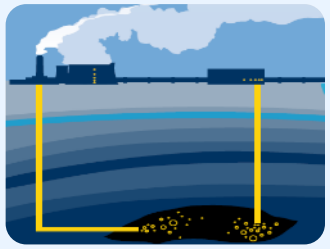








Commercialising hydrogen as a fuel

LowCVP Annual Conference 2019

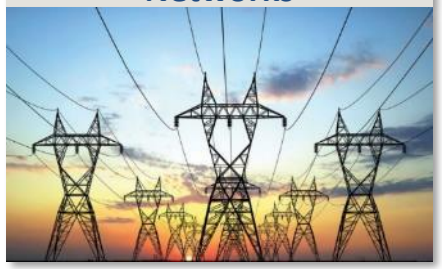
8th July 2019

Element Energy Ltd

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:

Smart Electricity and Gas Networks



Energy Storage

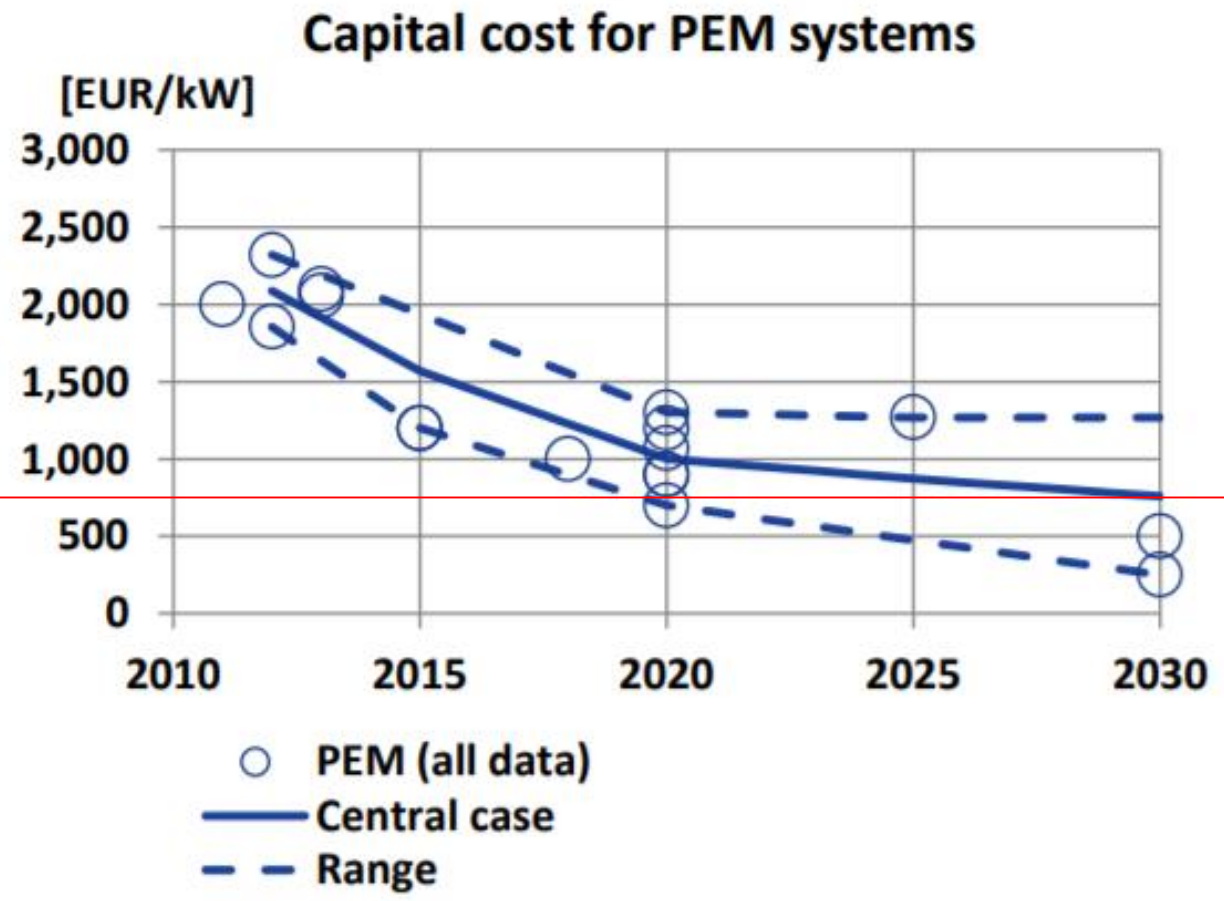
Carbon Capture and Storage

Hydrogen

Low Carbon Transport

Built Environment

There are three main elements to commercialising hydrogen as a fuel:
1- Technology learning

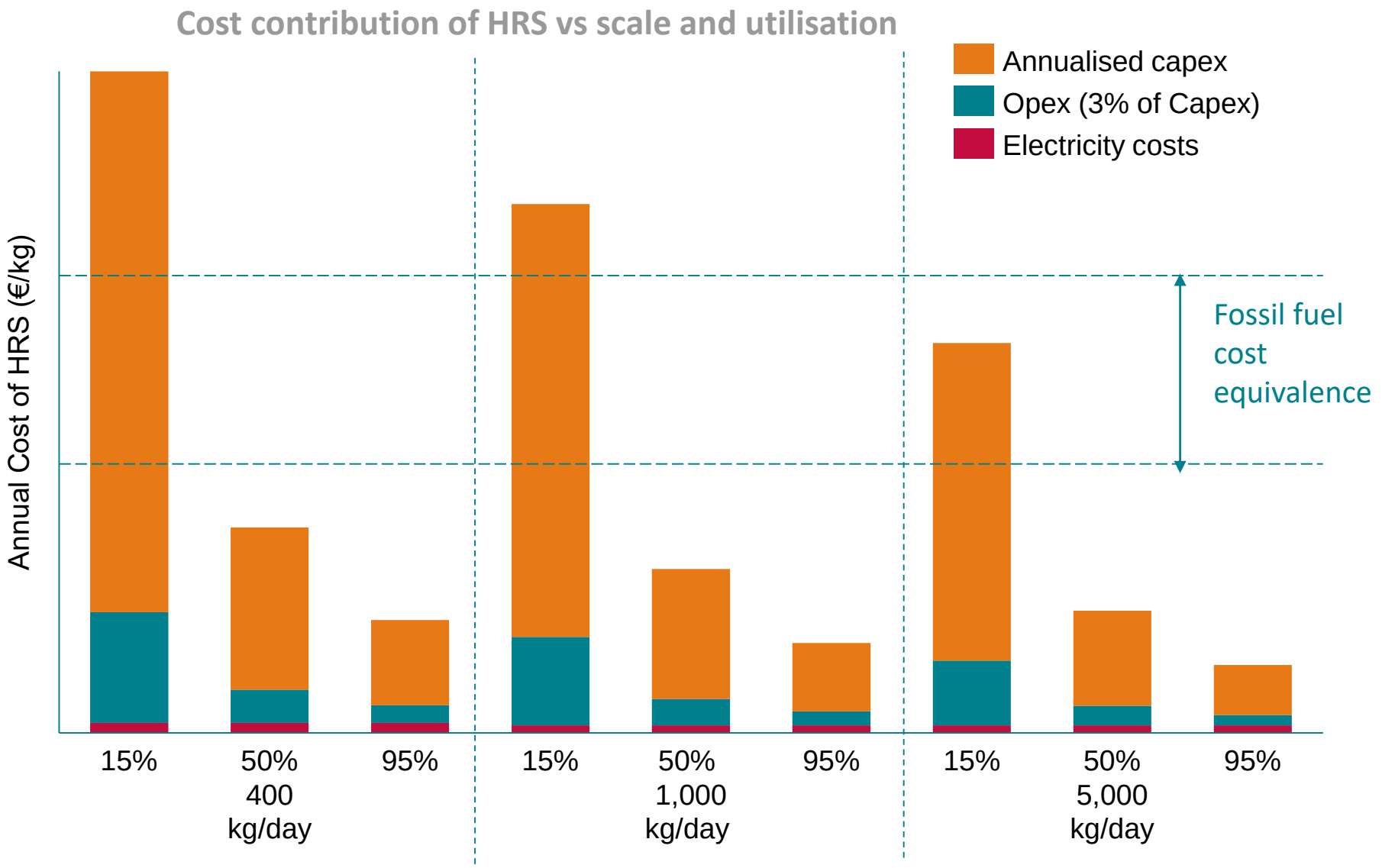


We are here (approx.)

Ref- 2014 – E4Tech and Element Energy for FCH JU

- Similar learning effects are occurring for:
  - **Hydrogen refuelling stations** (equipment cost for compressions and dispensing has fallen from ~€1m to ~600k)
  - **Hydrogen tube trailers and storage** - £/kg stored now ~€500 (from >€1,000)
  - **Vehicles** – Toyota project same cost a petrol hybrid in 2025.
  - Bus prices have fallen from >€1m to under €400k in 5 years

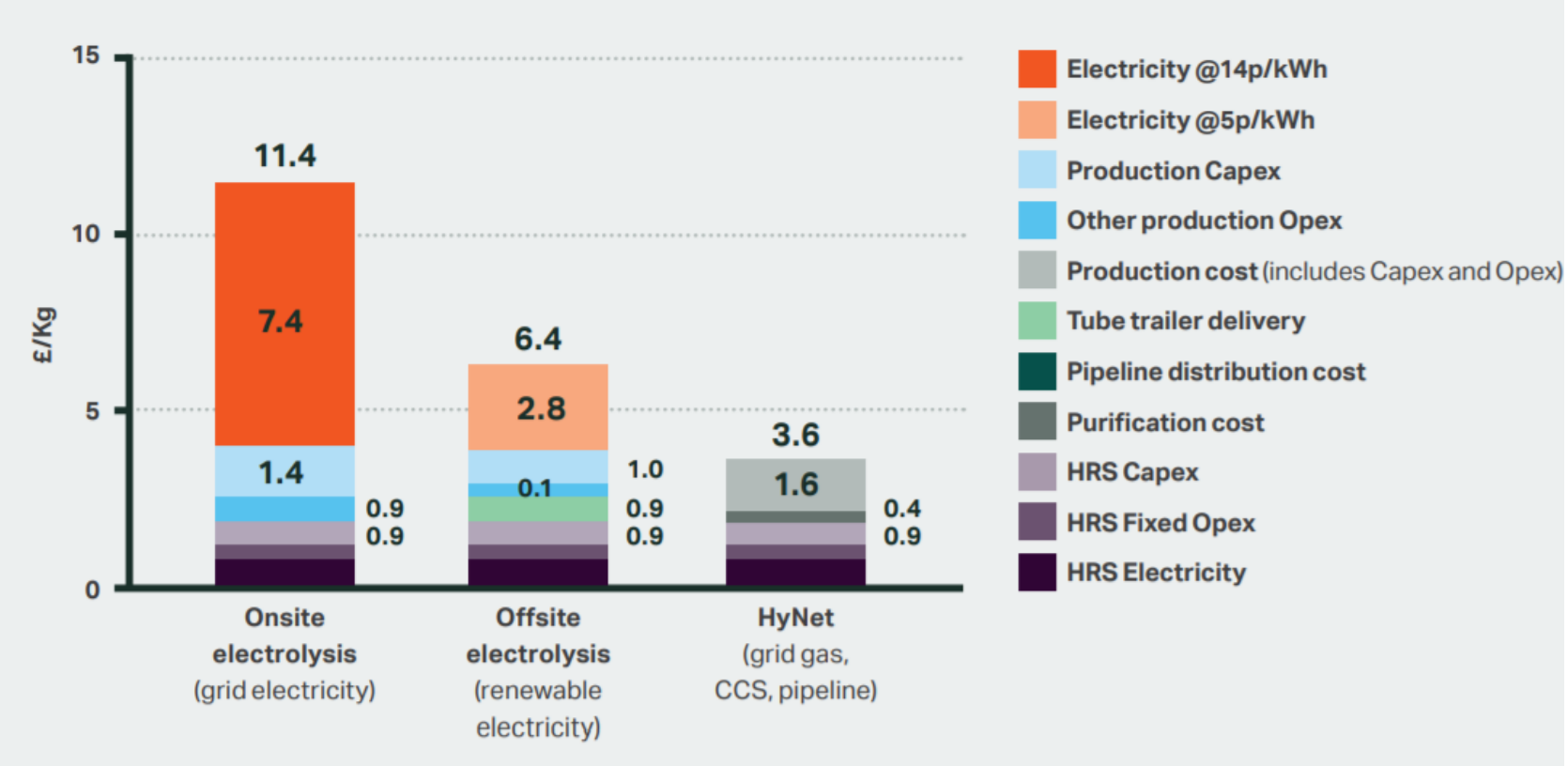
2- Scale: the key element to unlocking hydrogen based business models



Leads to:

- A need to **synchronise** demand with stations and production
- Initial focus on **heavy duty** and/or heavy use vehicles
- “high costs for hydrogen” when getting started

3- Hunt for low cost energy



Two main production options

- **Reformation of hydrocarbons** (+ CCS or biomass) – challenge is reaching scale + proving some gasification options
- **Low carbon electricity** – challenge is securing low cost AND low carbon power

Ref- 2019 – Cadent – HyMotion report

The most promising hydrogen projects achieve scale for both vehicles and hydrogen sales: 1. Hyundai and H2 Energy in Switzerland – 1,600 trucks by 2023

- Nationwide network is enabled by this volume of trucks
- Power sourced from hydro-electric spill-over (very low cost)
- Whole business case is enabled by Swiss zero emission truck legislation (tax system)

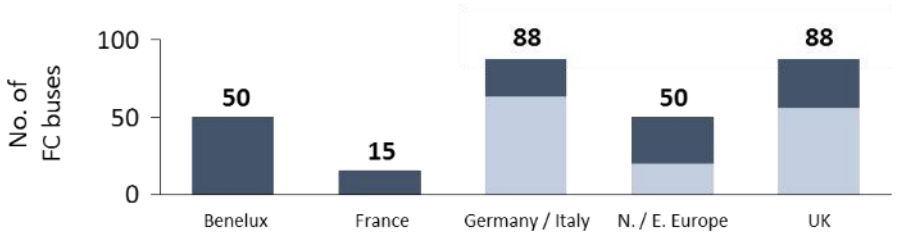
2. Buses - JIVE and H2Bus Partnership (1/2)

JIVE project – 300 buses across Europe

Objectives

- Deploy 290 FC buses across 22 cities
- Achieve a maximum price of €625k for a standard fuel cell bus
- Operate buses for at least three years / 150,000 km
- Validate large scale fleets in operation
- Enable new entrants to trial the technology
- Demonstrate routes to low cost renewable H_2
- Stimulate further large scale uptake

- **Benelux Cluster** (50 FC buses)
- **France Cluster** (15 FC buses)
- **Germany / Italy Cluster** (88 FC buses)
- **Northern / Eastern Europe Cluster** (50 FC buses)
- **UK Cluster** (88 FC buses)



Total = 291 new FC buses for Europe

UK bus builders starting to act (Wrightbus and ADL)

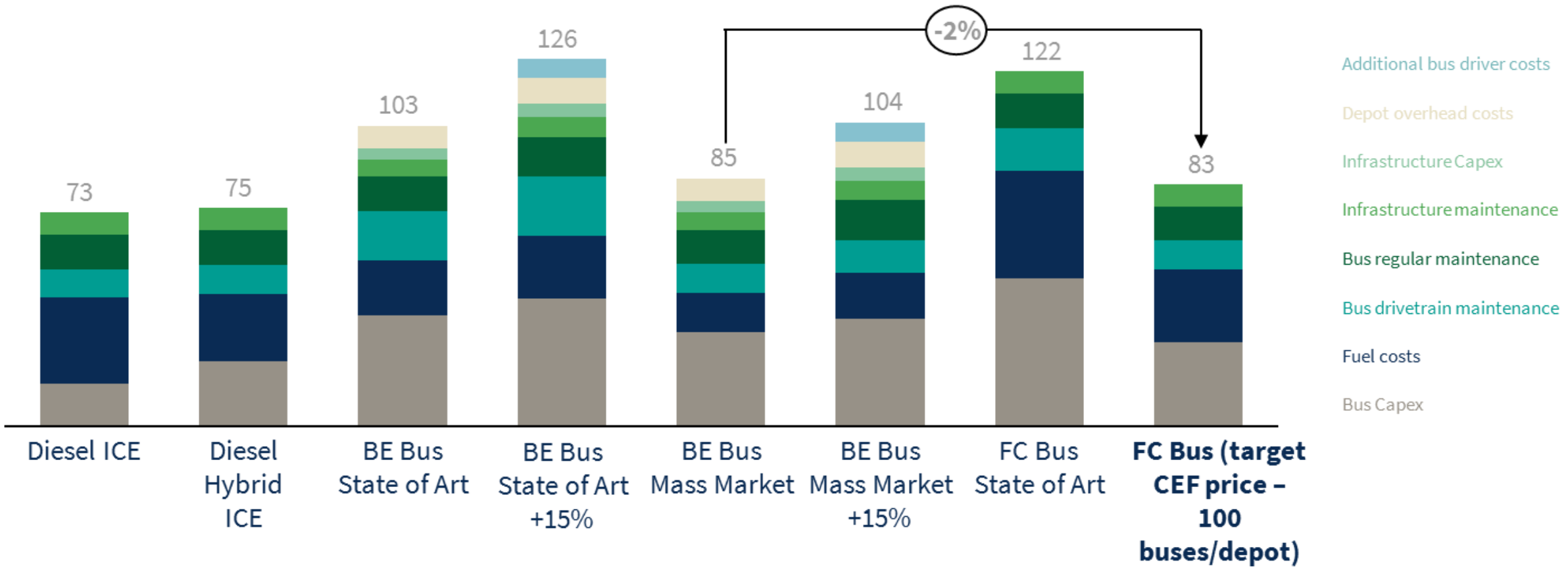
H2BUS

H2Bus Partnership

- 1,000 buses
- Reduced bus costs (below €400k)
- Fuel costs reduced by grouping buses in clusters
- Competition with all other ZE buses

2. Buses - JIVE and H2Bus Partnership (2/2)

Single-deck urban bus annuitised total cost of ownership *'000€/bus/year*



3. Large fleets of high utilisation cars and vans

Taxis offer the highest utilisation of hydrogen amongst passenger cars

Heavily regulated which allows the state to regulate in favour of zero emission options

Taxis can be scheduled to fuel at a limited umber of stations

Interesting projects emerging across Europe

- Paris – STEP - 600 taxis by 2020
- London – 50 Green Tomato taxis
- Copenhagen., The Hague etc

Other heavy vehicles types are emerging

The hydrogen industry will need a program of support to overcome the challenges of scaling a new fuel and synchronising with new demands

Need to move from competitions to a market introduction program.

Focus on heavy duty/use while maintaining the nationwide passenger car option

Key elements a market introduction program:

- Support per kg of hydrogen sold – RTFO or equivalent
- Extra incentives for green fuel
- Support for early vehicle purchase
- Degression - Sliding scale with volume

With a well structured support program, the UK is well placed to lead the global deployment of this fuel