Fuel Cell Electric Bus Training

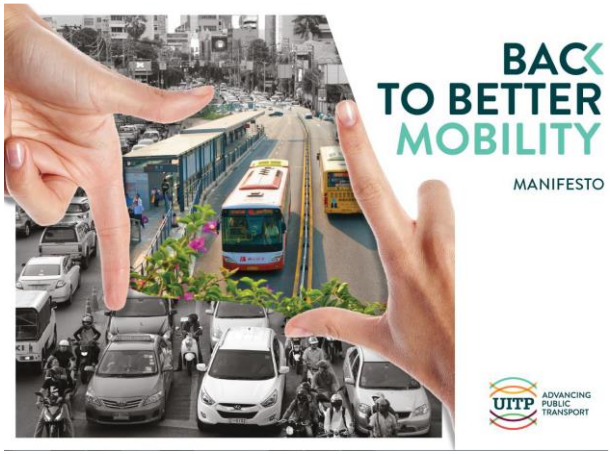
WELCOME!

Fuel Cell Electric Bus Training organised by *JIVE Projects in partnership with Clean Bus Europe Platform*

3 November 2020
10.00 – 13.00 CET
Contact: efe.usanmaz@uitp.org

CONTEXT

- In the frame of JIVE 2 poject UITP organises specialised fuel cell electric bus trainings: First of the **series of five trainings** in total to be focused on different topics
- March Groningen event: Outbreak of COVID-19 resulted 90% drop in ridership in various cities across globe
- Evolution of COVID-19: Public transport sector remains affected and challenged
- Opportunity to Build Back Better by further decarbonising our cities
- UITP ***Back to Better Mobility Campaign*** in June advocating for more liveable and healthier cities with clean and attractive PT solutions
- Fuel cell hydrogen bus technology is one of the main solutions ready for decarbonising our city bus networks
- JIVE Projects celebrate a milestone: **over 200 fuel cell buses** have been ordered by **14 JIVE cities and regions** and 50 in operation
- Sharing best practices and learnings to interested stakeholders



TODAY'S AGENDA

- Sessions Moderators: Madeline Ojakovoh (EE) & Sabrine Skiker (HE)
- FCH JU introduction: Lionel Boillot
- **Session I: Hydrogen buses in the transition to zero emission mobility**

✓ Sabrine Skiker, Hydrogen Europe
✓ Aida Abdulah, UITP
✓ George Carew-Jones, Element Energy

- **Session II: Planning and Procurement Strategies for FCB and HRS – Cologne Experience**

✓ Klaus Stolzenburg, PLANET
✓ Jens Conrad, RVK
✓ Marcel Corneille, EMCEL

- **Session III: Operating FCBs – Initial Insights from Operating Cities**

✓ Mélanie Pedeutour, SMTU Pau
✓ Julian Holz, WSW Mobil Wuppertal
✓ Jude Balfour, First Group Aberdeen

- Brighton approach to innovation: Patrick Warner, Brighton & Hove Buses

TIPS ABOUT THE PLATFORM

- Participants **are muted by default**
- Please type your questions in the **Q&A section of the dashboard** and moderators will introduce the questions to speakers
- If you want to speak up please click on the **'raise your hand'** icon in the dashboard – you will be unmuted
- Participate into online polls for more interactive sessions
- This is your training: don't hesitate to pose questions or comments throughout the sessions

- For speakers: to switch your video on while speaking

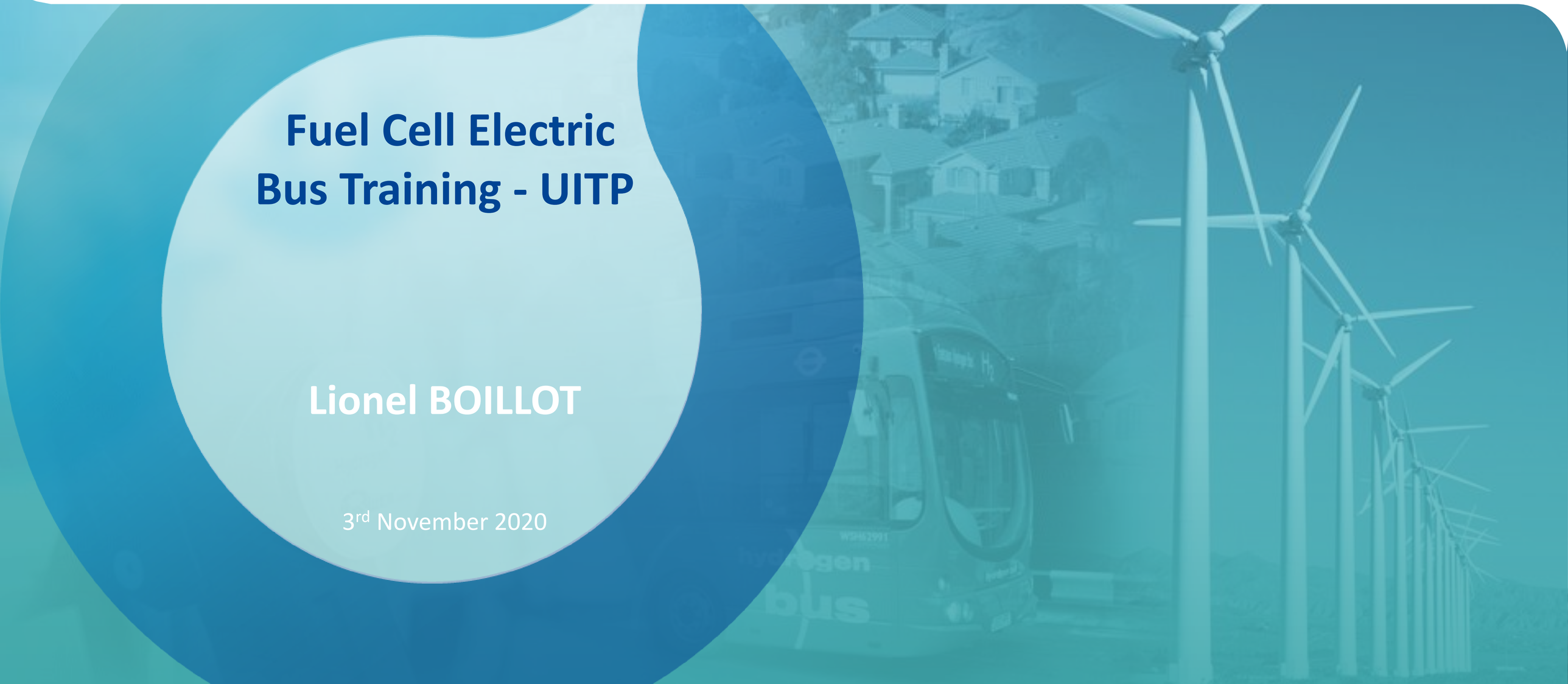
INTRO POLLS

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

Fuel Cell Electric Bus Training - UITP

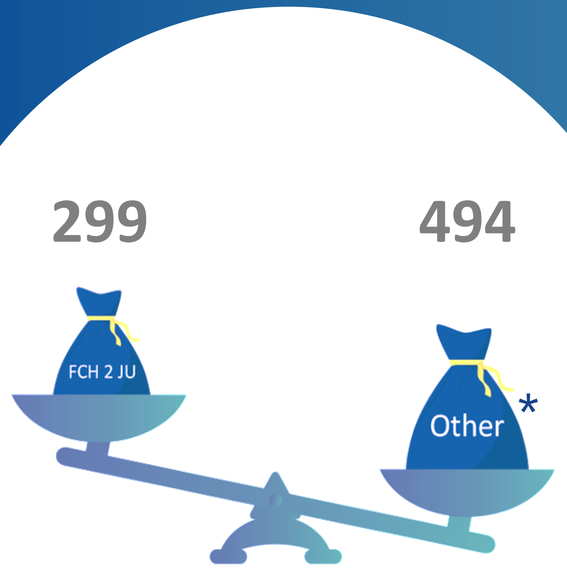
Lionel BOILLOT

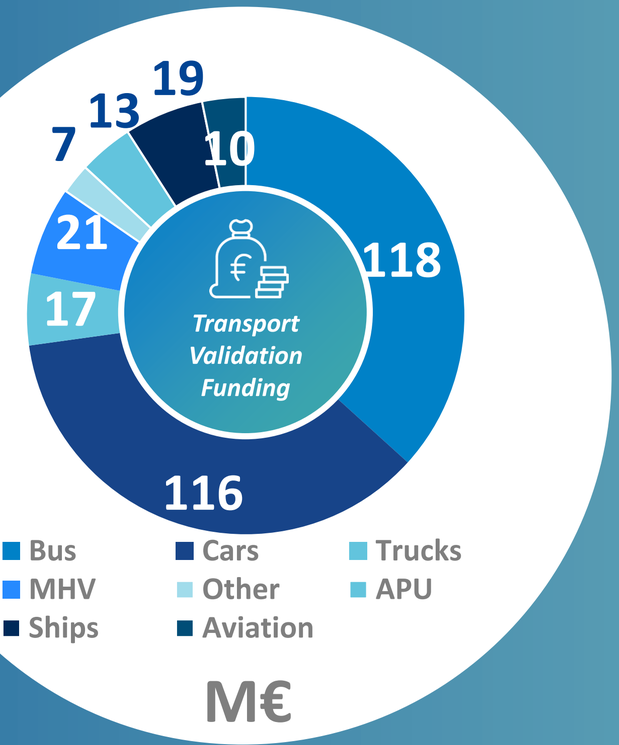
3rd November 2020



Hydrogen - on the road to widespread deployment

27 projects –792 M€





Extending the European network

Consolidating as market alternative

Exploring heavy-duty segments

DEPLOYING:

103 HRS

2000+ cars

360 buses

273 MHV

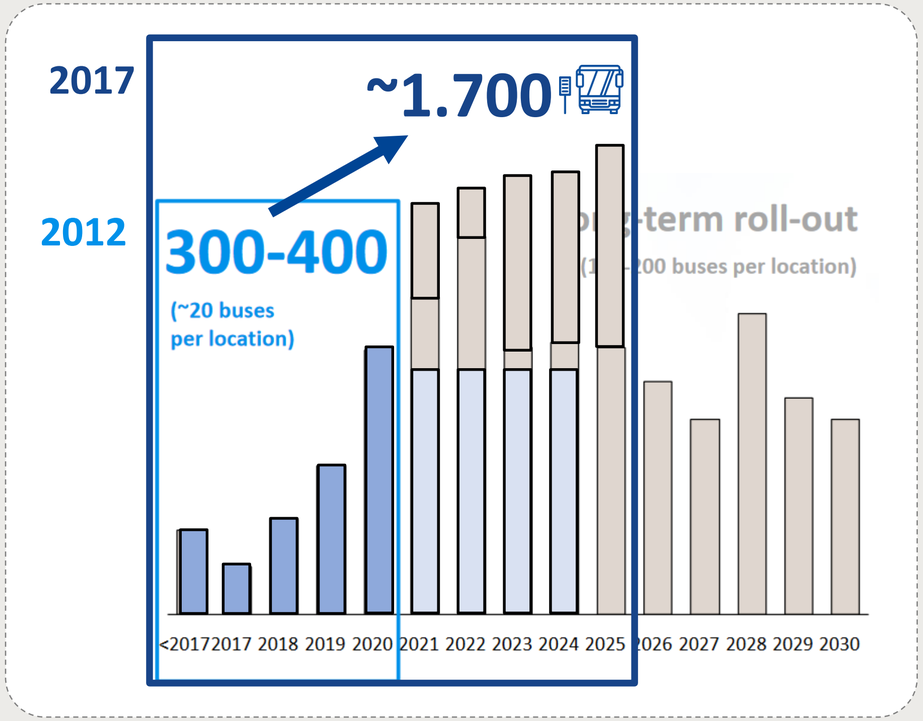
31 trucks

** Other resources including private and national/regional funding*

Not only projects but a full strategic development

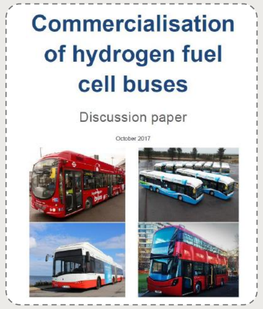
Results of study support since 2012 and strategy forward

Clockwise implementation of the identified deployment potential



New business and financing models

- Joint procurements
- Central purchase office
- Special Purpose Vehicle



Policy for funding mechanisms

- Discussion paper for policy purpose

Dissemination

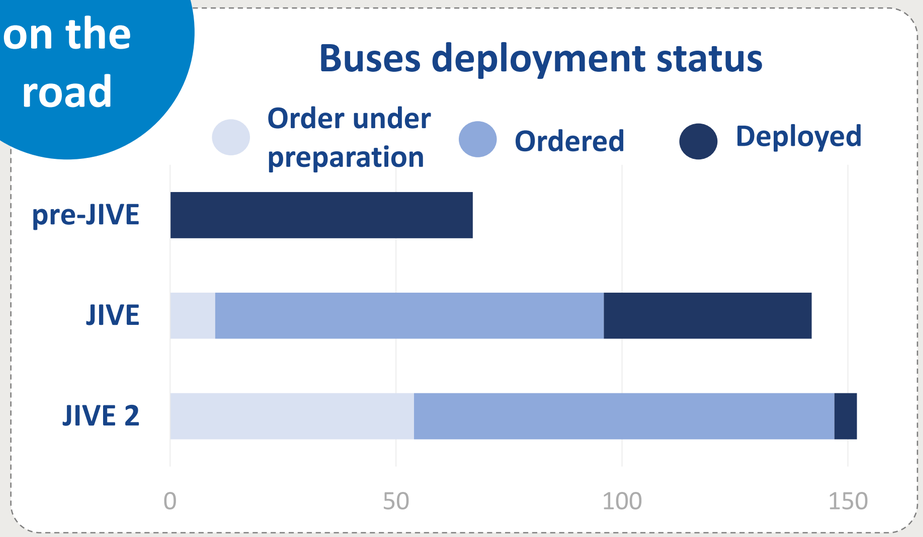
- Workshops and conferences
- **Zero Emission Bus conference**

2018 EUROPEAN ZERO EMISSION BUS CONFERENCE
Cologne • November 27th & 28th

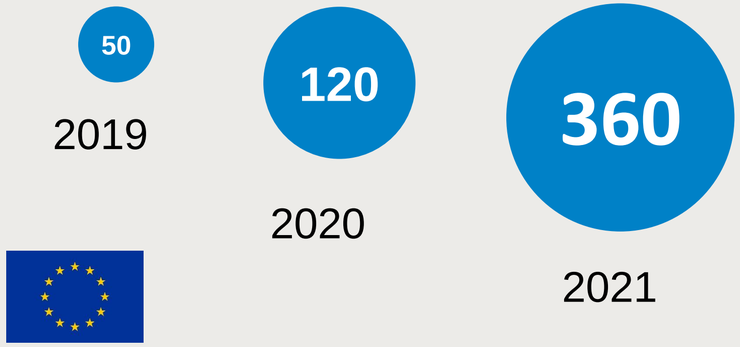
More cities, larger fleets, more suppliers: approaching market stage

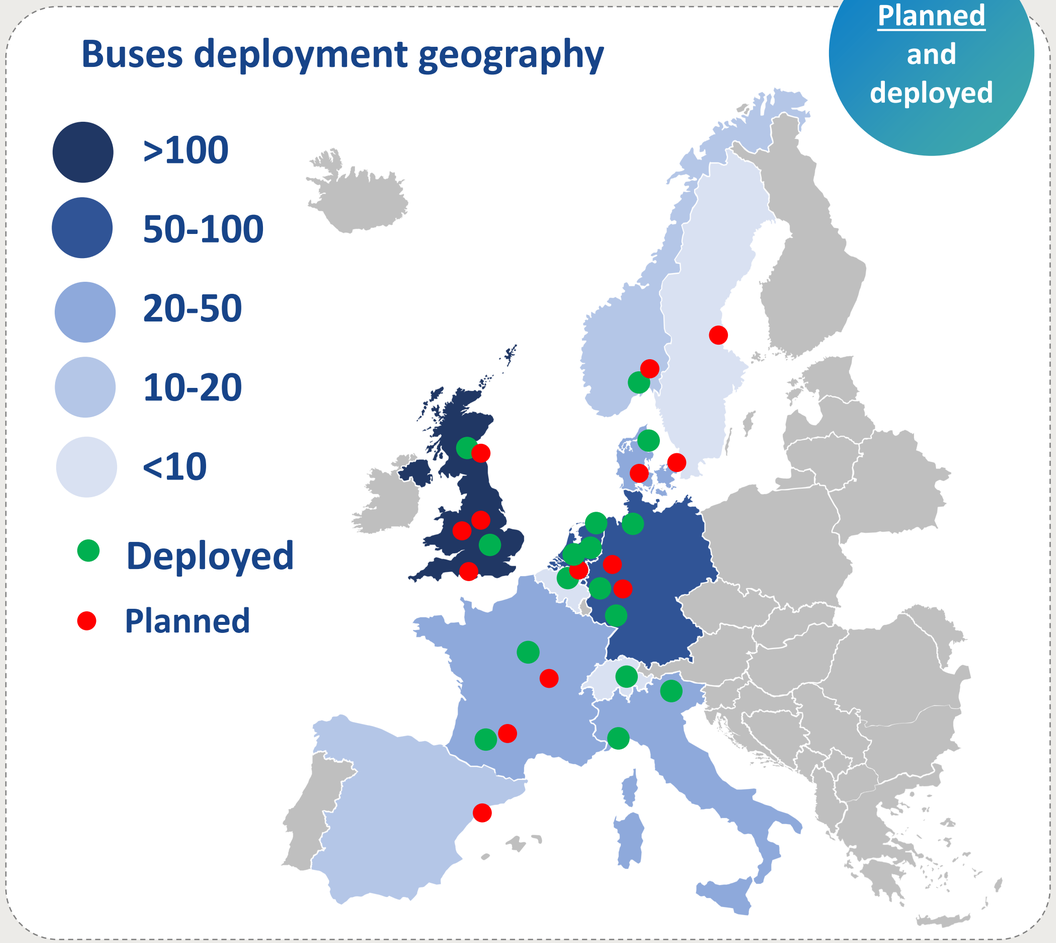
JIVE and JIVE 2 are putting the FCB on the roads

120 FCB on the road



Evolution of FCB in operation in EU





A flexible competitive clean solution

Europe is world leader

Trends

- Cities order **fleet of 10-40 buses**
- **Zero-emission tenders**
- **Novel HRS designs** (in-door, scalable)
- Zero-emission transport integrated in larger **hydrogen ecosystems**:
  - Waste to wheel
  - Hydrogen valleys

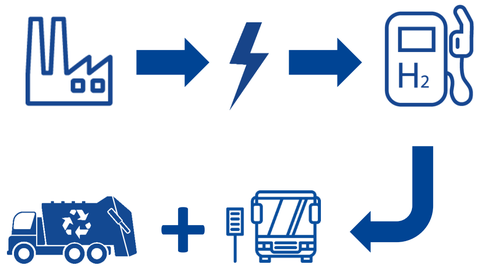
Achieved

- > 10,000,000 km since projects started
- > 35,000 h lifetime reached
- 625,000 €/bus offered
- 40.000km/y per bus on average

87%

low carbon hydrogen

"Waste to wheel", from waste incineration to hydrogen for mobility



European funding 2021-2027

Various EU programmes will fund decarbonisation of public transport:

- Innovation Fund for large First-of-a-Kind Demos
- Other mobility related Jus (Clean Hydrogen + Zero Emission Waterborne)
- CEF (Energy, Transport and Energy)
- Just Transition Fund for fossil fuel dependent regions and MSs
- ESIF (specially the Cohesion Fund and ERDF-Interreg)
- Invest-EU for financial instruments

Thanks for your attention

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

Lionel BOILLOT
Project Manager
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For futher information

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FCH JU

Regulatory framework and hydrogen momentum

Sabrine Skiker, Hydrogen Europe

JIVE FCB Training, 3rd November 2020

ZERO EMISSION

JIVEs / MEHRLIN projects

Table of contents

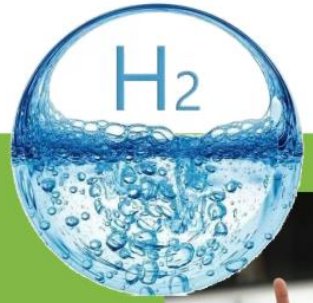
- European context
- National context

Hydrogen momentum at European level

A **Hydrogen Strategy** for a climate neutral Europe

#EUGreenDeal

- Targets for renewable hydrogen production in Europe:
  - 6 GW by 2024; 40GW by 2030.
- On mobility: Local city fuel cell buses seen as key for the uptake of hydrogen in ‘Phase 1’ (2020-2024).



“Next Generation EU should invest in Hydrogen.”
Ursula von der Leyen @State of Union speech, September 2020

“H2 rocks, and I am committed to making it a success!”
Frans Timmermans- Executive Vice-President for the European Green Deal

Legislation boosting clean buses uptake at European level - AFID

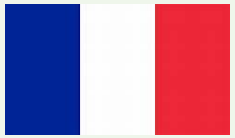
- The **Directive on Alternative Fuels Infrastructure** (2014/94/EU) sets mandatory targets for alternative fuels infrastructure deployment. (but hydrogen infrastructure targets are optional)
- Directive expected for review in Q2 2021
- Opportunity to lobby for a better matching of the Directive with needs to boost the uptake of fuel cell buses:
  - H2 as mandatory fuel
  - Enforcement of national plans
  - Extension of the geographical scope to allow HRS outside of the TEN-T Core Network → Link to EU funding - CEF
- The **Clean Vehicle Directive (**2019/1161) – see UITP presentation

Historical momentum

16 billion euros from France and Germany!

Billions to be invested at national level by 2030

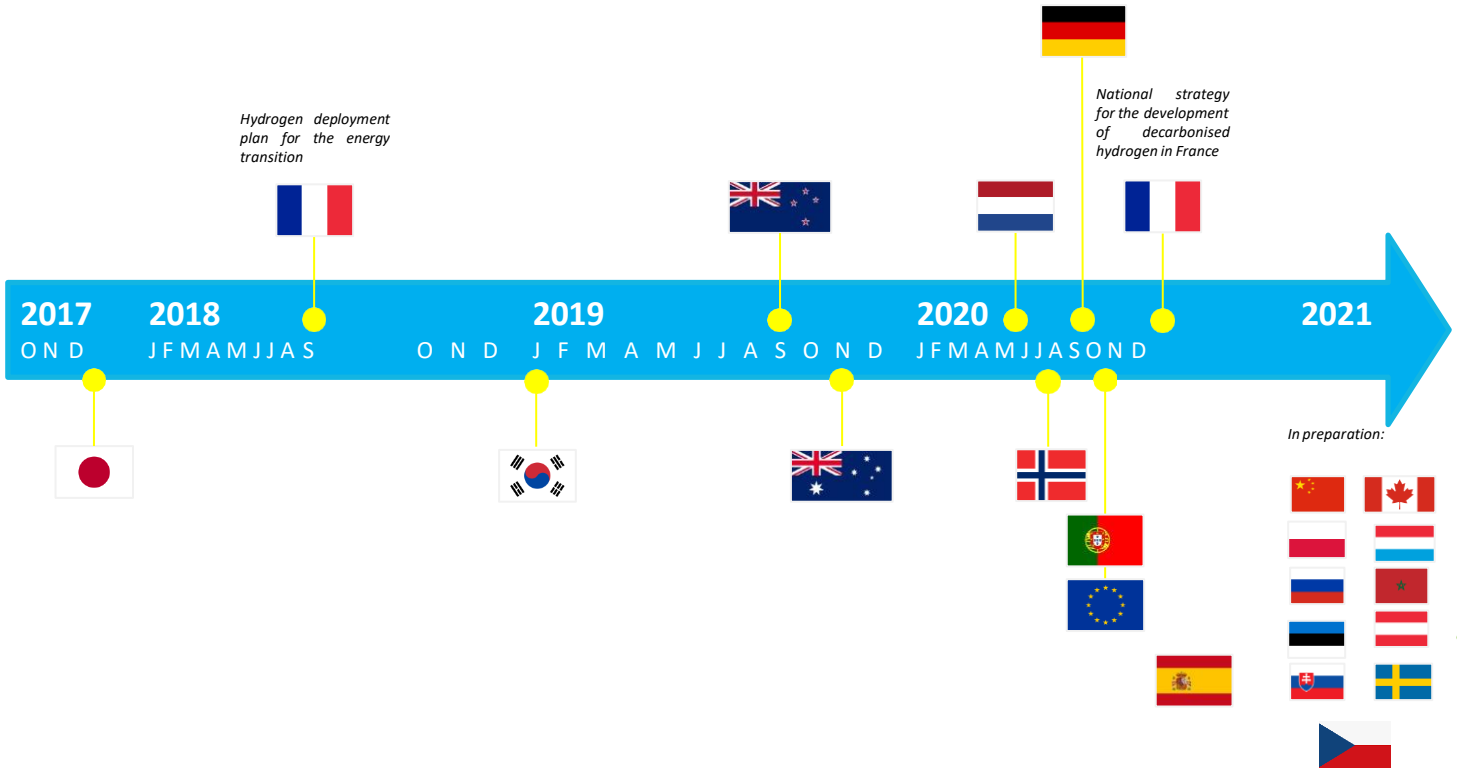
EU governments propose hydrogen strategies with dedicated 2030 investment plans:

Germany 	**€7bn** (+ €2bn external partnerships)
Spain 	Estimated mobilised investment: €8.9bn
France 	**€7.2bn** - of which €1.5bn for an IPCEI project
Portugal 	Ca. €1bn - estimated mobilised investment: €7-9bn
Austria 	Austrian Technical Universities advocate for €2bn of public support by 2030 (of which €1bn by 2024)

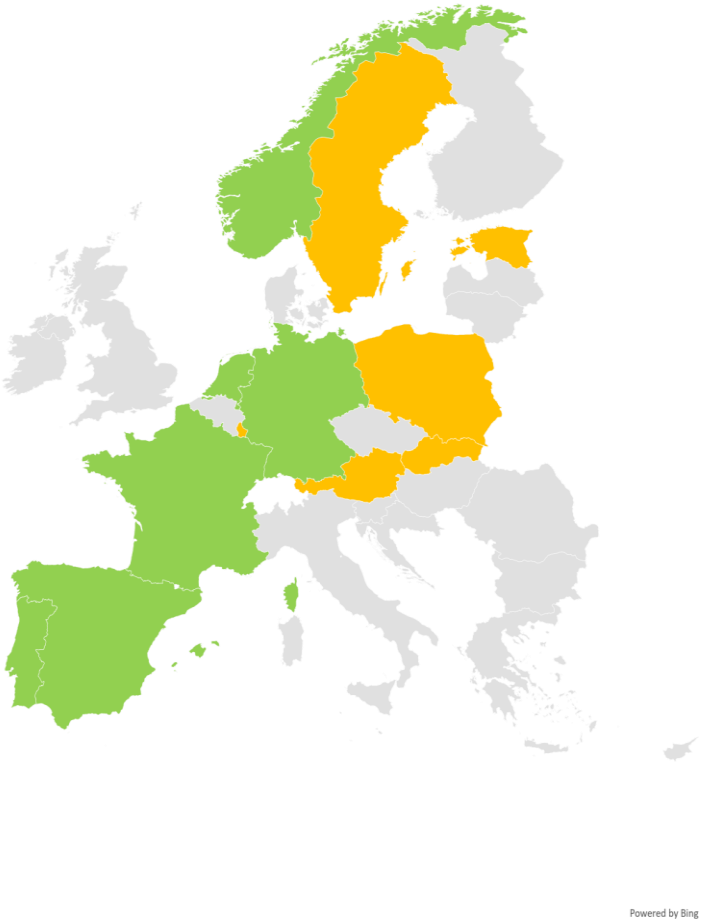
Source: Hydrogen Europe

National hydrogen strategies

Publication dates of national hydrogen strategies across the world per country



State of publication of National Hydrogen Strategies in EU/EEA Member States



Source: Hydrogen Europe

National Energy and Climate Plans - NECPs

- NECPs: Plans where EU Member States lay out the strategies and measures they plan to implement for the period 2021-2030 in order to comply with 2030 energy and climate targets at EU and national levels

- Mobility is the sector the most mentioned in the NECPS: 25 MS foresee development of hydrogen mobility

- Different levels of ambition: from R&I to deployments

Source: Hydrogen Europe

Thank you for your attention

Project coordination:

elementenergy

Project dissemination:

Hydrogen Europe

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Clean Bus Europe Platform – Enabling the transition to clean fleets

JIVE-CBEP FCEB Training

03/11/2020

Aida Abdulah – Senior PM, Bus Unit, K&I, UITP

The Clean Bus Europe Platform is financed by the European Union.

The Clean Vehicles Directive

List of technologies based on the AFI Directive on the deployment of alternative fuels infrastructure

A clean bus is fuelled by:

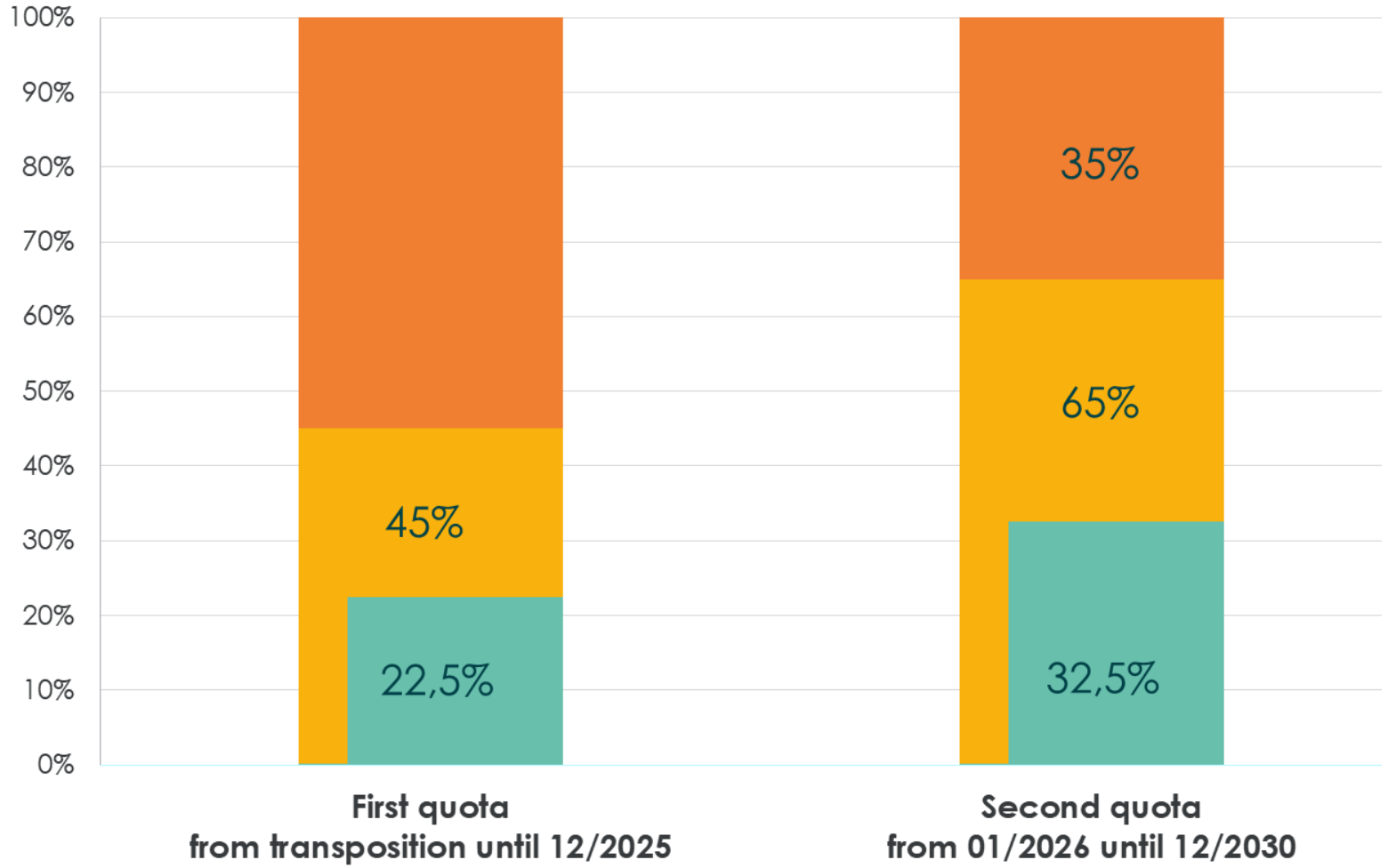
- **electricity;**
- **hydrogen;**
- **natural gas** (incl. biomethane), CNG and LNG;
- most biofuels
- synthetic and paraffinic fuels;
- liquefied petroleum gas (LPG)

A zero-emission (tailpipe) bus is a clean bus

- without an ICE, or
- with an ICE that emits less than 1g CO_2/kWh or less than 1gCO_2/km

Sources: Directive (EU) 2019/1161; Directive 2014/94/EU, Art. 2(1) and 2(2)

Quotas for public procurement of buses



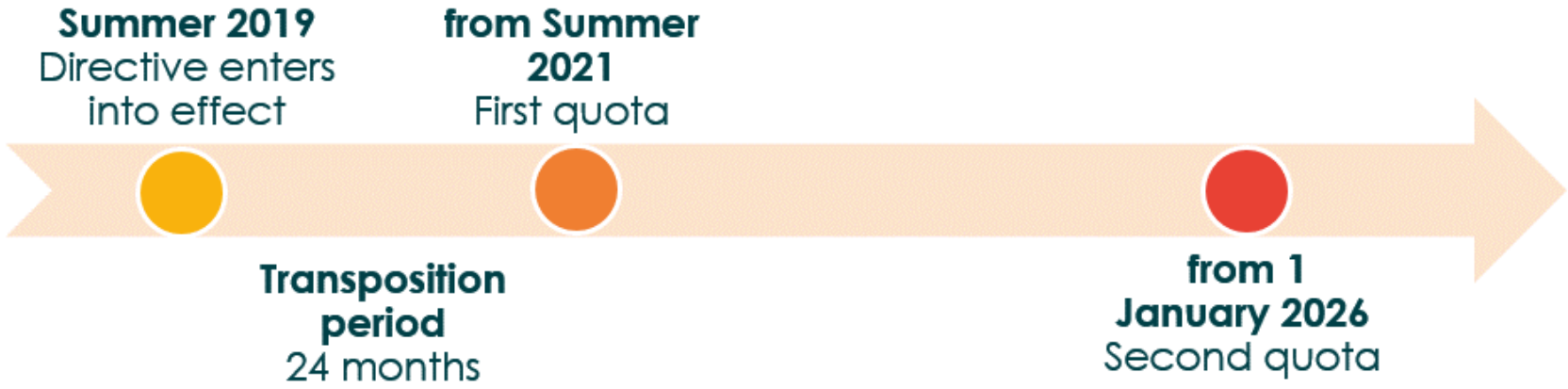
- no quota
- low-emission
- zero-emission

► *Applicable for: LU, SE, DK, DE,* UK*, NL, AT, BE, IT, IE, ES, CY, MT*

► *lower quotas apply for remaining Member States*

Source: Directive (EU) 2019/1161

Accelerated deployment of clean and energy efficient buses



- Challenge for cities, authorities and operators
- Exchange of expertise can facilitate the transition towards clean buses

Source: Directive (EU) 2019/1161

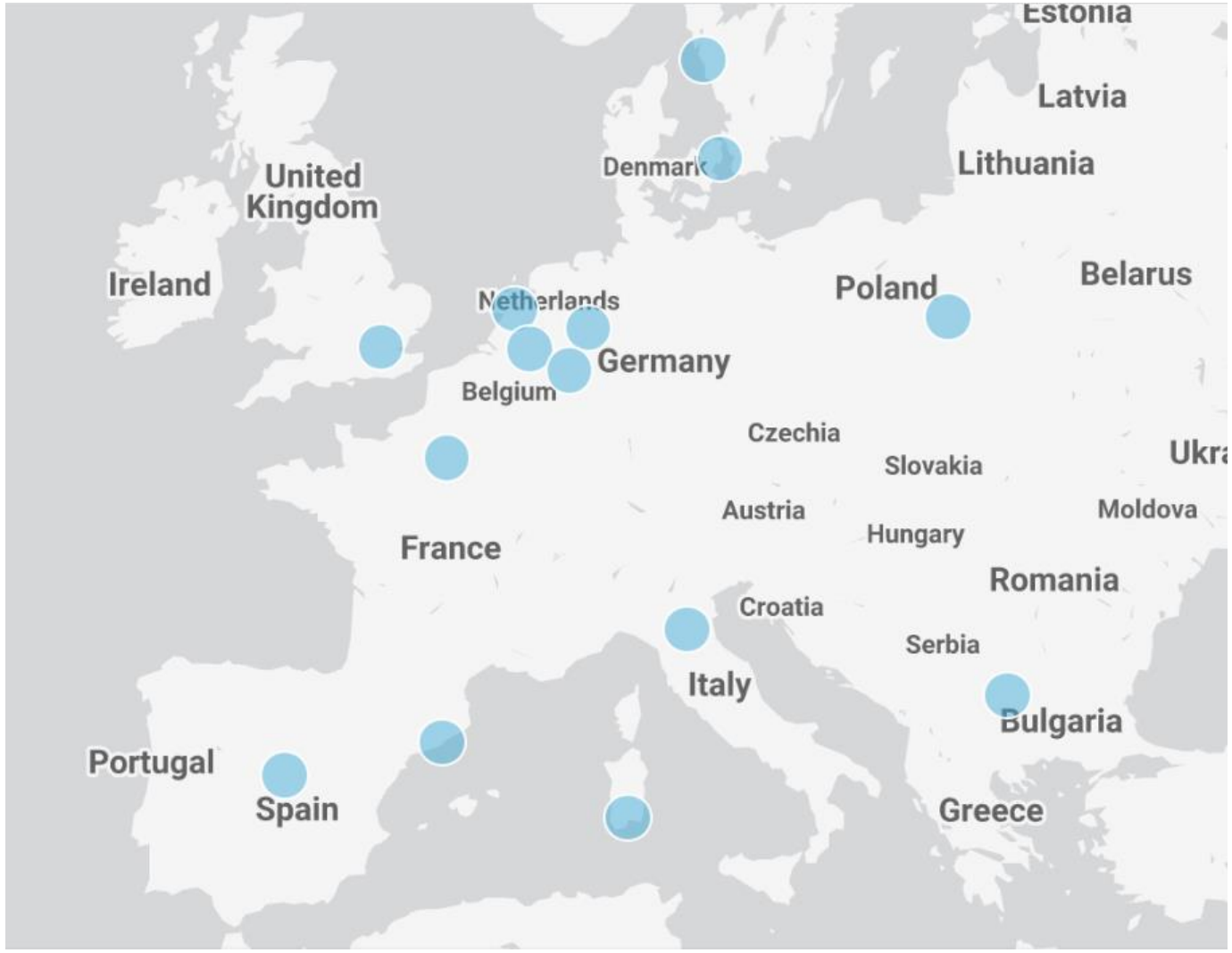
Clean Bus Europe Platform - enabler of large scale deployment

- Policies on decarbonisation & clean bus technologies are driving both market and cities towards clean buses
- Cities have political will, but lack the capabilities and know-how
- Elements for the scale up:
  - Policy framework
  - Financial & funding framework
  - Exchange of best practices and knowledge.
- The Clean Bus Europe Platform is the **strategic line of action** to develop, implement and support the transition towards clean bus fleets.

CBEP composition & goals

- The CBE Platform brings together all stakeholders related to CBD
  - PTOs, PTAs and city authorities
  - UITP bodies: BUS, TBUS, VEI, BHRM, OA
  - Associated Partner: European Transport Workers' Federation
  - Funding/financing institutions
  - Associations
- How?
  - Fostering knowledge & expertise exchange among EU cities
  - Providing **technical support** along deployment process
  - Matching supply & demand, through Industry & Financing Market Places.
- Technologies
  - Battery electric, Plug-in hybrid, **Fuel cells & hydrogen**, Natural gas (CNG, LNG), In-motion-charging trolleybuses (IMC)
- Twining learning cities with more advanced cities

Host Cities



- Gothenburg
- Copenhagen
- London
- Paris
- Amsterdam
- Eindhoven
- Cologne
- Munster
- Madrid
- Barcelona
- Bologna
- Cagliari
- Sofia

Target Cities & Regions

Klagenfurt, Antwerp, **Burgas**, **Sofia**, Koprivnica, Nicosia, Prague, Ostrava, Tallinn, Tartu, Helsinki, Nantes, La Rochelle, Dijon, Rethymno, Budapest, Dublin, Treviso, Riga, Vilnius, Rotterdam, The Hague, Warsaw, Gdynia, Poznan, Coimbra, Caldas da Rainha, Arad, Suceava, Bratislava, Košice, Maribor, Zaragoza, San Sebastian, County of Västmandland, County of Örebro, Jönköping, Tyne and Wear, West Midlands

CBEP Main pillars

Capacity building & knowledge transfer

Technical support & facilitation

Social dialogue on impacts on workforce

Dissemination & Monitoring

Activities, services, products

- Webinars on general & specific aspects of CBD
- Study tours to Host Cities
- Market Places Industry & Financing
- Technical support: meetings with local experts
- Social Dialogue activities
- Market evolution, tenders, orders, deploymt
- Specific products, material, info

Projects in the field of ZEB

- **www.cleanbusplatform.eu**
- **www.assured-project.eu**
- **www.fuelcellbuses.eu**
- www.e-lobster.eu
- www.trolleymotion.eu/trolley2-0
- www.zeeus.eu
- www.ebsf2.eu
- www.eliptic-project.eu

Thank You!

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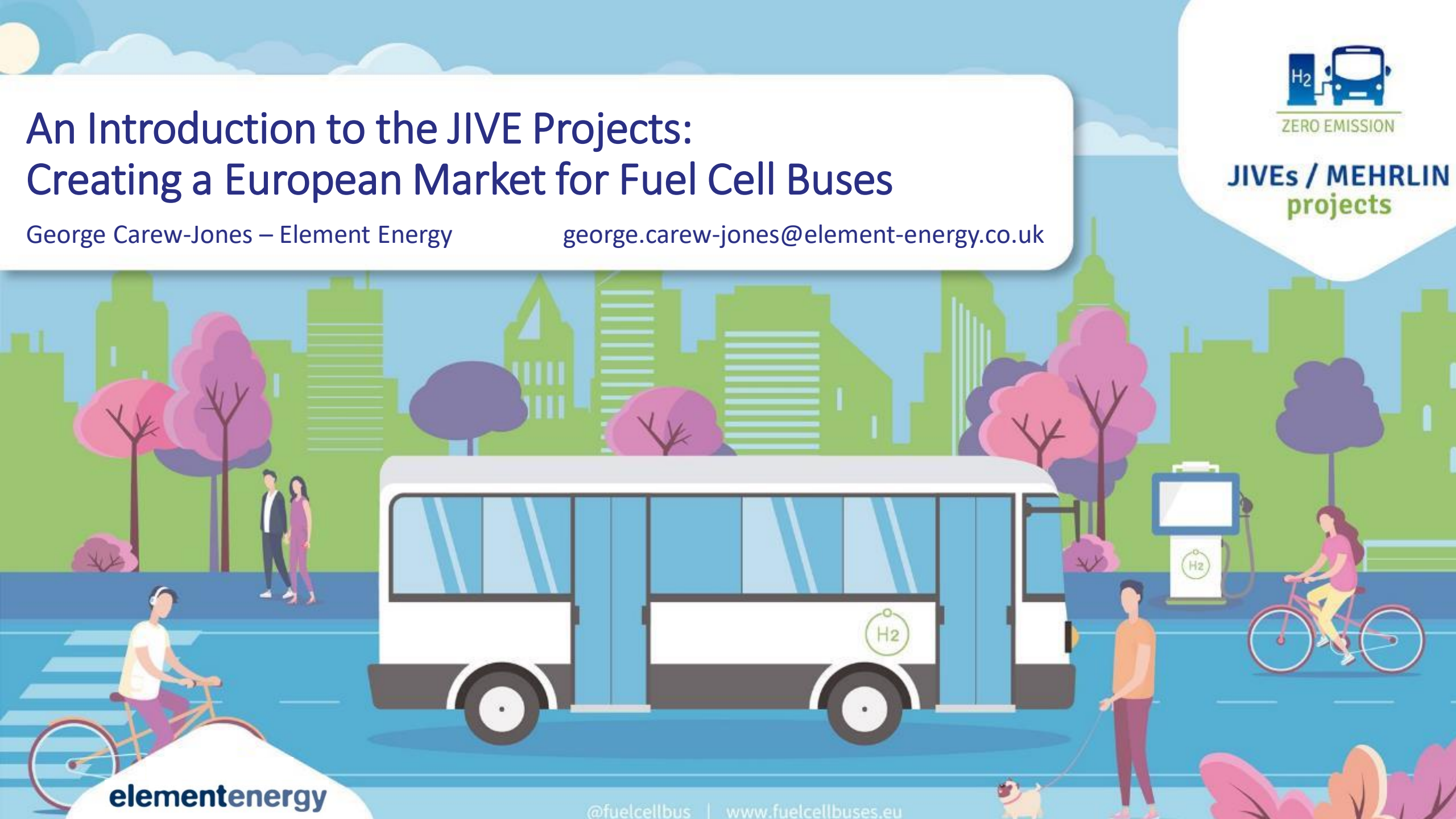
www.cleanbusplatform.eu

An Introduction to the JIVE Projects: Creating a European Market for Fuel Cell Buses

George Carew-Jones – Element Energy george.carew-jones@element-energy.co.uk

ZERO EMISSION

JIVEs / MEHRLIN projects



elementenergy

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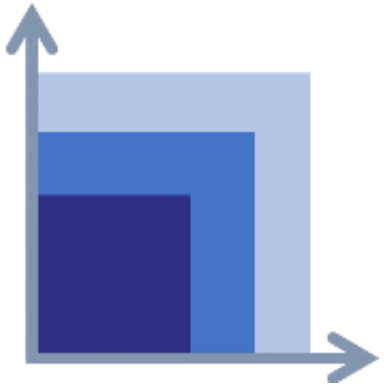
Why go for fuel cell buses?

High daily range

350+ km without refuelling; operating temperature does not affect range

Zero tailpipe emissions

Only water emitted: no air pollutants or CO_2 emissions (zero-CO2 well-to-wheel emissions with renewable H_2)



Scalability

The refuelling infrastructure is easily scaled up to accommodate growing fleets

Operational flexibility

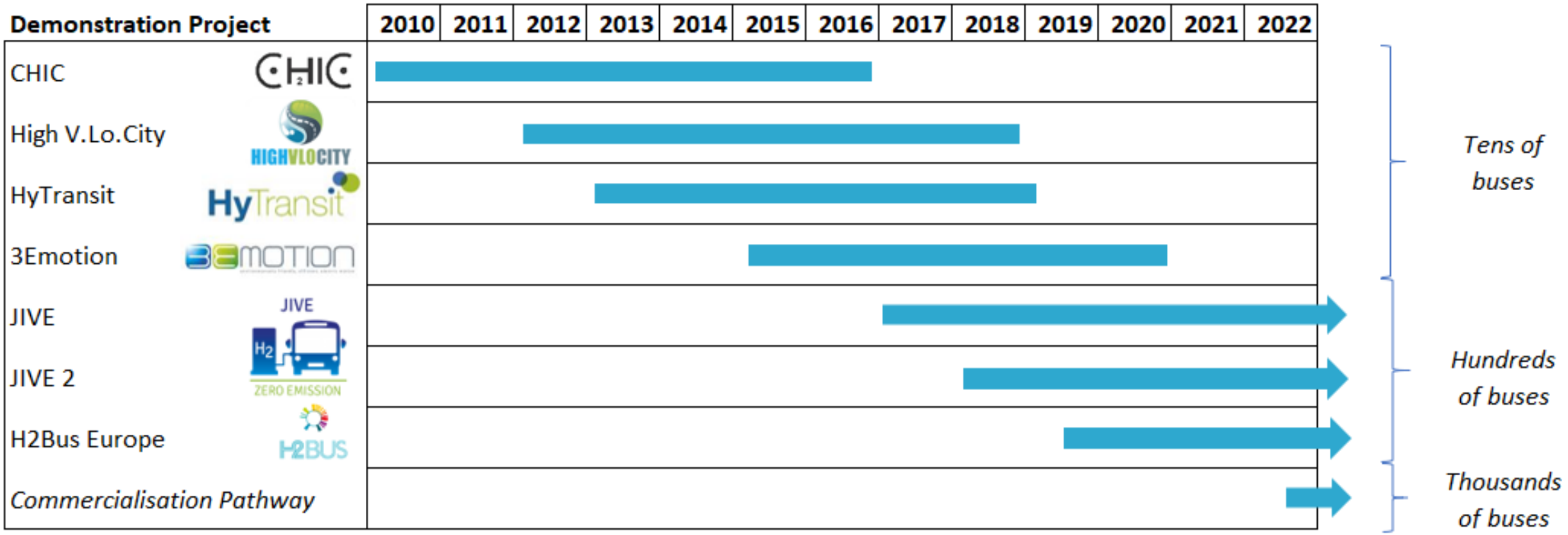
Similar user experience to diesel refuelling (5-10 min. fuel time)

Comfort for passengers and drivers

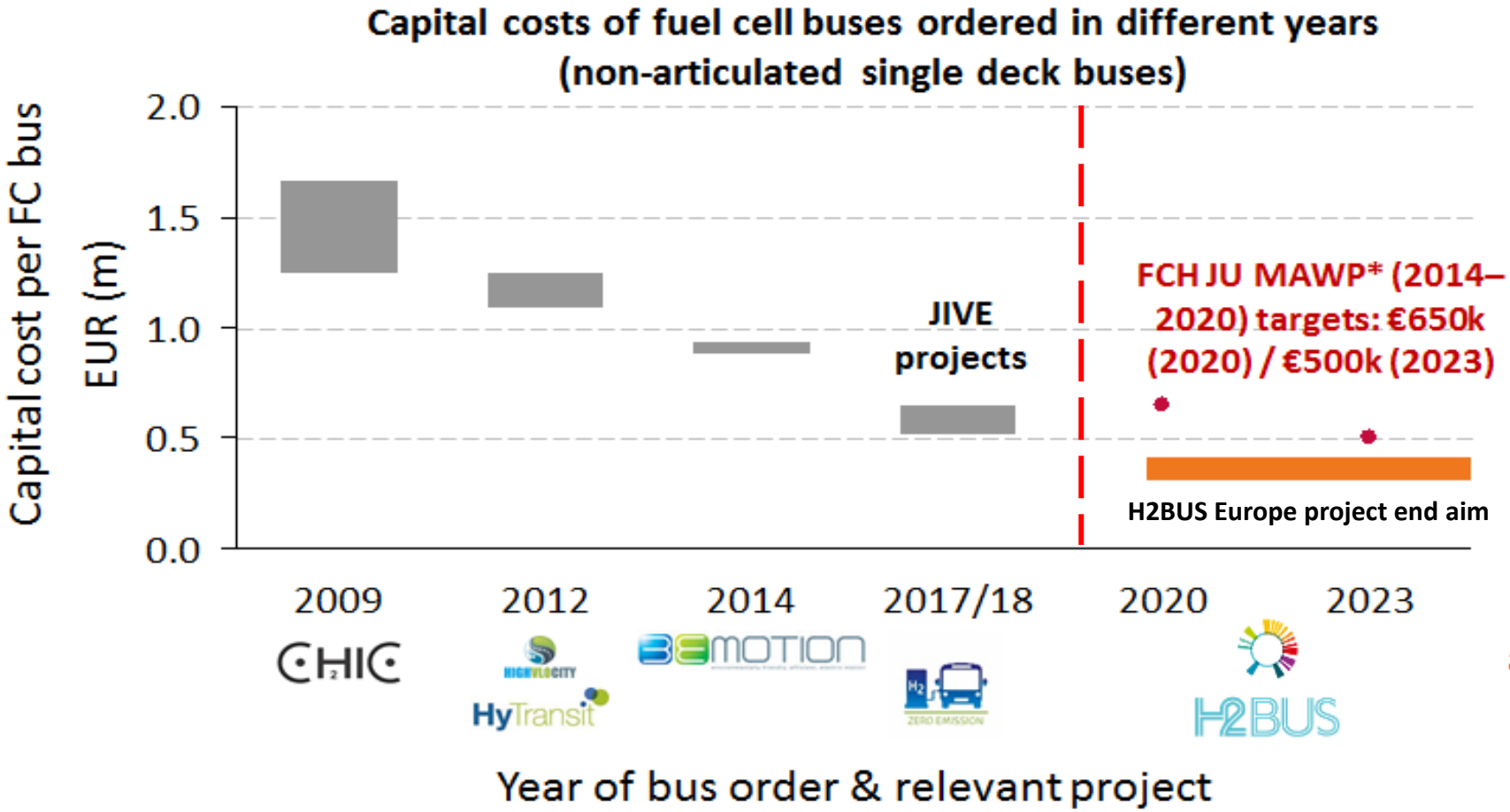
…due to reduced noise levels and a smooth driving experience

A concrete answer to ambitious policy targets set for transport decarbonisation

Fuel Cell Bus Project Context

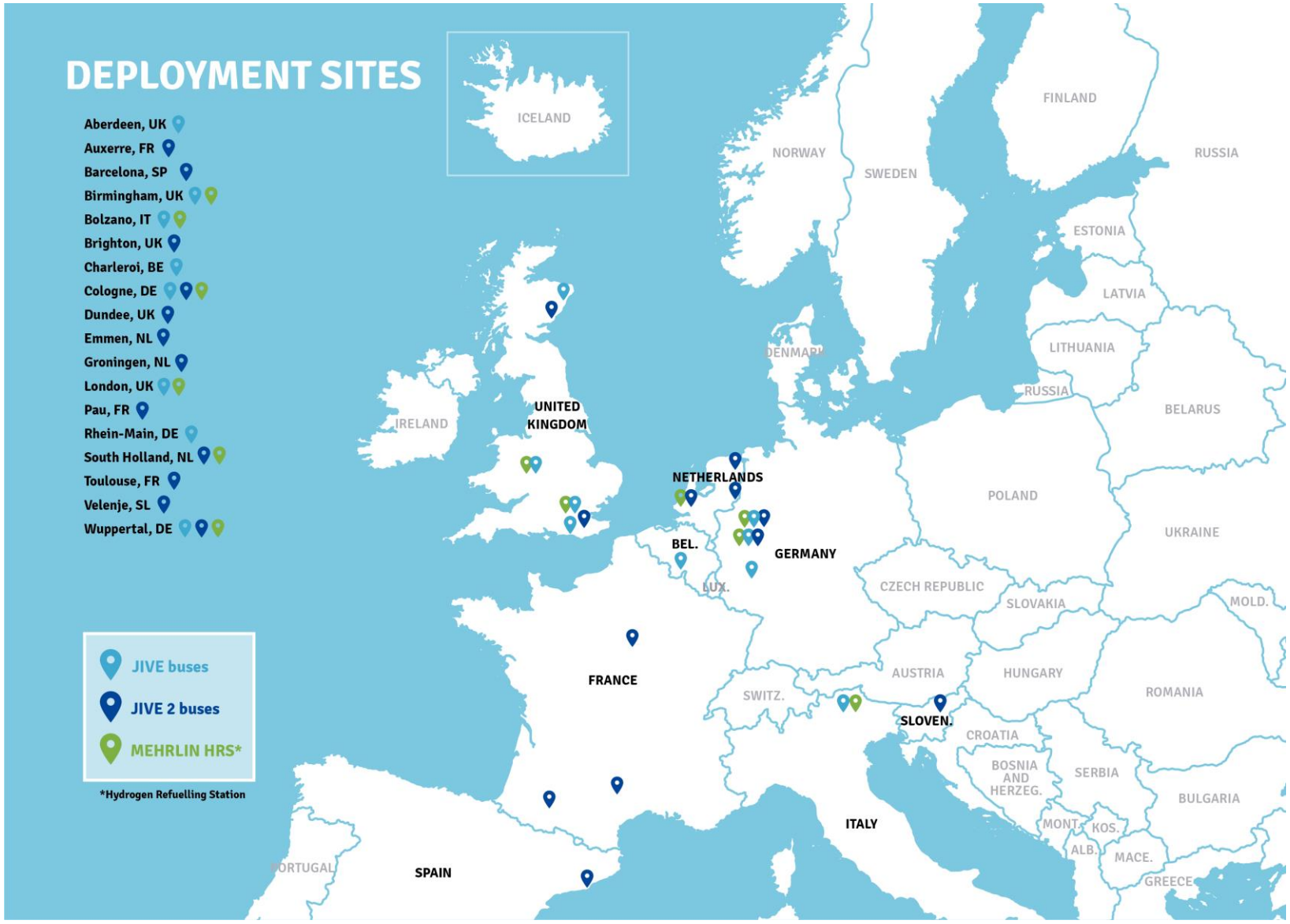


Fuel cell bus commercialisation progress



Range indicated by certain OEMs considering commercial roll-out <€375k per bus, assuming >100 buses per year and continuity of demand

JIVE Projects: Deployment sites and objectives



- **JIVE and JIVE 2 will deploy 294 buses across 20 European cities and regions in 8 countries – the largest deployment attempted to date.**
- A new generation of buses will be trialled at scale in standard operation.
- Demonstrate routes to low cost renewable H_2
- The projects will also **develop pathways for the next phase of deployment** at scale from the next generation of European operators and cities.
- European **funding from the FCH JU for the JIVE projects catalyses private and public investment** on the national and regional level.

JIVE Projects: Current status

- **To date, 14 cities and regions have placed bus orders, from 5 different suppliers. This totals 233 buses**:

Project	City	Country	Number of Buses	Bus Supplier	Size	Decks	Operational Status	Type of H2 Supply
JIVE + JIVE 2	Cologne	Germany	35 + 15	Van Hool + Solaris	12m	Single	100% Operational	Tube trailer – by-product H_2
	Wuppertal		10 + 10	Van Hool + Solaris	12m	Single	100% Operational	Waste-to-energy power – electrolysis
JIVE	Aberdeen	UK	25	Wrightbus	12m	Double	Near operation	Green – on-site electrolysis
	Birmingham		20	Wrightbus	12m	Double	Buses in manufacture	Green – on-site electrolysis
	London		20	Wrightbus	12m	Double	Near operation	Green – on-site electrolysis
	Bolzano	Italy	12	Solaris	12m	Single	Buses in manufacture	Green – on-site electrolysis
	Wiesbaden	Germany	10	Caetano	10.7m	Single	Buses in manufacture	Green – on-site electrolysis
JIVE 2	Auxerre	France	5	Safra	12m	Single	Near operation	Green – on-site electrolysis
	Pau		10	Van Hool	18m	Single	100% Operational	Green – on-site electrolysis
	Toulouse		5	Safra	12m	Single	Near operation	Green – on-site electrolysis
	Emmen	Netherlands	20	Wrightbus	12m	Double	Buses in manufacture	Green – on-site electrolysis
	Groningen		8	Van Hool	18m	Single	Near operation	Green – on-site electrolysis
	South Holland		20	Solaris	12m	Single	Buses in manufacture	Green – on-site electrolysis
	Barcelona	Spain	8	Caetano	10.7m	Single	Buses in manufacture	Green – on-site electrolysis

Fuel cell bus systems: Supply options

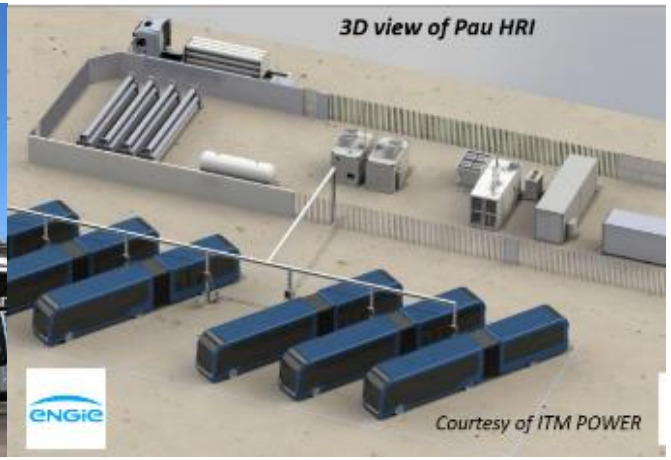
- The two basic elements of a fuel cell bus system are:

1. Fuel cell buses

- Most buses in the JIVE projects are **single deck 12m** buses.
- **18m articulated** buses and **double deck 12m** buses are also options in the market.

2. A hydrogen supply + refuelling station

- This requires a **hydrogen source** (electrolysis/reformation or external delivery); and a **refuelling unit** (a compressor, storage, and dispenser).



Fuel cell bus suppliers in Europe

European bus OEMs with fuel cell buses demonstrators / offering fuel cell buses for sale

ALEXANDER DENNIS

CAETANOBUS

ebe EUROPA

DAIMLER EvoBus

GOLDI MOBILITY

Hy-Hybrid Energy

Optare

rampini

Safra

ŠKODA

SOLARIS

URSUS BUS

VANHOOL

VDL BUS & COACH

WRIGHTBUS

Non-European OEMs active in the fuel cell bus sector

FOTON

YUTONG

TATA

TOYOTA

HYUNDAI

HYZON MOTORS

NEW FLYER

Source: Element Energy (based on public announcements). Note: lists are not exhaustive.

Fuel cell bus suppliers in Europe

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NEW FLYER

Source: Element Energy (based on public announcements). Note: lists are not exhaustive.

Hydrogen Refuelling Station (HRS) suppliers in Europe

- The following **suppliers** are offering HRS solutions to the sites in **JIVE / JIVE2**:

- Different suppliers have **experience with different solutions** (e.g. onsite green hydrogen provision vs. trucked-in hydrogen vs tube trailer).
- However, all European HRS OEMs are **growing their expertise through JIVE and other projects**, and are increasingly making competitive offers for infrastructure supply.

Fuel cell buses: What's next?

- **Demonstrable results from JIVE**: information on total cost of ownership (incl. variability), technology reliability.

- Responses from the **supply side**: new model options (18m, coaches); scaled multi-use infrastructure. This will help to overcome **existing challenges** (eg. high H_2 price).

- **Scaled systems**: individual city fleets of 100+ buses, and 1000s buses/year being manufactured.

- Value added from **integrated hydrogen energy systems**: reinforcing the additional benefits of hydrogen through the use of buses.

Thank you for your attention

Project coordination:

elementenergy

Project dissemination:

Hydrogen Europe

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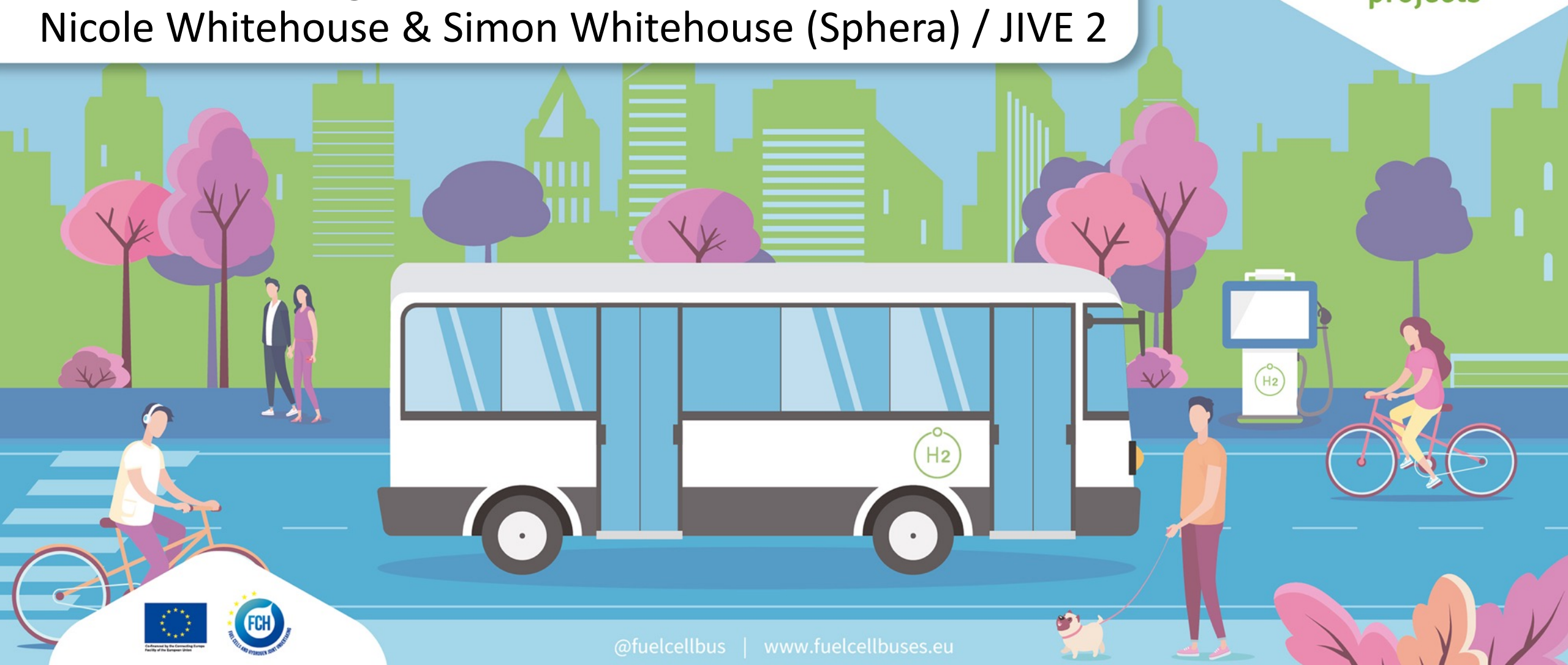
Best Practice Reporting in JIVE and JIVE 2

Klaus Stolzenburg (PLANET) / JIVE
Nicole Whitehouse & Simon Whitehouse (Sphera) / JIVE 2

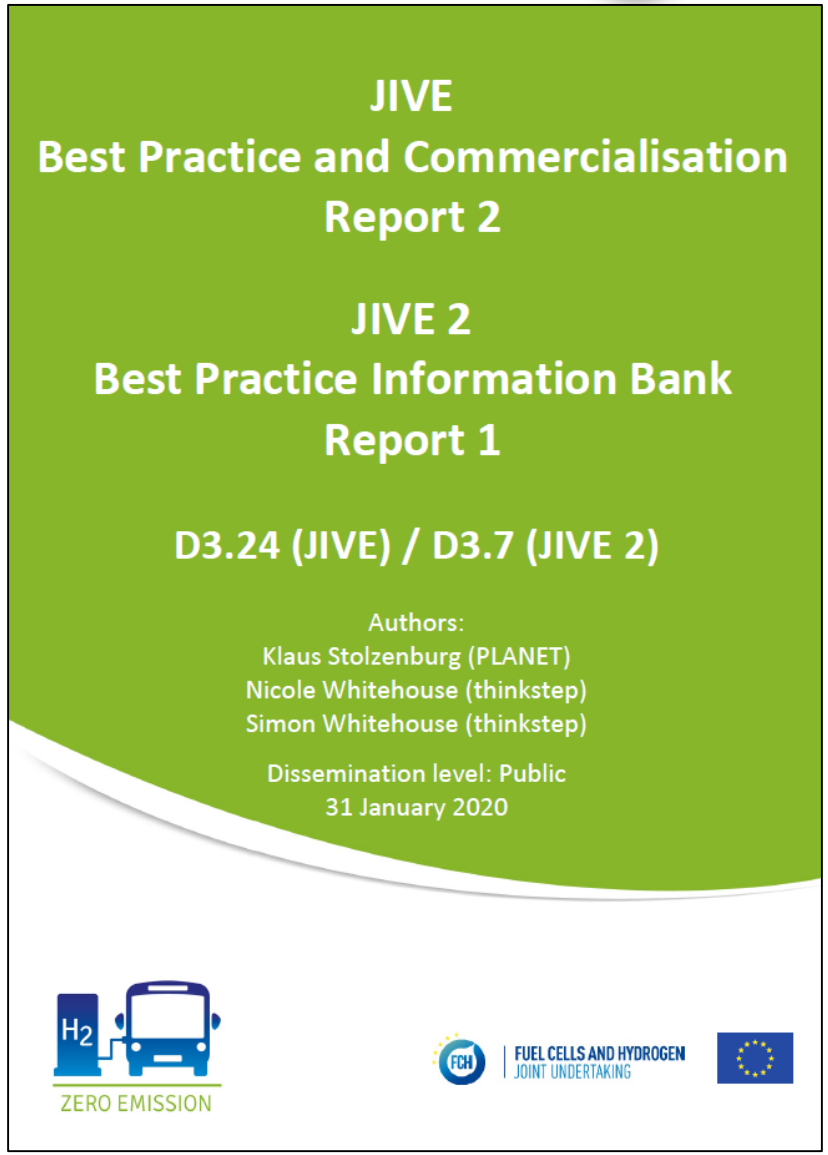
ZERO EMISSION

JIVEs / MEHRLIN projects



Overview

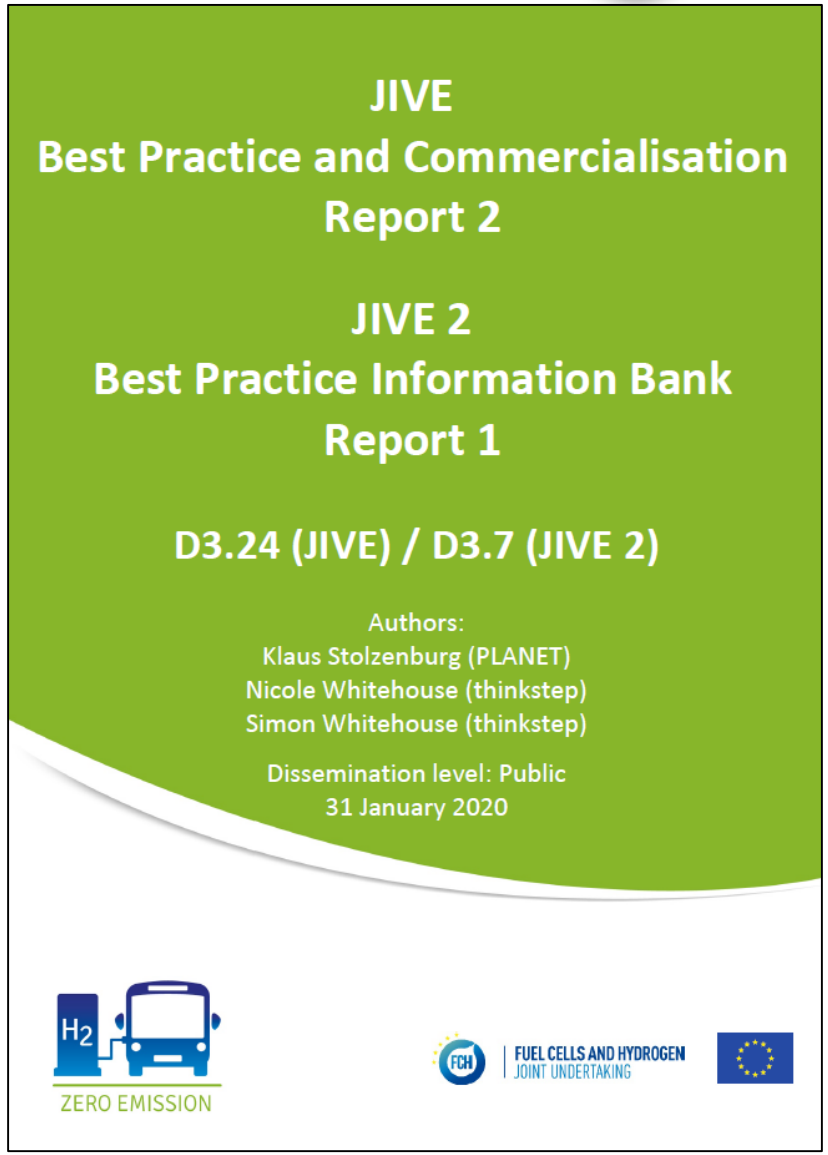
- Scope of the Work and Approach
- Project Stages / Report Structure
- Key Report Elements
- Key Fact and Close



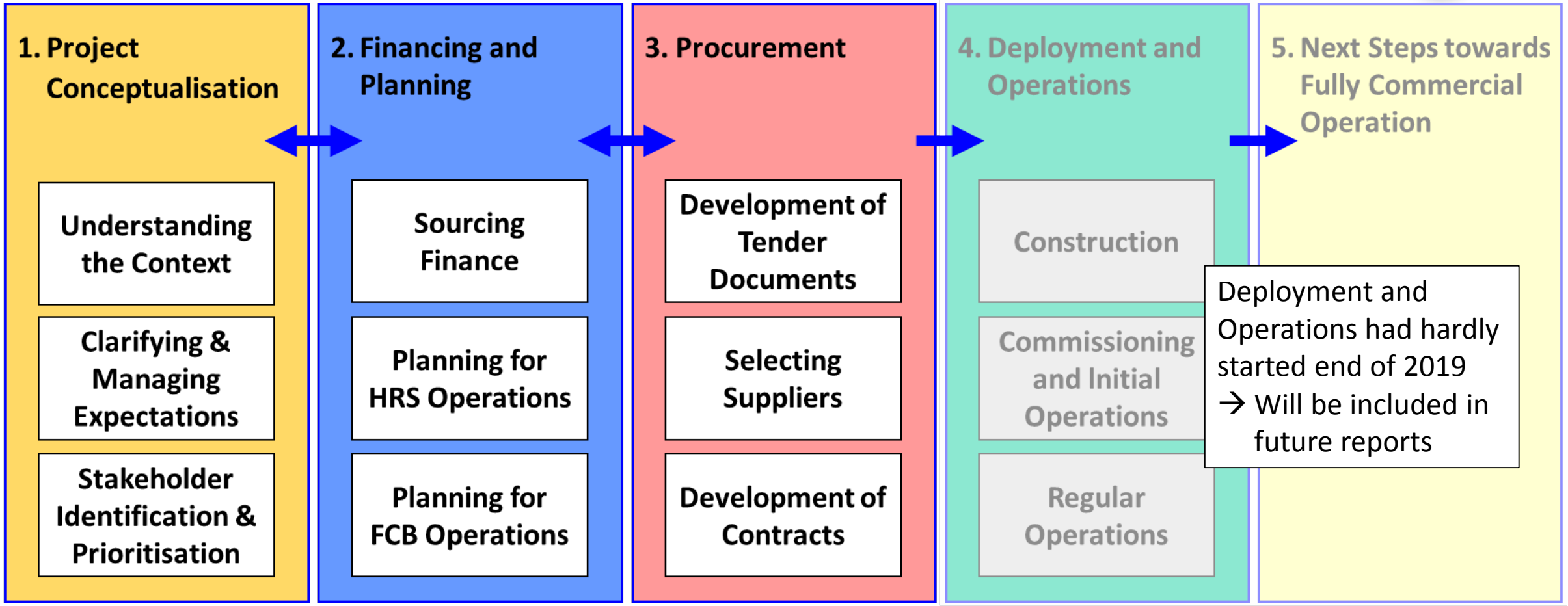
Scope of the Work and Approach

- Monitoring and analysis activities of JIVE / JIVE 2 include capturing Challenges and Best Practice solutions
  - ➢ Sites coordinators provide input on the local project progress, via questionnaires
  - ➢ Supplemented by interviews, site visits etc.
- Two dimensions
  - ➢ Internal: Feedback from the sites compiled, presented and discussed in regular project meetings
  - ➢ External: Joint public reports, in 2020, 2022 and 2024
- Big THANK YOU

  to all project partners for their input and support!



Project Stages / Report Structure



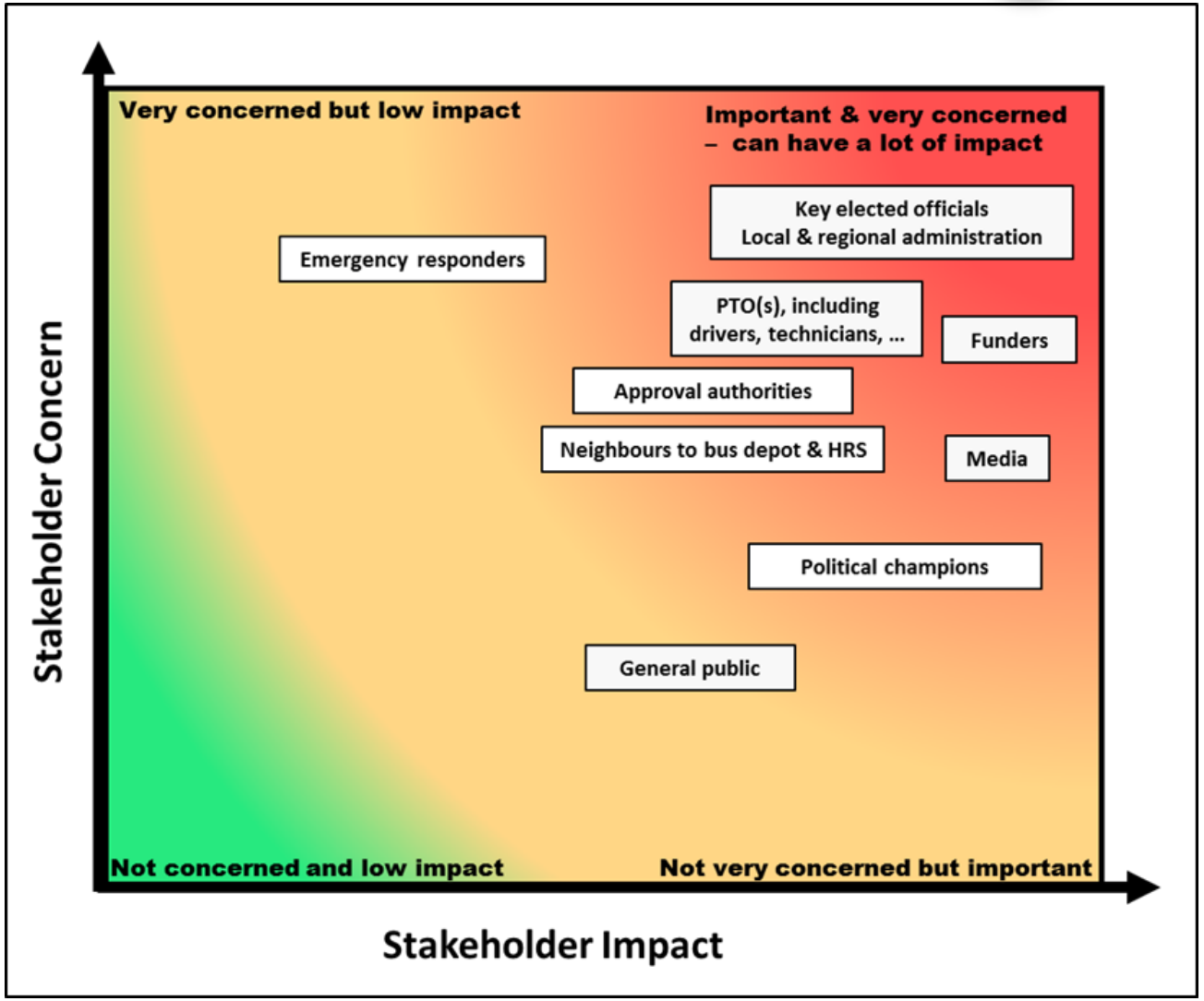
Key Report Elements: Tables

- One chapter per Project Stage
  - ➢ Condensed information in Tables (sample on financing below), with supporting text

Challenges	Best Practice Solutions
Level and complexity of costing: • Uncertainties around pricing of FCBs, HRSs, and H_2 fuel • Demand for FCBs is currently higher than supply, so the industry competition is immature • Inexperience with costing CAPEX and calculating revenue in short term (demonstration) projects • Inexperience and complexities of costing OPEX • Costing uncertainty is compounded by multiple options for H2 fuel supply **Lack of Information:** • Not enough general experience to be confident about bus performance in	• Build a draft but comprehensive business case from day one; then refine it as your project progresses, thereby improving accuracy • Learn from other cities with experience; some will be willing to provide sample specification information and provide figures from their operations **CAPEX:** • Consider procuring jointly with other sites to get better prices for the FCBs through higher volume (see Chapter 3). This can work, provided the sites have similar requirements and specifications, and similar regulatory structures • Consider including preventative maintenance costs in the capital costs of the buses to reduce the operating costs, which are a key consideration for any operator **OPEX:** • H_2 pricing can be difficult. A lower price can be achieved if a minimum purchase quantity is guaranteed to the supplier and the contract is lengthy and offers break clauses (ability to stop the contract at defined points in the future) • Seek to define Green H_2 and be aware that sources can be limited (for information on H_2 supply and

Key Report Elements: Stakeholder Focus

- One chapter per Project Stage
  - Condensed information in Tables
  - Links to Further Resources
  - Stakeholder Focus (sample chart on the right)



Key Report Elements: Case Study and Issues to be Addressed

- One chapter per Project Stage
  - ➢ Condensed information in Tables
  - ➢ Links to Further Resources
  - ➢ Stakeholder Focus
- Chapter with Case Study
  "in a perfect world",
  taken up as a Knowledge Brief by UITP,
  translated into eight European languages
- Chapter "Issues to be Addressed to Support Future FCB Deployment"

ADVANCING PUBLIC TRANSPORT

ZERO EMISSION

VIDENSBRIEF

BRÆNDSELSCELLEBUSSER:
BEDSTE PRAKSIS OG KOMMERCIALISERINGSMETODER

JULI | 2020

INTRODUKTION

Med det stigende pres på bymyndighederne for at arbejde hen imod Paris-aftalens mål og tackle luftforurening er brændselscellebusser (fuel cell buses FCB) en af de få nulemissionstransportløsninger. FCB'er har været under udvikling i nogle år og har vundet popularitet lige siden på grund af de korte tankningstider og den lange rækkevidde af køretøjerne, er FCB'er en levedygtig mulighed for dekarbonisering af offentlige transportnet.

Det fælles initiativ for brintbiler i hele Europa-programmet, kendt som JIVE og JIVE 2-projekterne finansieres sammen med MEHRLIN-projektet af EU og introducerer nye flåder af FCB'er og tilhørende infrastruktur for brændstofpåfyldning i byer og regioner i hele Europa. UITP er en partner i disse projekter. Denne vidensbrief gengiver et fiktivt casestudie[1] fra JIVE- og JIVE 2-rapporten for bedste praksis 2020, der giver en redegørelse for, hvordan en ny anvender muligvis kan gå til veje med at integrere en flåde af FCB'er. Formålet med denne brief er at give læserne en bedre forståelse af processen ved hjælp af en gennemgangstilgang fra start til slut og identificering af bedste praksis undervejs. For mere faktuel og teknologisk information kan du tjekke den fulde projektrapport[2].

OM JIVE OG JIVE 2

Det underliggende mål med JIVE- og JIVE 2-projekterne er at understøtte overgangen til, at FCB'er bliver et mere mainstream valg for offentlige transportmyndigheder og operatører i hele Europa. Derfor fokuserer JIVE og JIVE 2-projekterne på at forberede markedet til udrulning af FCB'er i større skala. Dette indebærer at tackle flere fremragende udfordringer for sektoren, såsom at reducere omkostningerne til køretøjsejerskab, øge valget af brændselscellebusmodeller og bevise muligheden for at betjene store flåder af brændselscellebusser.

Som den næste fase i FCB-overgangen distribuerer JIVE- og JIVE 2-projekterne omkring 290 nye busser, der bliver kørt i længere perioder i kommercielle standardoperationer på adskillige forskellige steder. Den overordnede vision er at bane vejen for fuld kommercia-

ZERO EMISSION

DOCUMENTO INFORMATIVO

US A CELLE A
MBUSTIBILE:
E E APPROCCI DI
RCIALIZZAZIONE

LUGLIO | 2020

imento di idrogeno nelle città e nelle regioni ta Europa. UITP è partner di questi progetti. sente documento informativo riporta un caso 'fittizio tratto dal Rapporto sulle Best Practice di JIVE e JIVE 2. Il suddetto rapporto fornisce panoramica su come un nuovo utilizzatore bbe integrare una flotta di FCB. Mediante proccio dettagliato e l'identificazione di "best ce", i lettori saranno accompagnati verso la rensione del processo. Per ulteriori informazioni he e tecniche, è possibile consultare il rapporto eto sul progetto[2].

OPOSITO DI JIVE E JIVE 2

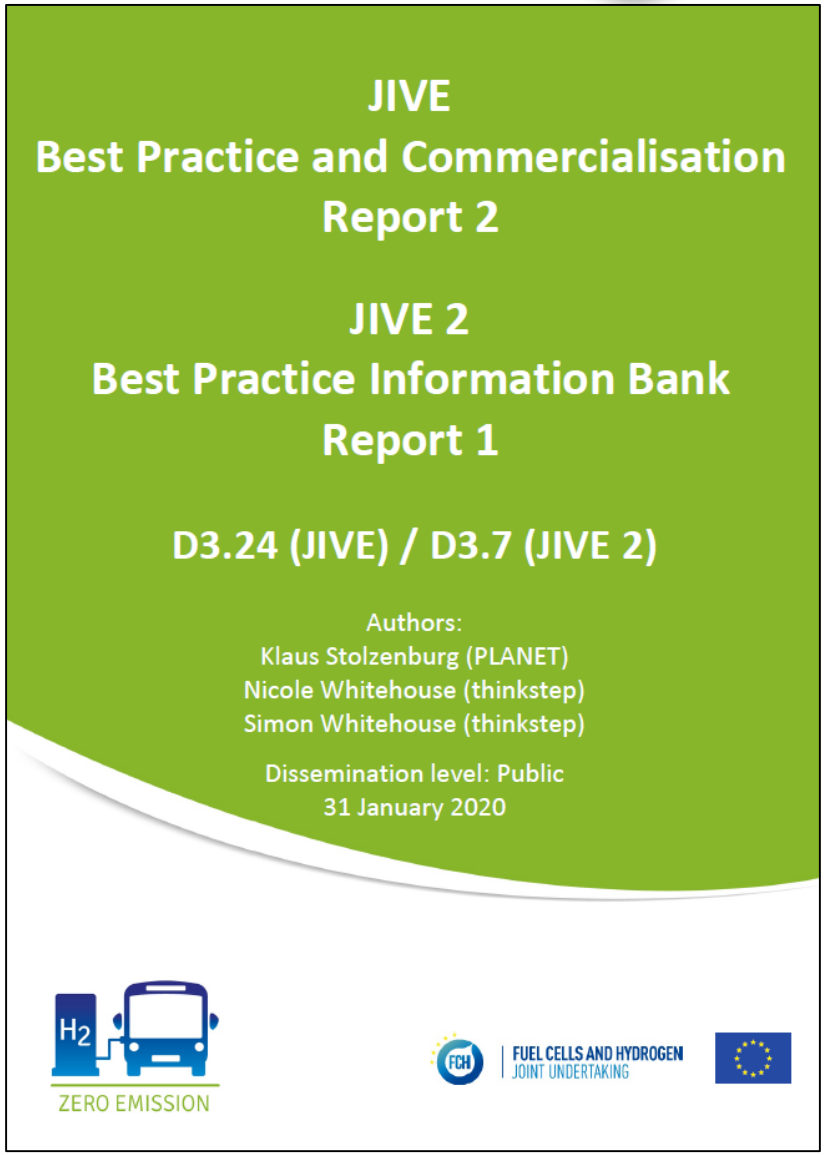
tivo di base dei progetti JIVE e JIVE 2 è quello muovere la diffusione degli FCB come scelta più nzionale per le autorità e gli operatori del trasporto o di tutta Europa. Per raggiungere questo obiettivo, tti JIVE e JIVE 2 si concentrano sullo studio e la azione del mercato per l'introduzione su larga scala FCB. Ciò permetterà' di rispondere in maniera le ed efficiente a diverse sfide in sospeso per il , come ad esempio la riduzione dei costi per il so dei veicoli, l'incentivazione all;utilizzo di modelli obus a idrogeno e la dimostrazione pratica della ta' e della convenienza che comporta la scelta di

Finally …

- Overall key fact is:
  - There is no recipe, no “one fits all”!
    This report and other documents can only provide guidelines to set up and deploy your own regional Fuel Cell Bus project

- Full Report and translated Case Study available here:
  - https://fuelcellbuses.eu/public-transport-hydrogen/best-practice-report-january-2020
  - https://www.uitp.org/publications/fuel-cell-buses-best-practices-and-commercialisation-approaches/

- Next full report in early 2022,
  but interim update to come sooner!



Thank you for your attention

Project coordination:

elementenergy

Project dissemination:

Hydrogen Europe

The JIVE and JIVE2 projects have received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 735582 and 779563.

This Joint Undertaking receives support from the **European Union's Horizon 2020** research and innovation programme, Hydrogen Europe and Hydrogen Europe Research. The **MEHRLIN** project is co-financed by the **European Union's Connecting Europe Facility.**

@fuelcellbus
www.fuelcellbuses.eu

Co-financed by the Connecting Europe Facility of the European Union

FCH
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

UITP ADVANCING PUBLIC TRANSPORT

Regionalverkehr Köln GmbH

Wir bewegen die Region

Cologne Experience of Planning and Procurement of a FCEB and HRS Project

JIVE

H_2

ZERO EMISSION

Marcel Corneille, Managing Director EMCEL

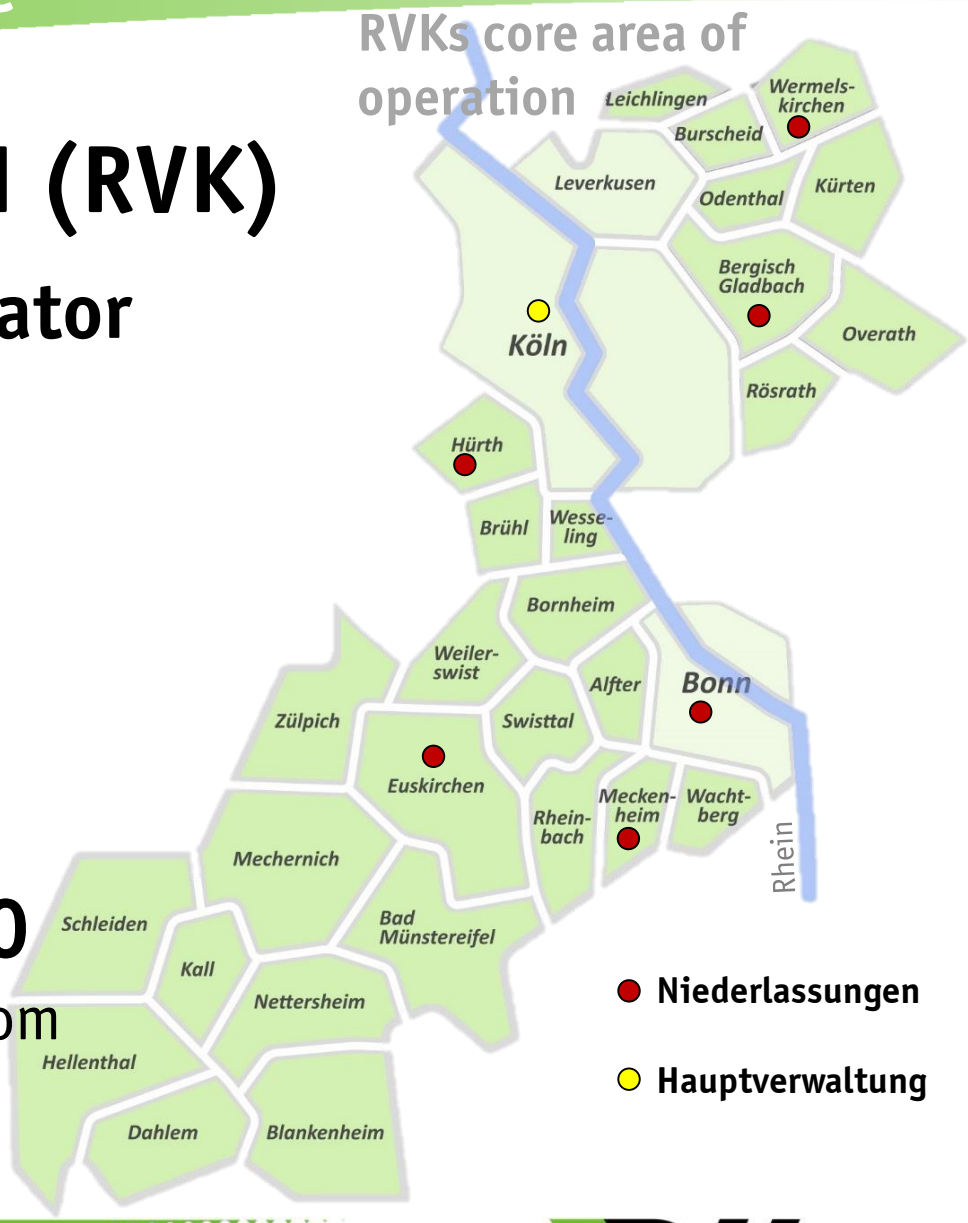
Jens Conrad, Project manager RVK

Online Training, 3rd November 2020

Regionalverkehr Köln GmbH (RVK)

Regional public transport operator

- Approx. **830** employees
- Area covered: approx. **2.800** km²; more than **2,3** mio. inhabitants
- Buses in daily operation: approx. **450** (**300** RVK owned buses plus approx. 150 buses from subcontractors)



Experience of RVK with deployment of FC buses

Fuel cell buses in service since 2011

From prototype…

…to pre- serial production

…to serial production!

2011 – 2016

2014 – (at least) 2024

2020 – ongoing

Expansion of FC bus fleet

50 Fuel cell electric buses

2 H_2-refueling stations

for the Cologne Region

JIVE
ZERO EMISSION

This project has received funding from the Fuel Cell and Hydrogen 2 Joint Undertaking under grant agreement No 735582. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research.

Gefördert durch: Bundesministerium für Verkehr und digitale Infrastruktur
Koordiniert durch: NOW, PTJ Projektträger Jülich Forschungszentrum Jülich

Expansion of FC bus fleet

Delivery of **35** fuell cell buses complete

10 buses in service since January 2020, **25** buses since October 2020

Delivery of additional **15** buses starting in early 2021

This project has received funding from the Fuel Cell and Hydrogen 2 Joint Undertaking under grant agreement No 735582. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research.

Gefördert durch: Bundesministerium für Verkehr und digitale Infrastruktur

Koordiniert durch: NOW, PtJ Projektträger Jülich Forschungszentrum Jülich

Establishing a network of H_2-refueling stations

1 x H_2 for 20

1 x H_2 for 20

for 5

Wir bewegen die Region

Regionalverkehr Köln GmbH

Bildquelle: RVK

Fuel Cell Buses in Europe

Funding Projects on EU-Level
(selection)

CHIC
- 2010 – 2016
- **34** Fuel cell buses

HIGH V.LO-CITY
- 2012 – 2019
- **14** Fuel cell buses

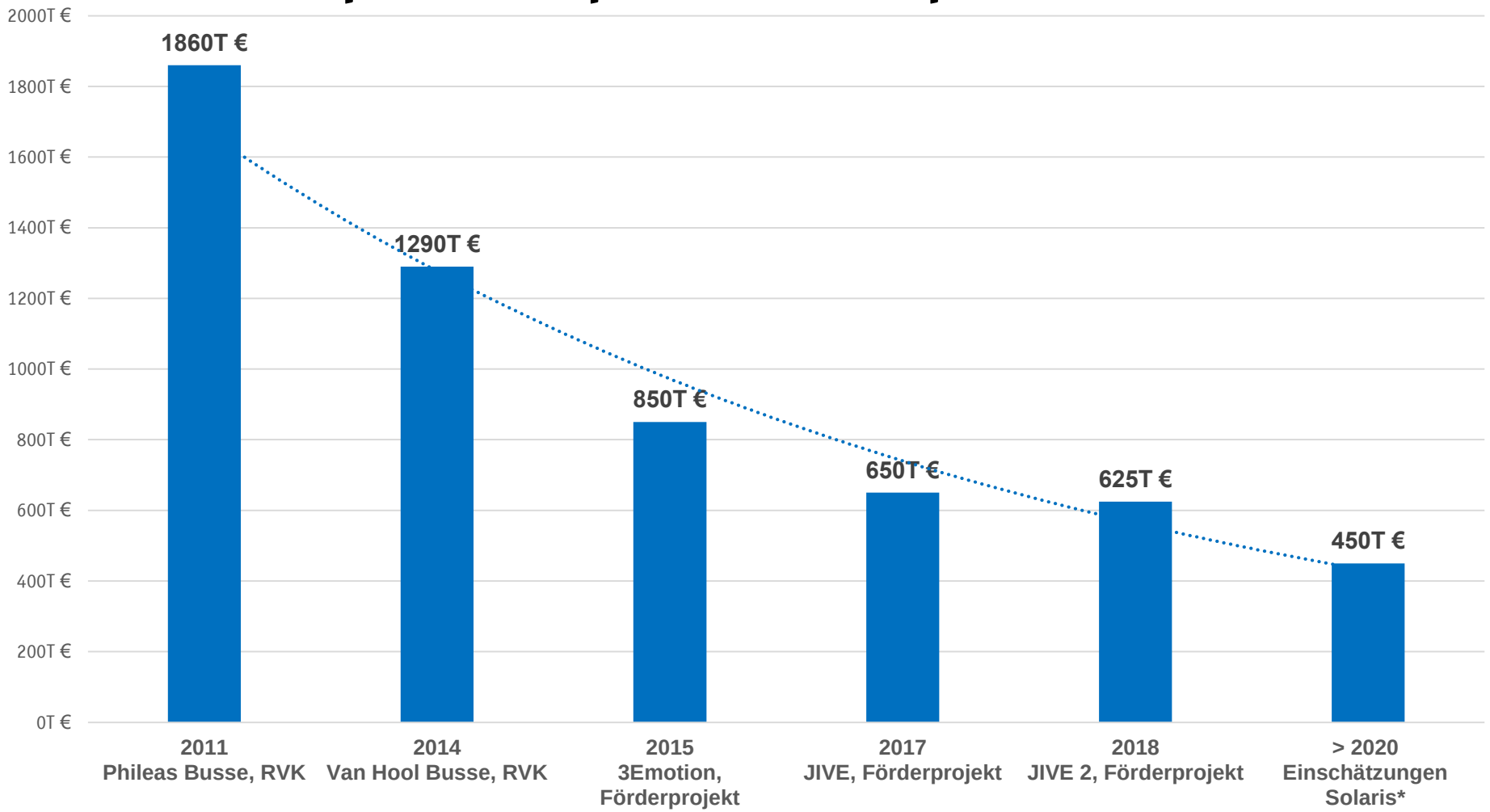
3 MOTION
- 2015 - 2022
- **29** Fuel cell buses

JIVE/JIVE 2
- 2017 - 2020
- **291** Fuel cell buses

This project has received funding from the Fuel Cell and Hydrogen 2 Joint Undertaking under grant agreement No 735582. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research.

Prices of FC buses

Development of procurement prices for FC buses

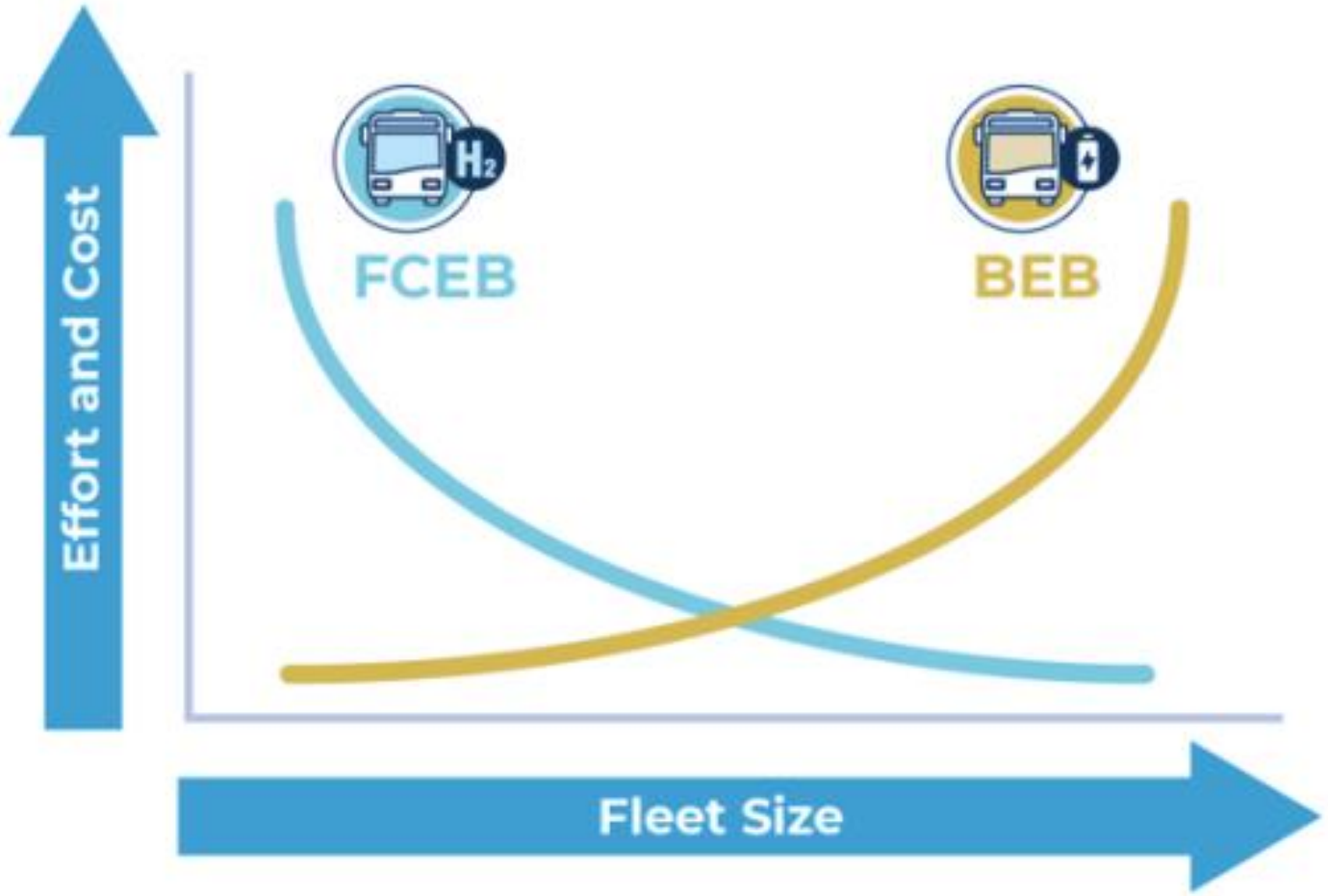


Regionalverkehr Köln GmbH

Quelle: RVK basierend u. a. auf SOLARIS, BALLARD, NEL (2017): White Paper im Zuge FCB CPH17, S. 14

Cost H_2-Infrastructur

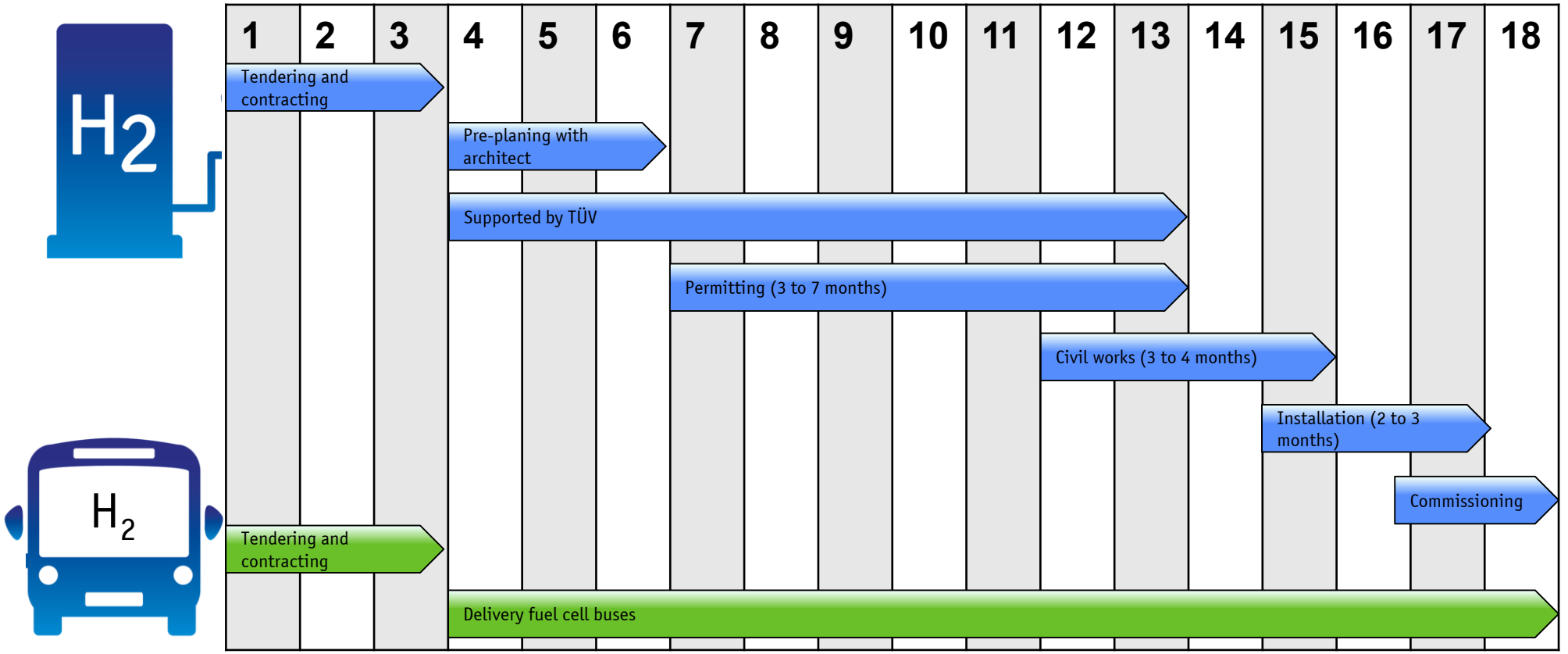
Dependency cost infrastructure and fleet size



Quelle: RAUDBAUGH, D. (2018), Center for Transportation and Environment (CTE)

Timing is everything

Timeframe



Recomendations

 # Don‘t make things to complicated

 # Learn from existing experience [https://www.fuelcellbuses.eu/]

 # Find (local) partners

 # try to avoid prototypes

 # approach the market with a RFI before tendering

Image source: https://blog.accepted.com/letter-recommendations-10-tips-for-recommenders/

EMCEL

Engineering Company for Fuel Cell,
Hydrogen Technology and Electric Mobility

Strategies for FCEB and HRI Projects

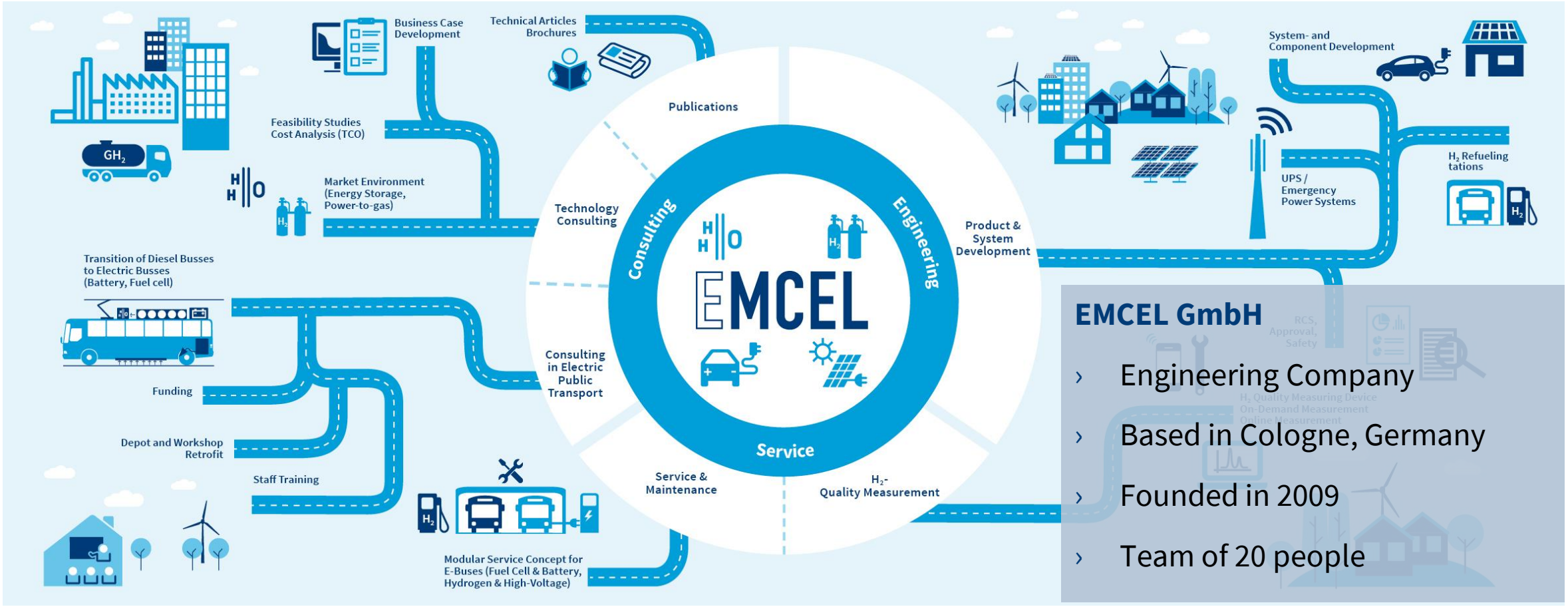
Lessons learned

Marcel Corneille

Cologne | 03. November 2020

Content

About EMCEL

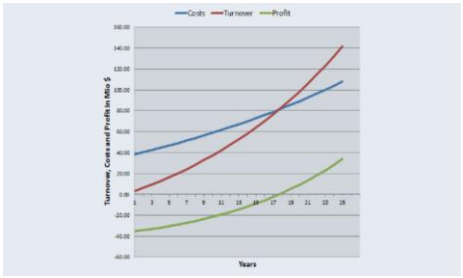


EMCEL GmbH

- Engineering Company
- Based in Cologne, Germany
- Founded in 2009
- Team of 20 people

About EMCEL

Consulting



E-Public-Transport-Fleet transition

- Feasibility Studies
- Fleet analysis
- Cost analysis

Engineering

- Product development
- HRS and charging infrastructure
- Safety / Certification

Service

- Maintenance for batteries and fuel cell buses
- Training

1. Hydrogen Refueling Infrastructure – 3 times 2 setups

EMCEL

3 different build-up and operator choices

- Do it yourself
  - Pro: full influence on design, build-up and tendering process
- Operator (H2 by kg)
  - Pro: little workload / one-time event
- General contractor (build and/or operate)
  - Pro: Contractual obligations advantages compared to operator model, funding conditions might be better

2 different Location options

- Own property / depot
  - Pro: known procedures (like diesel operation, indoor fueling etc.)
- Public road / next to field of operation
  - Pro: cost sharing for small projects

1. Hydrogen Refueling Infrastructure – RVK Case

EMCEL

RVK uses:

- 4 different Hydrogen refueling stations
- 3 different set-ups

Why?

- Market for operator and contractor sulutions rarely developed at that time (changed during the very last few years)
- Today contractor solutions on own property would be an ideal solution for RVK (see **X**)

	Own Property	Public
DIY	**2**	
Operator		**1**
Contractor	**X**	**1**

1. Hydrogen Refueling Infrastructure – in general

Lessons learned

- HRI designs vary from manufacturer to manufacturer
  (functional tendering / HRI description recommended)
- 25 kgH2/bus/day good first estimation
- Keep known procedures – cost reduction
  (like diesel operation, car wash, indoor fueling, etc.)

2. Depot Adaptation

First of all

- We talk about series-production vehicles
- Gas system of FCEB needs to be technically tight (Manufacturer needs to confirm)
- Standard risk assessment should be carried out (like for any other vehicle or machinery)

Two subjects are important

- Workshop
- Vehicle parking

2. Depot Adaptation - Workshop

4 types of work carried out

- Conventional vehicle
  (bodywork, 24 V system, cleaning etc.)
- Small amount of H2 could accidently be released
  (e.g. fuel cell system maintenance)
- Larger amounts of H2 could accidently be released
  (e.g. H2 storage system)
- FCEB operated in workshop

Lessons learned

- Safety first
- And safe solutions do not need to be expensive
- Look for support when doing the risk assessment for the workshop
- Supply chain / spare parts need to be available
  (a cost effective solution should be found together with OEM)

2. Depot Adaptation – Vehicle Parking

2 types of parking

- Standard overnight parking

- Unknown vehicle status
  (e.g. after road accident)

Lessons learned

- Out- and indoor parking is possible
  (follow your standard (diesel) procedure)
- Overnight heating of fuel-cells for new buses
  (probably) not required anymore

- Point out quarantine location
  (standard risk passement should point out how to handle (all kinds of) buses in unknown statuses – e.g. after accidents)

3. Training

Two subjects are important

- High Voltage
- Hydrogen

Lessons learned

- As Hydrogen Refueling Infrastructure and Depot Adaptation Training (for HV and H2) is important
- During the last few years good trainings are offered by various training providers
- But it is the least difficult subject for PTO/PTA to organise a good training (compared to HRI and Depot Adaptation)

4. Summary – Q&A

Lessons learned

- Safety first
  (and safe solutions do not need to be expensive)
- DIY? - Partners / operators for HRI are very helpful
- Today FCEB operate (almost) as reliably as diesel buses
- FCEB fleet operation is as “easy” as diesel bus fleet operation – it is just new

EMCEL

Engineering Company for Fuel Cell,
Hydrogen Technology and Electric Mobility

Thank you for your attention

… for your successful energy transition!

Marcel Corneille
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Operating FCEBs -Returns on Experience

JIVE/UITP Training

Mélanie Pédeutour
Project Manager
m.pedeutour@agglo-pau.fr

A project co-funded by under the Grant Agreements Numbers 735582 and 779563

Pau Electromobility project

ZERO EMISSION

PAU BÉARN PYRÉNÉES MOBILITÉS

Provide environmentally friendly mobility solution
by deploying 8 FCB along its major and brand-new bus route.

SMTU of Pau Pyrénées:

- Transport authority
- Representing 37 municipalities (182K inhabitants)
- Delegation of public service to SPL-STAP

The bus network "IDELIS" operated by SPL-STAP :

- 23 regular lines and 60 school lines
- 106 Bus:
  - 97 standard (12m length),
  - 4 electric minibus,
  - 4 minibus for disabled.
- 8,5 M travelers/year
- 323 employees including 246 drivers

A New BRT route: vector of urban & social development

ZERO EMISSION

- Deploy 8 FCB into the main corridor for the use of public transport
- From the Hospital in the North to the railway station in the south

Characteristics :

- 14 bus stops
- Commercial length : 6 km
- Dedicated buslane : 5,1 km (80%)
- Frequency: 7 to 10 minutes
- Travel time: 17 minutes
- Amplitude from 5:30 am to midnight
- Commercial Speed: 21 km/h

A major project with high impact for Pau:

- Provide an efficient and sustainable public transport network
- Link the main poles of the territory
- Enhance urban development
- Support and stimulate public and private investments
- Increase the attractiveness of the agglomeration
- Participate in developing "Pau 2030“
- Investment: 60 M€ HT

Travel along the Bus route
https://www.youtube.com/watch?v=61sArjrqlQ8

Pau's Hydrogen Transport System

ZERO EMISSION

Contracts following tender procedure

PAU BÉARN PYRÉNÉES MOBILITÉS

- AOM / MOA
- Carries all the investments

Public contract (performance)

IDELIS

FEBUS

- Bus operation
- maintenance

ENTREPRISES

Joined answer

ENTREPRISES

- Built dedicated maintenace hall

Atelier

VANHOOL

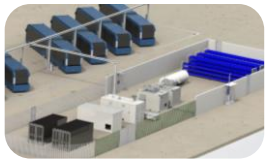
- 8 FCB 18m
- full maintenance
- Training
- Onsite support

Bus H2 18m

Subcontractor

GNVERT

- HRS
- 0peration
- Maintenance



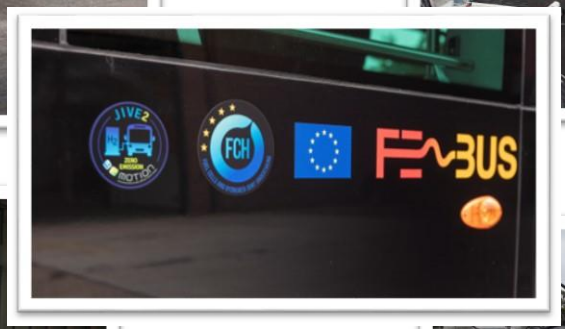
Station

ITM POWER

- Electrolysor
- Other equipements

Handed over

Pau's Hydrogen Transport System



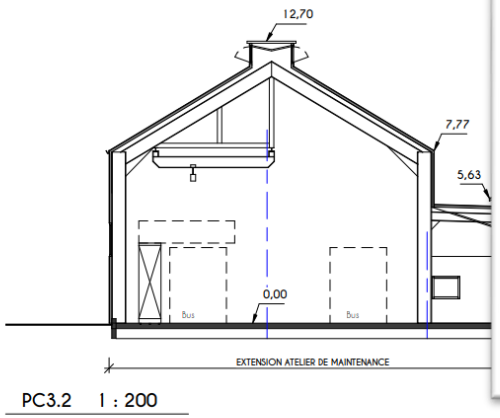
Visit the bus

https://roundme.com/tour/410927/view/1435185/

Visit the HRS

https://www.pau3d.fr/febus/

FCB maintenance facilities = New building



Workshop setup:

- New
- 2 maintenace lanes
- Detectors
- Fans (2 level of air extraction), rooftrap,…

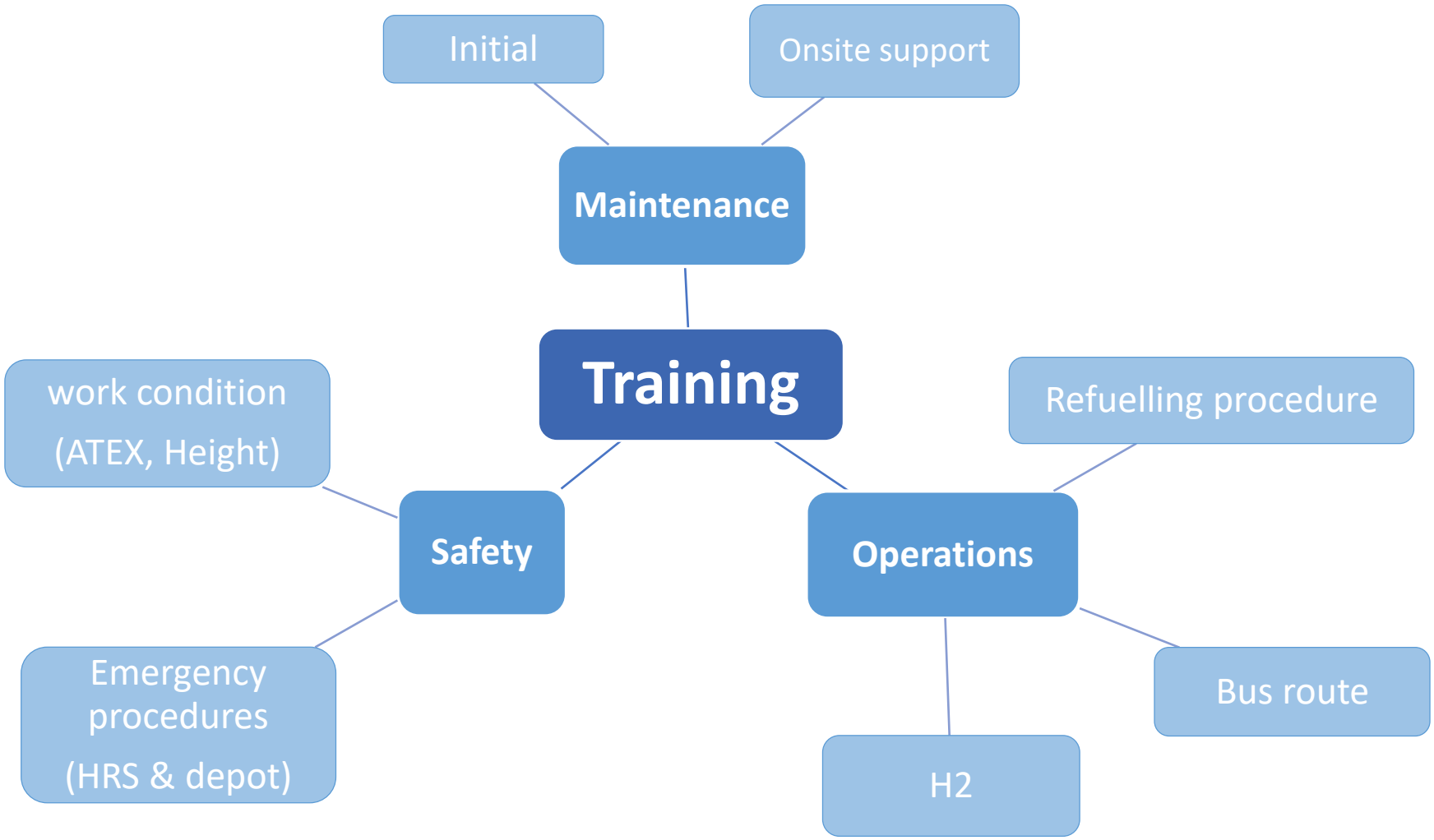
- plans and layout being defined with architect
- Support from INERIS to define ATEX zone and required ventilation

Maintenance

- **FCB**
  - Full maintenance
  - Price/km (negociable)
  - VH dedicated super technician on site for 2 years
  - Training included.
  - Storage of spareparts and special tools included

- **HRS**
  - Full maintenance
  - Price/year
  - Maintenance vs operation
  - GNVERT in Charge
  - Power and water supply paid by operator.

Training


Initial
Onsite support
Maintenance
Training
work condition
(ATEX, Height)
Refuelling procedure
Safety
Operations
Emergency
procedures
(HRS & depot)
Bus route
H2

Operating FCEBs -Returns on Experience

JIVE/UITP Training

Thank you for your attention

Mélanie Pédeutour
Project Manager
m.pedeutour@agglo-pau.fr

A project co-funded by under the Grant Agreements Numbers 735582 and 779563

Aberdeen Hydrogen Buses

November 2020

First Bus

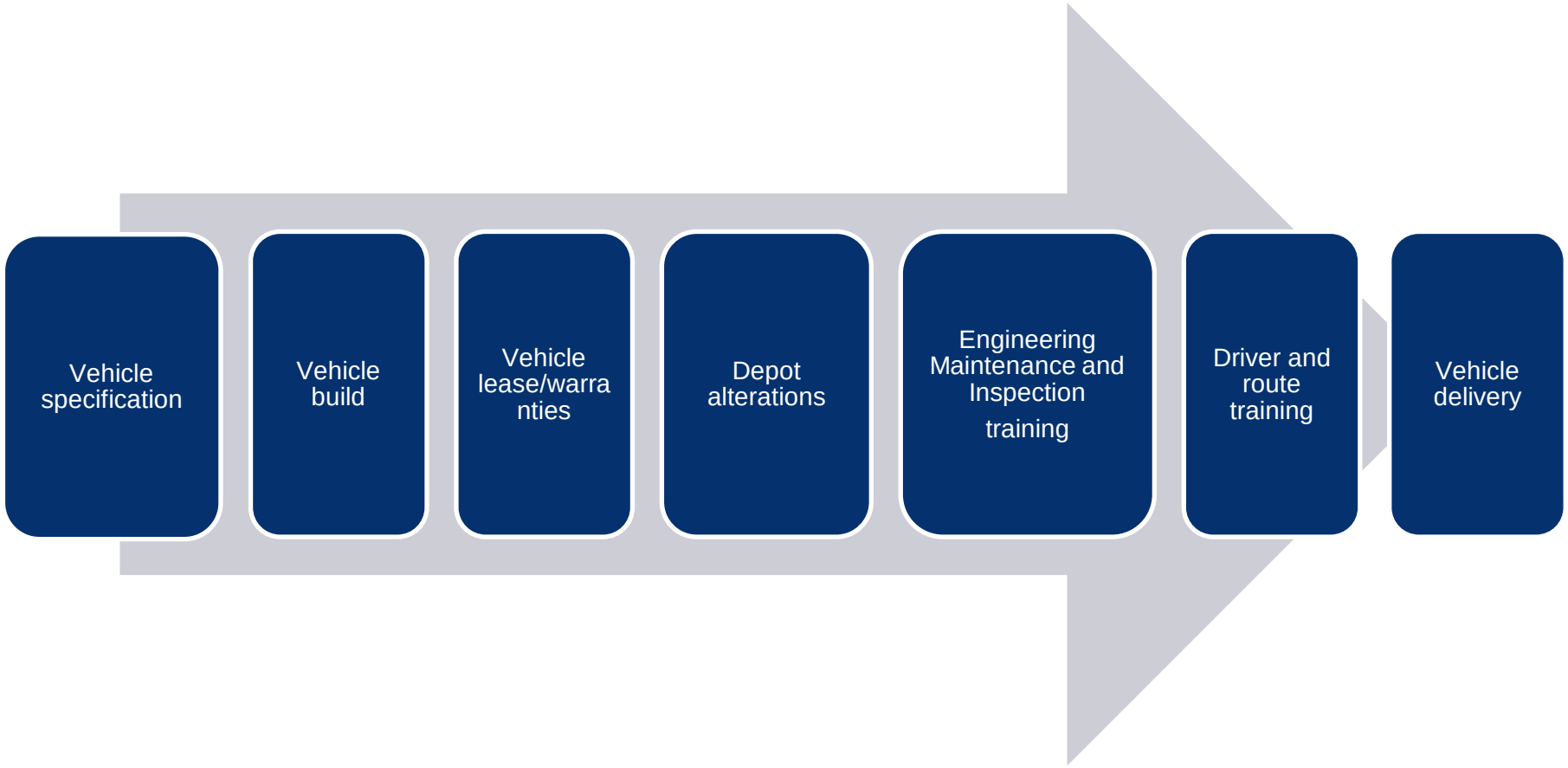
The Project

- Funded by consortium of The Scottish Government, JIVE, FCH and Aberdeen City Council.
- Leased and operated by First Bus
- 15 Double Deck Wrightbus Streetdeck
- Hydrogen fuel cell with 26kg fuel tank (range of c190 miles)
- Run on two urban bus routes
- Fueled off site at Council refueling facility
- Guaranteed price per kg of hydrogen for 5 years
- Maintained off site initially

Hydrogen-specific requirements

- Operational and depot risk assessments
- Operational and depot procedure changes
- Vent hosing
- Freeze protection
- Connectivity
- Hydrogen availability
- Qualifications – tiers 1, 2 and 3
- Blue light services

Timeline


Vehicle specification
Vehicle build
Vehicle lease/warranties
Depot alterations
Engineering Maintenance and Inspection training
Driver and route training
Vehicle delivery

Achievements

- Switching to zero emission bus saves 1 kg of CO2 per km.
- Integrated approach to project management between Owner/Operator
- New technology and enhanced training for employees

Challenges

- Delivery timelines
- Training plans
- New product
- Hydrogen availability

Future

- Vehicle monitoring
  - fuel consumption
  - reliability – lost mileage
  - defect reporting
- More vehicles?
  - Driving a lower unit cost
  - Public sector support
  - Increased hydrogen supply

Hydrogen Buses as a powerful enabling force for wider decarbonisation and improved public health

Patrick Warner
Head of Innovation Strategy

Our Zero Emission Vision is Fuel Cell Electric

- 22 Fuel Cell Electric 12 metre long Single Deckers
- First commercial application of this technology anywhere in the world
- Delivered in partnership with funding from EU FCHJU Jive Project, the UK Government's Ultra Low Emission Bus Scheme & Gatwick Airport
- Green generation of Hydrogen included
- Due in service Q4 2021
- Active planning for follow on batches throughout our network

Active Planning for more hydrogen buses

Consolidating Metrobus Crawley Depot in partnership with Gatwick Airport and public sector partners to expand the fleet there to 54 buses – comprising a mix of 12m single decks, 10.7m single decks and full size double decks

Following this with an ambitious plan for a joint bus depot and refuse collection fleet refuelling facility on the south coast where 30+ double deck buses will operate on some of the most challenging topography in the network plus 40-50 refuse collection vehicles from two local councils

Zero emission buses alone, are not the answer

With just 4% of UK roadside emissions coming from existing buses, putting zero emission buses on the road at twice the price is not the answer alone.

Buses can also be a powerful enabling force in the wider fight against climate change & improved public health

Collaborating with other local heavy fleets to share HRS & reduce entry costs	Using our big group buying power and fleet scale to increase entry options to the sector	Increase our own hydrogen fleet size faster by bringing costs down quicker
More vehicles switching to hydrogen making bigger impact on emission reduction	Raising our profile as a key regional stakeholder and working closer with partners in other areas	Introducing improved bus priority measures to slash bus journey times
Better air quality and increased activity changes public health outcomes	Greater modal shift from car to active travel increases personal fitness	Faster buses, generate more use and greater modal shift from cars

Brighton&Hove

METROBUS

Thank You

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Questions

JIVE 1 / JIVE 2 / MEHRLIN - “H2-W” Wuppertal, Germany
First experiences of operation (20th of June 2020 – 31th of August)

JIVE 1 - “H2-W” Wuppertal, Germany
5 of 10 FC Buses

JIVE 1 - “H2-W” Wuppertal, Germany
Buses Operational: (10 of 10)

	Parameter		Value
Specifications	OEM		Van Hool
	Vehicle model and length		A330 FC; 12 meter
	Fuel Cell		Ballard, HD85
	H_2 Storage		38,5 kg in 5 tanks @ 350 bar (Type III)
Milestones	Procurement	start date	June 2017
		end date	January 2018
	Order Date		January 2018
	Delivery Date of First Bus		November 2019
	Delivery Date of Last Bus		April 2020
	First Date of Operation for Buses		June 2020

JIVE 1 - "H2-W" Wuppertal, Germany
Buses - Key Issues, Risks and Mitigation Activities

Common Issues	Comments on experience
Long manufacture lead times / Delays in manufacture	Time between order and delivery = 22 Months
Quality control issues upon delivery	Necessary rework at the buses after delivery
Driver training/scheduling issues	c. 400 employees are trained (bus driver, mechanic,…)
Data collection	Ongoing data discussion (close to regular collection)
Driven km in total	51,000 km
Average fuel consumption	<9 kg/100 km
Feedback	Positive feedback of bus driver and passenger
Maintenance and repair	Engage the (partial needed) support from Van Hool and Ballard

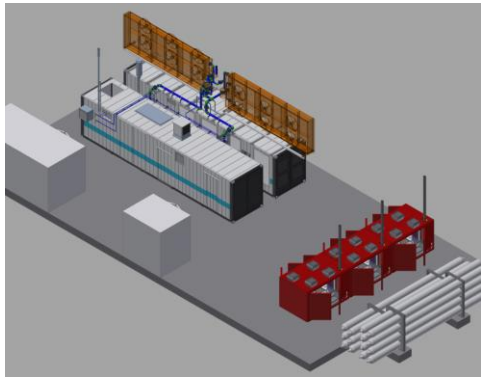
JIVE 2 - “H2-W” Wuppertal, Germany
Buses Operational: (0 of 10)

	Parameter		Value
Specifications	OEM		Solaris
	Vehicle model and length		Urbino, 12m FC buses
	Fuel Cell		Ballard HD 60
	H_2 Storage		5x7,5 kg @350 bar (Type IV)
Milestones	Procurement	start date	12th September 2019
		end date	January 2020
	Order Date		02.03.2020
	Delivery Date of First Bus		Q4 2020
	Delivery Date of Last Bus		Q4 2021
	First Date of Operation for Buses		TBC

JIVE 1 / MEHRLIN - "H2-W" Wuppertal, Germany
HRS Operation: June 2020

Parameter	Value	
	New station building	1st stage of expansion
Station supplier /operator	Maximator GmbH / AWG	
New or Existing?	New	Upgrade
Source of H_2	On-Site Electrolysis	
If electrolysis – renewable energy?	Renewable energy directly from the Waste-to-Energy-Plant (AWG)	
Pressure	350 bar	
Capacity	427 kg/day (@100%)	Possibility of > 427 kg/day
Public or Private	Private	
At Bus Depot or Offsite	Offsite	Feasibility study regarding the possibility of an onsite station
Vehicle Types Served	Buses @ 350 bar	

HRS action	Delivery date
Site Identified	August 2017
Site Contracts Obtained	July 2018
Permits Requested	October 2017
Permits Obtained	December 2018 (Part 1) December 2019 (Part2)
Civil Works started	January 2019
HRS Commissioned	1st components in October 2019
Envisaged Teething/Run-In Period	< June 2020
Start of Operation	June 2020



JIVE 1 - “H2-W” Wuppertal, Germany
HRS - Pictures

JIVE 1 / JIVE 2 / MEHRLIN - “H2-W” Wuppertal, Germany
Refuelling Data

Data: 20th of June 2020 – 31th of August 2020	
Average vehicle tank temperature at start of refuelling	18,3 °C
Average vehicle tank temperature at end of refuelling	42,0 °C
Average ambient temperature at start of refuelling	22,4 °C
Average vehicle tank pressure at end of refuelling	344 bar *
KPI of duration of refuelling process ≤ 10 min.	✓

* Completed optimisation up to an end pressure of c. 350 bar in Septmeber 2020

JIVE 1 - "H2-W" Wuppertal, Germany
Maintenance Infrastructure at the busdepot

Common Issues	Comments on experience
Parking lot	Outdoor, with power plug
Workshop / Garage (l=28.5m, w=18.5m, h=6.7m)	Upgrade of a part of the existing Workshop for 3 buses
H2 detection	- Permanent measurement of H2 with 6 H2-Sensors - 9 self-acting dormer windows and 6 gates - Automatic stop of generall air circulating system - 8 flashlights, 2 siren and 2 alarm displays
1st H2 alert phase (10% of lower explosive limit)	- Optical warning - Automatic stop of generall air circulating system - Automatic opening of dormer windows - Automatic stop of generall air circulating system
2nd H2 alert phase (20% of lower explosive limit)	- Optical and acoustical warning - Drop out of elctrical installations with the exception of safety devices (explosion protected installations)
Specific feature	- Special flooring to to discharge static charges - Pipe to blow of H2 in a safe way - Displaceable ladder/rack
Insecure bus condition	- One separated outdoor parking lot with safety distance to other vehicles and buildings

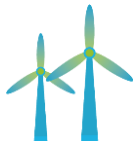
JIVE 1 / JIVE 2 / MEHRLIN - “H2-W” Wuppertal, Germany
Busdepot

JIVE 1 / JIVE 2 / MEHRLIN - “H2-W” Wuppertal, Germany
End of presentation

A project co-funded by under the Grant Agreements Number 735582 and 779563

Conclusions - 1

The **regulatory framework & soft legislation** is in place to support the deployment of hydrogen technologies.



Hydrogen is an **enabler of a renewable energy system** – it is a way to integrate, distribute and store large quantities of renewable electricity.

Fuel cell buses are a great choice for operators tackling long/challenging routes, they provide operational flexibility in complementarity with battery buses and require no major changes in user behaviour, operation or refuelling. Scaling up is not an issue (no grid capacity problems).

Procurement – make sure you are doing the procurement process for bus and HRS/hydrogen supply in parallel to avoid unforeseen delays in operations.

Joint procurements/agreeing on standards specs is a way to aggregate enough bus orders/create demand certainty for the OEMs → get the bus CAPEX down.

Hydrogen supply: different local situations will lead to different solutions: by-product hydrogen, H2 generated from waste or from renewable electricity – look into your regional/local context. Long term contract for hydrogen supplies can be obtained provided the customer commits to a reasonably high level of demand and break clauses are included

Hydrogen refuelling stations options: Pro and cons of operating the HRS yourself/vs. with an operator/general contractor were addressed as well as the different stations locations options (own property/public)

Conclusions - 2

Safety first: standard risk assessment to be carried out - adaptation to the bus workshop/depot are required – (e.g. sensors and ventilation), safe solutions do not have to be expensive; seek support for these activities.

Training: essential to train your drivers and technicians on high voltage, maintenance and hydrogen specific features.

Maintenance: set up maintenance agreements on the buses and infrastructure side – for ex. full maintenance, with a price/km (bus), price/year (HRS), inclusion of training, spare parts storage

Build in a teething period to test out the new technology and deal with early problems which naturally arise from adjusting to the new technology.

Price/Choice – improvements through JIVE and other projects are demonstrably bringing down the price of the technology, this is also valid for the cost of renewable hydrogen, as significant efforts are done at European level. New models from an increasing number of OEMs are being introduced to cater for specific markets (coaches, articulated) -> expected from 2022/23.

Collaboration: with stakeholders/OEMs, hydrogen suppliers/HRS operators, PTO etc at an early stage and peer collaboration: JIVE partners are ready to share lessons learnt, don't hesitate to reach out and check www.fuelcellbuses.eu