Development of Business Cases for FCH Applications for Regions and Cities

5th General Assembly Meeting

Brussels, 19 January 2018

5th General Assembly Meeting, 19 January 2017 in Brussels – **Agenda**

Topic		Presenter	Time
Welcome coffee and registration			09:30 – 10:00
A.	Introduction and "State of the Union"	FCH2 JU, RB	10:00 – 10:05
B.	Detailed Business Cases: Methodology, assumptions and results	RB	10:05 – 11:15
C.	Break out session: Detailed Business Case Tool introduction and training	RB, participants	11:15 – 12:15
Lunch break			12:15 – 13:15
D.	Presentation of workshop concept and organisation for Phase 2	RB	13:15 – 13:30
E.	Kick-off discussion H_2 Valleys: Introduction to H_2 Valley concept; presentation of Orkney Island project experience with Q&A and discussion	RB; J. Clipsham	13:30 – 14:30
Coffee break			14:30 – 14:45
F.	Input presentation public/private financing approaches with Q&A and discussion	RB	14:45 – 15:45
G.	Conclusion and open issues/next steps	FCH2 JU, RB	15:45 – 16:00
H.	Networking drinks/ get-together	-	from 16:00 on

Contents

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A. Introduction and "State of the Union"

A

Phase 2 has started – Financing Navigation and Detailed Business Case Tools have been distributed, regional workshops scheduled

Project status – Beginning of Phase 2

- **The coalition is further growing** in terms of participating Regions and Cities as well as industry partners – Strong interest in FCH deployments
- **All regional workshops have been scheduled** and are expected to create additional outreach as interested stakeholders are invited to join
- The **Detailed Business Case Tool** has been developed and all relevant input data been compiled – Detailed introduction to participants today
- The **Funding and Financing Navigation Tool** has been distributed and reviewed by the coalition members – Final version will be circulated shortly
- Further **focus topics of Phase 2 are under preparation** for discussion in workshops – Kick-off on H_2 Valleys and input on financing approaches today

A

Detailed Business Cases will be in focus today – Kick-off discussion on H_2 Valleys and input on financing approaches further topics

Overview of project status for each module

Phase 1: Preliminary business cases

1. Regional "self-assessment" survey as initial market screening (a)
   Technology introduction for Regions/Cities (b)
2. Assessment of preliminary business cases (generic)
3. Assessment of "fit" for Regions/Cities (refined market screening)
4. Ranking of applications
5. Mapping funding/financing mechanisms

Phase 2: Detailed business cases, roadmaps

7. Detailed business cases
8. Concepts for maxi-mising use of funding
9. Roadmap and implemen-tation plan
10. Engage-ment of local stake-holders

For H_2 valleys ("Tier 1 Regions/Cities")

For demonstration projects ("Tier 2")

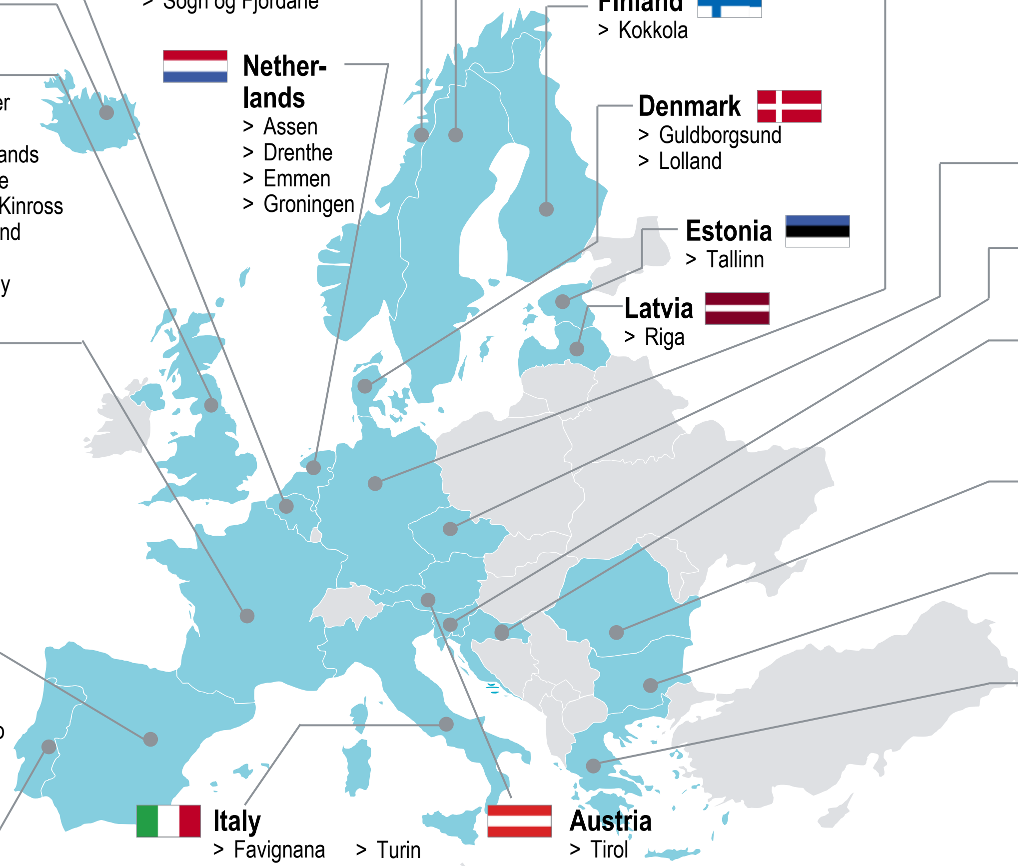
11. Dialog platform for technology development ("Tier 3")

6. Communication outreach/impact

Modules completed | Modules under way | Pending modules

A

85 Regions & Cities from 21 countries have signed the MoU so far – Additional outreach to be expected from regional workshops



Belgium
> Flanders
> Pom West-Vlaanderen

Iceland
> Reykjavik

United Kingdom
> Aberdeen
> Birmingham
> Cornwall
> Dundee
> Fife
> Leeds
> London (Greater Authority)
> Manchester
> Newcastle
> Orkney Islands
> Oxfordshire
> Perth and Kinross
> Swindon and Wiltshire
> Tees Valley

France
> Auvergne Rhône-Alpes
> Bourgogne-Franche-Comté
> Centre-Val de Loire
> Grenoble
> La Roche sur Yon
> Normandie
> Occitanie-Pyrénées
> Orléans
> Pays de la Loire

Spain
> Aragon
> Barcelona
> Cantabria
> Castilla – La Mancha
> Murcia
> Port of Valencia
> Puertollano
> Valladolid

Portugal
> Torres Vedras
> Médio Tejo

Norway
> Akershus
> Møre og Romsdal
> Oppland
> Sogn og Fjordane

Netherlands
> Assen
> Drenthe
> Emmen
> Groningen

Sweden
> Gavleborg
> Mariestad

Finland
> Kokkola

Denmark
> Guldborgsund
> Lolland

Estonia
> Tallinn

Latvia
> Riga

Italy
> Favignana
> Lazio
> Toscana
> Turin
> South Tyrol

Austria
> Tirol

Germany
> Baden-Württemberg
> Bremerhaven
> Hamburg
> Heide region
> HyCologne-Hydrogen Region Rhineland
> HYPOS (East Germany)
> Kreis Steinfurt
> North Rhine-Westphalia
> Recklinghausen/Northern Ruhr area
> Saxony-Anhalt

Czech Republic
> Trutnov

Slovenia
> Velenje

Croatia
> Split
> Split-Dalmatia County

Romania
> Constanta

Bulgaria
> Bulgarian Ports
> Sofia

Greece
> Agia Paraskevi
> Alimos
> Heraklion
> Ierapetra
> Kalymnos
> Kozani
> Milos
> Papagoou-Halargos
> Region of Crete
> Vrilissia
> Western Macedonia

Legend: Map shows all Regions and Cities which have signed the MoU"

A

A large number of FCH industry players has also become part of the project by now to support FCH deployment project developments

Current FCH industry participants

FCH

- Ferguson Marine
- BMW Group
- AD-VENTA Onboard Hydrogen Specialist
- Air Liquide
- Plug Power Europe
- Statoil
- Asahi KASEI – Asahi Kasei Europe
- Ballard
- Naval Group
- Saga Fjordbase AS
- Helbio – Hydrogen & Energy Systems
- elcore
- HydrogenHub
- Ceres Power
- Solid Power
- atawey
- HDF
- iht – Industrie Haute Technologie
- Hyseas Energy
- cEnergy
- Bosch
- PM Proton Motor – Fuel Cells · Power Systems
- convion
- Holthausen Group
- Fronius
- cmi
- Daimler
- fuelcellenergy
- H2B2
- Faun Kirchhoff Gruppe
- Wrightbus
- VDL Bus & Coach
- AFC Energy
- HyET Hydrogen
- iPower
- ABB
- ariema
- Toyota
- PersEE Innovation
- genport Power Solutions
- eps
- Linde
- Areva
- Swiss Hydrogen
- SymbioFCell
- EMCEL
- ITM Power
- Maritim Forening Sogn og Fjordane
- storengy
- Nedstack PEM Fuel Cells
- sunfire
- uniper
- Pitpoint Clean Fuels
- Auriga energy
- Logan Energy limited
- Seiya consulting
- BOC – A Member of The Linde Group
- Nimbus
- Viessmann – climate of innovation
- Hydrogenics – Advanced Hydrogen Solutions
- Calvera Hydrogen
- Alstom

B. Detailed Business Cases

B

Objective of the Detailed Business Case module is to support participants in assessing their individual FCH deployment costs

Objectives and key contents of Detailed Business Cases

Main objectives

> **Provide an FCH business case framework that can be adjusted** to local FCH deployment project scope and framework conditions

> Support Regions and Cities in calculating individual FCH deployment project costs to **identify financing needs** and **provide a base for local decision-making**

> **Facilitate deeper understanding on main cost drivers** of business cases and main areas with need for further analysis during project development

Key contents

> **Time horizon:** Calculate FCH deployment costs for the next 10 years – Focus on projects to be initiated in next 3 years

> **Selection of applications and infrastructure options:** Choose individual project configuration based on pre-defined selection of applications and infrastructure options

> **Input parameters:** Adjust all main input parameters according to individual needs

> **Scenarios:** Look at future cost developments for main CAPEX items in different cost development scenarios

> **Benchmarking:** Compare cost implications of FCH deploy-ments against conventional diesel technology

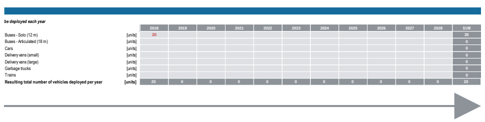
> **Environmental benefits:** Develop a view on CO_2 and NOx emission reduction by FCH deployments

B

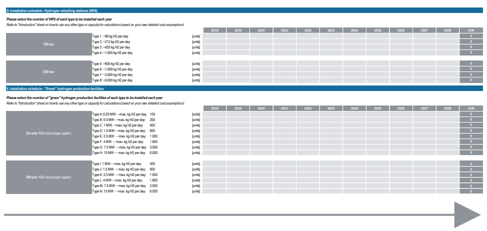
To compute their detailed business cases based on individual inputs, participants are provided with a comprehensive excel tool

Input A

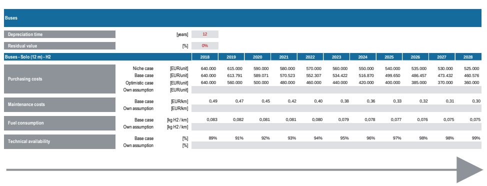
FCH vehicle deployment schedule



Infrastructure installation schedule



Other basic and detailed input assumptions



Results B

Annual evolution of total costs

B. Total annual costs		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Hydrogen vehicle fleet												
Downtime costs	[EUR/year]	158.541	143.845	128.911	112.109	95.028	70.298	54.357	38.110	30.783	23.313	15.696
Financing costs	[EUR/year]	396.477	396.477	396.477	396.477	396.477	0	0	0	0	0	0
Infrastructure depreciation & Opex	[EUR/year]	0	0	0	0	0	0	0	0	0	0	0
Fuel costs	[EUR/year]	433.024	441.751	450.600	460.093	469.720	479.482	489.381	499.418	506.330	513.329	520.417
Vehicle maintenance costs	[EUR/year]	521.740	527.878	534.016	540.768	547.520	554.272	561.024	567.776	570.845	573.914	576.983
Vehicle depreciation costs	[EUR/year]	1.066.667	1.066.667	1.066.667	1.066.667	1.066.667	1.066.667	1.066.667	1.066.667	1.066.667	1.066.667	1.066.667
Total costs	**[EUR/year]**	2.576.449	2.576.618	2.576.671	2.576.115	2.575.413	2.170.719	2.171.428	2.171.970	2.174.624	2.177.223	2.179.762
Diesel vehicle fleet (benchmark)	[EUR/year]											
Financing costs	[EUR/year]	148.806	148.806	148.806	148.806	148.806	0	0	0	0	0	0
Infrastructure depreciation & Opex	[EUR/year]	35.087	35.087	35.087	35.087	35.087	35.087	35.087	35.087	35.087	35.087	35.087
Fuel costs	[EUR/year]	610.898	623.115	635.578	648.289	661.255	674.480	687.970	701.729	715.764	730.079	744.681
Vehicle maintenance costs	[EUR/year]	321.454	321.454	321.454	321.454	321.454	321.454	321.454	321.454	321.454	321.454	321.454
Vehicle depreciation costs	[EUR/year]	389.899	389.899	389.899	389.899	389.899	389.899	389.899	389.899	389.899	389.899	389.899
Total costs	**[EUR/year]**	1.506.144	1.518.362	1.530.824	1.543.535	1.556.501	1.420.920	1.434.410	1.448.169	1.462.204	1.476.519	1.491.121

C. TCO		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Hydrogen vehicle fleet	[EUR/km]											
Downtime costs	[EUR/km]	0,13	0,12	0,11	0,09	0,08	0,06	0,05	0,03	0,03	0,02	0,01
Financing costs	[EUR/km]	0,33	0,33	0,33	0,33	0,33	0,00	0,00	0,00	0,00	0,00	0,00
Infrastructure depreciation & Opex	[EUR/km]	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Fuel costs	[EUR/km]	0,36	0,37	0,38	0,38	0,39	0,40	0,41	0,42	0,42	0,43	0,43
Vehicle maintenance costs	[EUR/km]	0,43	0,44	0,45	0,45	0,46	0,46	0,47	0,47	0,48	0,48	0,48
Vehicle depreciation costs	[EUR/km]	0,89	0,89	0,89	0,89	0,89	0,89	0,89	0,89	0,89	0,89	0,89
Total TCO	**[EUR/km]**	**2,15**	**2,15**	**2,15**	**2,15**	**2,15**	**1,81**	**1,81**	**1,81**	**1,81**	**1,81**	**1,82**
Diesel vehicle fleet (benchmark)	[EUR/km]											
Downtime costs	[EUR/km]	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Financing costs	[EUR/km]	0,12	0,12	0,12	0,12	0,12	0,00	0,00	0,00	0,00	0,00	0,00
Infrastructure depreciation & Opex	[EUR/km]	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
Fuel costs	[EUR/km]	0,51	0,52	0,53	0,54	0,55	0,56	0,57	0,58	0,60	0,61	0,62
Vehicle maintenance costs	[EUR/km]	0,27	0,27	0,27	0,27	0,27	0,27	0,27	0,27	0,27	0,27	0,27
Vehicle depreciation costs	[EUR/km]	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32
Total TCO	**[EUR/km]**	**1,26**	**1,27**	**1,28**	**1,29**	**1,30**	**1,18**	**1,20**	**1,21**	**1,22**	**1,23**	**1,24**

TCO development

Environmental benefits

D. Environmental analysis												
Total CO2 emissions saved by using H2 instead of diesel	[t CO2 / year]	-275	-279	-282	-285	-289	-293	-296	-300	-301	-303	-305
Total NOx emissions saved by using H2 instead of diesel	[kg NOx / year]	-537	-537	-537	-537	-537	-537	-537	-537	-537	-537	-537

Tool features

- > The tool automatically computes annual total costs, TCO development as well as environmental benefits of FCH deployments
- > A comprehensive result sheet shows case calculation results based on individual inputs
- > The tool offers high customisation potential – All input parameters can easily be modified with results being updated instantly
- > Validated assumptions for cost data already included in the tool can be used for indicative cost calculations if individual costs for participants are not yet known

The tool includes several selection options for individual project configurations for which costs can be calculated

Main selection options included in the Detailed Business Case Tool

1 5 focus FCH mobility applications

> Focus FCH mobility applications that have been selected in the application ranking at the end of Phase 1:
  – Trains
  – Buses (solo/articulated)
  – Cars
  – Delivery vans (N1-I[1]) and N1-III types)
  – Garbage trucks[1])

2 H_2 infrastructure and production facilities

> Hydrogen refuelling stations (HRS)
  – Options for 350 bar and 700 bar stations at different pre-defined capacity thresholds

> Hydrogen production
  – On- or off-site "green" H_2 production facilities using PEM electrolysis at various capacities

3 H_2 costs

> Standard assumption for H_2 cost from external SMR incl. truck-in

> Calculation for H_2 costs from electrolysis considering individual electricity prices

> Any other local H_2 price based on user input

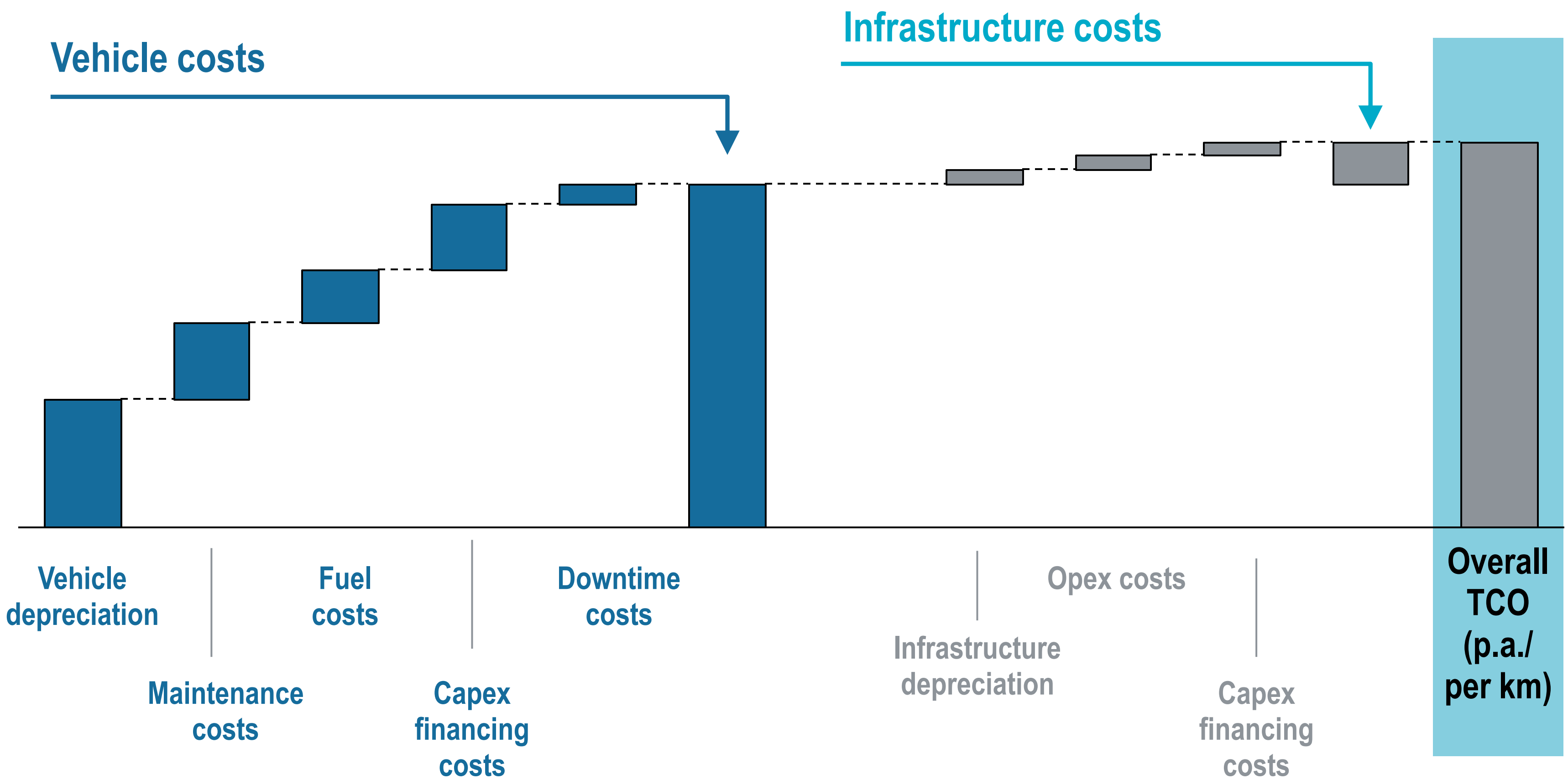
The tool allows participants to choose any kind of combination of FCH applications as well as different numbers and sizes of HRS and production facilities – Dependent on individual local project configurations

1) BEVs with FC range extender like vehicle models currently in use in Europe

B

Main cost components considered in calculations will reflect Total Cost of Ownership (TCO) of FCH deployments

Overview on cost calculation methodology



B

Where sensible, the DBC tool includes 3 future cost development scenarios for vehicle and HRS Capex depending on market uptake

Overview cost development scenarios

Use of cost scenarios

- To perform the cost analysis, three different Capex cost development scenarios for vehicles and HRS can be selected – They reflect expected cost development in the next 10 years
- Cost-down curves are based on analysis from PBCs, desk research (e.g. study review) and industry interviews
- Cost-down scenarios are included for all Capex for which sensible indicative data can be provided – **Scenarios are available for HRS, buses, cars and trains**
- The cost-down curves of the three scenarios can be used as standard cost assumptions – However, also own assumptions can be inserted in the tool

Base scenario

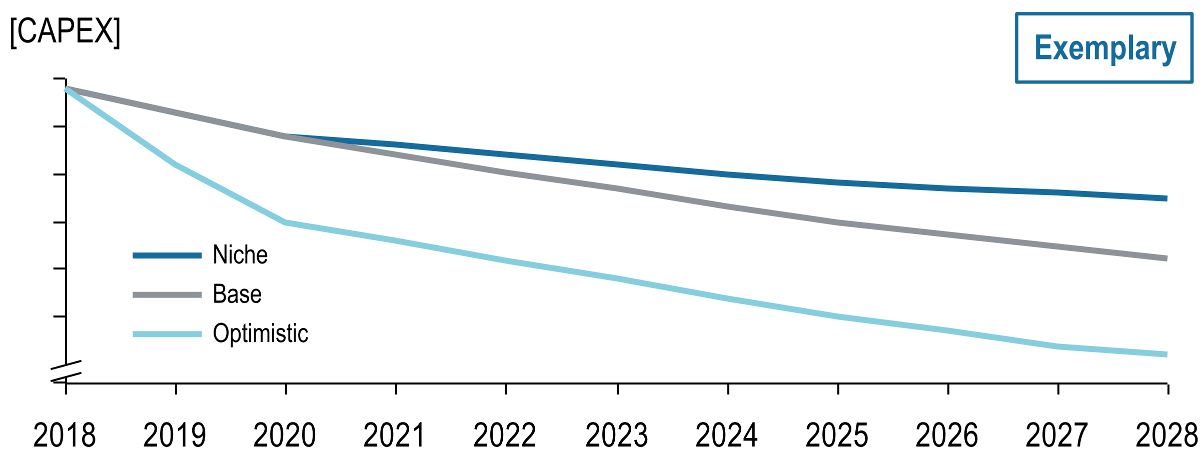
- The base scenario is the development that is currently anticipated by most studies and industry experts
- It reflects a moderately positive cost development across applications and infrastructure

Niche scenario

- The niche scenario assumes a development that is less positive than the base scenario. FCH technology will remain a niche application and accordingly, scale effects will not materialise as strongly

Optimistic scenario

- The optimistic scenario assumes a stronger market take-off. Accordingly, scale effects will bring down costs more significantly for applications as well as infrastructure



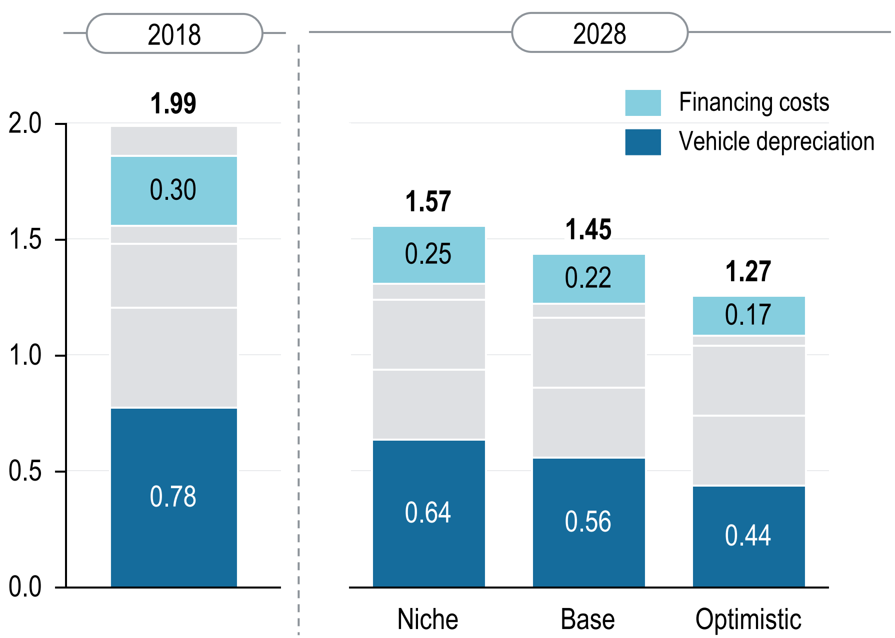
DBC = Detailed Business Case, PBC = Preliminary Business Case

B

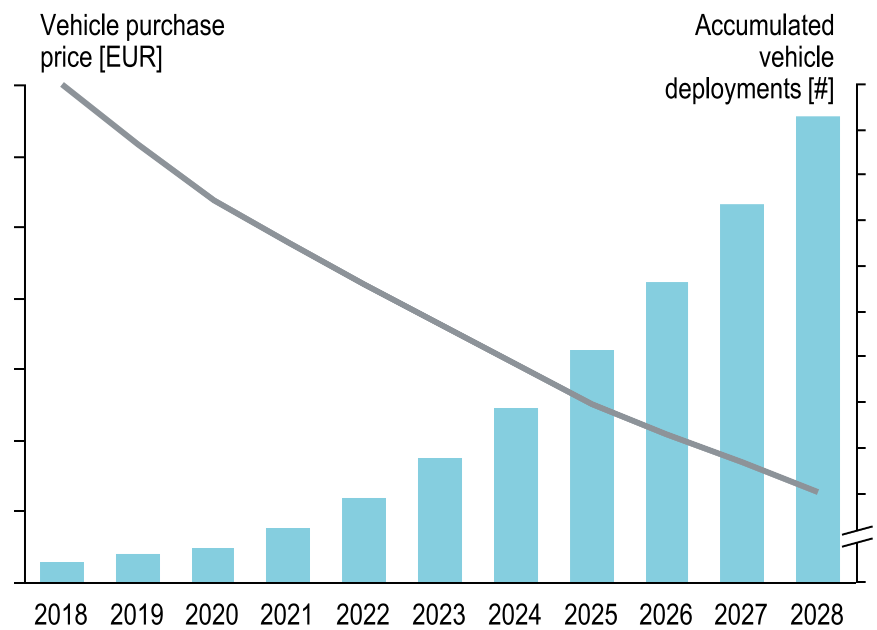
Bringing down today's high vehicle purchasing costs is a main lever to reduce TCO – To reach this, scale in market uptake is required

Results and sensitivities – Vehicle costs and cost development scenarios

Impact of FC vehicle cost reduction on TCO [EUR/km][1)]



Impact of vehicle deployments on purchasing costs[2)]



Vehicle purchasing and associated financing costs constitute the most significant part of overall TCO – Reduction of these costs is main lever to reduce overall deployment costs

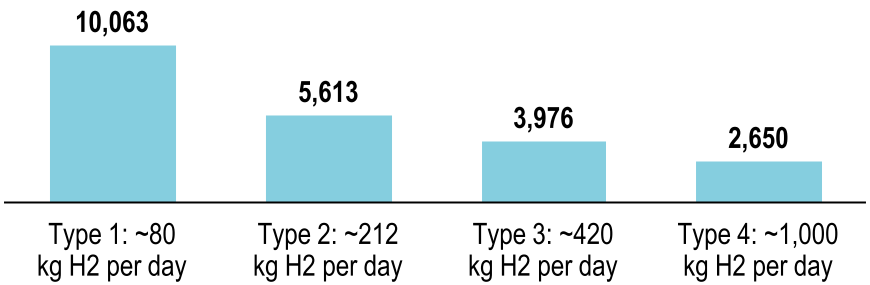
For significant cost-down effects to materialise, production volumes need to be increased in next years to come – Near term large scale deployments are required for future scale effects

1) Exemplary TCO for FC solo bus fleet (40 buses and HRS), 68,000 km annual mileage, H_2 from SMR, 12 year vehicle depreciation and repayment period, 5% WACC, in 2018
2) Indicative illustration based on results of FC bus commercialisation study (2015) – According to latest JIVE project targets, cost down can also be reach with lower prod. volumes

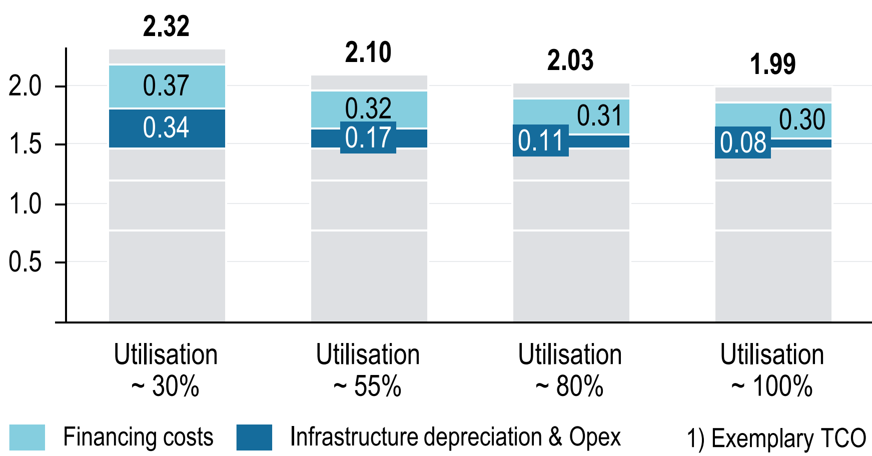
Installation of large capacity HRS and ensuring high HRS utilisation can bring down costs – Potential local cost drivers to be considered

Results and sensitivities – HRS costs and utilisation

Capex 700 bar HRS in 2018 [EUR /kg daily capacity]



FCEV TCO at different HRS utilisation levels [EUR /km][1)]



Individual HRS cost drivers

- **The tool includes standard assumptions** for HRS Capex including equipment and installation/set up costs as well as HRS Opex including standard fixed and variable costs (in % of equipment Capex)
- Nevertheless, users need to consider that **individual costs can differ significantly** due to e.g.:
  - Different HRS configurations (capacities or 700/350 bar dispensing option combinations. liquid H_2 storage etc.)
  - Need for enhanced consecutive refuelling
  - Need for additional redundancy for compressors/ storage
  - Higher civil works costs due to higher labour costs or need for installation of additional safety measures
  - Incurring land lease or purchase costs
  - Costs for complex and lengthy permitting procedures
- Therefore, **actual local HRS installation and operation costs need to be analysed individually** – Cost figures in the tool can provide a first orientation

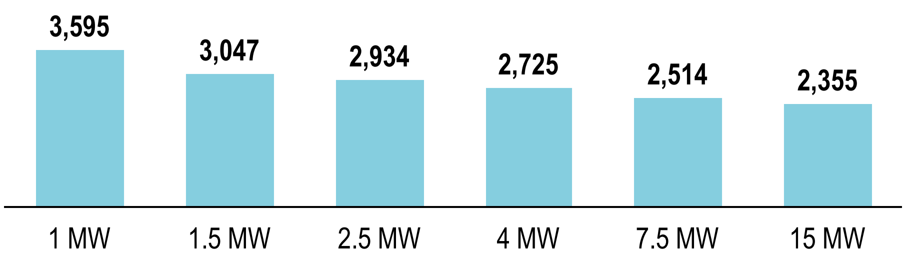
1) Exemplary TCO for FC solo bus fleet at different sizes in 2018, for case assumptions see previous page

B

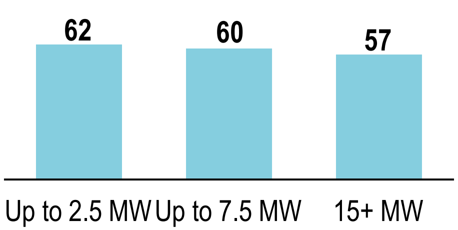
Also large-scale H_2 production facilities have more favourable cost implications – Again, high cost variance to be observed

Results and sensitivities – H_2 production facility costs

Total Capex off-site H_2 production in 2018 [EUR/kW]



Required electricity for H_2 production [kWh/kg]



Optimising Capex, low-priced RES electricity usage, potential grid balancing revenues and revenues created from sufficient off-take of produced H_2 is required for favourable investment case

H_2 production facilities cost drivers

- Tool cost assumptions mainly build on latest figures from FCH JU study on P2H applications assuming a standard production facility configuration using PEM electrolysis[1)]
- Again, **individual costs can differ significantly** with an even higher variance than HRS due to e.g.:
  - Use of alkaline instead PEM electrolyser systems
  - Need for higher compression levels or liquefaction of H_2
  - Need for additional storage capacity
  - Installation of gas grid H_2 injection interface or re-electrification fuel cell system
  - Differences in costs for civil works, grid interconnection, land lease or purchase etc.
  - Costs for complex and lengthy permitting procedures
- Therefore, also **actual local production facility installation and operation costs need to be analysed individually** – Cost figures in the tool can only provide initial orientation

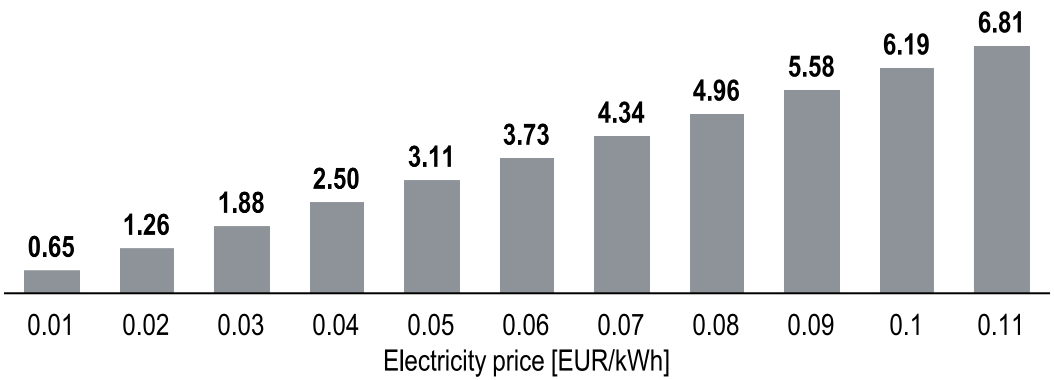
1) Including electrolyser system, filling station (off-site) or compressor skid (on-site) with 200 bar compression, storage for 100% of maximum daily production capacity and other costs (both off-site only – costs for civil works, engineering, distributed control system, energy management unit, interconnection, commissioning and start-up)

B

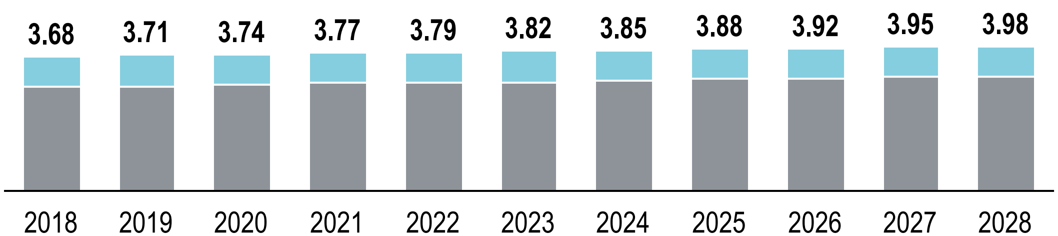
Low H_2 costs are also important for reducing overall costs – Use of cheap electricity is key to reducing costs for H_2 from electrolysis

Results and sensitivities – H_2 costs

Costs for self-produced H_2 from electrolysis in 2018 [EUR/kg][1)]



Costs for externally supplied H_2 from SMR [EUR/kg][2)]



Comments

- H_2 costs in the tool only include H_2 production/ supply costs – Capex/Opex of HRS and production facilities calculated separately
- As standard options, costs for H_2 from SMR or electrolysis production (on-/off-site) can be calculated based on individual feedstock prices
- H_2 from SMR represents large majority of H_2 produced today – As it comes additionally with very competitive costs, it will likely play an important role in FCEV commercialisation in the coming years
- To realise the full CO_2 reduction potential of H_2 and to use H_2 as energy storage, it needs to be produced from electrolysis using RES
- Use of very low electricity prices is required for H_2 production from electrolysis to become cost competitive with H_2 from SMR (depending on feedstock cost development) – Additionally, Capex and Opex for production facilities are to be considered in overall costs

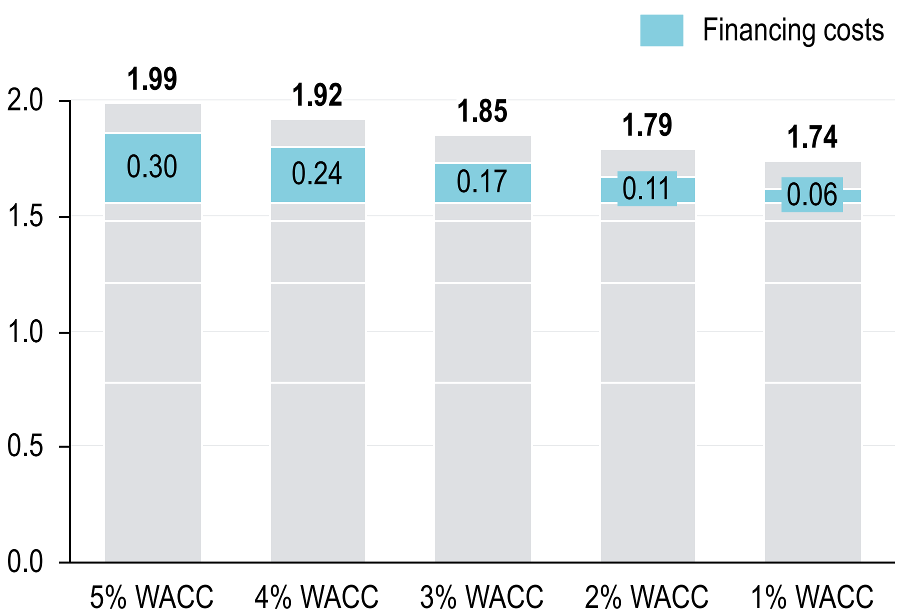
1) On-site, at electrolyser efficiency of 60 kWh electricity per kg H_2 produced and 1.7 kWh/kg consumed for compression 2) Based on assumptions from FC bus commercialisation study at current natural gas price of 0,0297 EUR/kWh with 1% annual increase, including delivery costs (in light blue), production plant Capex and Opex and supplier profit margin

B

Reducing financing costs also is an important lever to reduce overall costs, especially as high Capex volumes are reached

Results and sensitivities – Financing costs and other selected sensitivities

Impact of financing costs on TCO [EUR/km][1)]



Due to typically high Capex investment needs for FCH deployments (costs of vehicles, HRS and production facilities), low financing costs have a considerable impact on TCO

1) Exemplary TCO for FC solo bus fleet in 2018, for case assumptions see page 16

Other selected business case sensitivities

> **Increased technical availability:** Improved technical availability of conventional vehicles reduces downtime costs

> **Increased vehicle lifetime:** Electric vehicles can be assumed to have less wear and tear and could be utilised longer

> **Increased vehicle utilisation:** Intensified vehicle usage (increased annual mileage) improves asset utilisation

> **Feedstock prices:** Feedstock cost development e.g. for natural gas and electricity can highly influence H_2 fuel costs – both, positively and negatively

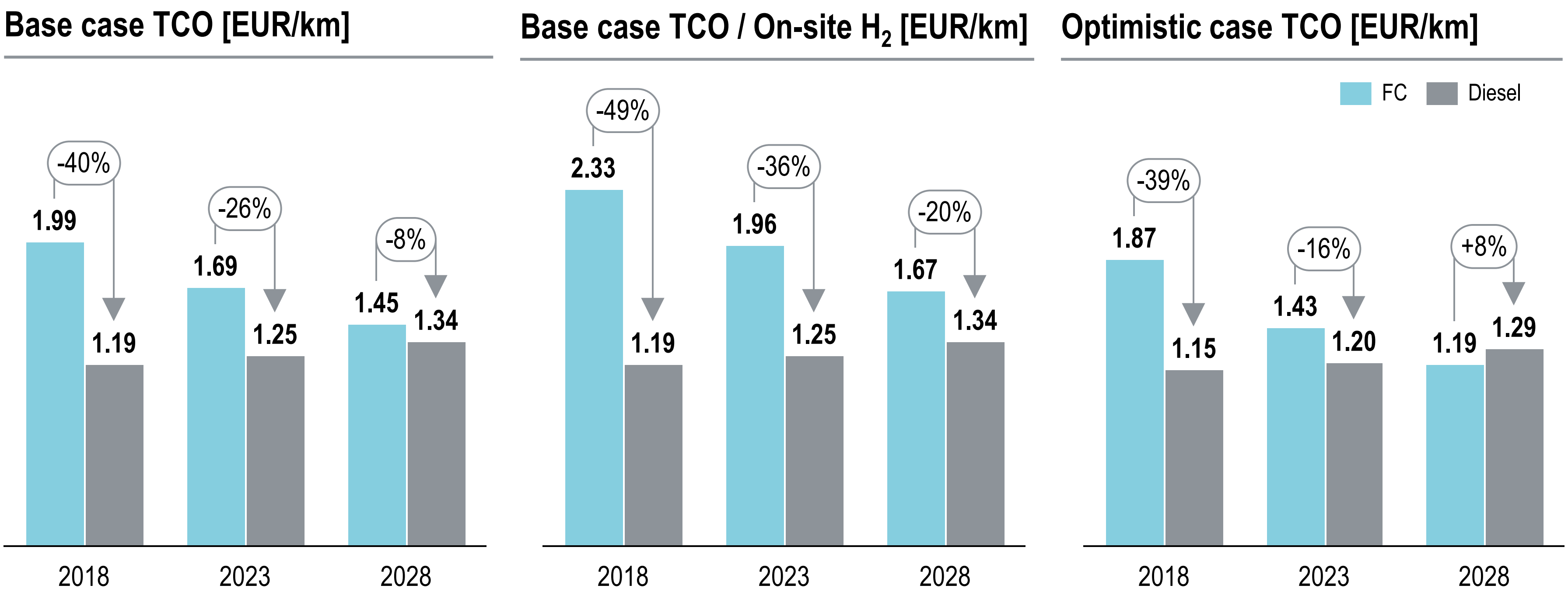
> **Fuel taxation:** Increasing taxes on diesel fuel while maintaining or decreasing taxes on H_2 and electricity can reduce fuel costs and close the gap to diesel vehicles – especially in the next years

> **Other policy instruments**: Especially in the short to medium term, additional policy measures can help closing the gap to diesel vehicles, such as subsidies on FCH vehicle purchases, congestion/ pollution charges, application of emission costs as defined in the Clean Vehicles Directive etc. – Impact highly depends on configuration of individual measures

B

As a result, individual FCH deployment costs can differ significantly – Impact of different levers determines local FCH business case

Results – Comparison of different scenarios[1)]



Base case TCO [EUR/km]	Base case TCO / On-site H_2 [EUR/km]	Optimistic case TCO [EUR/km]
Base case cost-down assumptions Financing costs at 5% WACC H_2 from SMR (external supply) with natural gas costs of 0,0297 EUR/kWh in 2018 with 1% annual increase	Base case cost-down assumptions H_2 from on-site electrolysis and electricity costs of 0,0987 EUR/kWh in 2018 with 1% annual increase	Optimistic case cost-down assumptions Financing costs at 3% WACC H_2 from SMR (external supply) with natural gas costs of 0,0297 EUR/kWh in 2018 with 1% annual increase

1) Exemplary TCO for FC solo bus fleet, for case assumptions see page 16 ; diesel fuel costs at EUR 1,30 in 2018 with 2% annual increase

B

As a cost premium for FCH deployments is to be expected, it is important to highlight their benefits and relevance to stakeholders

Key reasoning to justify cost premium for FCH deployments

Main arguments for FCH deployments

- **Zero emission potential** for both greenhouse gas and local emissions, thus contributing to meeting political goals and regulatory requirements as well as expectations from society
- **Central relevance for creating future energy systems** in which H_2 can serve as energy storage and be utilised for all kinds of energy needs
- **Contribution to security of energy supply** by withdrawing from restrained conventional energy sources
- **Contribution to economic competitiveness and growth as well as job creation** by strengthening local value creation and investing in innovation
- **Contribution to reduction of external costs** caused by conventional energy use, e.g. due to impacts on health and environment
- **High flexibility in usage and operational advantages** with a variety of use cases and operational characteristics similar to conventional fuels
- **High level of technology maturity and real-life experience** for a large number of applications in several European cities and regions

Recent example:

78% of executives in the automotive industry agree that

FCEVs will be the real breakthrough for electric mobility

due to infrastructure challenges for BEVs and faster refuelling of FCEVs

Source: KPMG Global Automotive Executive Survey 2017

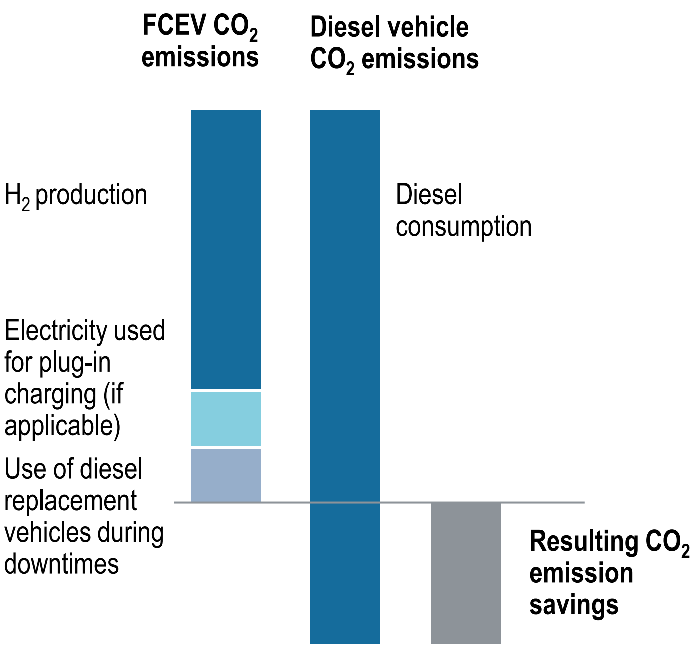
A comprehensive Stakeholder Communication Package is currently under development to support Regions & Cities in stakeholder engagement – Key rationale and benefits of deploying FCH technologies will be highlighted

B

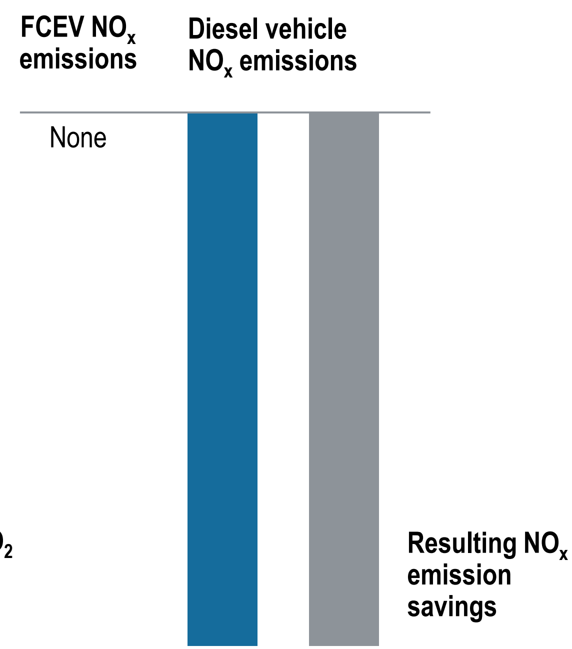
Concrete environmental benefits of FCH deployments vis à vis current diesel vehicles are calculated in the tool for individual cases

Overview on environmental analysis methodology

WTW CO_2 emission savings calculation



NO_x emission savings calculation



Comments

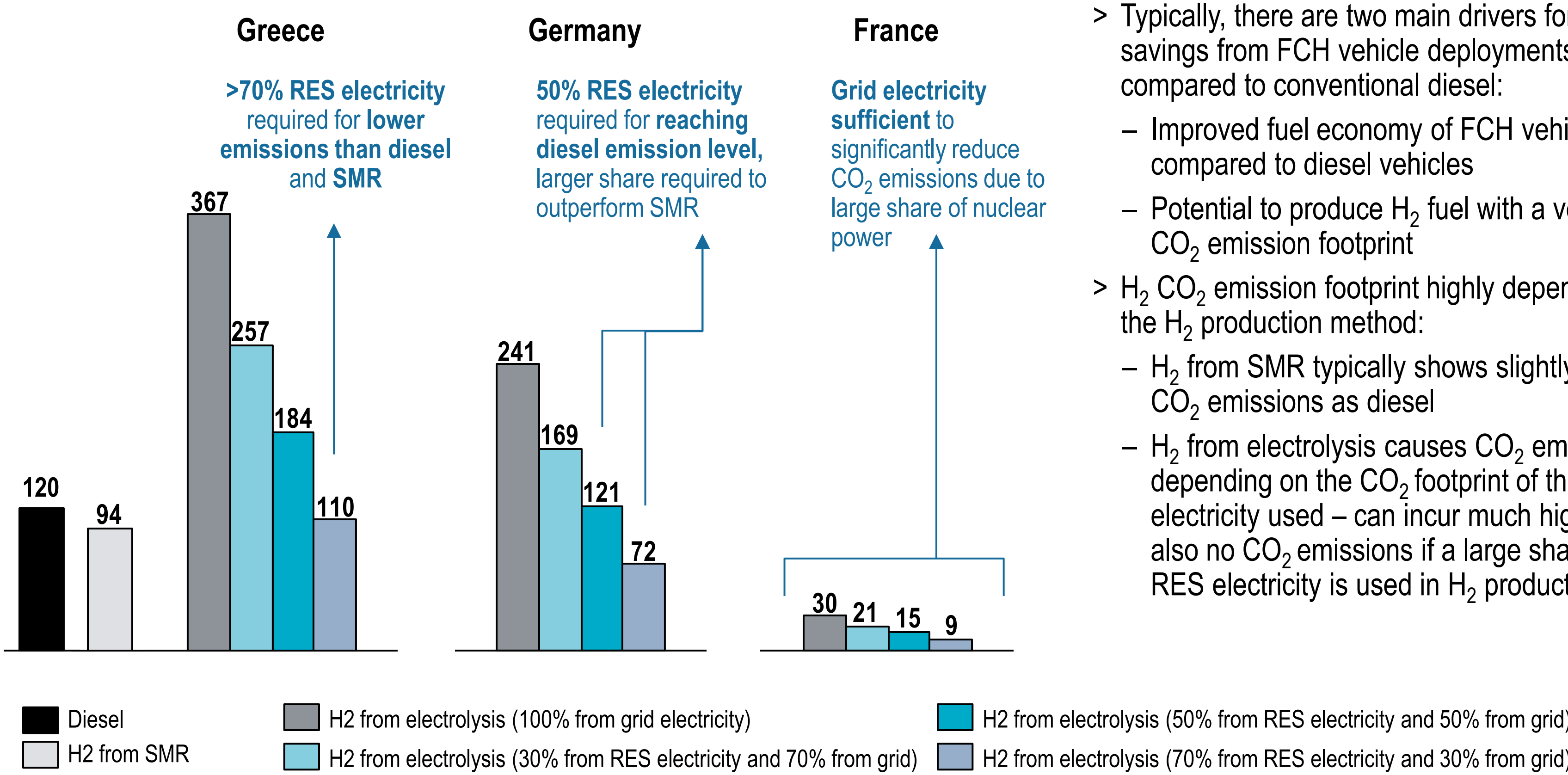
- Emission savings from FCEV deployments are calculated in the tool to illustrate their environmental benefits
- Results can be used in stakeholder communication to justify the cost premium for FCEV deployments as calculated by the tool
- NO_x emission savings will be reached in any case as FCEVs cause no local emissions
- Availability of CO_2 emission savings depends on selected H_2 production method – Individual CO_2 footprint calculations can be made for H_2 from electrolysis which can strongly affect the results

For emissions benchmarking, fuel economy and emission performance of new diesel vehicles is compared to emissions caused by FCEVs to illustrate additional savings potential from FCEV deployment compared to deployment of new diesel vehicles

B

CO_2 emission savings highly depend on H_2 production method and CO_2 footprint of feedstock used as well as H_2 fuel economy

Example: CO_2 emissions of solo buses (WTW cycle) [kg/ 100 km] in 2018



> Typically, there are two main drivers for CO_2 savings from FCH vehicle deployments compared to conventional diesel:
  – Improved fuel economy of FCH vehicles compared to diesel vehicles
  – Potential to produce H_2 fuel with a very low CO_2 emission footprint

> H_2 CO_2 emission footprint highly depends on the H_2 production method:
  – H_2 from SMR typically shows slightly lower CO_2 emissions as diesel
  – H_2 from electrolysis causes CO_2 emissions depending on the CO_2 footprint of the electricity used – can incur much higher but also no CO_2 emissions if a large share of RES electricity is used in H_2 production

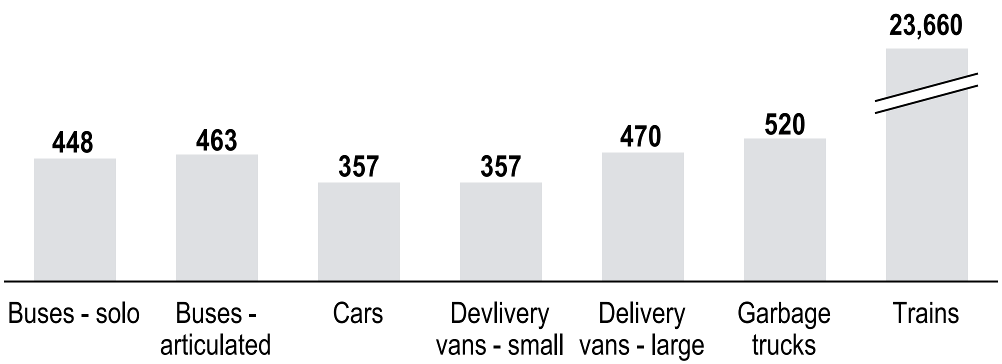
Assumptions for solo bus emissions: Diesel fuel consumption 39,2 litre/100 km, diesel CO_2 footprint 3,05 kg/litre; H_2 fuel consumption 8,3 kg/100 km; CO_2 footprint H_2 from SMR 11,3 kg/kg H_2, CO_2 footprint of grid electricity per country acc. to latest Eurostat figures, electricity consumption of 60kWh electricity to produce 1 kg H_2 from electrolysis

B

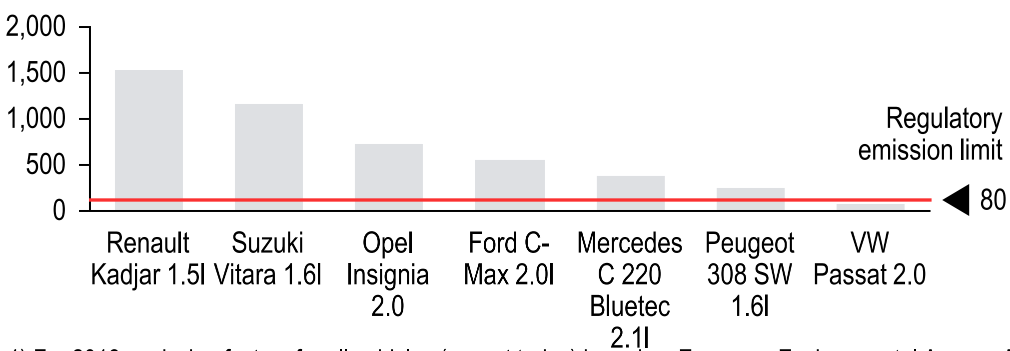
Calculation of NOx emission savings is based on "real world" diesel vehicle emissions – Partially, large variance to be considered

Overview on NOx emission assumptions

Tool assumptions on NOx diesel vehicle emissions [mg/km][1)]



"Real world" NOx Euro 6 diesel car emissions [mg/km][2)]



Comments

> For all vehicle types European legislation defines NOx emission limits, but real world tests have shown that limits are not met in many cases – Therefore, the tool includes "real world" emission data for emission savings calculations

> Whereas for heavy-duty vehicles test data shows that emission limits are not systematically exceeded, the opposite applies for light-duty vehicles, especially for diesel cars, which in many cases significantly exceed Euro 6 emission limits

> In this context, large variance of real world emissions has been found between different vehicle models (even from the same OEM) – Therefore, averaged emission factor assumptions have been included in the tool based on EEA data for latest emission standard vehicles

> Nevertheless, results may deviate significantly if emission factors for individual vehicle models are considered

1) For 2018; emission factors for all vehicles (except trains) based on European Environmental Agency Air Pollutant Emission Inventory Guidebook 2016 for Euro 6/VI; emissions for trains based on Stage IIIb/V EC regulation emission limits for railcars 2) ICCT (2016) based on KBA/BMVI test results

C. Break out session: Tool introduction and training

C

In the next 60 min, we would like to introduce you to the Detailed Business Case Tool in more detail and answer your questions

Proposed composition of break-out groups and moderators (RB team)

INDICATIVE

Group 1

- A. Spieß
- V. Álvarez Alhambra
- M. Cadic
- G. Ciudad
- J. Clipsham
- F. Da Col
- P. Defranceschi
- P. Faber
- G. Figueruelo
- F. Vigalondo

Dr. Simon Lange

Group 2

- C. Funez Guerra
- J. Jordan
- T. Kattenstein
- B. Krajnc
- M. Lewis
- M. Loonstra-Buzogany
- H. Lucas
- A. Martens
- M. Nogueira
- D. Vladikova

Felix Heieck

Group 3

- F. Palacín
- F. Pfeffer
- F. Pingault
- L. Rohleder
- L. Rubio Bremard
- J. Sanz-Argent
- T. Stromgren
- A. Vasquez
- A. Venema
- M. Weber
- V. Willmann

Johannes Pfister

Industry participants are invited to join any of the groups!

D. Presentation of workshop concept and organisation

D

The workshops in Phase 2 of the project are cross-cutting through all project modules and discussion topics

Overview of modules covered in workshops

Phase 1: Preliminary business cases

1. Regional "self-assessment" survey as initial market screening (a)
   Technology introduction for Regions/Cities (b)
2. Assessment of preliminary business cases (generic)
3. Assessment of "fit" for Regions/ Cities (refined market screening)
4. Ranking of applications
5. Mapping funding/financing mechanisms

Phase 2: Detailed business cases, roadmaps

7. Detailed business cases
8. Concept for maxi-mising use of funding
9. Roadmap and implemen-tation plan
10. Engage-ment of local stake-holders

For H_2 valleys ("Tier 1 Regions/Cities")

For demonstration projects ("Tier 2")

11. Dialog platform for technology development ("Tier 3")

6. Communication outreach/impact

Modules completed | Modules under way | Pending modules

D

The timing of the 1st regional workshops is spread over February and March – 2nd workshop round to be scheduled for April soon

Overview of regional workshops

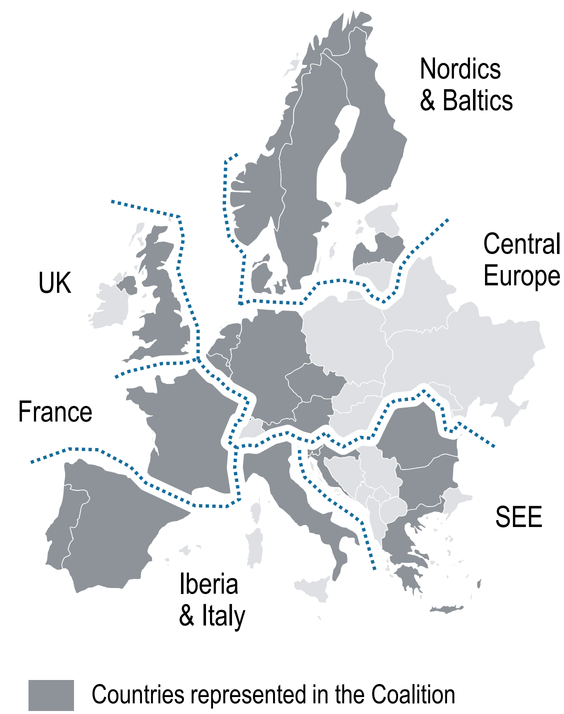
Dates for the regional workshops

Workshops	February 07	08	09	March 10	11
Iberia & Italy – Puertollano Host: CNH2	14.02.2018				
Central Europe – Leipzig Host: HYPOS		20.02.2018 *(together with HYPOS conference)*			
Nordics & Baltics – Oslo Host: Akershus Region		22.02.2018			
SEE – Athens Host: Municipality of Vrilissia			01.03.2018		
UK – London Host: Greater London Authority				09.03.2018	
France – Paris Host: AFHYPAC					13.03.2018 *(together with AFHYPAC Regions Working Group meeting)*
H_2 Valleys – Frankfurt			27.02.2018		

You are free to participate in any of the workshops offered – Register now and spread the word also to interested stakeholders outside the coalition!

Registrations are open on http://www.fch.europa.eu/event/local-workshops-fch-ju-regions-and-cities-initiative

Meetings organised for each of the six geographical clusters:



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The 1st round of workshops in Phase 2 will focus on knowledge exchange on best practices in FCH project development

Content concept for 1st round of regional workshops

	Project development input	Technology input	Best practice input
Concept	> Short introduction to FCH project plans of participants > Input presentation and joint discussion on best practices in main challenges for FCH deployment project development > Discussion of way ahead in the initiative	> Presentation of industry view and experience on deployment of specific technologies > Input either on selected focus application from Phase 1 or technology with cluster/ regional relevance > OR cross-cutting technology topic (e.g. HRS, H_2 production) > Room for discussion and Q&A	> Presentation of practical example of a deployment project in a region or city > Input on experiences in project setup and development, challenges and lessons learnt > Preferably focus on one of the focus applications for Phase 2 > Room for discussion and Q&A
Focus	Functional focus	Application focus	Deployment project focus
Input by	RB, participants	Industry representative	Region & City representative
Indicative timeframe	~3 hours with interactive formats and discussion	~45 min with Q&A/ discussion	~45 min with Q&A/ discussion

D

The agenda for all regional workshops will follow the same structure, but feature individual input presentations – Registration is now open

	Topic	Presenter	Time
	Arrival of participants		09:30 – 10:00
Program suitable for local stakeholders	**A. Welcome and objectives**	*RB*	10:00 – 10:15
	B. From vision to reality – Experiences in implementing FCH projects		
	Presentation of deployment project experience + Q&A	*Region or City*	10:15 – 11:00
	Presentation of industry view on FCH technology deployment + Q&A	*Industry partner*	11:00 – 11:45
	C. Creating a clean energy future – Developing FCH projects	*RB + participants*	
	Regional H_2 ambitions – Short presentations of local FCH plans	*Participants*	11:45 – 12:45
	Lunch break		12:45 – 13:30
Program focusing on project developers/ participants	Success factors in developing local FCH projects	*RB*	13:30 – 15:15
	- Creating conducive framework conditions: Soft measures and policies		
	- Scoping local FCH project concepts: Key elements and success factors		
	Coffee break		*in between*
	- Engaging local stakeholders: Stakeholder management		
	- Identifying financing needs: Initial deployment cost assessments		
	D. Way ahead: Discussion of next steps for realisation of FCH projects	*RB + participants*	15:15 – 16:00

D

An additional pan-European event is planned for all participants specifically focusing on H_2 Valley concept development

Concept and indicative agenda for the H_2 Valley workshop

1 **Input presentation**: The role of H_2 in the future energy system and H_2 Valleys as potential role models for its development (~45 min)

2 **Introduction round**: Presentation of H_2 Valley development plans of participating Regions and Cities (~5 min per case, ~1 - 1.5 hours)

Lunch break

3 **Joint discussion**: Existence of archetypes, synergy potentials and main challenges for H_2 Valley implementation (~1 hour)

4 **Joint discussion**: Developing a joint roadmap and plan for H_2 Valley implementation (~1 hour)

5 **Wrap up and way ahead** (~15 minutes)

Organisational details

- Timeframe: 10:00 – ~16:00
- Incl. lunch and coffee break
- Participation via telephone/video conference possible

All participants can take part in the regional workshops AND the H_2 Valley workshop!

D

As a result of the facilitation work and discussions in Phase 2, participants shall outline their concrete FCH projects until May

Expected outcome of Phase 2 of the project

- To define a joint way forward on how FCH deployment projects can jointly be realised in the framework of the initiative, transparency on concrete FCH project plans is required
- Therefore, participating Regions & Cities will be asked to provide a FCH Project Concept until May that describes their planned FCH deployment projects in the next 3 years
- To prepare the FCH Project Concepts a template will be provided that includes the main elements as outlined on the right side
- Further facilitation work and topics to be discussed in the regional workshops shall cover these elements and provide support to Regions & Cities to compile their FCH Project Concepts

FCH Project Concepts

- Background and objectives, support policies and strategies in place
- Project outline, including:
  - Envisaged project setup and concept
  - Type and volumes of FCH applications and infrastructure to be deployed
  - Main required product specifications
  - Indicative deployment timeline
- Status on implementation preparation, including:
  - Stakeholder engagement
  - Project organisation
  - Funding/ financing approach
  - Other relevant steps (feasibility studies etc.)
- Next steps

Roland Berger

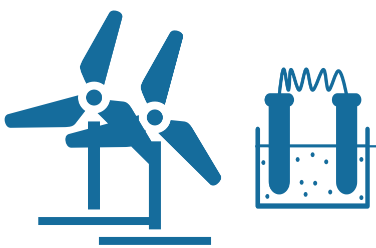
E. Input presentation on H_2 Valley concepts

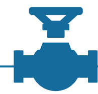
E

A H_2 Valley combines "green" H_2 production, distribution and usage across a variety of applications in a distinct local setup

Conceptual overview of a H_2 Valley – Basis for discussion

H_2 Valley



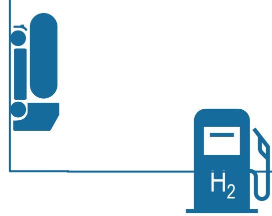


H_2 Production

> Distributed local H_2 production, focus on "green" H_2 from renewable energy sources

> Local distribution via trailers or pipeline for use in different applications

Set up across one distinct geographic location/ area showcasing the systemic relevance of H_2 for the local energy system covering the entire hydrogen supply chain



H_2 refuelling infrastructure

> Installation of relevant H_2 refuelling infrastructure (350 and 700 bar) to fuel mobility applications

Stationary sector

> Use of H_2 in local stationary applications (e.g. CHP for private or commercial buildings)

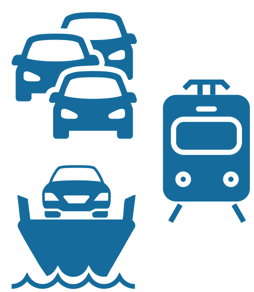
Other sectors

> Use as industry feedstock

> Injection of H_2 into gas grid

> Mobile, backup or off-grid power production

> …



Transport/ Mobility sector

> Use of H_2 in local transport/mobility sector across any application possible (e.g. cars, buses, ships etc.)

> Tendency towards multiple technologies even within one coherent sector

E

H_2 Valleys are characterised by potential levers for synergies and an improved business case as well as inherent complexity

Challenges and benefits of H_2 Valleys

H_2 Valleys
Challenges and benefits

Complexity

> Increased complexity due to "first-of-its kind" projects – need to put together several individual sub-projects into one concept
> Increased number of stakeholders across different sectors involved leading to more communication and management effort
> Necessity for sound/ new operational and/ or business models and concepts
> Larger amount of financing required to cover FCH deployments across value chain and different applications

Synergies

> Showcase for potential role of H_2 in future integrated energy system
> Economies of scale on the H_2 production side (e.g. via locally centralised production from curtailed RES)
> Additional revenue potential for H_2 (e.g. injection into gas grid, grid balancing)
> Potential for infrastructure sharing between applications in one sector or even between sectors as well as achieving high capacity utilisation
> Potential benefits through local knowledge sharing (e.g. for maintenance capacities etc.)

Level of complexity demands special efforts to implement H_2 Valley projects

Potential benefits through synergies optimise overall business case for combined FCH deployments

Presentation on Building an Island Hydrogen Economy on the Orkneys by Jon Clipsham (European Marine Energy Centre)

– Presentation will be distributed after the GA meeting –

Roland Berger

F. Input presentation public/ private financing approaches

FCH

F

For funding of FCH deployment projects, moving away from grants alone becomes increasingly important – Examples presented today

Archetypes of financing technology innovation (projects)

SIMPLIFIED

	Public	Public-private (PPP)	Private
Brief description	> **Public grants** (EU, national., regional), budget financing, comprehensive subsidies and tax incentives – with co-financing from project promoters > **Non-repayable** finance	> **Combination** of public and private finance, e.g. (development) bank loans and government grants/subsidies > **Partially repayable** finance	> **Financing from private intermediaries**, i.e. comm. bank loans, other debt finance, mezzanine, (private) equity > **Repayable** finance
Project bankability/ commercial viability	> **Low** > Pilot & prototype phase of new technologies; typically unbridgeable gap to purely commercially funded and viable business cases	> **Medium** > Bridgeable gap to viable business case, thus revenue support, CAPEX relief mechanisms, etc.	> **High** > Typically available for applications that are comm. developed with a defined use/business case (TRL[1] 8-9)
FCH examples (selection)	> FCH transport project in South Tyrol / Bolzano, Italy	> FCH (and other) buses and infrastructure in Riga, Latvia > KfW 433 for FC mCHP in DE	> Amazon procurement of Plug Power FCH Forklifts

Technology readiness, commercial viability

Focus of Funding and Financing Navigation Tool

Focus of presentation today

1) Technological Readiness Level

Riga combined the modernisation of conventional transport systems with the integration of zero emission technology

Financing case study Riga Transport Company

Key project details

Total project volume	EUR 195 m
> EU financed	> ~ EUR 87 m
> Public financing (city of Riga)	> EUR 8 m
> Private funding (via balance sheet of Transport Operator)	> ~ EUR 100 m
Purchased items	> 10 hydrogen fuel cell buses > 10 trolleybuses with FCH range extender > H_2 refuelling infrastructure > H_2 production capacities > Upgrade of existing tram system (20 low-floor trams & infrastructure) > Modernisation of tram depot

F

Riga has innovatively and successfully financed a large zero-emission procurement

Riga Transport project summary

Challenges

> Air quality issues and emission reduction requirements

> Ambitious Riga City Development Strategy 2030 incl. the decarbonisation of public transport

> Lack of funding for necessary renovation of conventional tram system

Success factors

> Rehabilitation of entire public transportation system to implement zero emission strategy (potential for EU financing)

> Extensive pre/feasibility-studies (participation in European strategy initiatives/studies and local technical feasibilities)

> Comprehensive city development strategy to frame the "story" of zero emission technology holistically

> Combination of zero emission with conventional technologies in project package

Results

✓ **EU funding for major renovation and procurement project** (almost 50% EU funding)

✓ Front-runner in low emission strategy/implementation in the Baltics

✓ Front-runner and best practice example in new EU fund blending strategy (ex. CEF and EFSI for more private leverage effect)

Source: Riga Hydrogen Council, EIB, Roland Berger

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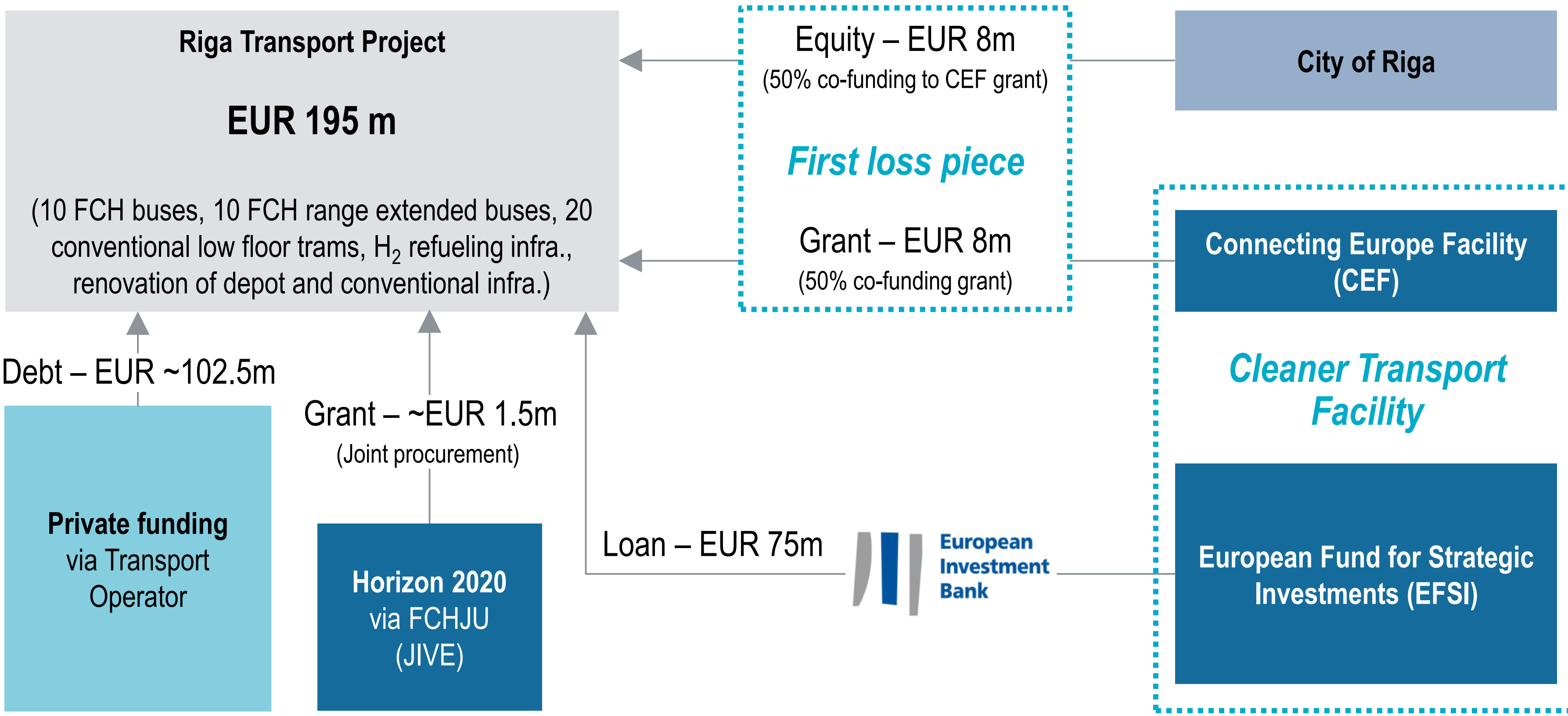
Riga innovatively combines EU funding to finance zero-emission as well as conventional technology procurements

Riga transport financing – Schematic overview



EU financed | National/Regional public funding | Private financing

Source: Riga Hydrogen Council, EIB, Roland Berger

Riga has followed a long-term strategy culminating in a major renovation and procurement project for its transport system

EU activities

H2 feasibility activity
- Study: "Use of hydrogen technologies in Riga public transport"
- HIT2–Corridors Hydrogen Infrastructure
- FCH JU Study: "New Bus Fuel"

H2Nodes – CEF budget – Grant – EUR?
Implementing H2 refuelling infrastructure

Clean Transport Facility
(CEF + EFSI)
EUR 8 m
Grant
First loss piece
50% co-financing

EFSI
EUR 75 m

Loan
managed by EIB

Technical DD
by EIB experts

Co-funding requirement

JIVE – FCHJU budget – Grant – ~EUR 1,5 m
Clustered procurement and financing of FCH buses

Development of Riga transport system – Timeline (rough)

National/Regional activities

Supporting policy framework
- Emission targets
- Air quality regulation
- etc.

Technical feasibility studies
- Bus technology
- Public transport route assessments
- Bus depot scoping
- etc.

City of Riga
EUR 8 m
50% co-financing required

Riga Transport Company (via balance sheet)
~ EUR 100 m
Mixed/structured financing

Ex.: Lease financing via Scania (tram OEM)

Riga City Development Strategy 2030 (policy framework)

Legend: EU financed | National/Regional public funding | Private financing

F

Another innovative financing instrument is the current CEF Transport Blending Call that aims at leveraging debt investments

Connecting Europe Facility (CEF) – Transport Blending Call

Overview on CEF Transport Blending Call

OBJECTIVES

1 Support the deployment of a sustainable and efficient transport system and to promote the decarbonisation of all transport modes along the TEN-T core network

2 Establish innovative ways to shift financing away from a grant based logic towards more market based approaches in order to leverage private involvement/soft loans

PROGRAMME DETAILS

Overall available funding	EUR 1.35 bn
Organisation	Two rounds: 1st and 2nd cut-off
Currently open	2nd cut-off: EUR 350 m, **application deadline on April 12**
Experience so far	65 projects selected for funding in 1st cut-off – 15 for "Innovation" with CEF funding of ~EUR 117 m

SUCCESSFUL PROJECT IN 1st CUT-OFF

Zero Emission Valley Auvergne-Rhônes-Alpes

Deployment of 20 HRS (15 with on-site H_2 production from electrolysis) and 1,000 FC vehicles

Total project volume: EUR 70 m (over 10 years) - Contribution of CEF Transport Blending Call: EUR 10.1m grant

All relevant information can be obtained from: https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/apply-funding/2017-cef-transport-blending-map-call

F

The 2nd cut-off focuses on funding projects in "Innovation and new technologies", including also FCH applications

Parameters for the 2nd cut-off

Eligibility for 2nd cut-off

- Projects of Common Interest and horizontal priorities
- Minimum project size of EUR 5 m
- Full financial close with a private sector investor, the EIB, or a National Promotional Bank can be reached within 12 months
- Only works are eligible, no demo or trial project
- 20% of eligible costs can be reimbursed
- Grant component can only cover the difference in costs between new technology and conventional technology
- Mobile equipment must be registered in the Member state for at least 5 years

Timeline for project applications 2nd cut-off date

- 8 February 2017 – **Call launch**
- 8 November 2017 – **Call Update**
- 23 January 2018 – **Virtual Info Day** (webstreamed)
- 12 April 2018 – **Proposal submission deadline**
- April to June 2018 – **Evaluation**
- September 2018 – **Decision on selected projects/Info to applicants**
- January 2019 – **Signature of grant agreements**

2nd cut-off date – **EUR 350 m** available for Innovation and new technologies projects

Source: https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/apply-funding/2017-cef-transport-blending-map-call

G. Conclusion and open issues/next steps

Next steps

Key activities:

> Preparation of Regional Workshops and H_2 Valley Workshop (incl. FCH project best practices, stakeholder mapping and mgmt., policy mapping)

> Offering support for using the DBC Tool

> Launch of final Funding and Financing Navigation Tool

> Preparation of Stakeholder Communication Package

Upcoming events:

> Regional Workshops and H_2 Valley Workshop: Register now!

> Detailed Business Cases Q&A Calls, Tuesdays at 14:00 (from January 30)

> **6th and next GAM: 23, March 2018**

G

Please do not hesitate to get in touch with us

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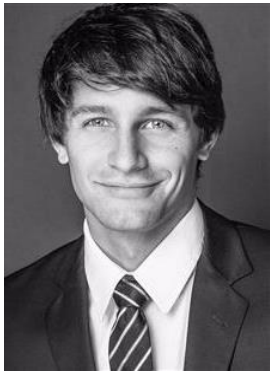

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Roland Berger

50 YEARS

navigating complexity