Cities speeding up the integration of fuel cell electric buses

Results of the High V.LO-City & HyTRANSIT projects

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Hydrogen, Fuel Cells and Electro-mobility in European Regions

Giantleap Workshop, Belfort, 12th December 2017

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

Content

I. Introduction to projects

II. Deployment sites

III. Achievements so far and lessons learned

IV. Next steps

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I. INTRODUCTION TO PROJECTS

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WHY FUEL CELL ELECTRIC BUSES?

Fuel cell electric buses are a zero-emission solution ready for commercialisation

- ONLY EMIT WATER VAPOUR
- REDUCING CO2 EMISSIONS AND IMPROVING AIR QUALITY
- REDUCED NOISE AND VIBRATION LEVELS
- PASSENGERS AND DRIVERS ENJOY THE BUSES
- LARGE RANGE WITH ONLY 1 REFILL A DAY (<12 MINUTES)
- READY FOR MARKET DEPLOYMENT

From greenhouse gas emissions to clean cities

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PROJECTS ACROSS EUROPE

Funded by the FCH-JU

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

CHIC — 26 buses, 5 H2 stations

HIGHVLOCITY — 14 buses, 4 H2 stations

HyTransit — 6 buses, 1 H2 station

3EMOTION — 31 buses, 5 H2 stations

ZERO EMISSION — 139 + 5 buses, 5 H2 stations

JIVE / MEHRLIN

2010 — NOW — 2020

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ACHIEVEMENTS OF THE CHIC PROJECT

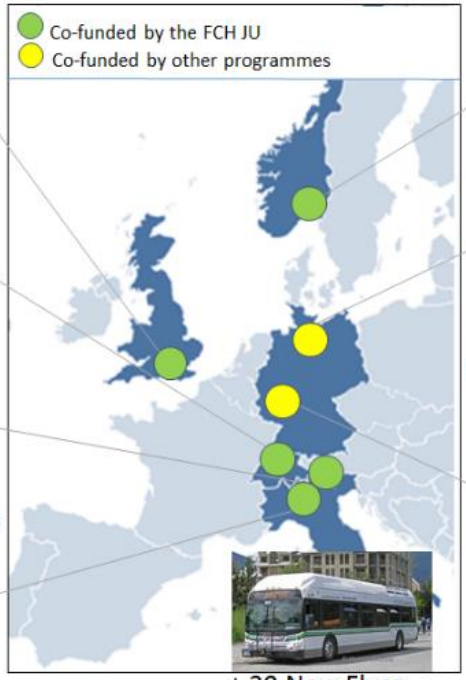
CHIC delivered 56 fuel cell buses in eight cities from six different OEMs (2010-2016)

London - 8 Wrightbus

Aargau - 5 EvoBus

Bozen/Bolzano - 5 EvoBus

Milan - 3 EvoBus



+ 4 ICE H2 buses in **Berlin**

+ 20 New Flyer – **Whistler** (Canada)

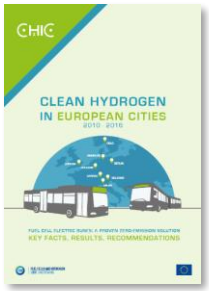
Oslo - 5 Van Hool

4 EvoBus **Hamburg**

2 Solaris

2 APTS/ Phileas **Cologne**

2 Van Hool



Report available at
http://www.fuelcellbuses.eu/public-transport-hydrogen/fuel-cell-electric-buses-proven-zero-emission-solution

Recommendations

- **Improve bus availability,** especially at the beginning – by resolving teething technical issues & increasing scale
- **Reduce the technology costs – bus and hydrogen prices –** coordinated commercialisation process
- **Harmonise regulations** on hydrogen refuelling stations – work underway on international standards

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Project objectives

	Reduce hydrogen consumption to 7-9kg/100km
	Reduce the cost of hydrogen production
	Reduce the total cost of ownership of the buses
	Increase overall operational availability
	Further increase of bus lifetime
	Contribute to commercialisation of FCEBs in Europe

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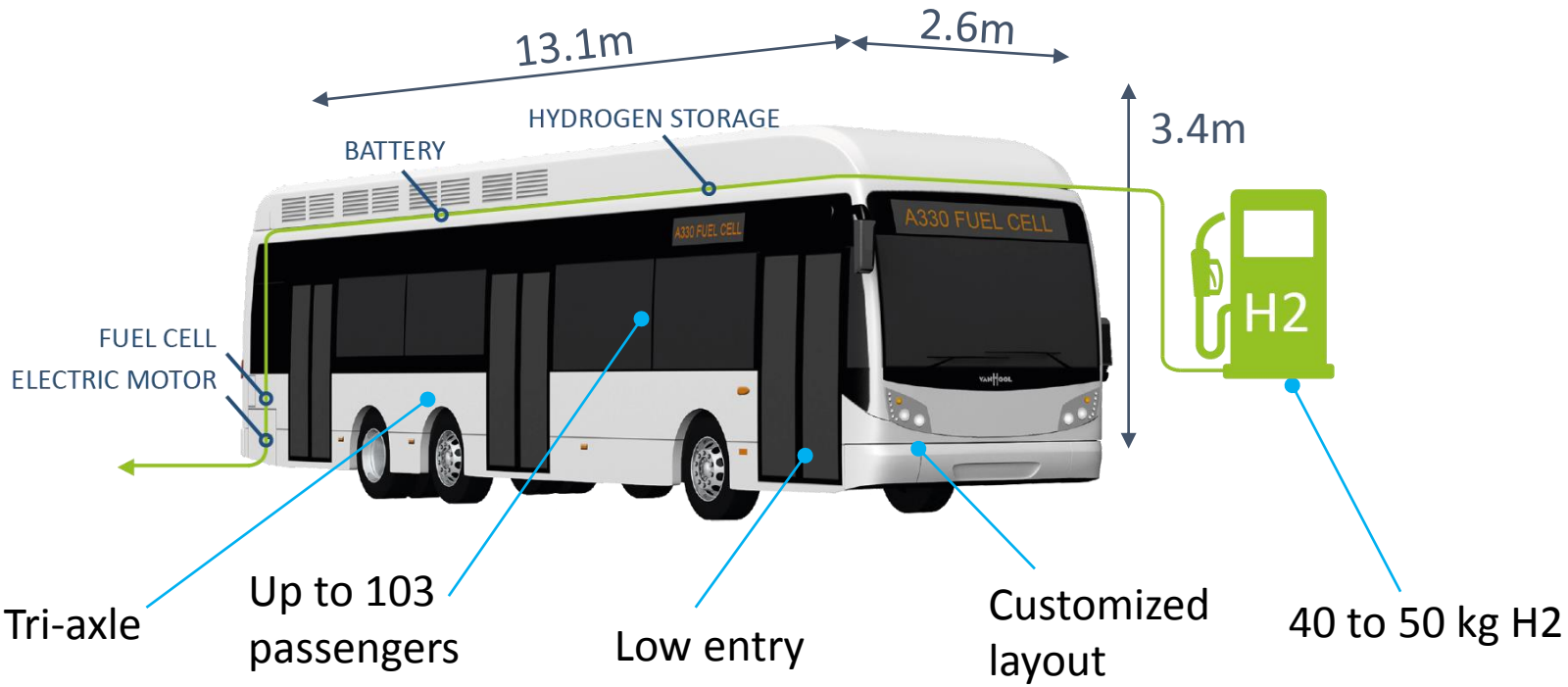
FUEL CELL BUS – SPECIFICATIONS

Van Hool A330



TRI-AXLES CONFIGURATION ALLOWS FOR DISTRIBUTION OF ADDITIONAL WEIGHT OF HYDROGEN STORAGE, FUEL CELL AND BATTERY OVER TRI AXLES AND THEREFORE GUARANTEEING SIMILAR PASSENGER CAPACITY

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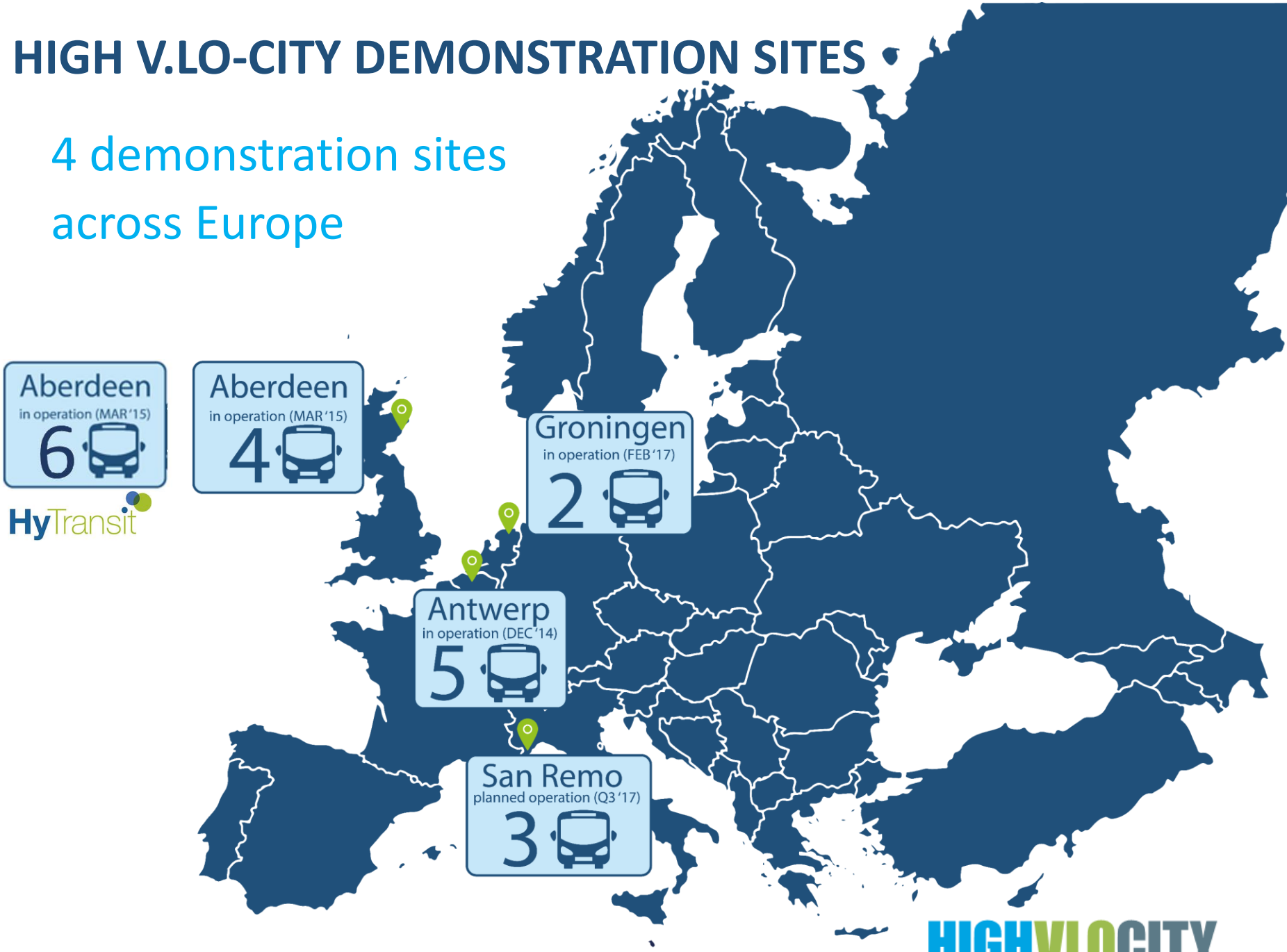
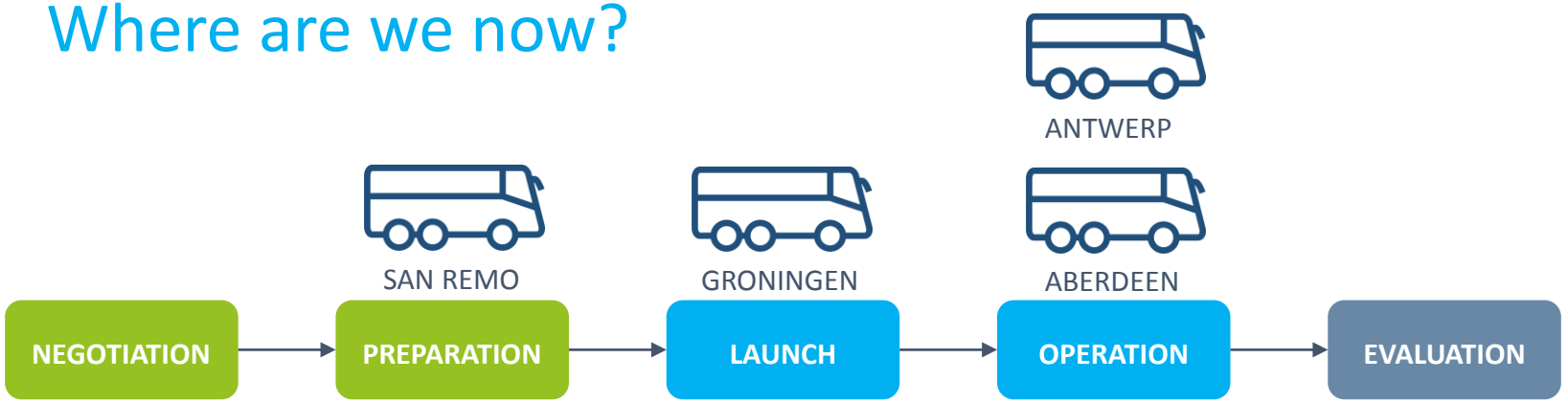
HIGH V.LO-CITY DEMONSTRATION SITES

4 demonstration sites
across Europe



PROJECT STATUS

Where are we now?



Antwerp

December 2014

Aberdeen

March 2015

Groningen

February 2017

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II. DEPLOYMENT SITES

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ABERDEEN

Developing a hydrogen economy

Strategic aim : to become '*a world-class energy hub leading a low carbon economy and at the forefront of hydrogen technology in Europe'*

Local drivers

- Highly skilled workforce in energy sector (oil and gas industry)
- Accustomed to the use of hydrogen in industrial processes
- Production of excess renewable energy (wind)

Policy drivers

- Reduce cross-sector greenhouse gas emissions by 42% by 2020 and 80% by 2050 (Scotland)
- Aberdeen City and Region Hydrogen Strategy 2015-2015

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ABERDEEN

Europe's largest FC Bus fleet

Europe's largest fuel cell electric bus fleet: 10 buses in total

- 4 buses First part of the HIGHVLOCITY project
- 6 buses Stagecoach part of the HyTransit project

+ **10 more buses to be deployed in 2019** – JIVE project

Aberdeen HydrogenBusProject

H2 Aberdeen

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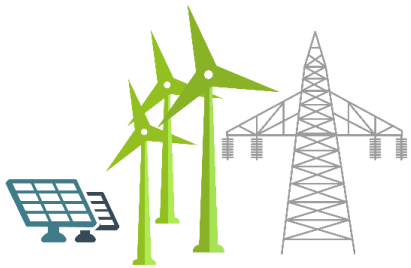
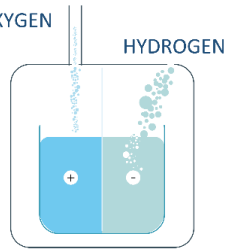
ABERDEEN

Hydrogen supply chain



ELECTRICITY



WATER ELECTROLYSIS

DIRECT

REFUELLING STATION

Aberdeen
in operation (MAR'15)
4

99% AVAILABILITY

REDUNDANT DESIGN

BUSIEST REFUELLING STATION IN EUROPE

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ANTWERP

Investing in clean public transport

Focus on sustainability:

- Public transport operator De Lijn is testing different types of buses: full battery electric, fuel cell electric and diesel hybrid buses
- Investments in fuel cell electric buses corresponds to the vision of the Flemish government to reduce emissions from road transport

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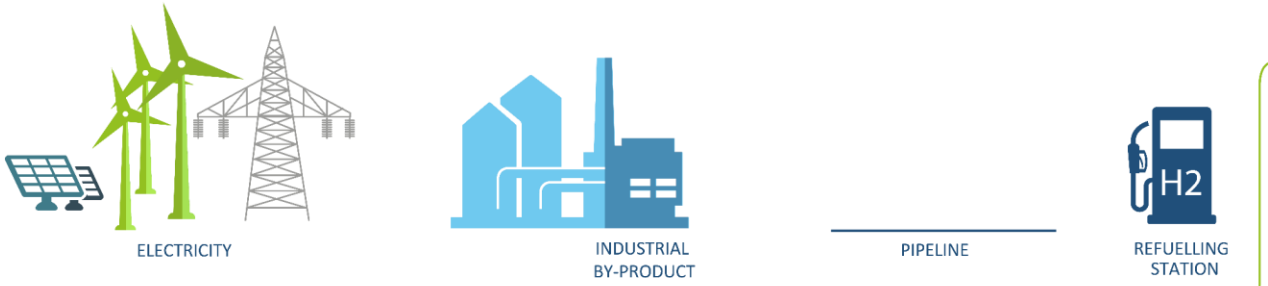
ANTWERP

Hydrogen supply chain

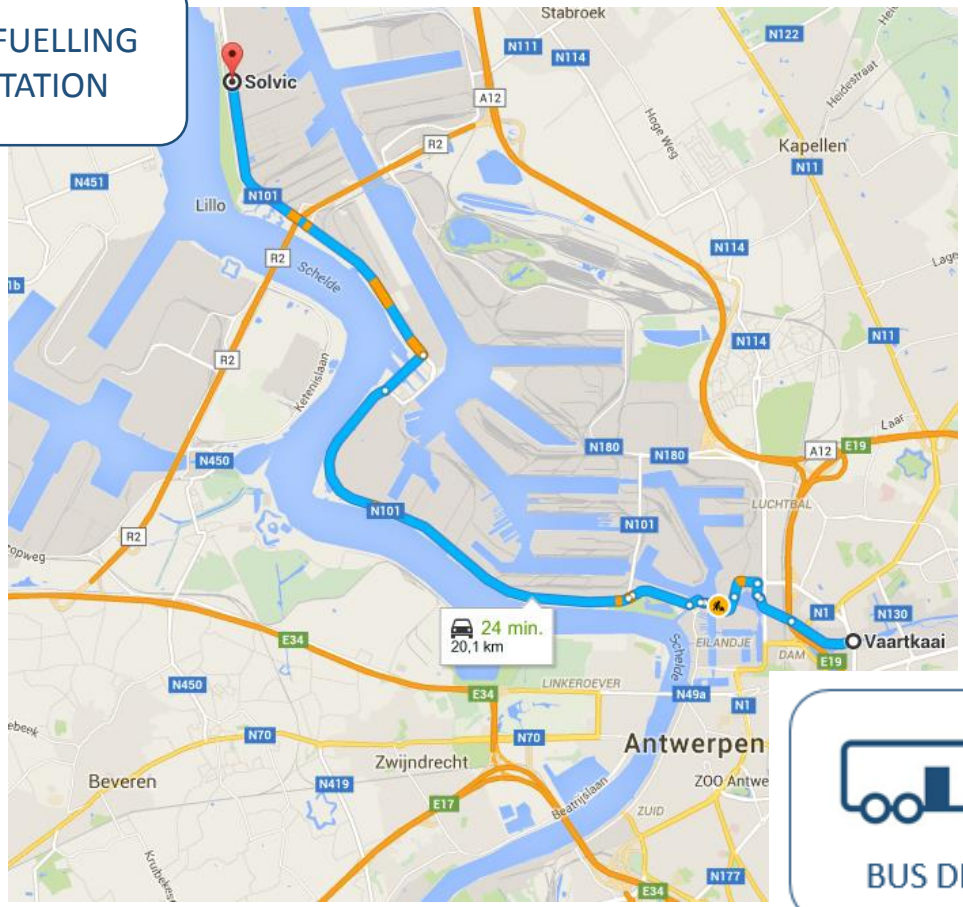


ANTWERP

Looking for an optimal solution

H2 REFUELLING STATION

- Current refuelling station is 20km away from DeLijn bus depot
- For optimal operation of the buses, the refuelling station should be close to the bus depot
- Refuelling station will be moved to the bus depot in 2018



BUS DEPOT

Operation of the buses will become more efficient

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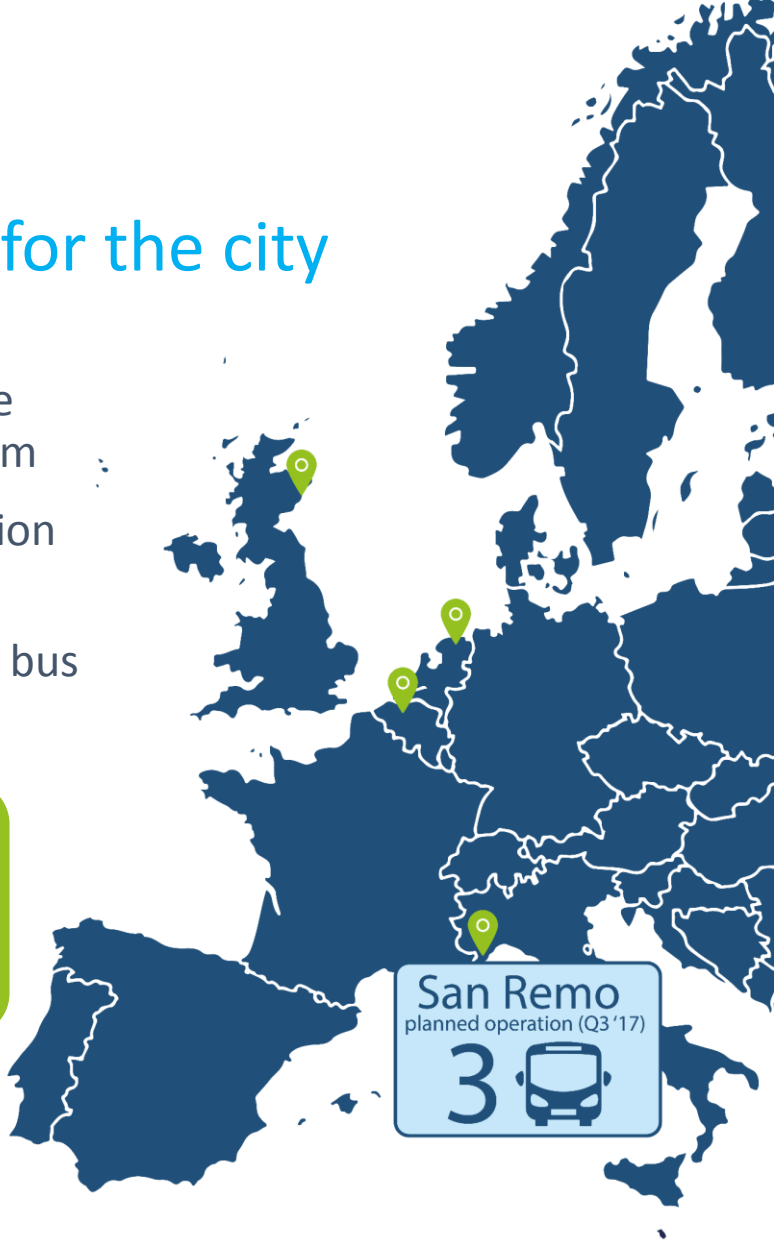
SAN REMO

A flexible zero-emission solution for the city

- Trolleybus system since 1942: high infrastructure maintenance cost and low flexibility of the system
- Fuel cell electric buses are a suitable zero-emission solution to gradually replace trolley buses
- Buses will be operated on sub-urban line – each bus will drive 300km/day

Delivery of station: December 2017

Start of operation buses: January 2018



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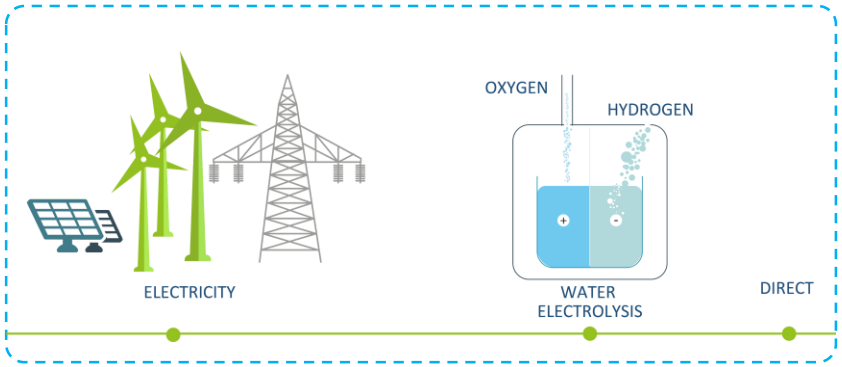
SAN REMO

Hydrogen supply chain



FROM SUPPLY THROUGH TUBE TRAILERS TO ON-SITE ELECTROLYSIS

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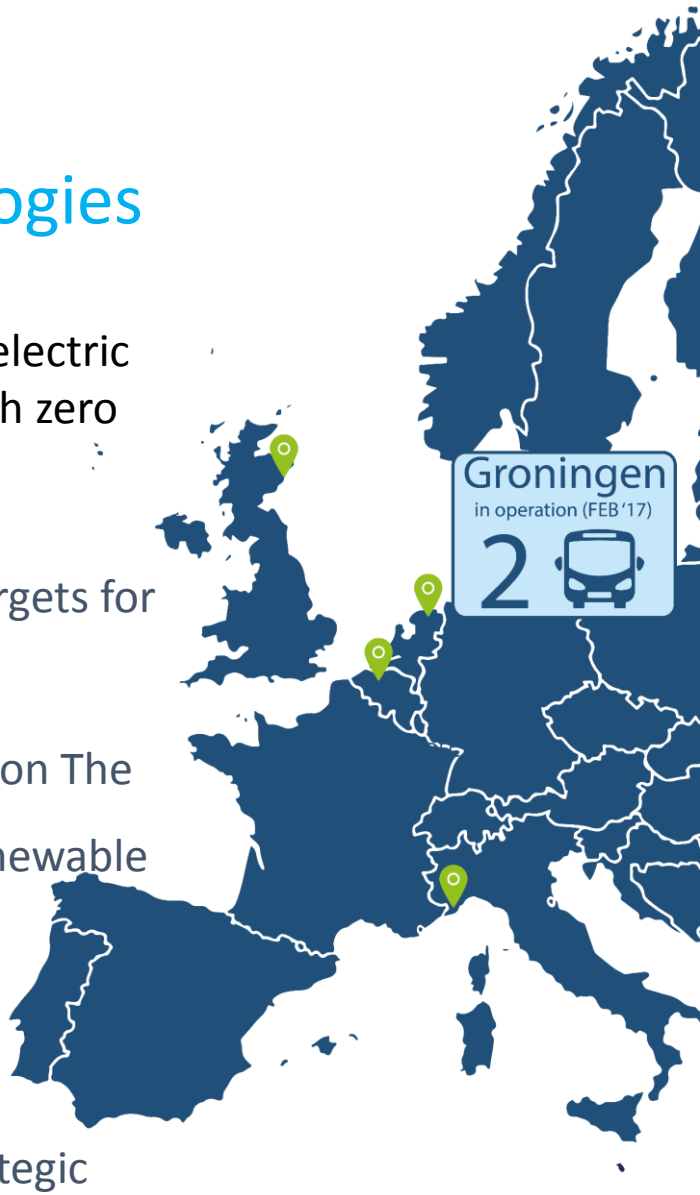
GRONINGEN

Transition to zero emission technologies

Public transport operator Qbuzz invests in fuel cell electric buses and battery electric buses to gain experience with zero emission technologies



Policy drivers: the Dutch government has ambitious targets for public transport in the Netherlands:

- From 2025 onwards, all buses should be zero emission The energy used to fuel the buses should come from renewable sources (zero emission well to wheel)
- Public funding made available for each region

Local drivers: developing a hydrogen economy is a strategic aim for the region

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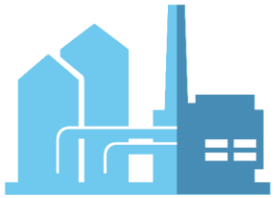
GRONINGEN

Hydrogen supply chain

WIND ENERGY

ELECTRICITY



INDUSTRIAL BY-PRODUCT

PIPELINE

REFUELLING STATION

CHLORINE-ALKALI BY-PRODUCT

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III. ACHIEVEMENTS SO FAR AND LESSONS LEARNED

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ACHIEVEMENTS SO FAR

A short overview

AROUND
KM DRIVEN
1.5 million
(Nov 17)

9-10
KG HYDROGEN PER 100 KM

>97%
AVAILABILITY OF STATIONS

>85%
BUS AVAILABILITY

>97% FUEL CELL AVAILABILITY

10-12 mins refuelling time

Around
TONNES OF CO2 SAVED* **200**

*COMPARED TO EURO VI VEHICLES

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AVAILABILITY OF THE BUSES

3 periods can be observed

Period	Duration	Nb of failures	Time off per fail
1 – Teething period	Around 6 months	Decreases	Constant
2 – Further initialisation	Around 10 months	Constant	Constant
3 – Wear	16 months onwards	Decreases	Increases

→ During the teething period, a lot of technical failures but which are fixed rapidly

→ During the wear period, much less technical failures but they take longer to fix

- The number of technical failures is decreasing for all sites.
- In Aberdeen most of the failures are bus failures rather than FC failures (standard wear of components). A number of bus failures are related to the previous experience of the maintenance team
- Batteries are a point of concern but only during summer time and when they are frequently used. **Mitigation**: having a spare battery stored on site
- Most of the failures in the projects up to Summer 2017 were from the compressor, especially in Antwerp. The issue was the short lifetime of the compressor pump. **Mitigation:** A new FC compressor is in evaluation now – looks promising.

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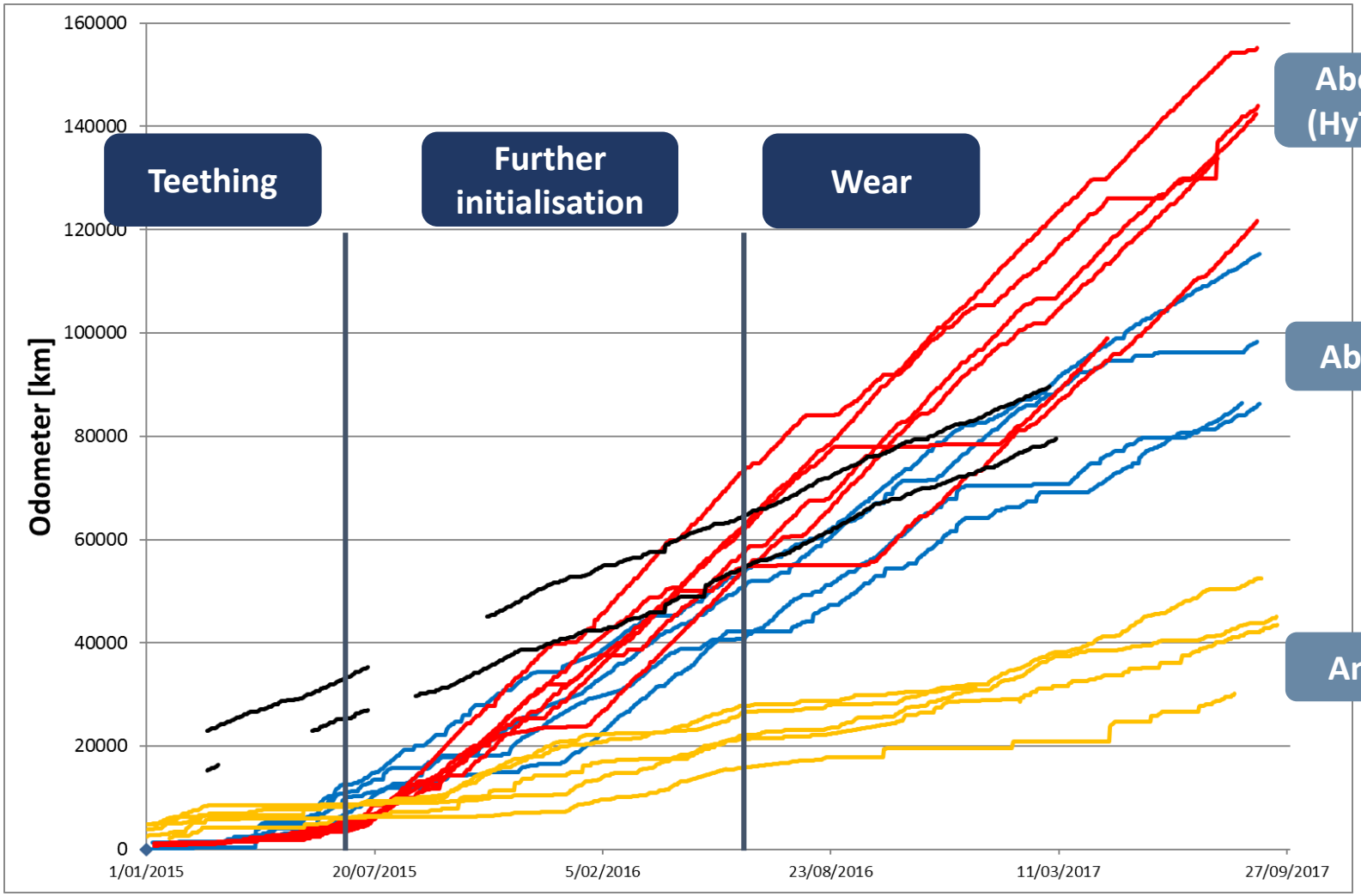
BUS MILEAGE

Accumulating experience



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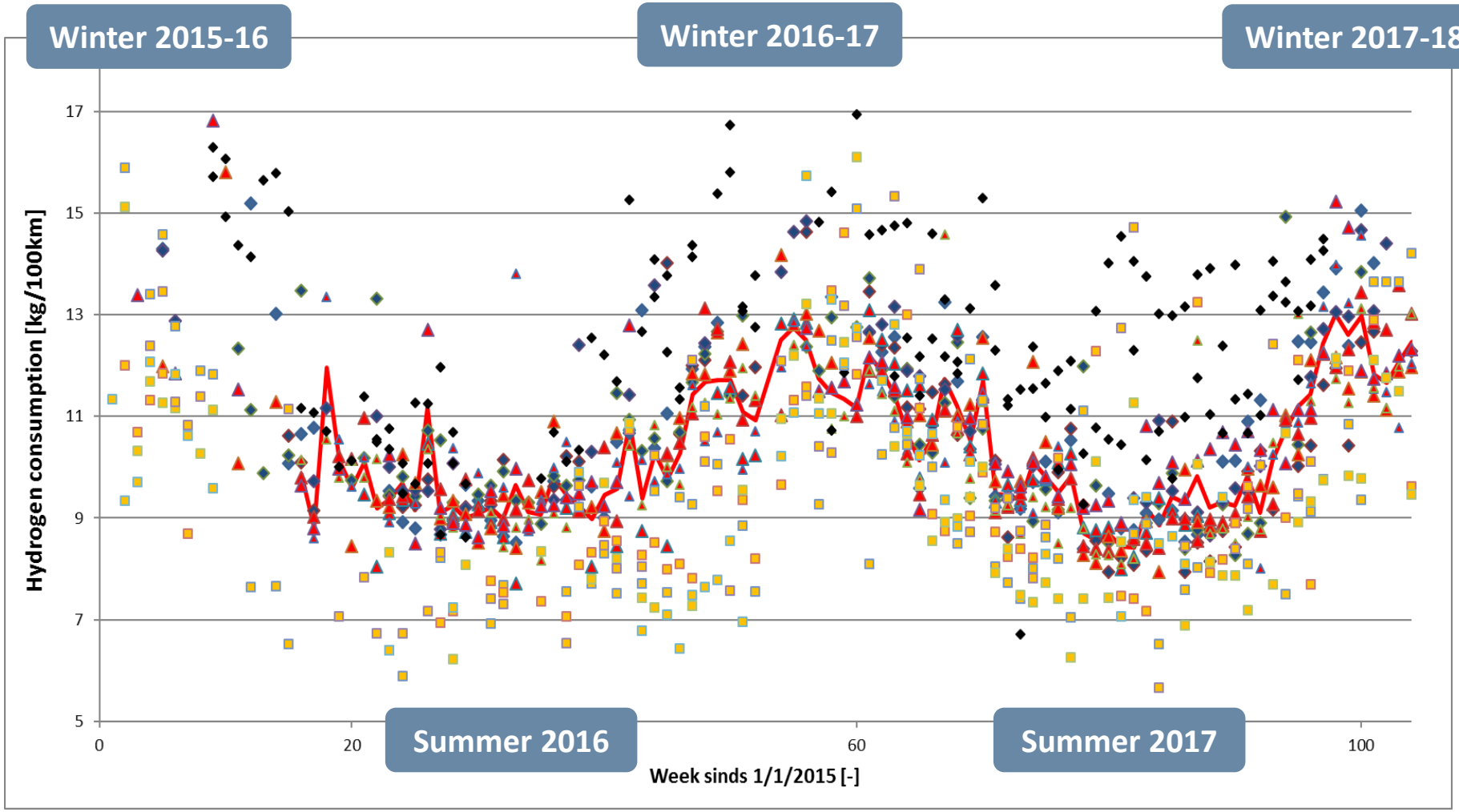
FUEL CONSUMPTION

Monitoring driver style and winter-summer differences



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FIRST CONCLUSIONS

Lessons learned – project management

The deployment of vehicles needs to be aligned with the infrastructure construction

Roles and responsibilities need to be **clearly defined** at the beginning of the project

Bus drivers are your best ambassadors: ensure they are **well informed** to answer passenger questions

Communication is key!

Manage expectations about technology, especially in a commercial environement

Inform passengers about the buses: passengers are curious about new bus technologies

Training of drivers: essential before but also during the project

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FIRST CONCLUSIONS

Lessons learned – operation of the buses

FC Buses need to have **special equipped workshops**: budget and transformation required depend on initial situation

Ensure that there is an efficient supply chain in place: keep **spare parts on site**

Very good customer acceptance: drivers and passengers enjoy the buses which are quieter than conventional fuel buses

Technical assistance on site for the buses should be optimal – ensure technicians are well trained

Introduce FC buses smoothly: introduction of a new technology can cause operational stress

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FIRST CONCLUSIONS

Lessons learned – refuelling infrastructure

Refuelling process takes around 12 minutes –> similar to conventional fuel buses

Presence of **local operation manager** is important

Stations are more efficient if they are used at full capacity

Refuelling station **should be located close to the bus depot** to ensure the operation is efficent

Technology is mature and stations are **highly reliable**: <97% availability

Refuelling stations can easily be **scaled up** when the fleet is growing

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SOCIAL SURVEY RESULTS

For the Aberdeen and Antwerp sites

Most people keen to use the buses- no safety issues

Most people believe it is important or very important that PTOs invest in clean buses

Drivers like to know enough about buses to be able to answer passengers questions

Passengers enjoy the buses – less noise and vibrations

PASSENGERS

Concerns about breakdowns: improving

DRIVERS

What people want to know: which routes buses are running on + what benefits for the city and the citizens, but also if there will be more of these buses in the future

Majority thinks more buses should be deployed, but with adequate training

«I love driving hydrogen buses, they are nice and quiet and comfortable. Feedback from passengers is unbelievable. They don't have to shout when they are taking to me!»

Ron, bus driver in Aberdeen

- Very good acceptance of the buses and positive attitude towards innovative and environmental friendly technologies

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JIVE PROJECT

Largest FC bus deployment project to date - started Jan 17

ZERO EMISSION

JIVE – bus deployment

139 new zero emission fuel cell buses across 5 countries

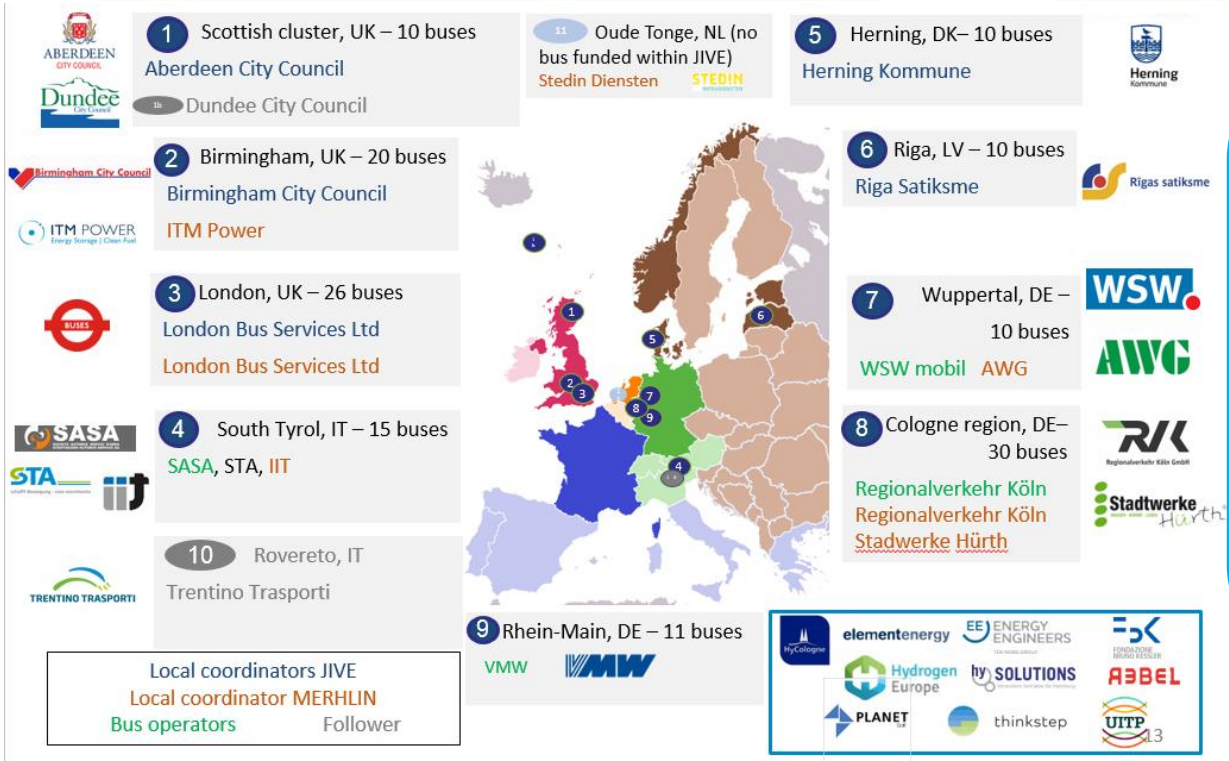
MEHRLIN – infrastructure

7 hydrogen refuelling stations in 7 EU locations

Aim: advance the **commercialisation of fuel cell buses** and **boost the deployment of hydrogen as an alternative fuel** in the EU through large-scale deployment of vehicles and infrastructure

Co-funded by €32M from the **FCH JU** under **Horizon 2020**

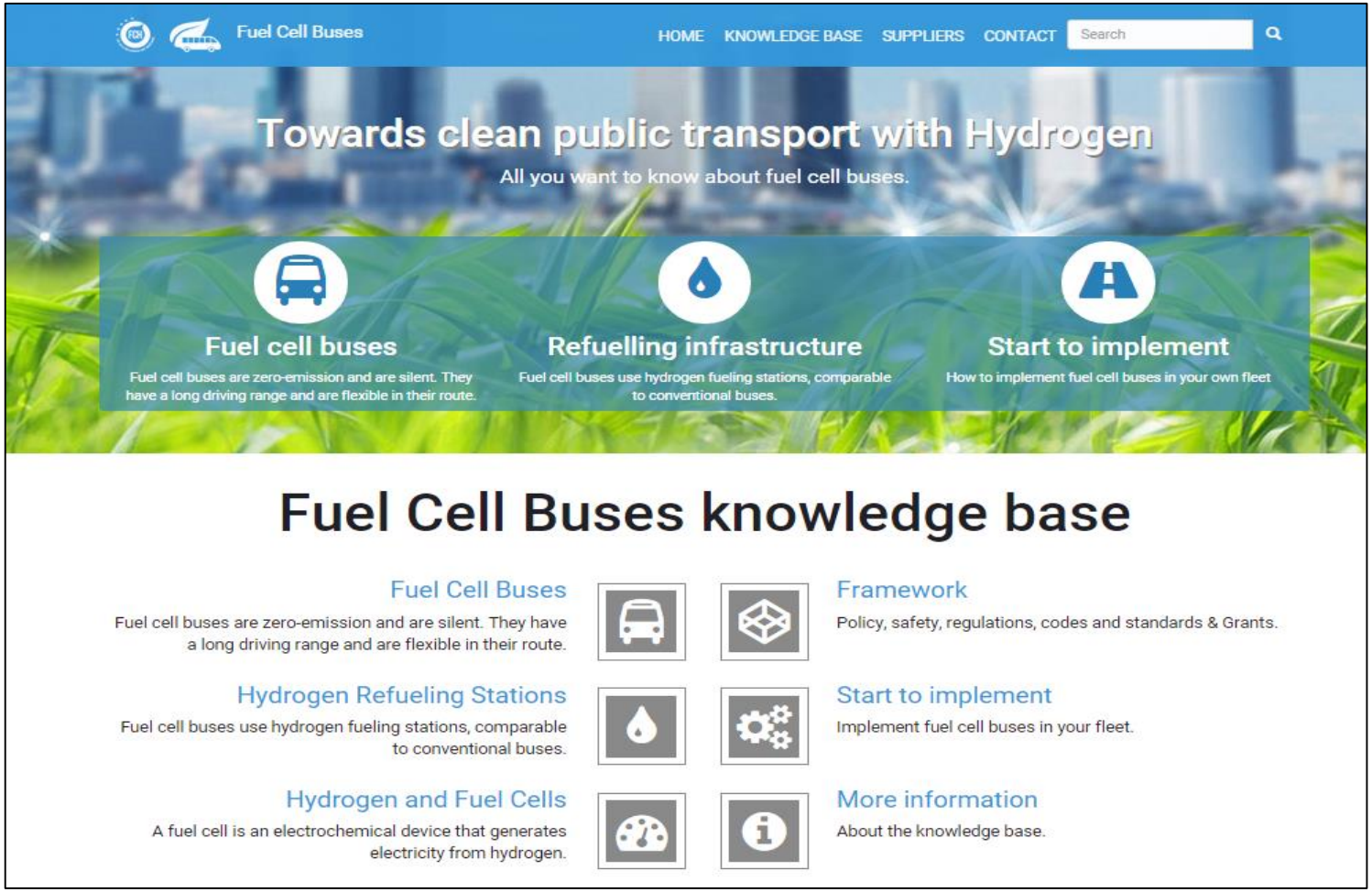
Co-funded by €5.5M from the EU **Connecting Europe Facility**



- Large-scale deployment project (fleets of 10-30 buses)
- Procurement exercise launched in the UK and Germany
- Indications of a number of suppliers interested in delivering buses below the JIVE price target (€650,000)

FOR MORE INFORMATION…

www.fuelcellbuses.eu



THANK YOU FOR YOUR ATTENTION!

Websites:

- **www.highvlocity.eu**
- **www.fuelcellbuses.eu**

Twitter:

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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

THE HIGH V.LO-CITY PROJECT HAS RECEIVED FUNDING FROM THE FUEL CELLS AND HYDROGEN JOINT UNDERTAKING UNDER THE EUROPEAN UNION'S 7TH FRAMEWORK PROGRAMME UNDER GRANT AGREEMENT NR. 278192

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