

#h2nw

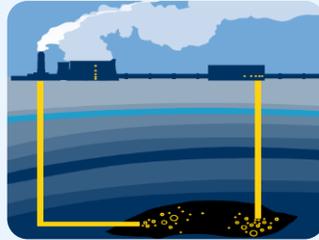
INITIATING HYDROGEN TRANSPORT DEMAND IN THE NORTH WEST USING HYDROGEN BUSES

BEN MADDEN
DIRECTOR, ELEMENT ENERGY



DELIVERING THE
HYDROGEN
ECONOMY

North West



Initiating hydrogen transport demand in the North West using hydrogen buses

NW Hydrogen Showcase

5th June 2019

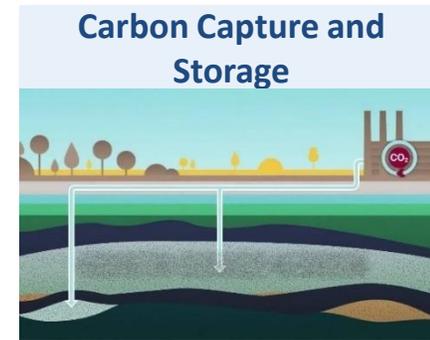
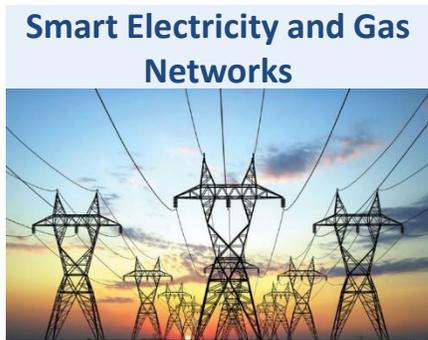
Element Energy Ltd

inovyn
An INEOS company

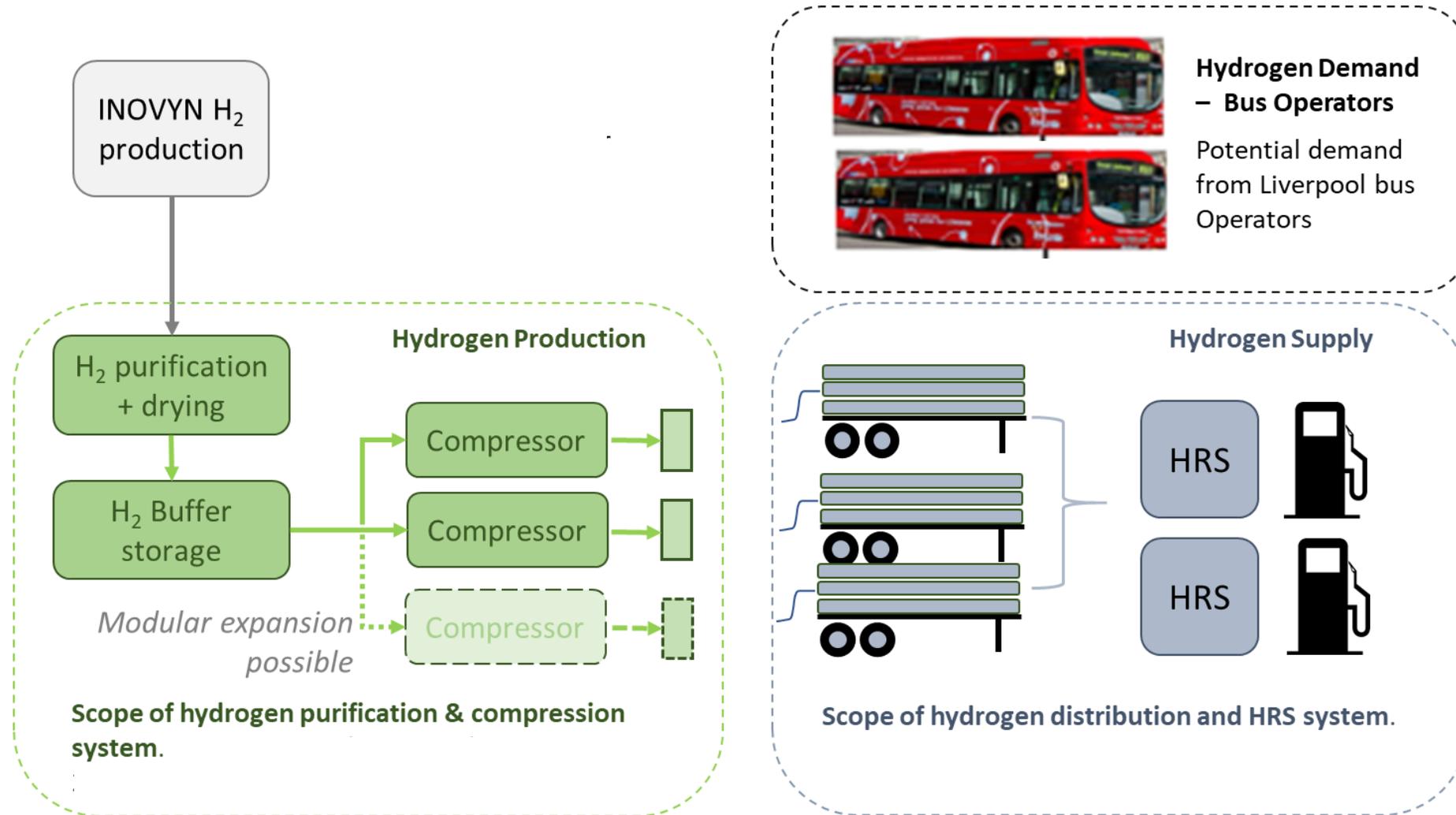


Element Energy, a consultancy focussed on the low carbon energy sector

- Element Energy is a **specialist energy consultancy**, with an excellent reputation for rigorous and insightful analysis in the area of low carbon energy
- We consult on both **technical and strategic issues** – our technical and engineering understanding of the real-world challenges support our strategic work and vice versa
- Element Energy covers all major low carbon energy sectors:

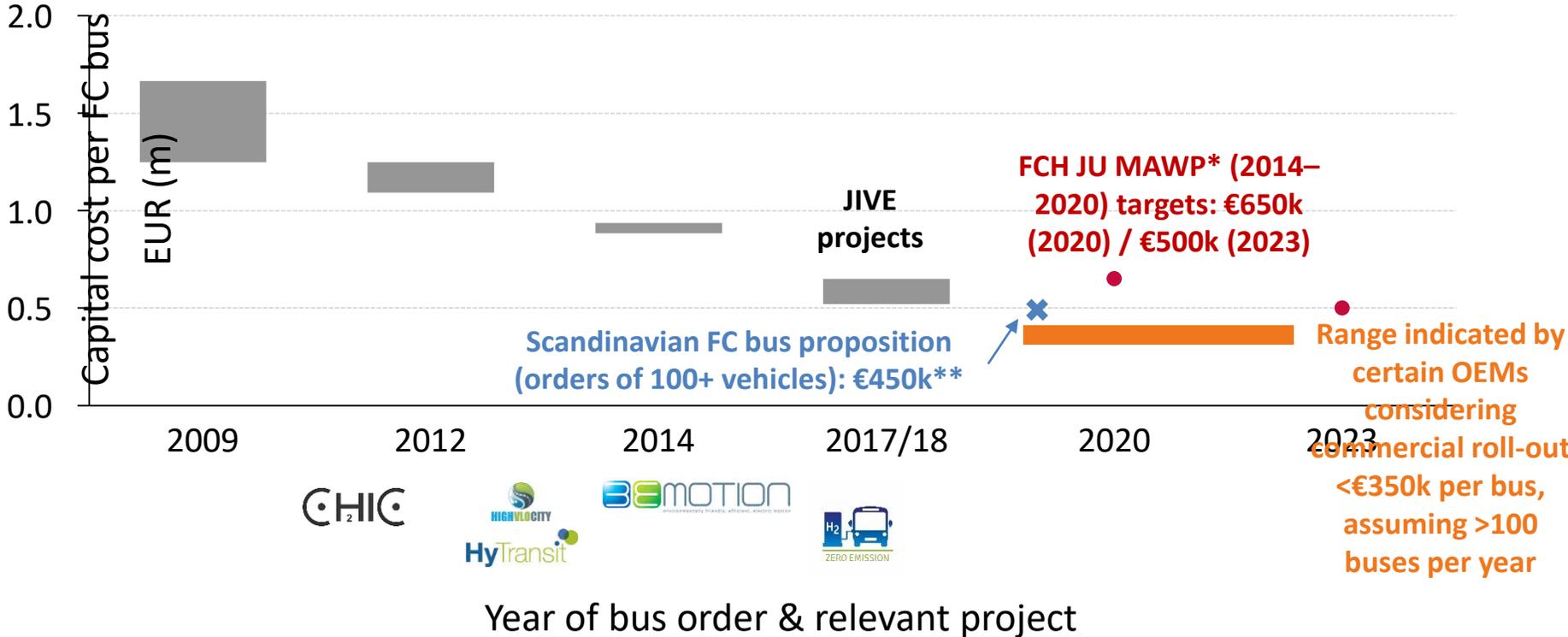


The study involved consideration of the work at the INOVYN plant (Costain + INOVYN) and the potential to supply to bus operators



Fuel cell bus capital cost reductions enable a plausible case for fuel cell buses if a sufficient scale order is achieved

Capital costs of fuel cell buses ordered in different years (non-articulated single deck buses)



* **FCH JU MAWP** is the Fuel Cells and Hydrogen Joint Undertaking’s Multi-Annual Work Plan, the document that sets out the work plan and strategic targets for the second phase of the FCH JU’s programme of research and innovation.

** See <http://hydrogenvalley.dk/white-paper/>.

The two leading UK bus builders can supply double and single deck fuel cell buses as integrated and fully OEM backed products



Wrightbus double and single deck vehicles – prototype operational today - available for order in 2019



Alexander Dennis – operational prototype recently unveiled – now selling a double deck model



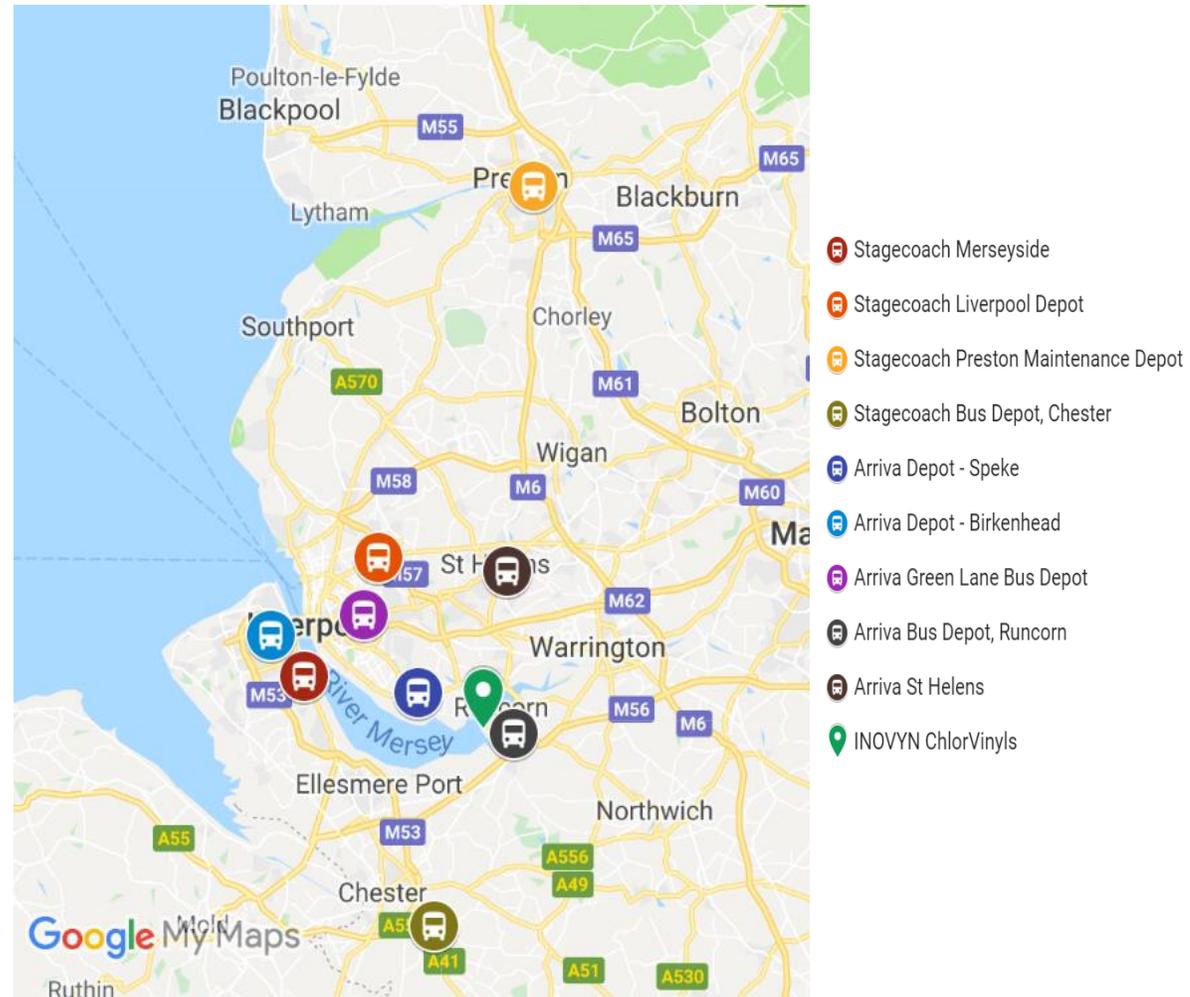
Solaris 12m buses – operational prototype available in 2019, orders in 2020



Van Hool – 40 buses on order in Cologne and Wuppertal

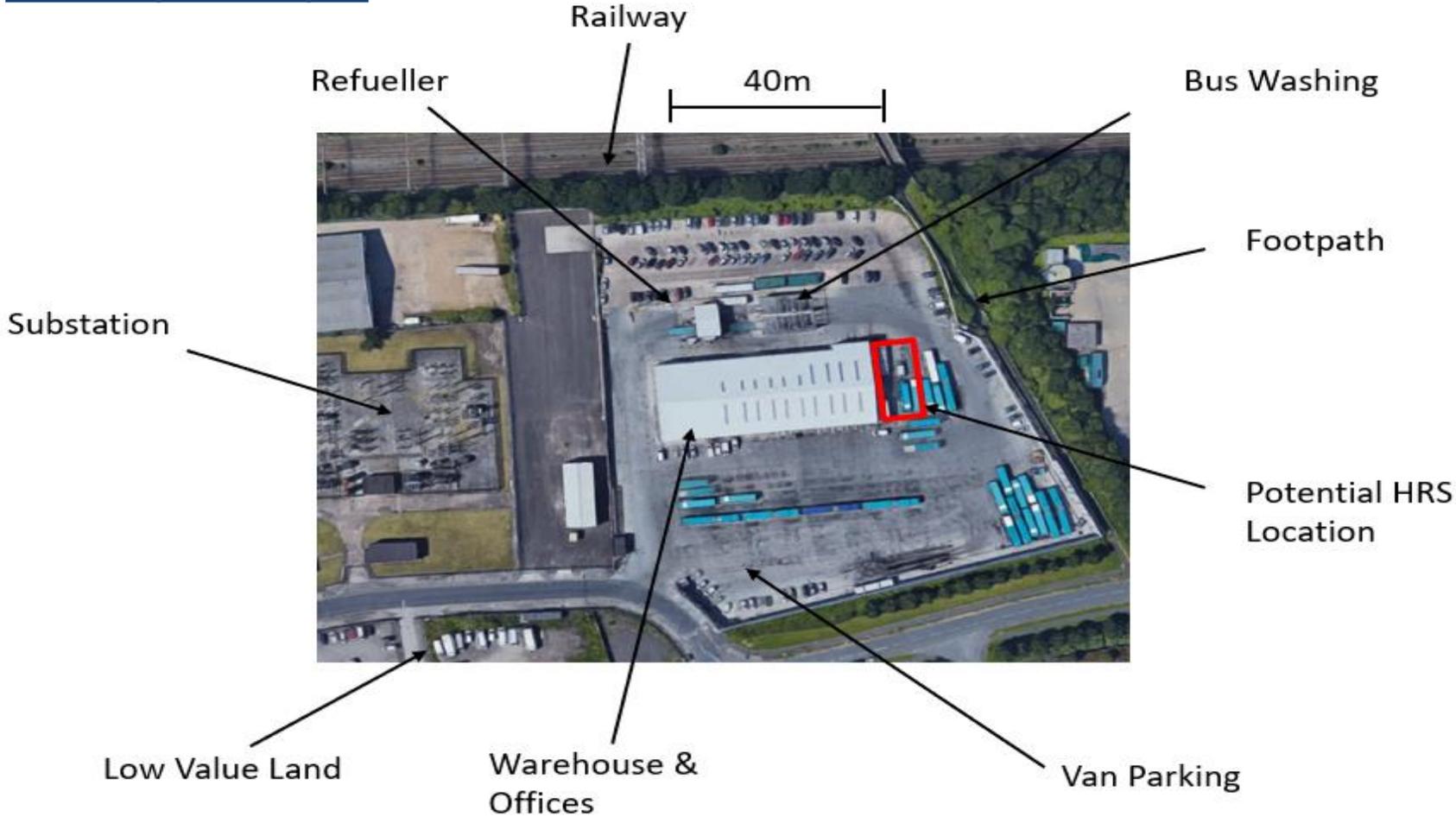
Other new models coming from **Evobus** (12 and 18m), **VDL** (12m single deck), **Solbus**, **Ursus** and others

There are over 1,100 urban buses operating in the greater Liverpool region



Site surveys were carried out at the main operators – initial conclusion there are options for locating refuelling facilities at each depot

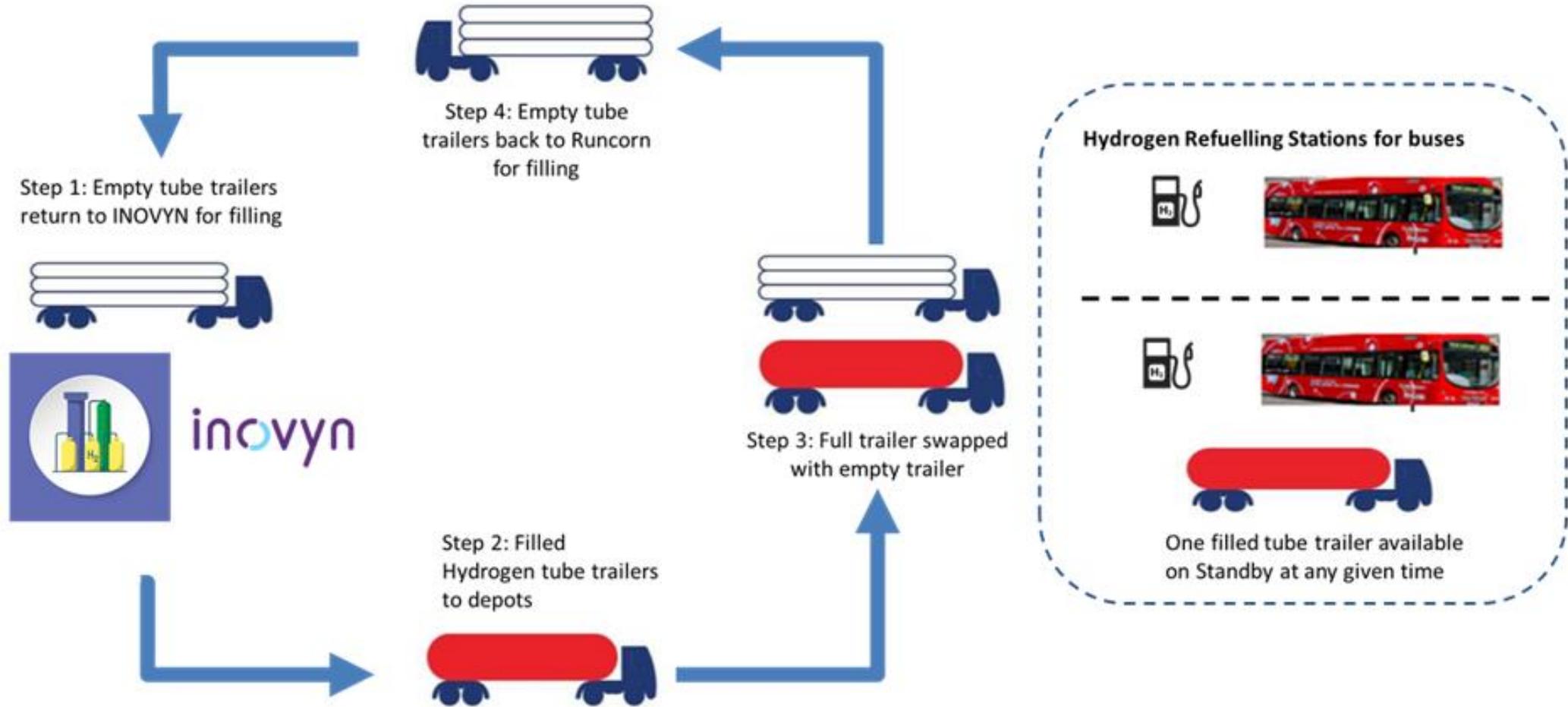
Arriva Speke depot



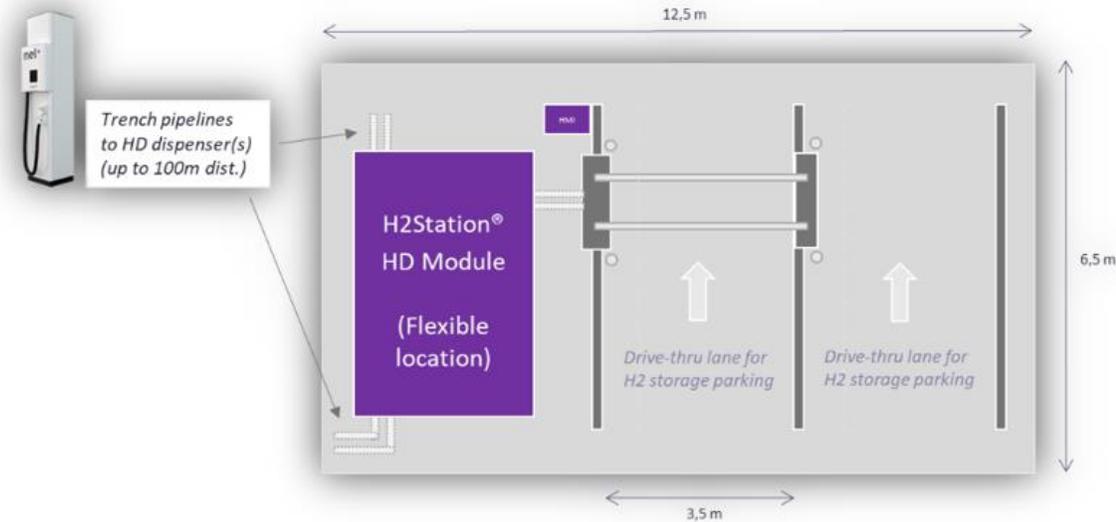
A strategy based on two routes for the two leading operators is proposed.
This will require two in depot fuelling stations.

Route Details		Arriva at Speck		Stagecoach Liverpool	
		Route 79	Route 86	Route 82/86	Route 10A
Number of FC buses deployed	#	22	24	28	16
Yearly mileage	km/bus	77,248	77,248	71,082	78,227
Hydrogen fuel economy	KgH ₂ /km	0.075	0.075	0.075	0.075
Total Hydrogen demand/route	Kg-H ₂ /day	349	381	409	257
Total Demand/Depot	Kg-H ₂ /day	730		666	

A trailer swap solution will be used to move hydrogen from the Runcorn facility to the hydrogen stations



The trailer swap strategy allows for low footprint refuelling solutions (images from Nel)

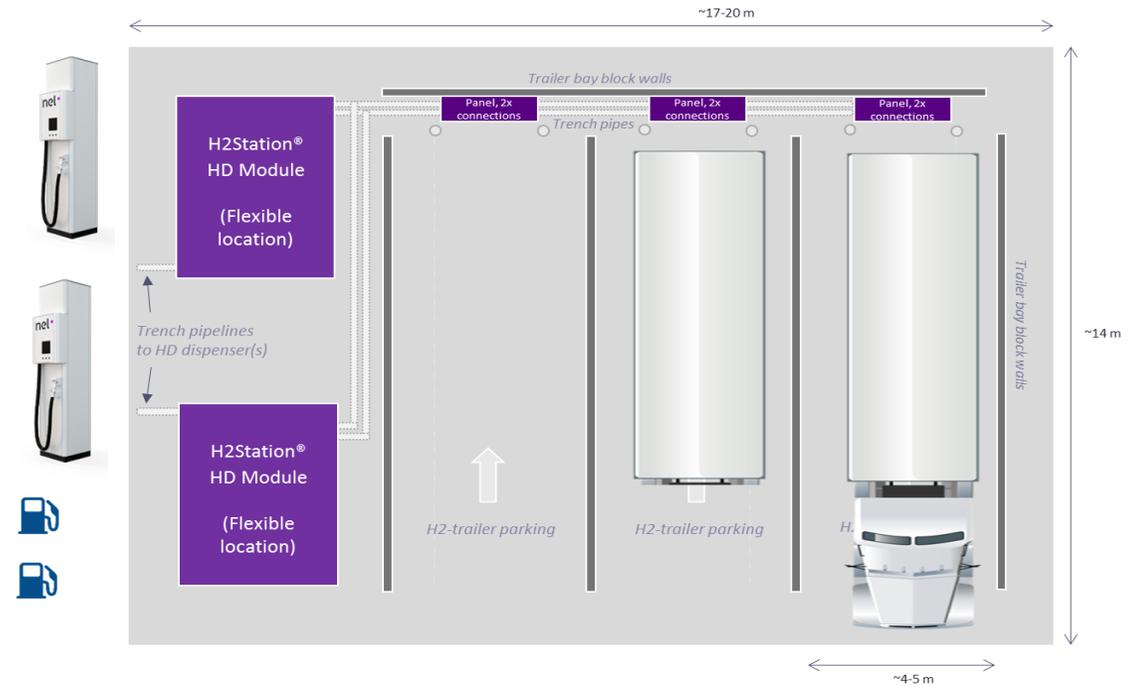


- ↑ SWAP-lane driving (flexible direction)
- ▬ Concrete firewall (for H2 SWAP-trailers)
- Distance pole
- ⋯ H2 piping (under ground)
- ▬ H2 piping (elevated)
- ▬ Connection-panels for SWAP-trailers
- HMI Activation/Supply Cabinet
- H2Station 4,9x3.3m Redundant setup Cooling & controls
Optional: compressor & buffer storage

<100m²

Easy expansion

<300m²



There are no technical obstacles to installation of compression and purification equipment at INOVYN



The design based on 2 x 5 tonne/day compressors and PSA for gas clean-up
This allows for substantial expansion with no extra costs

Conclusion - A viable large scale project operational by 2022

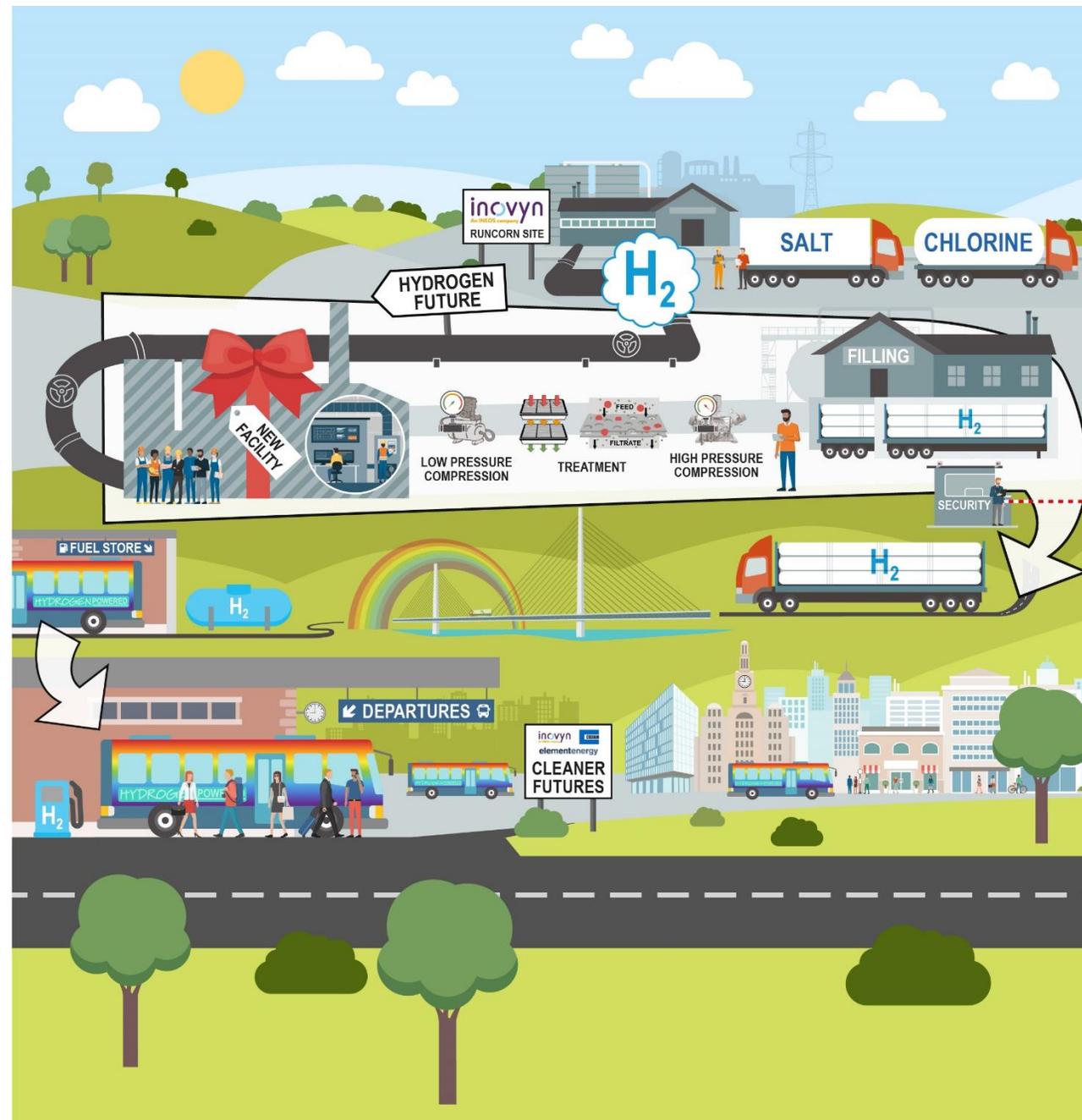
An initial 90 bus project which enables the conversion of the Liverpool bus fleet

- There are **no major technical obstacles**
- **UK based bus builders** are ready to supply
- **Bus operators are willing to act**
- There is a requirement for **public sector leadership**

Main benefits:

- This will offer **truly zero emission public transport** for the region
- Bringing **new employment** to the region
- A **major differentiator and enabler** for the region
- A **catalyst for the entire hydrogen mobility sector**

The vision



(image prepared by COSTAIN)