

Hydrogen bus deployment JIVE2, Zuid-Holland the Netherlands

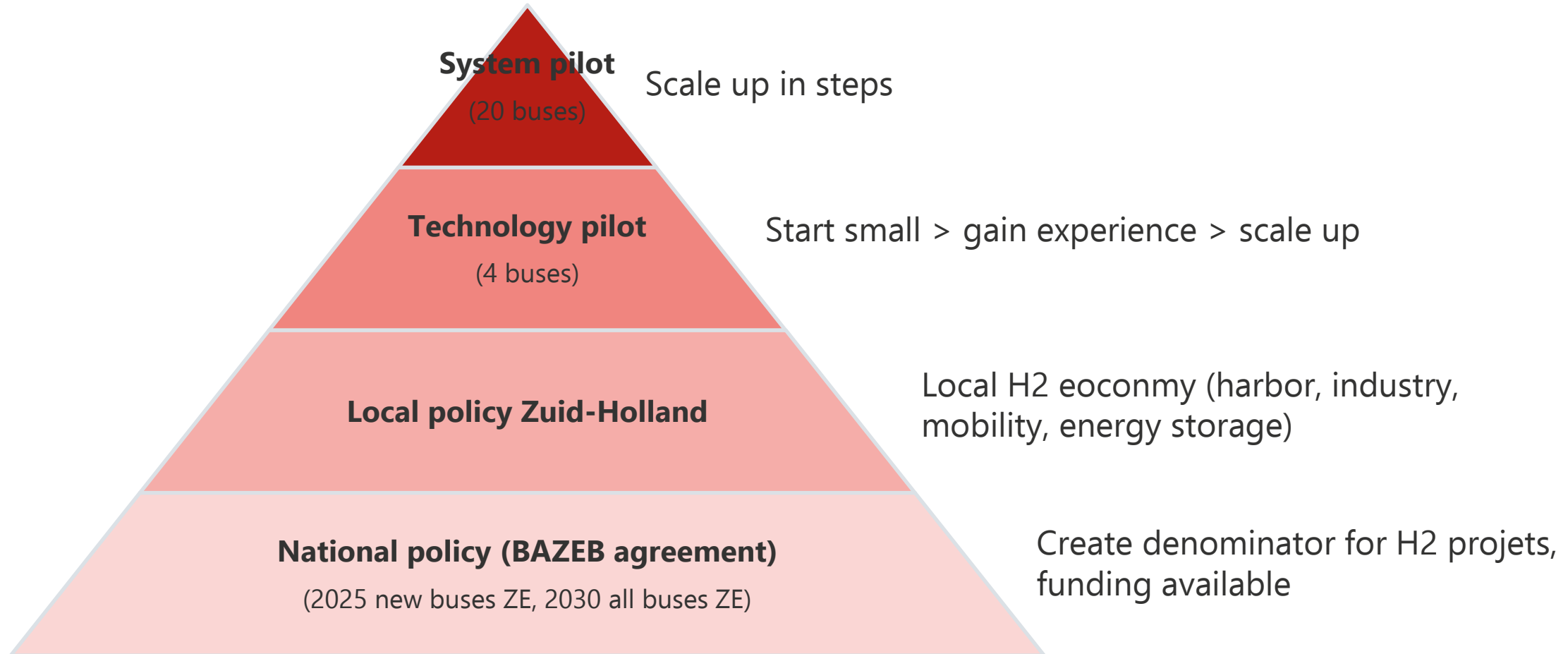


Everfuel

Policy goal: 2025 every new bus ZE, 2030 all buses (5.000+) ZE
Support in development of both BEB and FCEB technology



Create the right conditions, a hydrogen bus project is not on its own



Project scope and parameters

Pilot project, 4 buses under 3Emotion flag

- ▶ Innovative concept with range extender
- ▶ 3,5 year with possible extension
- ▶ Long distant routes
- ▶ High average speed, 50km/h
- ▶ Existing HRS

- ▶ Operator: Connexxion
- ▶ OEM: VDL
- ▶ HRS: Air Liquide



Project scope and parameters

Scale-up project, 20 buses under JIVE2 flag



- ▶ 12 year H2 contract
- ▶ High average speed, 50km/h
- ▶ HRS is scale-up ready
- ▶ Possible scale up to full H2 fleet

- ▶ Operator: Connexion
- ▶ OEM: Solaris
- ▶ HRS: Everfuel

Lessons learned from pilot project - buses

- ▶ Standard battery-electric bus combined with range extender
- ▶ 'electric bus' part operated as expected
- ▶ Challenge: bus type approval from Road Authority
 - ▶ Delay in start operation (1,5 year)
 - ▶ Standstill due to 'Haringvliet' bridge repair (4 months)
 - ▶ Standstill due to Adjust route to avoid bus lock (2 months)
- ▶ Fuel cell power too low to meet high speed requirements

Lessons learned from pilot project - HRS

- ▶ Public HRS: **A** client vs **THE** client
- ▶ Upgrade of existing HRS from Air liquide in Rhoon (capacity and extra nozzle)
- ▶ Secure hydrogen supply by pipeline
- ▶ Pre-cooling added to increase refueling time
- ▶ Depreciation over just 3,5 year caused high H2 price (€ 15,5/kg); long term contract = better price
- ▶ Challenges:
 - ▶ Permit
 - ▶ Refueling speed
 - ▶ Parallel refueling of vehicles not possible



Lessons learned from scale-up project - buses

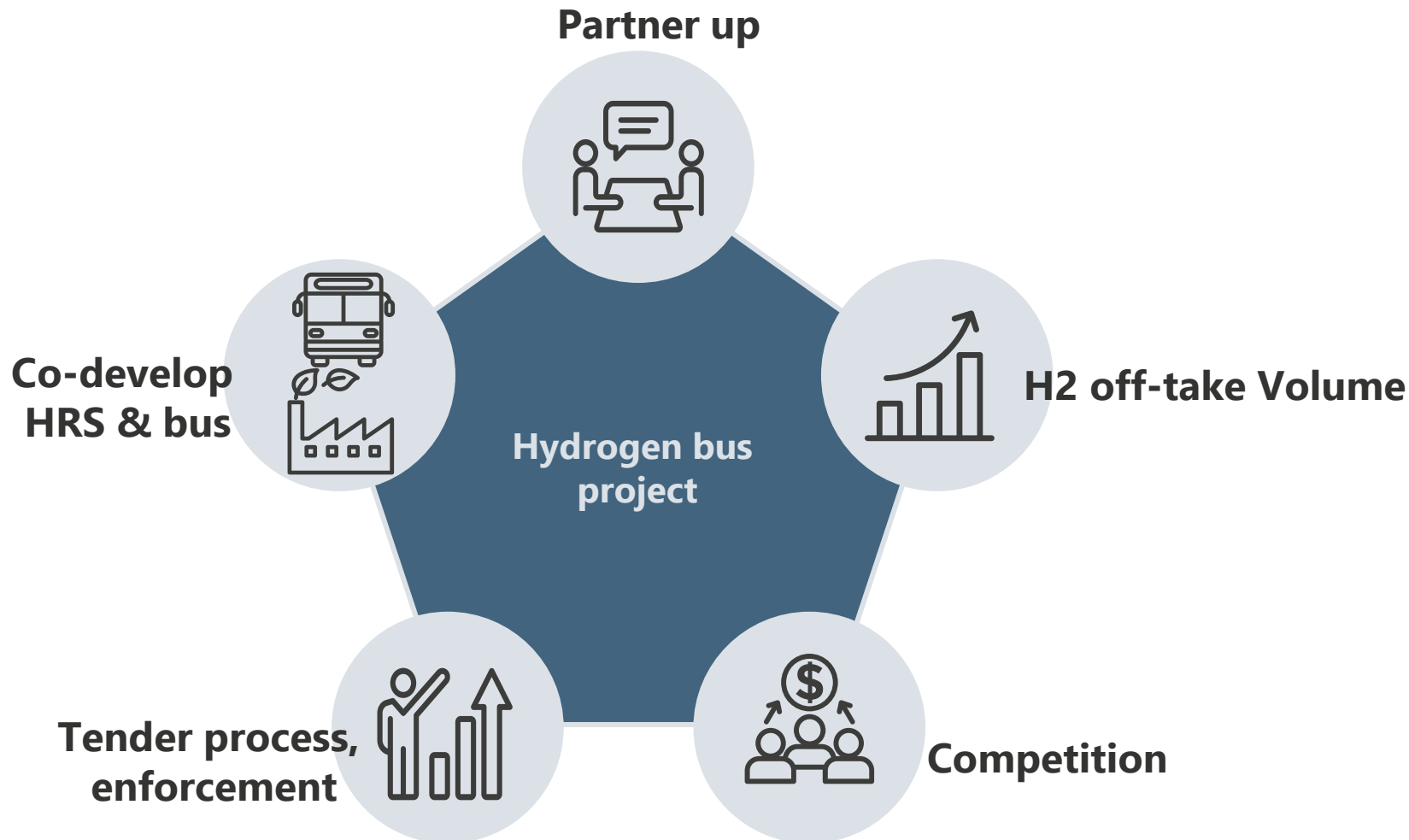
- ▶ Drivers are satisfied with driving behavior
- ▶ Thoroughly discuss requirements with EOM
 - ▶ Technical requirements
 - ▶ Key spare parts reserve
 - ▶ Response times
- ▶ Hydrogen buses not yet 'assembly line' produced
- ▶ Fuel cell power (still) too low to meet high speed requirements

Lessons learned from scale-up project - HRS

- ▶ Long term contract enables low H2 price
- ▶ Semi-public HRS
- ▶ Expect a 6-month teething period
- ▶ Contracting: fixed and variable H2 price
- ▶ For larger fleets multiple HRSs recommended
- ▶ Challenges:
 - ▶ Refueling speed



Developing a hydrogen bus project takes time and effort



Main challenge:
hydrogen price
per kg



Concluding lessons learned

- ▶ Stick to a standardised bus concept (EU approved)
- ▶ Passengers and drivers: good experience with the buses (besides standstill)
- ▶ For intensive (highway) routes good alignment with OEM to secure requirements
- ▶ Communication Bus – HRS to reach acceptable refueling times
- ▶ Procuring buses and HRS in one contract can cause better alignment between OEM and hydrogen supplier

Thank you!



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