



FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

***Technology validation
in transport
applications:
vehicles, infrastructure,
APU and fuel cells***

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Agenda



PROGRAMME REVIEW DAYS 2017
FUEL CELLS AND HYDROGEN: FROM TECHNOLOGY TO MARKET
23-24 NOVEMBER, BRUSSELS

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PANEL 1

TECHNOLOGY VALIDATION IN TRANSPORT APPLICATIONS: vehicles, infrastructures, APU, fuel cells

- | | |
|---------------|--|
| 09:00 - 09:20 | Portfolio overview by Giron Enrique, FCH JU |
| 09:20 - 09:40 | 3EMOTION: Environmentally Friendly, Efficient Electric Motion |
| 09:40 - 10:00 | Clustering Bus Study |
| 10:00 - 10:20 | H2ME 2: Hydrogen Mobility Europe 2 |
| 10:20 - 10:40 | HRS Availability Study |
| 10:40 - 11:00 | HYLIFT-EUROPE: Large scale demonstration of fuel cell powered material handling vehicles |



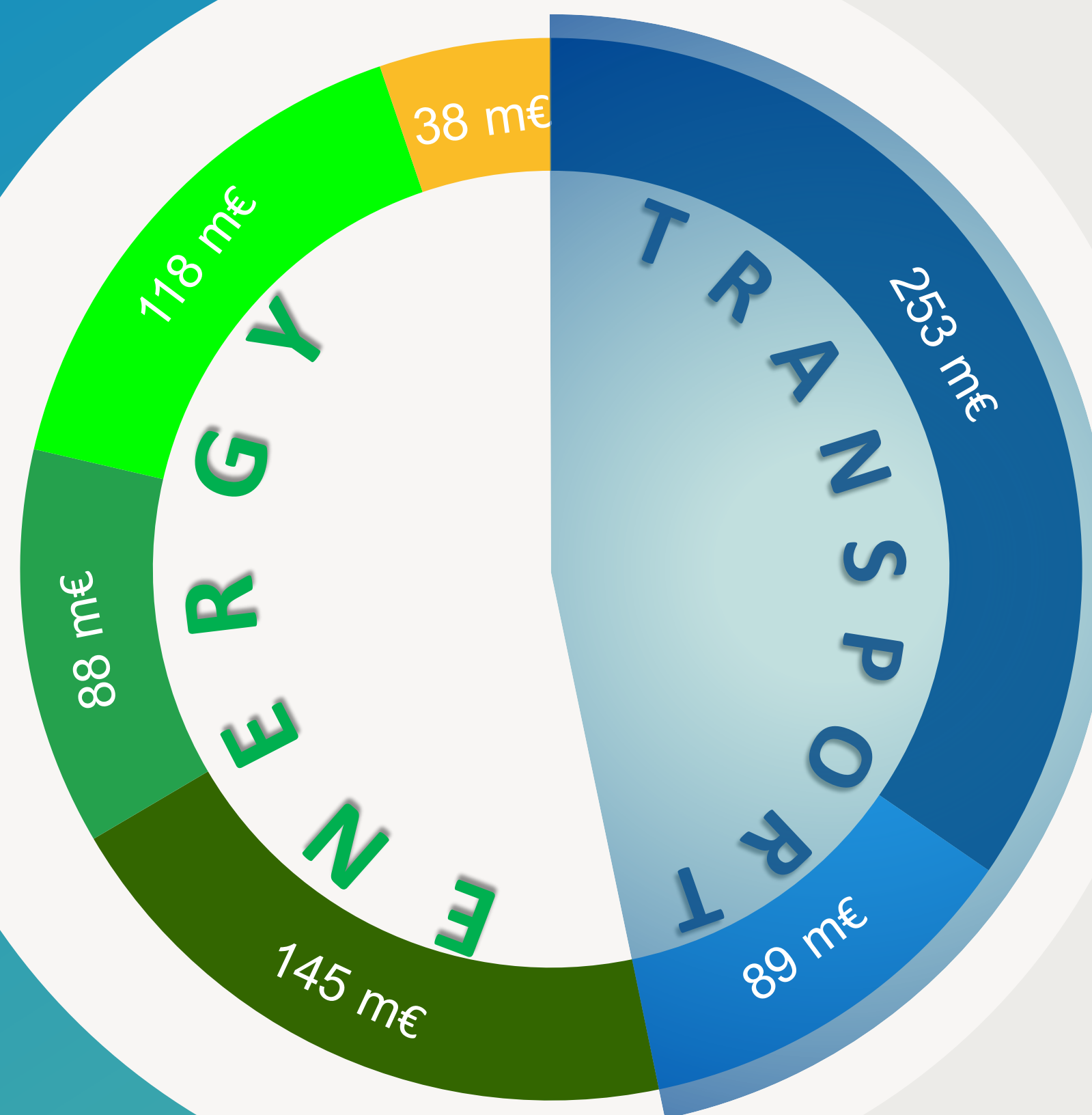
Technology validation in TRANSPORT APPLICATIONS

Related FCH JU objectives



Reduce fuel cell system costs for transport applications while increasing lifetime

Reduce use of critical raw materials



Transport

47 %



342 Mill Euros

53 Projects

Technology Validation

35 %



253 Mill Euros

25 Projects

Searching for a clean solution, as flexible as diesel...



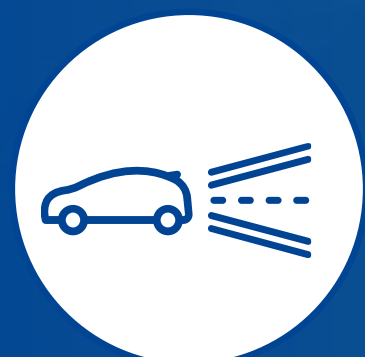
Clean



Performance



High passenger comfort



High daily ranges



Ready to buy



Fast refueling

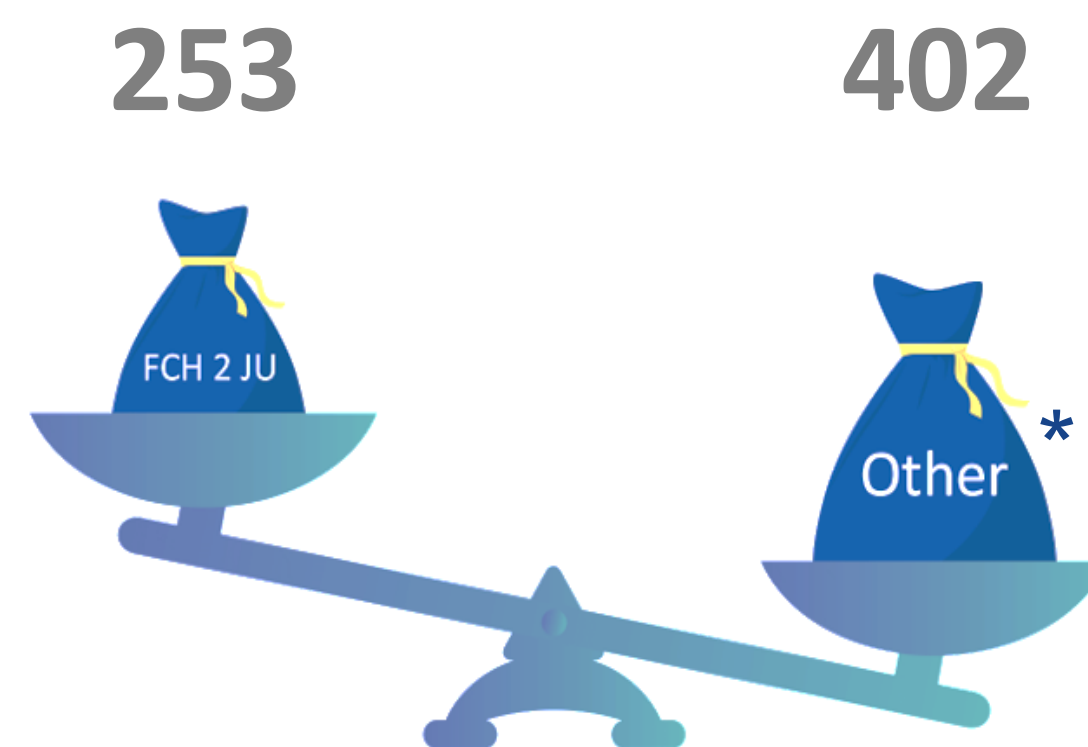


Full route flexibility

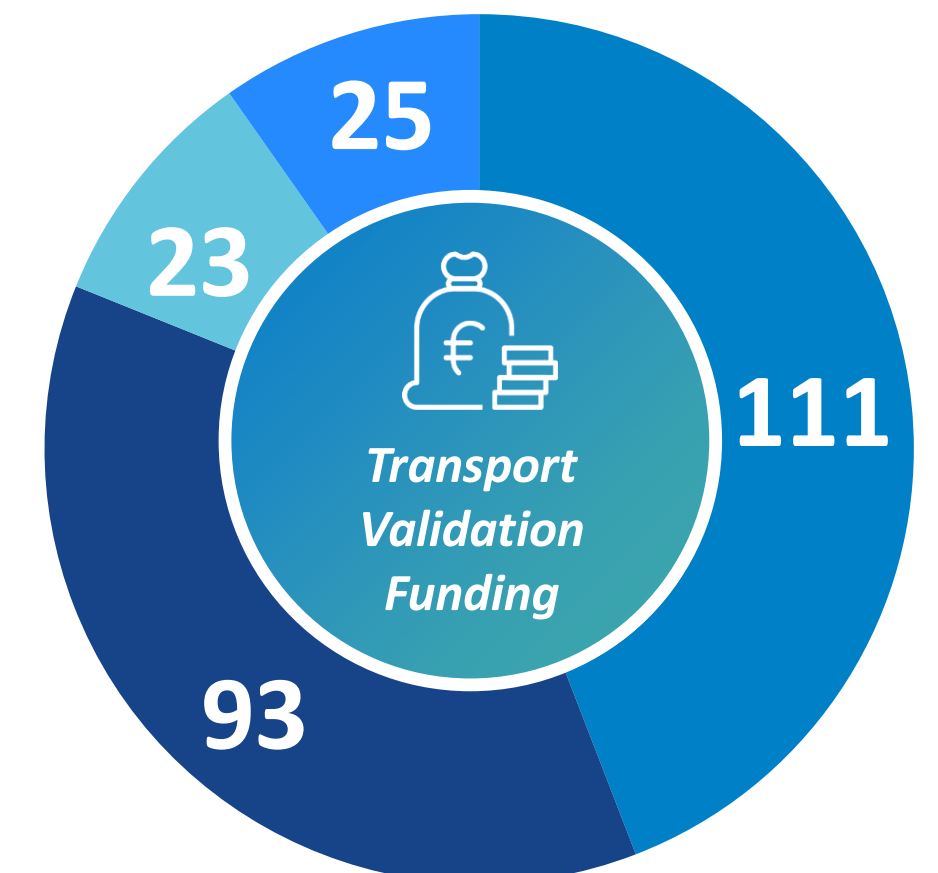


On the road to widespread deployment

25 projects – 655 M€



M€



■ Car ■ Bus ■ MHV ■ Other

M€



Extending the European network



Consolidating as market alternative



First steps to EU business case

DEPLOYING:

90 HRS
1,600 cars
200 buses
280 MHV



* Other resources including private and national/regional funding

Putting the numbers in the streets

Seven models on the road today



Deploying along the full European geography

11 countries to deploy vehicles within our projects



Availability close to 100%



Rated consumption < 0.90 kg/100km

Project logo	#FCEV	Already deployed	Countries
H2MOVES	19	19	2
Hytec	24	24	3
SWARM	50	3	3
Hyfive	131	129	5
H2ME	325	142	7
H2ME 2	1109	24	7
BIGHIT	10	-	1

117

82

55

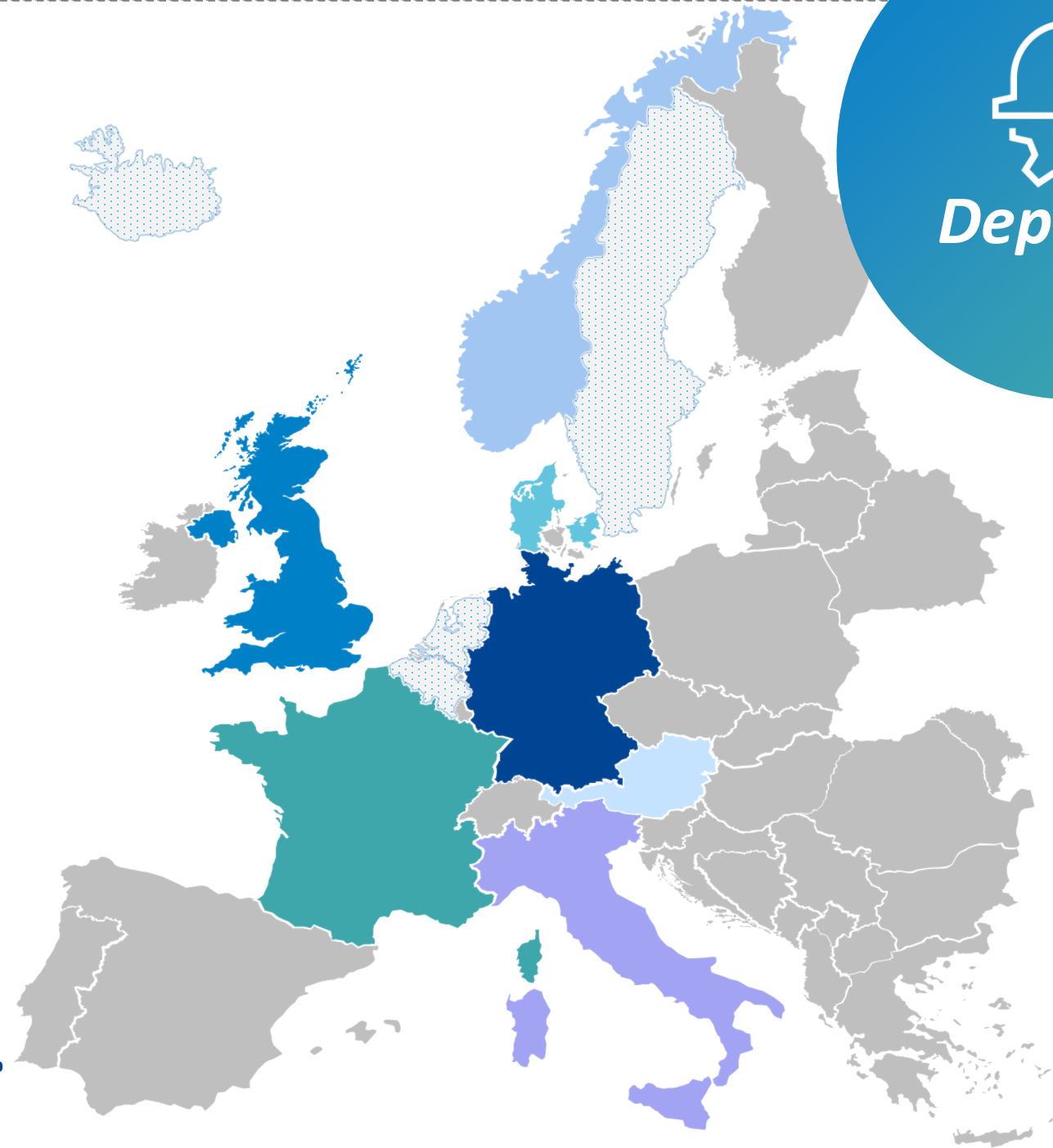
41

27

11

8

PLAN.



Deployed



Cars and small vans are at commercial standards

7 models in the roads: more coming



Achieved

- >1,980,000 km driven
- > 3,800 refuelling operations in 2016
- >10.2 tons of H₂ consumed in 2016

Product ready for commercialisation

- Up to 594 km of driving range
- 99.26 % availability
- 1.2 kg/100km average consumption

Challenges

Infrastructure development
Vehicles

- Few choices in the market
- Cost

Fleet
validations
to come



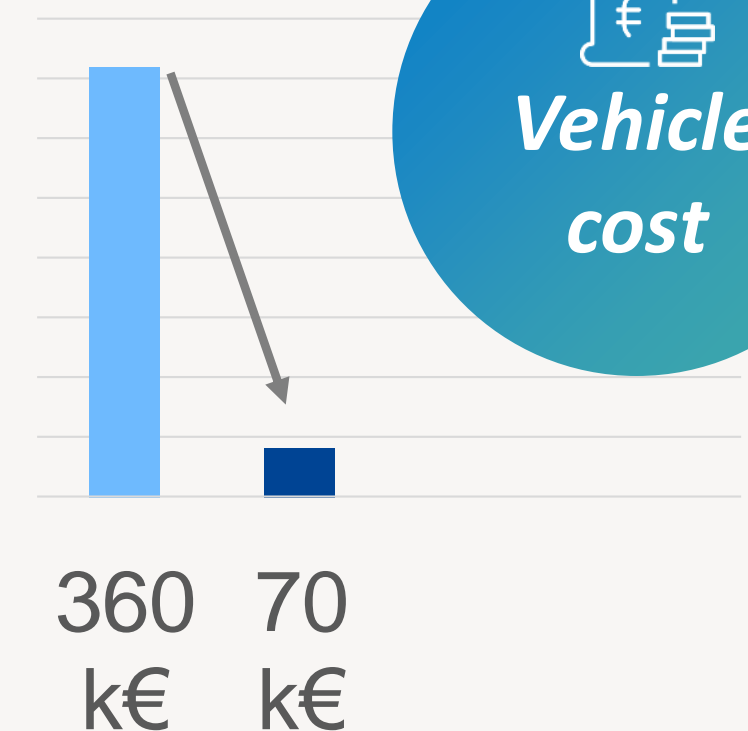
New
models
coming



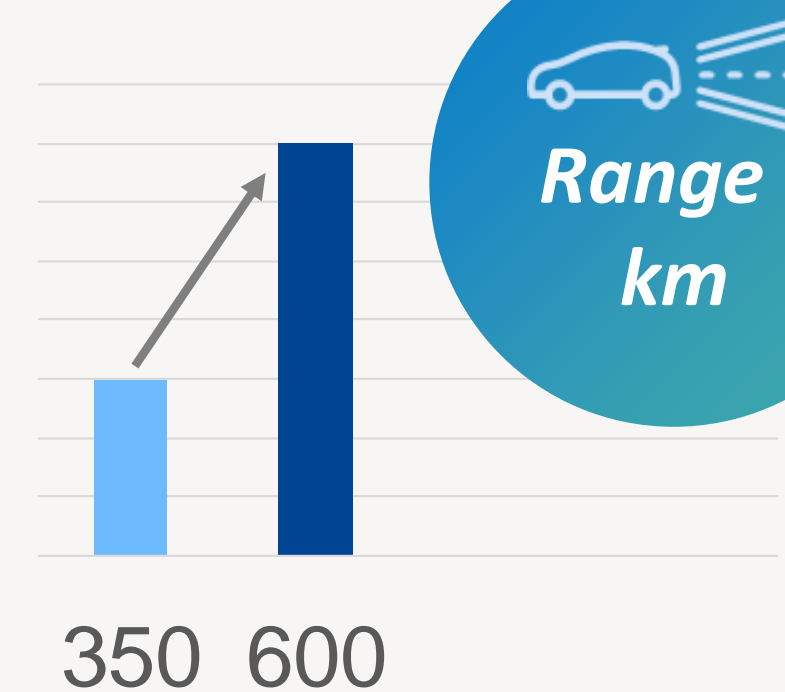
Increase
HRS
usage!



Vehicle
cost



Range -
km



Reaching the market phase

Offering a flexible clean competitive public transport solution



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

Need to fulfill the project plans

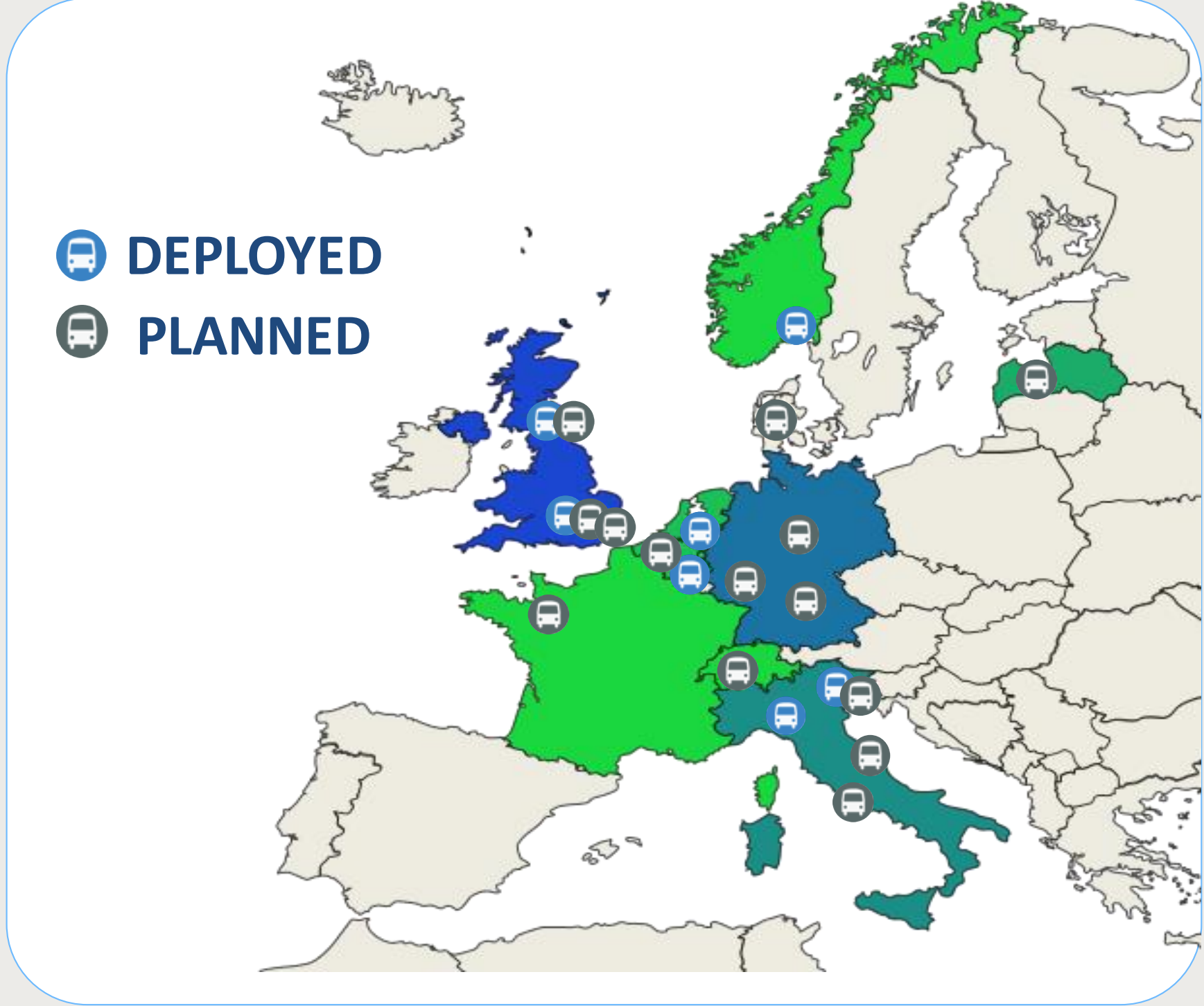


60% reduction in price



Buses reaching 90% availability

Project	#FCBuses	Deployed	#cities
CHIC	26	26	7
High V.LO-CITY	14	11	4
HYTRANSIT	6	6	1
3EMOTION	21	4	6
JIVE	139	0	9



A flexible competitive clean solution

Europe is world leader



Achieved

- >5,000,000 km driven since project started
- > 300,000 h of operation
- >159 tn of H₂ consumed only in 2016

Pre-commercialisation phase

- 25,000 h lifetime reached
- Availability proven but with teething problems
- 650,000 €/bus offered
- Average 9.86 kg/100km (very dependent on city)

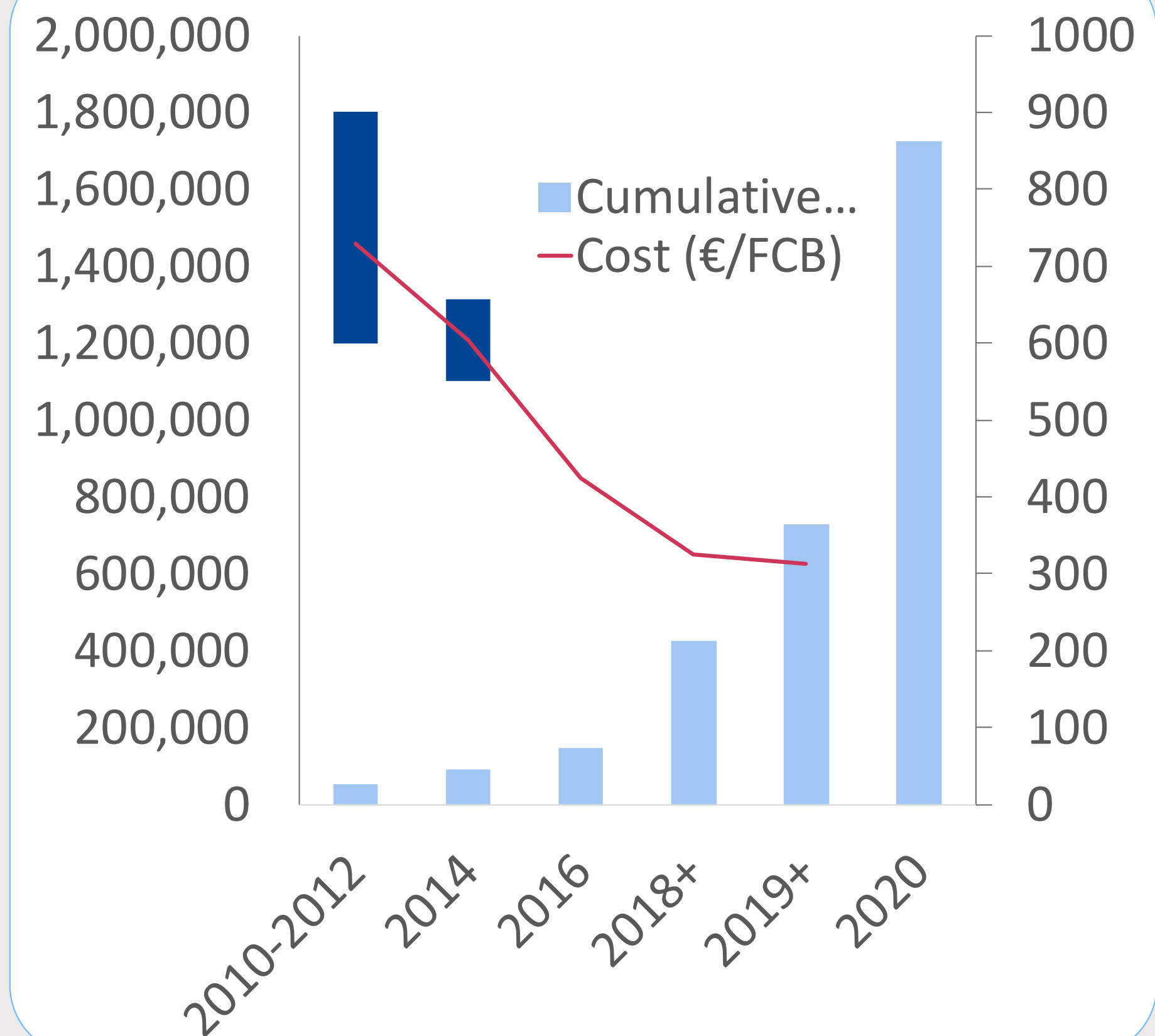
Challenges

Mature supply chain to ensure availability
Continue reducing the price of the bus
European fuel cell supplier

Joint
procurement
exercises

Co-
financing

Larger
fleets



Not only projects but a full strategic development

Strategy forward



Roadmap

Execution

A

Create independent **fact base study** and confirm feasibility along value chain

B

Create European rollout **scenario** based on typical business cases

C

Develop **frameworks**, investment guidelines, and communication tools

D

Launch first **procurements**, financial engineering for post-subsidy phase, extension of market

Milestone reached

Milestone reached

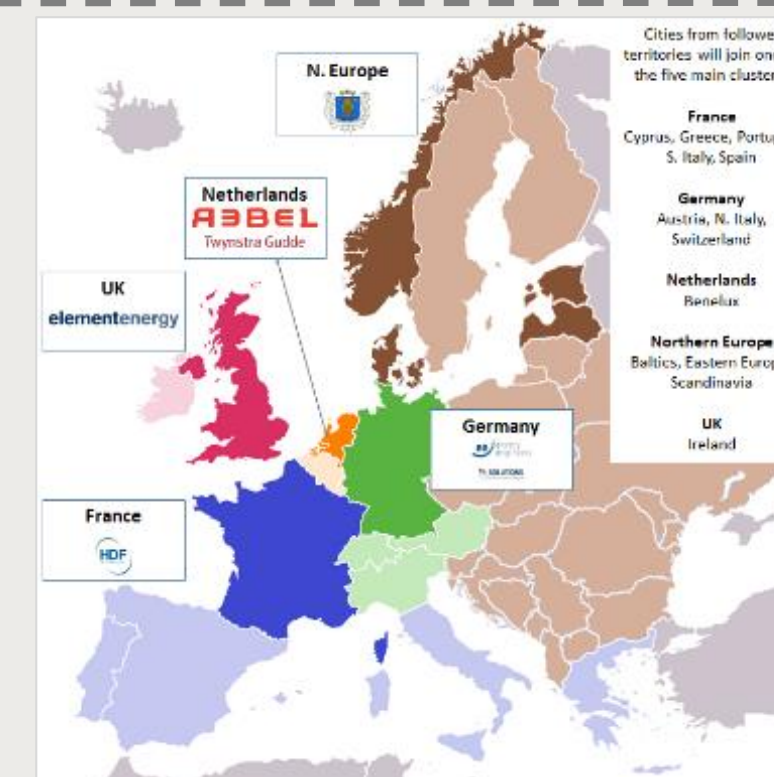
Milestone go/no go



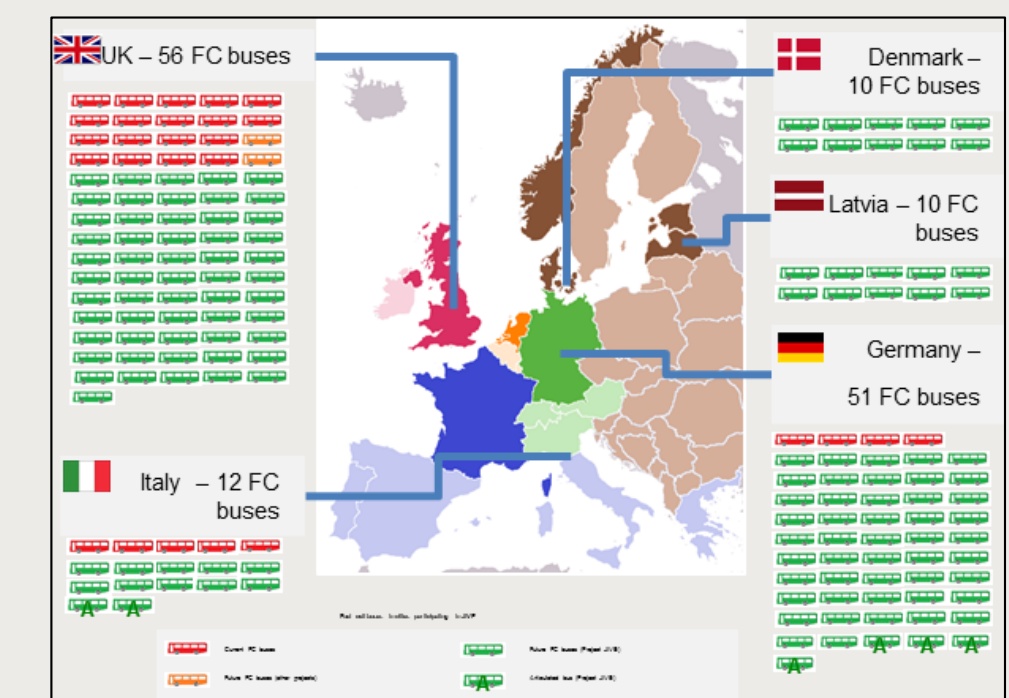
Study issued: 6/12/12



Study issued: 16/10/15



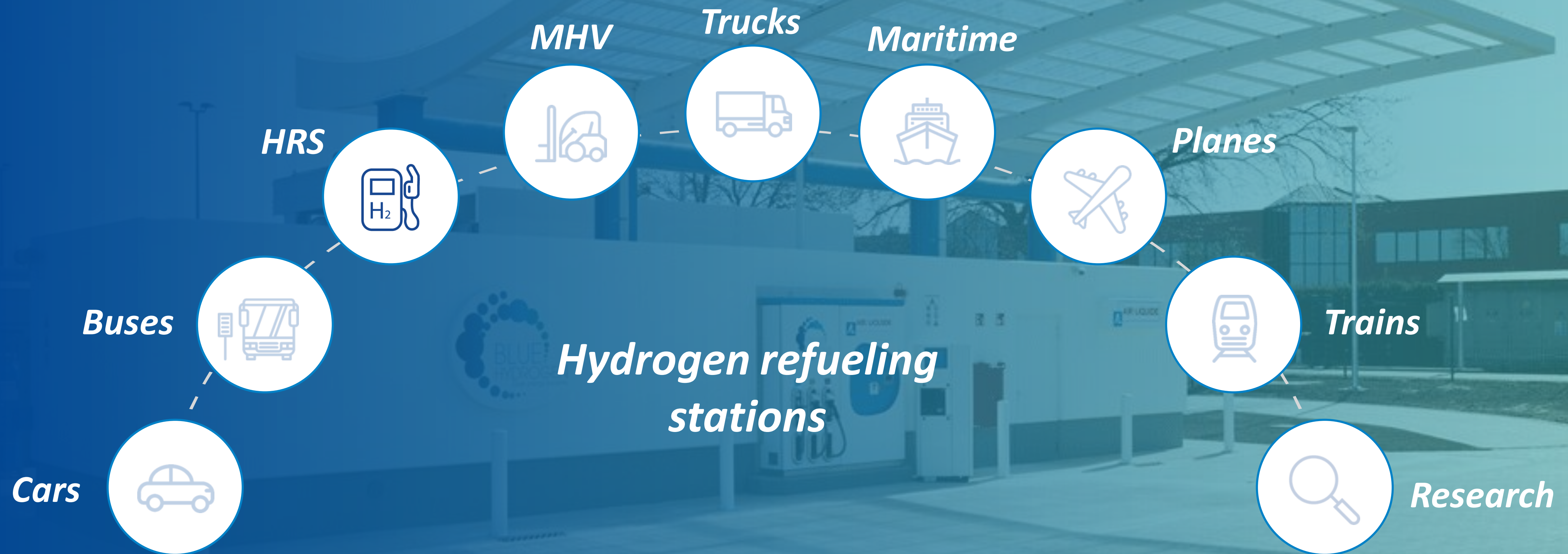
- Joint procurement
- Secure co-financing
- Further outreach



- Market prospection
- Co-financing strategy
- Dissemination

Paving the way for FCEV deployment in Europe

Exporting technology



Making FCEV deployment possible

13 countries involved in HRS deployment



>95% average availability



HRS electrolyzers: 40% cost reduction

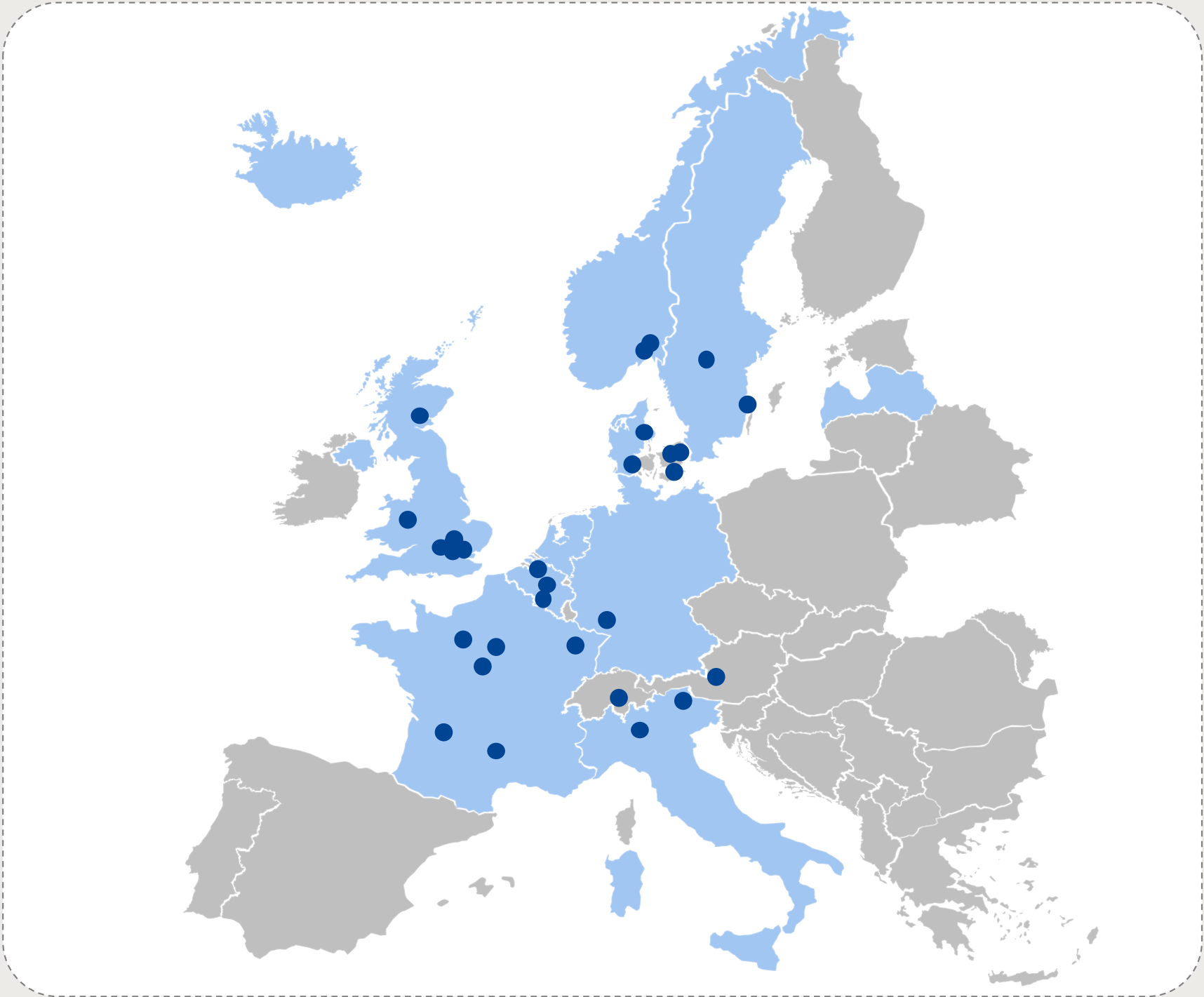
Cars: HRS per project

H2MOVES	2
Hyfive	6
Hytec	4
SWARM	5
H2ME	29
H2ME 2	20
BIGHIT	1

Buses: HRS per project

CHIC	4
High V.LO-CITY	2
HYTRANSIT	1
3EMOTION	3
JIVE	4
MobyPost	2
HyLIFT-DEMO	5
HyLIF-EUROPE	2
HAWL	1

MHV: HRS per project



DEPLOYED



PLANNED



Developing technology with a global mindset

Exporting technology



Achieved

- >39,000 refuelling operations in 2016
- > 182 tn H₂ dispensed
- >70% renewable H₂

Product ready for commercialisation

- Refilling
 - < 5 min for cars
 - < 10 min for buses
- >95 % average availability
- 70m² for 200kg/day stations

Challenges

- Reaching profitability
- Surviving underutilization
- Price of H₂
- Faster refueling for buses

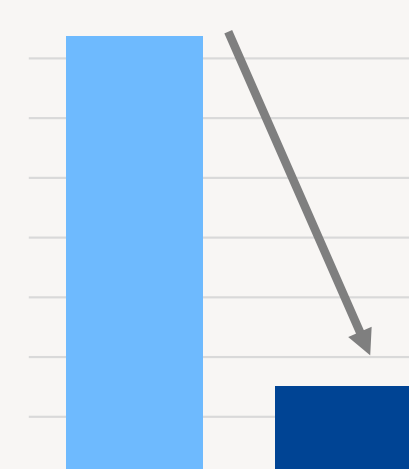
Large
fleet
validation



Grid
balancing
services

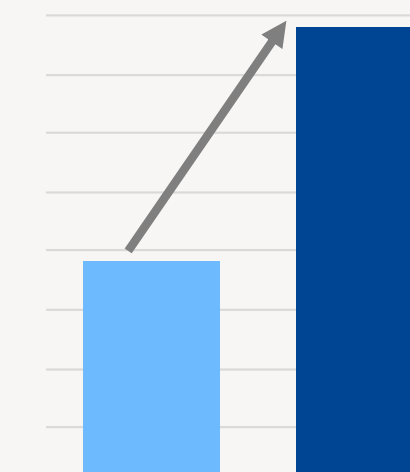


Increase
usage



HRS*
CAPEX

3.7 M€
760 k€



%
Availability

79% 99%

*HRS: 200 kg/day 700bar



First steps into the business case

Expanding the fleets giving answers to the market



First steps to develop the European business case

First greenfield warehouse with the largest fleet in Europe



KPI	SoA (2012)	FCH JU projects results 2016*	MAWP 2017 Objectives
Specific FC System cost, €/kW	4,000		<1,500
FC system Lifetime (MHV), h	>10,000	 10,000	>10,000
Availability, %	>90		>95
Efficiency, %	>45	 45	>50

- ✓ 105 MHVs in 6 warehouses
- ✓ > 33k refuelings
- ✓ >390k hours of operation in 2016
- ✓ >450k hours of operation cumulative in total
- ✓ >14.3 tn of H₂ fed in 2016

* Based on the data collection exercise from TRUST templates



Learning by operating

First large demonstration to prove business case

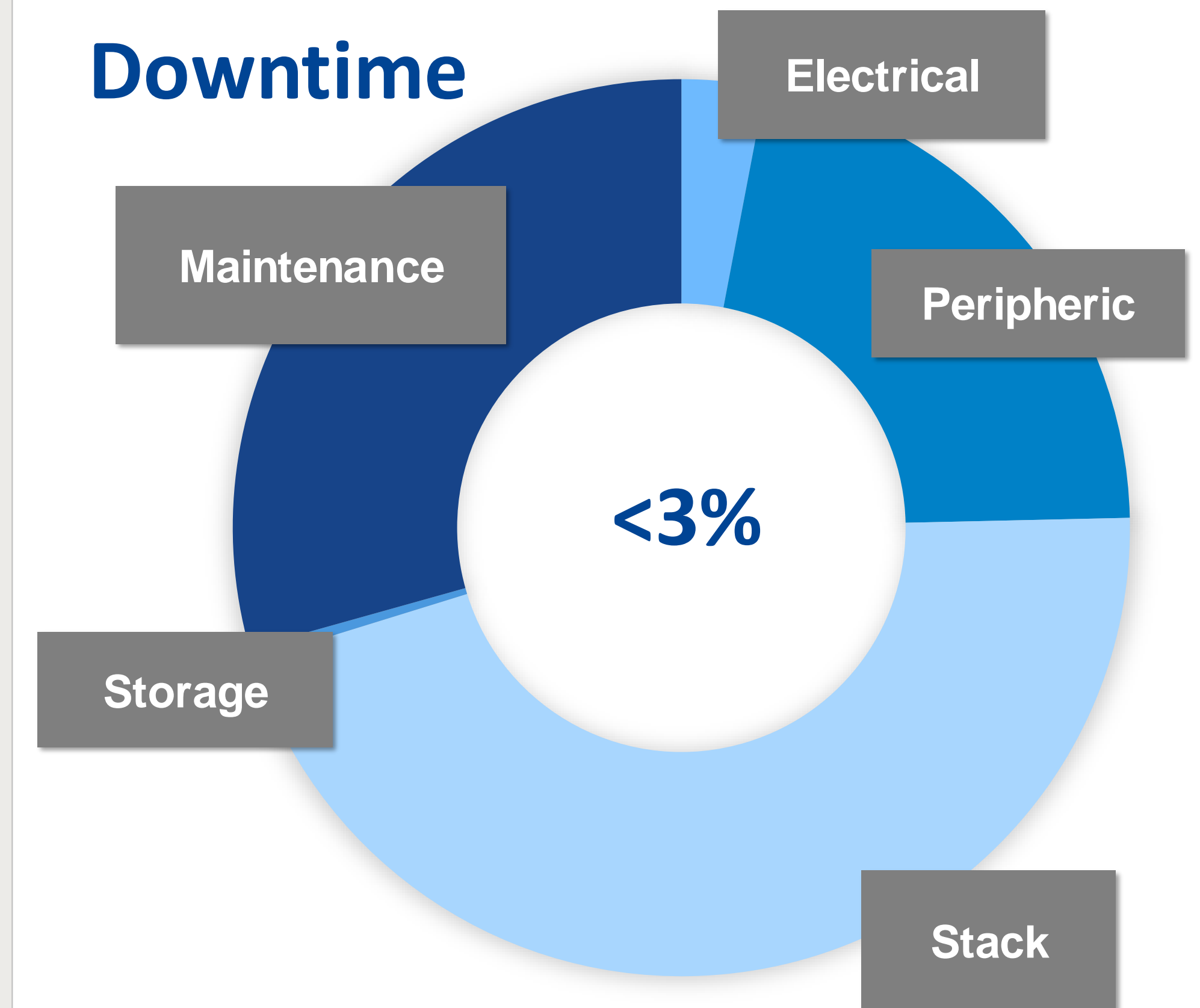


- 8 fuel cell systems and 6 vehicles models certified for use in Europe
- 4 MHV suppliers
- Greenfield site with over 50 MHVs

Challenges

- Prove the business case
 - Minimum fleet to pay for infrastructure
 - Hydrogen price
- More models available

Downtime



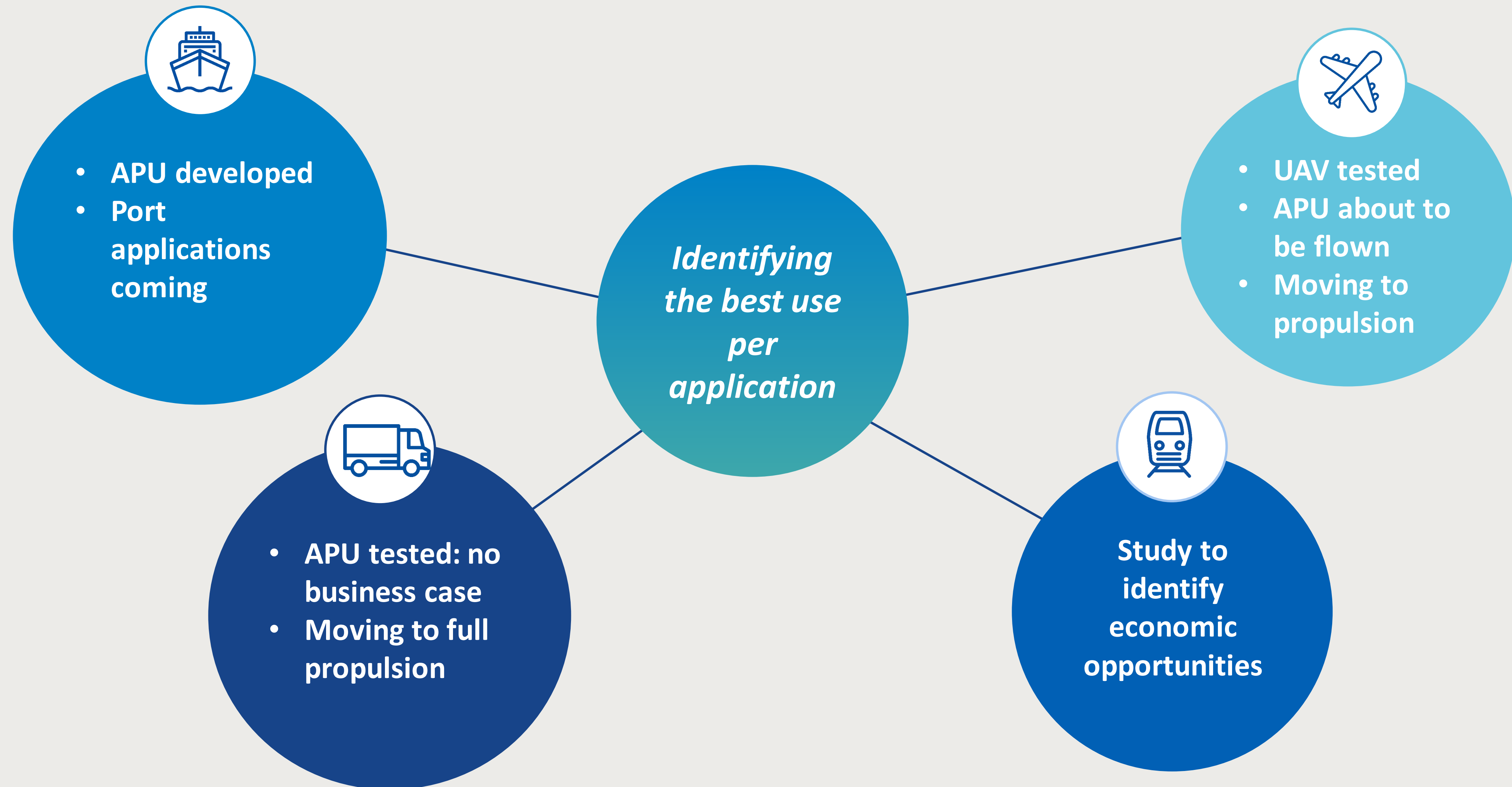
Reaching out to cover all transport applications

Testing the technology, broadening its application



Decarbonizing the transport sector

Finding the best fit



Reaching out to cover all transport applications

Making transport clean

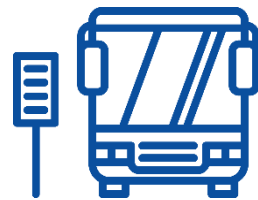


Decarbonizing the European transport sector

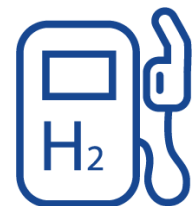
Allowing to meet the European CO₂ targets



Increasing the models available



From demonstration to the market



Paving the way for FCEV deployment



Closer to the European business case



Finding the best fit per application





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