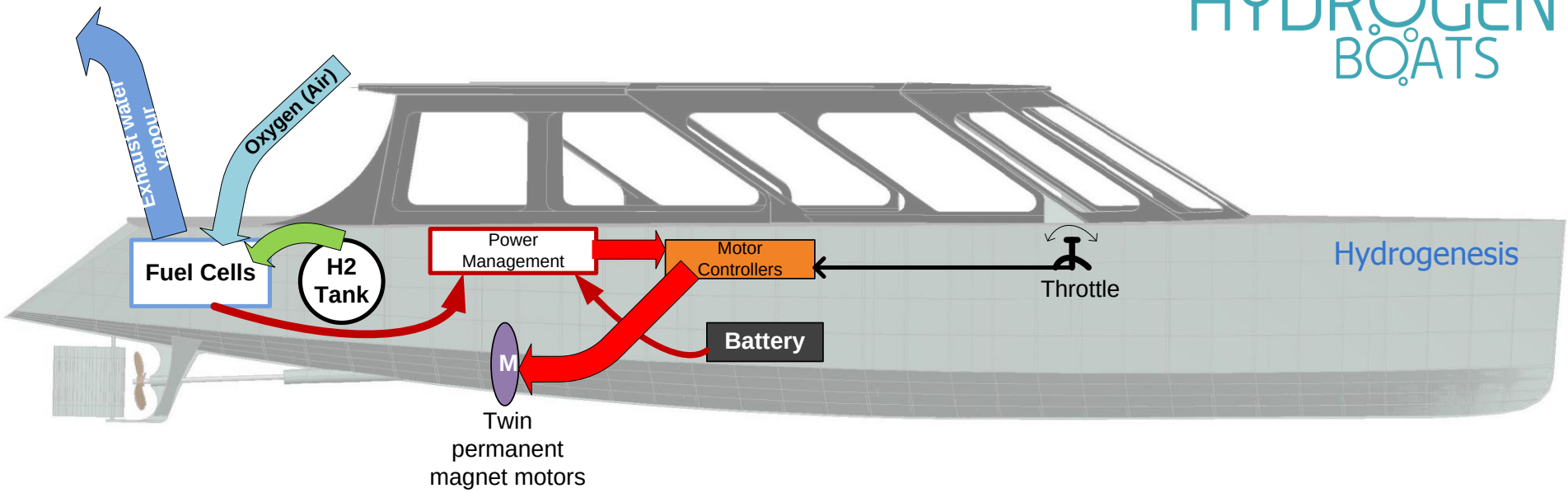
AIR PRODUCTS

Bristol hydrogen ferry

- **11m x 3.6m steel hull construction**
- **Glass panel top - partially retractable**
- **Sized for 12 passengers + 2 crew**
  - To allow MCA approval
- **12kW power via permanent magnet motors**

Bristol hydrogen ferry

BRISTOL HYDROGEN BOATS



BRISTOL HYDROGEN BOATS

UK supply chain

- Auriga Energy (Bristol)
- Avon Steel (Midsomer Norton)
- Batt Cables
- B&Q (Bristol)
- Breaksea Boats (Weston-Super-Mare)
- Bristol Fluid Systems Technology Ltd
- Bristol Hose (Downend)
- Bristol Marina
- Bristol Packet Boat Trips
- Bristol Spaceworks (Bristol)
- C&O engineering (Newton Abbot)
- Cad Cut (Bristol)
- Clifton/Dacrylate Paints (Bristol)
- F&B Profiles Limited (Warmley)
- Fairway Engineering (Bristol)
- Fastlink Data Cables (Swindon)
- GSF Slides (Wrexham)
- HPI Verification Services (Wallingford)
- Lynch Motor Company (Honiton)
- Maplin (Bristol)

- Marineware (Southampton)
- Marine Windows (Chelmsford)
- Newbury Electronics (Newbury)
- Number Seven Boat Trips (Bristol)
- PGDT (Christchurch)
- Powerstax plc (Farnborough)
- Piston Broke (Bristol)
- Premier Farnell (Leeds)
- Pure Signs (Bristol)
- Robins Timber (Bristol)
- RS Components (Bristol)
- Screwfix (Bristol)
- Selco builders (Bristol)
- Stockall Precision Sheet Metalwork (Bath)
- Terminal Technology (Bristol)
- W.E. Livermore & Son (Engineers) (Weston-Super-Mare)
- Weston Fabrication (Weston-Super-Mare)
- Wickes (Bristol)
- Windward Marine (Bristol)
- WSM Fasteners (Weston-Super-Mare)
- and more.....

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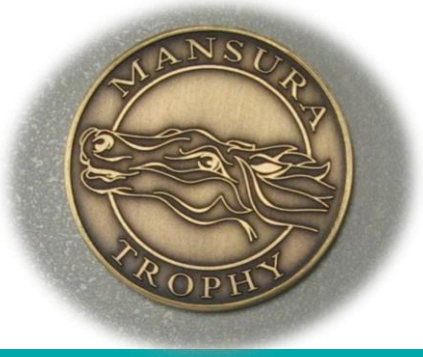
BRISTOL HYDROGEN BOATS

Hydrogenesis

BRISTOL HYDROGEN BOATS

Award winning

- Sustainable Shipping: **Environmental Innovation of the Year 2011**
- Royal Thames Yacht Club: **Winner Mansura Trophy: Lake and Inland Division Technology award 2012**



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BRISTOL HYDROGEN BOATS

Certification

- **CE marked, against EU Recreational Craft Directive 94/25/EC & as amended by 2003/44/EC by HPi Verification Services Ltd.**
- **Hydrogen & FC system independently checked for safety by KIWA Gastec at CRE.**
  - Later separately checked by Lloyds Register
- **The Hydrogenesis licensed to carry passengers by the Bristol Harbour Master.**

AIR PRODUCTS

Temporary refuelling station

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BRISTOL HYDROGEN BOATS

Fuelling

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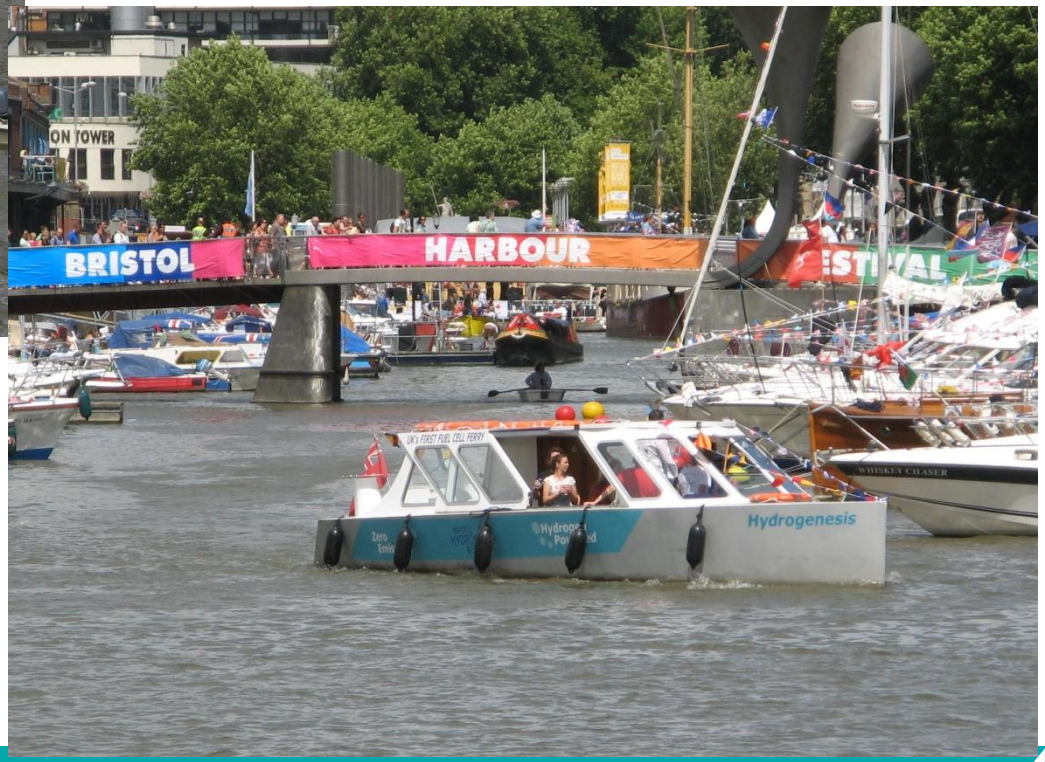
BRISTOL HYDROGEN BOATS



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BRISTOL HYDROGEN BOATS

Zero-emissions

- **The CO_2 emissions reductions relative to equivalent diesel engined boat**
  - **43Kg of CO_2eq saved per 6.5 hour day → up to 16 Tonnes / year**
- **If all daily operators in Bristol Harbourside adopt this technology**
  - **Approximately 178 Tonnes CO_2eq saved per year**
- **No air or water pollution and no noise.**

Competitive operational costs

- **The *Hydrogenesis* achieved a low fuel consumption using the Auriga Energy fuel cell and power management system**
  - Daily OPEX are lower than diesel.
  - Low fuel consumption brings new challenges
    - Equipment for low flow rates
    - Fuel supply economics (refuelling station)

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BRISTOL HYDROGEN BOATS

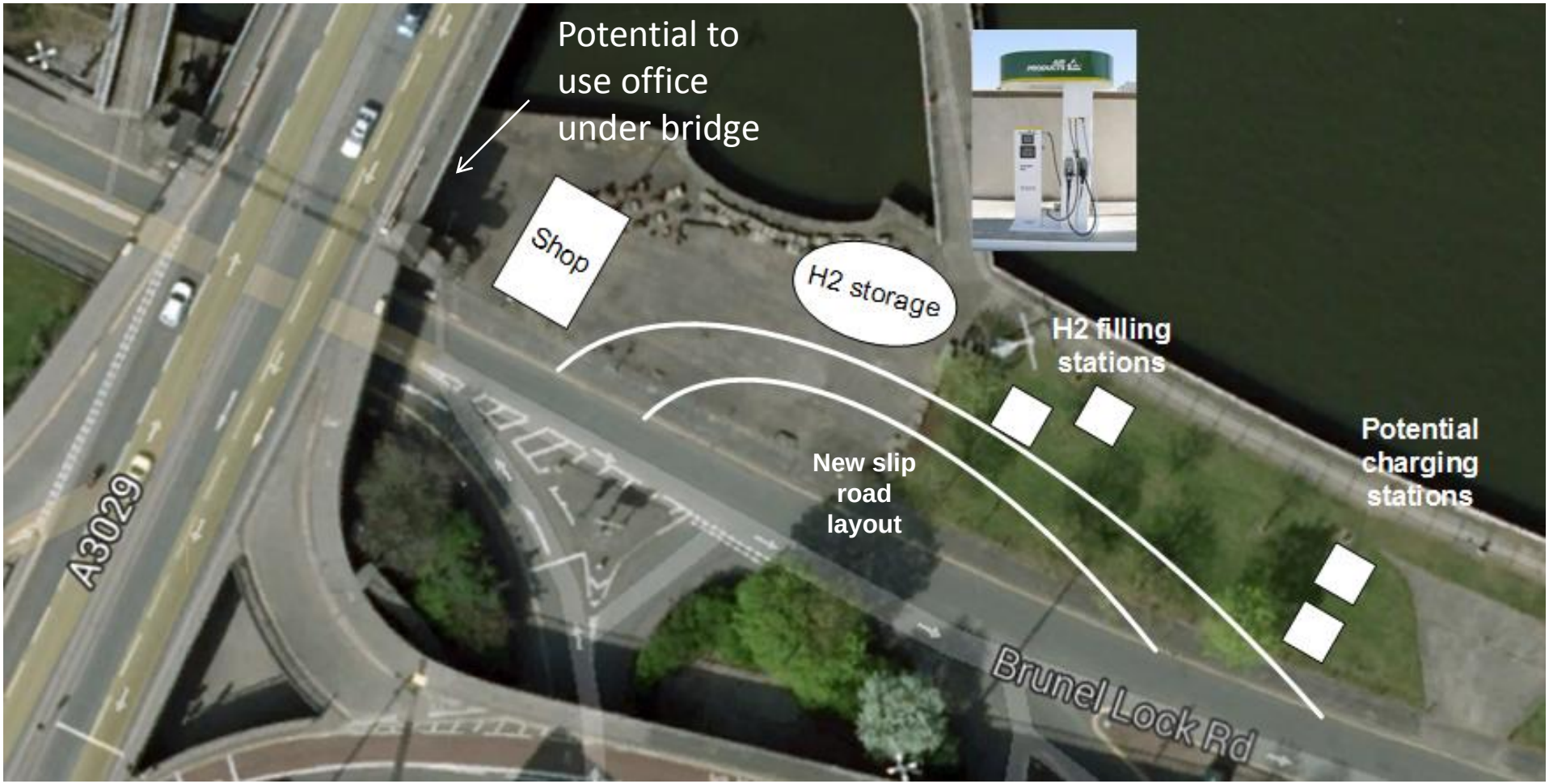
The UK's first fuel cell ferry

BRISTOL CITY COUNCIL

Recommendations for short-medium term

- **CAPEX funding from UK govt. for ULEV infrastructure**
  - Permanent refuelling station
    - Multi-modal = marine + road
    - Built-in growth capability
    - Local servicing
- **Local renewable hydrogen generation**
  - Using water power, wind, waste recycling.....

Example HRS site layout



Recommendations for short-medium term

- **Increase hydrogen users:**
  - Introduce fuel cell buses to rapid transit routes
  - Pursue introduction of cars into local fleets
    - Provision for local servicing
  - Declare low/zero-emissions zone from e.g. 2022
- **Inspire the next generation**
  - Introduce the teaching the emerging hydrogen economy and its technologies

A sustainable future

- **An improved environment**
- **A new green economy**
- **New industries**
- **Exports**
- **New jobs**

- **Hydrogen is a plentiful and fuel cells systems provide a route to a sustainable future.**

Opening the gates to a sustainable hydrogen fuel cell powered future

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