Development of Business Cases for FCH Applications for Regions and Cities

3rd General Assembly Meeting

Brussels, 13 September 2017

3rd General Assembly Meeting, 13 September 2017 in Brussels
Agenda

Topic		Presenter	Time
A.	Welcome coffee and registration	-	10:00 – 10:30
B.	Introduction and "State of the Union"	FCH2 JU, RB	10:30 – 10:45
C.	Cross-cutting results of the preliminary business case analysis	RB	10:45 – 11:30
Coffee break			11:30 – 11:45
D.	Break-out sessions in smaller groups: prel. business case analysis (cont'd)	RB, SteerCo	11:45 – 13:00
Lunch break			13:00 – 13:45
E.	Framework for strategic-fit-assessment, FCH application ranking	RB	13:45 – 14:30
F.	Excursus: EU support for FCH bus deployment in Europe	Element Energy	14:30 – 15:00
Coffee break			15:00 – 15:15
G.	Financing FCH projects: new navigation tool for Regions/Cities	RB	15:15 – 15:45
H.	Conclusion and next steps	FCH2 JU, RB	15:45 – 16:00
I.	Networking drinks / get-together	-	from 16:00 on

Source: FC2 JU, Roland Berger

Rev. Draft for Discussion

Contents

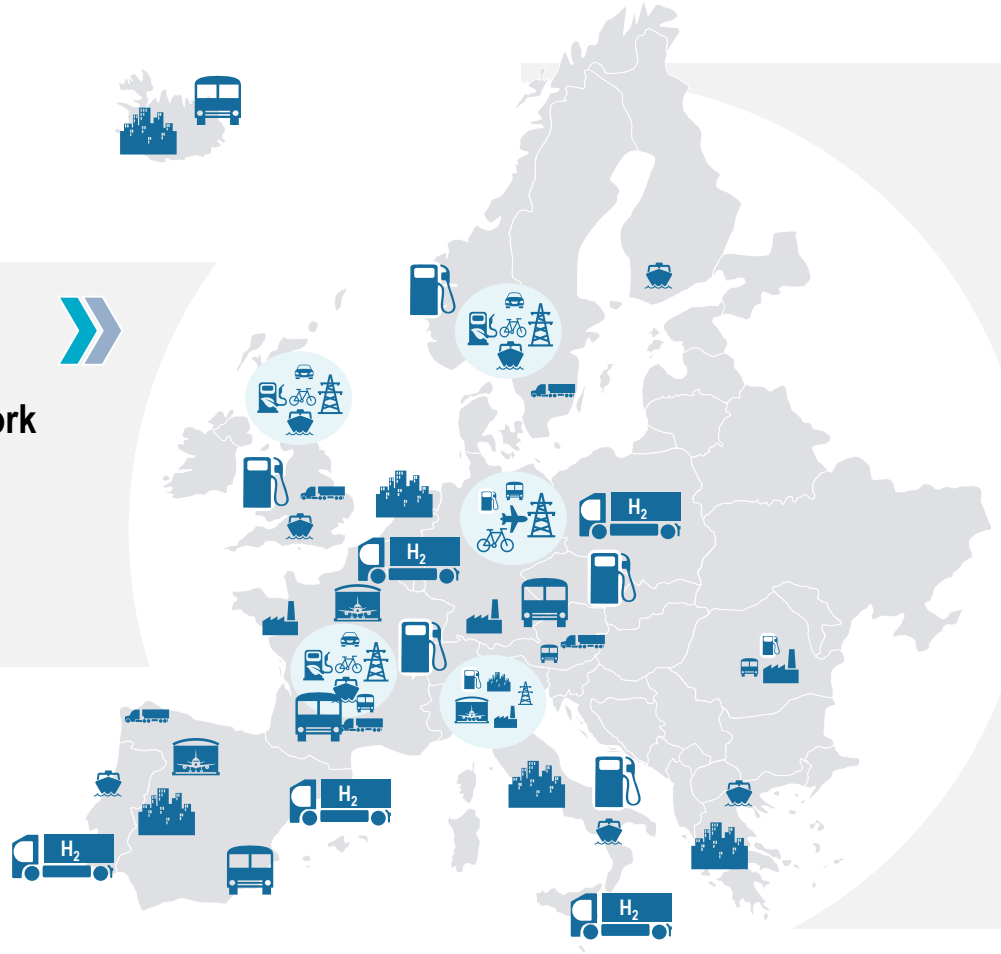
A. Welcome and objectives for today

Today, we'd like to wrap-up the discussion of the preliminary business cases and prepare the finalisation of Phase 1

Today's objectives

Connections …

Possibility to network and get together **throughout the day** particularly in the break-out sessions



Updates …

Presentation and **discussion** of the prel. business case analyses, the funding tool and a deep-dive on FCH buses

Progress ….

Presentation and **discussion** of the framework to rank applications and select focus of Phase 2 – for and with Regions & Cities

Source: FCH2 JU, Roland Berger

B. General introduction, "State of the Union"

B

The technology introduction has been completed, business case analyses as well as funding/financing mapping are under way

Project status

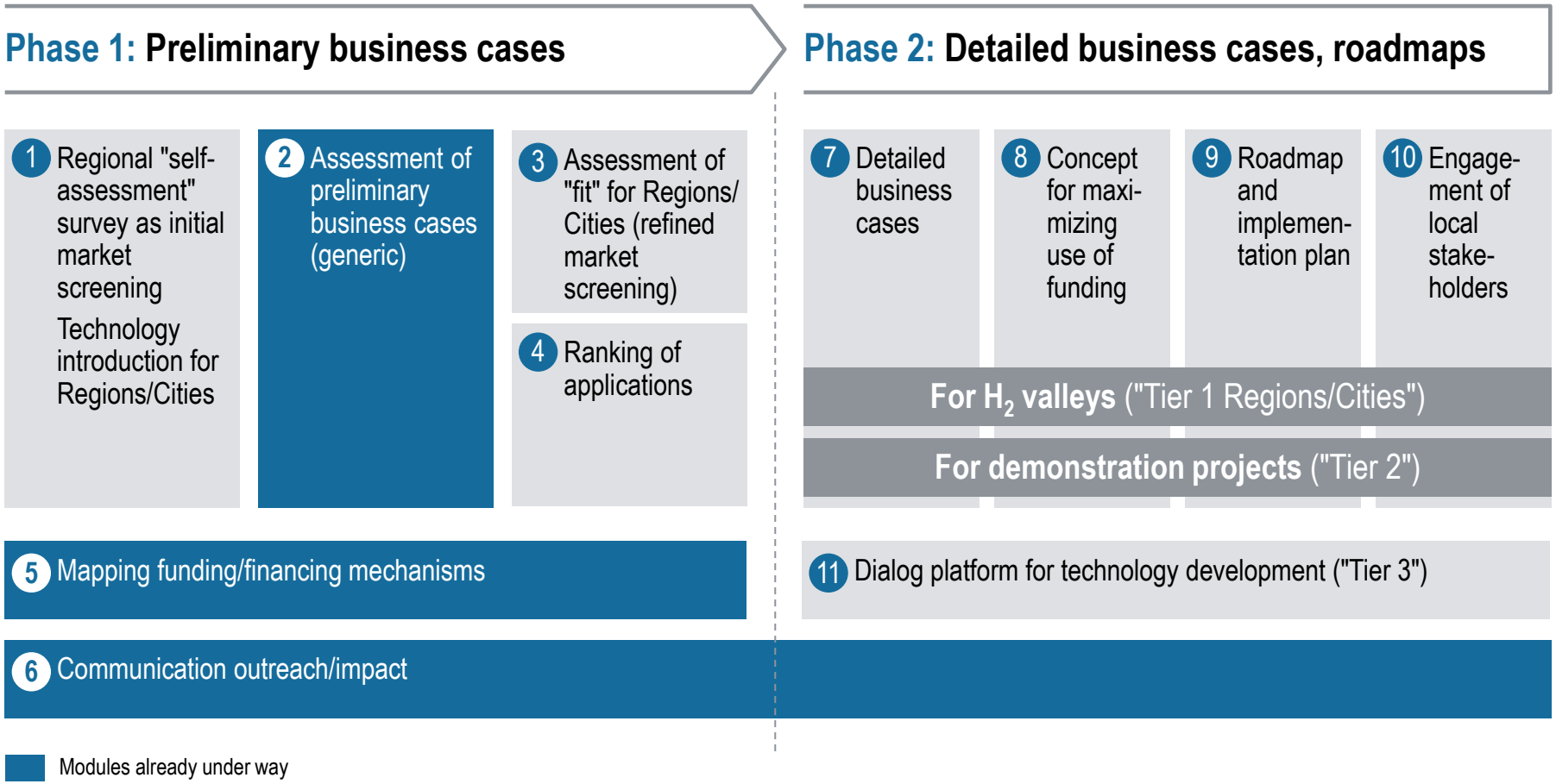
- The coalition has been continuously growing to **80+ Regions and Cities from 20+ countries, as well as some 50 industry partners**
- **Technology Introduction Dossiers have been completed** and distributed for more than 25 distinct FCH applications
- The Working Groups have discussed **Preliminary Business Cases for almost all applications** over the past weeks
- The **funding and financing navigation database** has been populated with more than 60 data sets; a search tool has been developed as well
- The project has continued to facilitate **further outreach to interested stakeholders** within and beyond the participating Regions and Cities

Source: Roland Berger

B

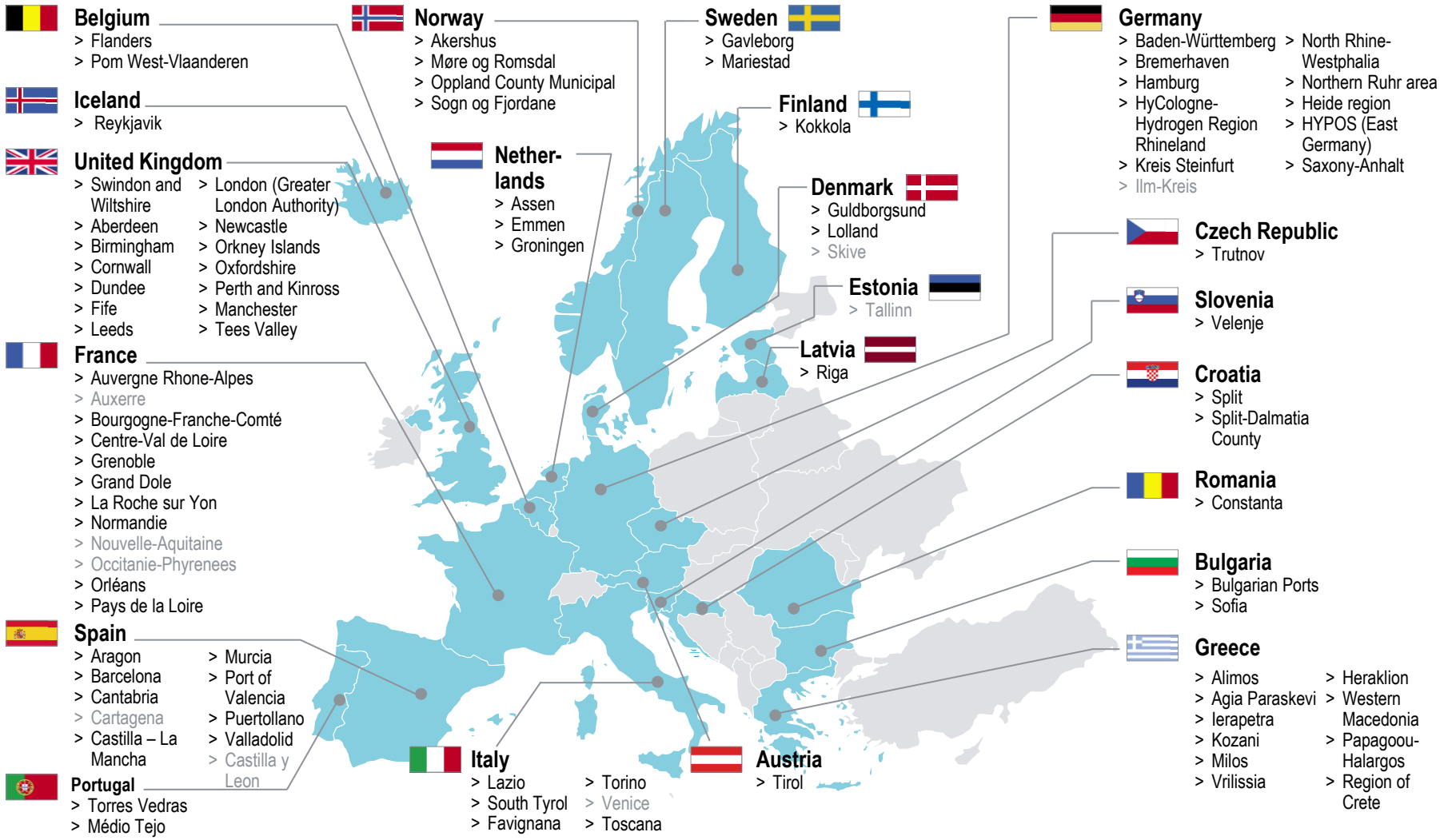
Moving forward, we will complete Phase 1 and enter into the assessment of detailed business cases

Detailed project approach: two phases and eleven modules



Source: Roland Berger

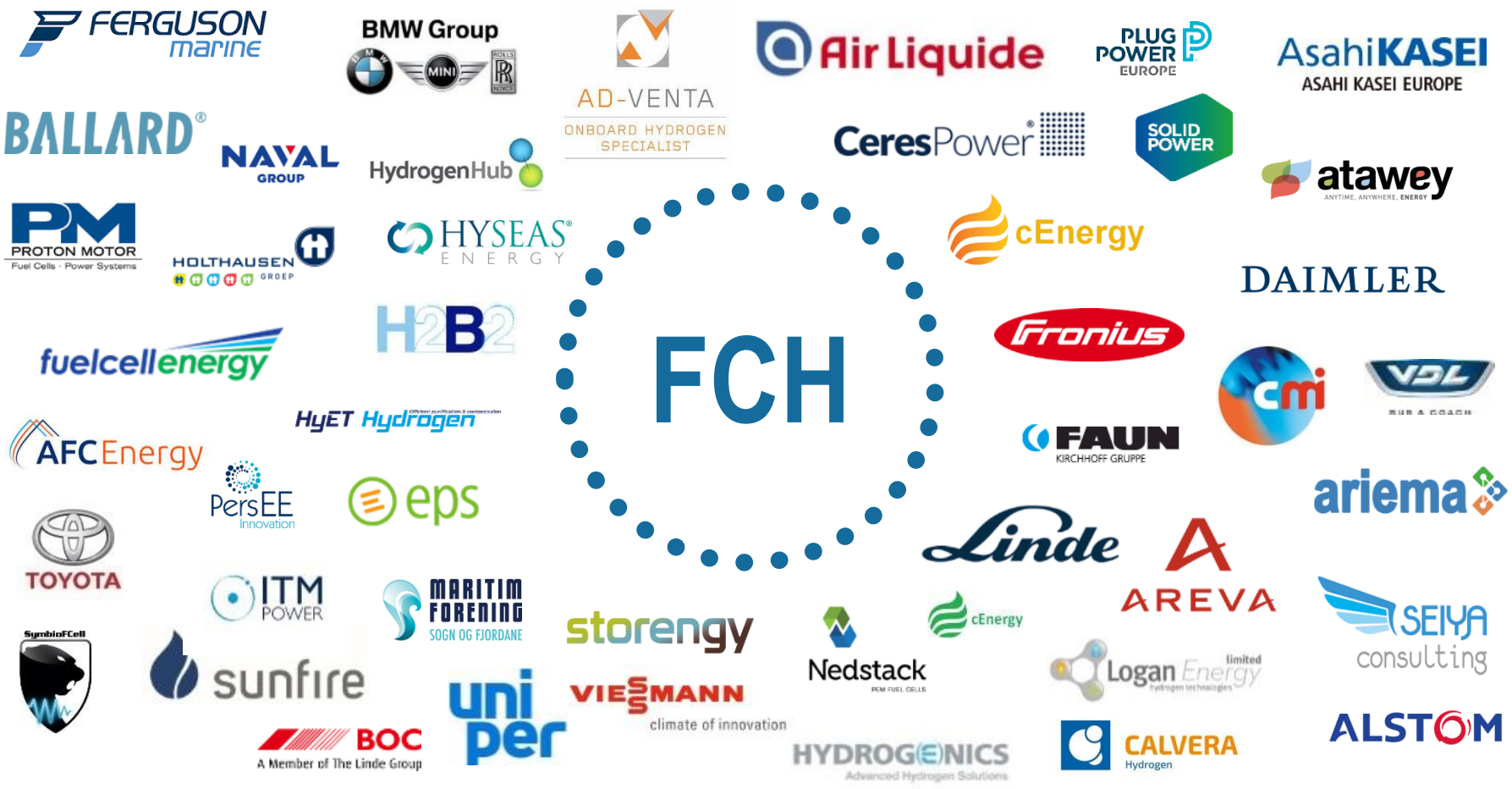
80+ Regions from 20+ countries now participate in the project – and the coalition keeps on growing



Signed MoU / "observers" or "in MoU process"
Source: FCH2 JU

Approximately 50 FCH industry players (and counting) have also become part of the project by now

Current FCH industry participants



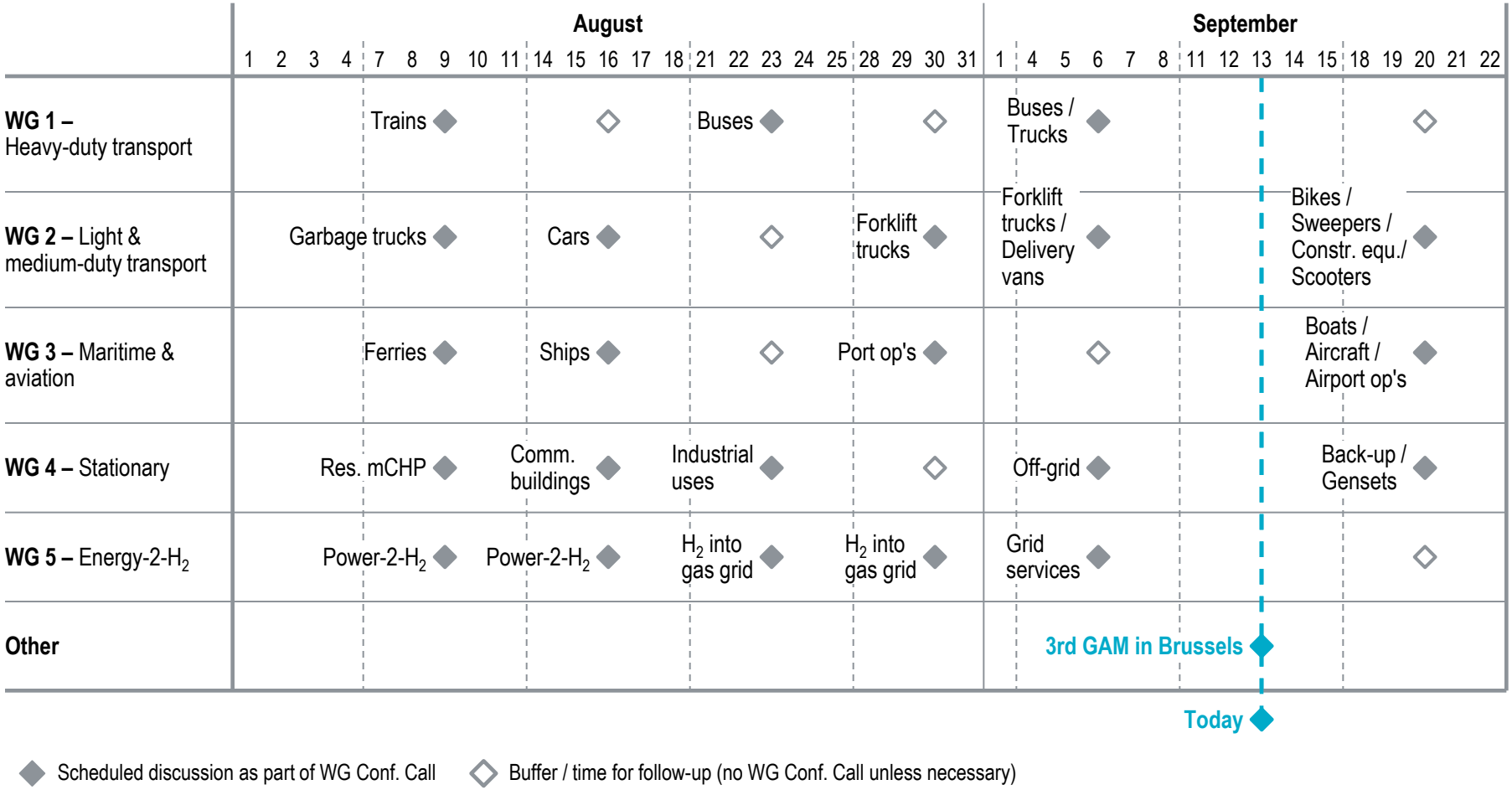
Source: Roland Berger

C. Cross-cutting results of the preliminary business case analysis

C

We have covered the vast majority of applications over the past six weeks, prior to the 3rd GAM today

Timeline for discussing preliminary business cases in WGs



Source: Roland Berger

C

The business case analyses show great FCH potential overall, but also a significant heterogeneity, e.g. re. commercial readiness

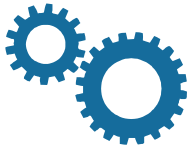
Key findings of the preliminary business case analyses so far

Technology readiness – The level of technological readiness varies strongly; several app. are already commercially available and deployed in significant numbers (e.g. forklifts, buses)

Use cases – Use cases vary from "fully public", e.g. garbage trucks for public waste management operators, to "fully private" use cases e.g. forklift fleets deployed in warehouses

Economics – Economic competitiveness varies significantly as well; some few applications are competitive already; others can reach TCO parity in the medium-long run

Environmental benefits – FCH applications are a 0 tailpipe/local emission option with the potential of 0 well-to-wheel/total emissions, dep. on the sourcing of hydrogen or other fuels



Operational aspects – Many applications operate similarly to conventional fossil-fuel alternatives, providing the same usability (e.g. range, refuelling times, flexibility, personnel)

Source: Roland Berger

Fuel cell buses are a highly flexible zero emission option for public transport; they can in principle be operated like diesel buses

Value propositions of fuel cell hydrogen buses

High daily ranges

… of up to 400 km without refuelling – range extension possible

Full route flexibility

… not bound to any required infrastructure on the route

Strong performance

… comparable to diesel buses, e.g. acceleration or gradeability

Fast refuelling

… down to 7 min per bus possible – several refuelling cycles per day possible as well

High passenger comfort

… due to reduced noise levels and smooth driving experience

Close to full technological maturity

… with more nearly 15 years and 10 million km of operational experience in Europe

Note: for a comparison of different alternative powertrain solutions, please refer to the FCH study "Urban buses: Alternative powertrains for Europe", 2012

Source: Roland Berger

To assess their performance in 3 key dimensions, we look at an exemplary use case and compare FCH buses to other technologies

Prel. business case components and flow of analysis

SCHEMATIC

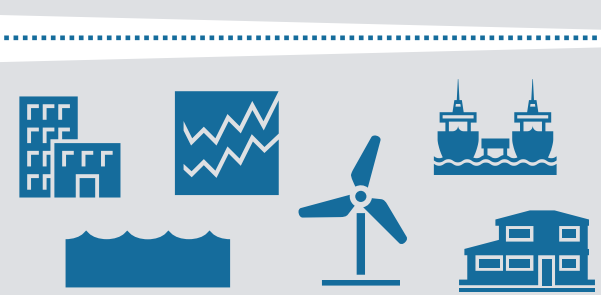
Exogenous assumptions, e.g. energy/fuel cost, carbon intensities

FCH bus

> Technical features (e.g. output, efficiency, lifetime, fuelling requirements) and general readiness
> Est. CAPEX / system cost
> Est. OPEX (e.g. maintenance)

… plus 2 conventional applications as benchmark: battery electric bus & diesel bus

1 "generic" use case



…consisting of typical deployment requirements of European Regions and Cities

Basic performance

- Technical / operational
- Economic
- Environmental

Source: FCH2 JU, Roland Berger

We considered the deployment of 20 new buses from one depot, covering a typical distance of ~200 km per day and bus

Use case assumptions and exogenous factors in two scenarios

SIMPLIFIED

Use case

> Bus operator renews (part of) his fleet out of the same depot: deployment of ~20 new buses with routes of each ~200 km per day, i.e. annually ~65,000 km per bus

> Financing costs of bus operator: 5% p.a.

> Labour costs: based on 2 FTE per bus with average Western European wages of each EUR ~32,000 p.a.

> CAPEX for refuelling stations: one HRS at depot for FCH buses as well as substation, central transformer and cable charging infrastructure for BE buses; no additional investment considered for counterfactual diesel bus deployment

> Resulting hydrogen consumption (considering the assumptions on the next slide): ~15-20 kg per day (bus), ~350 kg per day (fleet)

Exogenous factors[1)]

> Cost of hydrogen for operator: 8.00 / 4.00 EUR/kg H_2

> Cost of diesel: 1.01 / 1.30 EUR/l

> Cost of electricity: 0.14 / 0.12 EUR/kWh

> CO_2 intensity of "grey" hydrogen: 9.00 kg / kg H_2 (~0.5427 kg CO_2 / km)

> CO_2 intensity of diesel: 2.64 kg/l (~1.056 kg CO_2 / km)

> CO_2 intensity of electricity: 0.51 / 0.30 kg/kWh (~ 0.765 kg CO_2 / km)

> NO_x intensity of diesel: 4.00 g/l (~1.5 g NO_x / km)

Strongly dependent on specific regional circumstances

1) Two scenarios: "CURRENT" / "POTENTIAL"

Source: FCH2 JU, Roland Berger

Within our analysis we benchmark FC buses with electric as well as conventional diesel buses in a current and a future scenario

Application-related assumptions in two scenarios

SIMPLIFIED

CURRENT / POTENTIAL	**FCE Bus**	**BE Bus**	**Diesel Bus**
Technical specifications	FCH-dominated powertrain 12 m; ~35-40 seats Holding period: 12 years Availability: 85% / 95%	Overnight charging BE[1] 12 m; ~35-40 seats 12 years 90% / 95%	Full diesel powertrain 12 m; ~35-40 seats 12 years 95% / 95%
CAPEX ('000 EUR)			
Purchase price	~620 / ~400[2]	~450 / ~350	~230 / ~250
Refuelling station	~2,400 / ~2,000	~1,000	-
Fuel			
Fuel type	Hydrogen (350 bar)	Electricity	Diesel
Consumption (per km)	0.086 / 0.065 kg	1.5 kWh	0.4 l
Maintenance costs (EUR)			
Bus per km	0.37 / 0.26	0.30 / 0.26	0.26 / 0.26
Refuelling station p.a.	~80,000	~30,000	~10,000
Replacements[2]	~60,000 / ~30,000	~90,000 / ~60,000	-

1) Guaranteed year-around ranges for BE buses will only become apparent through ongoing European procurements (2017-18), assumed range of 200 km/d in this use case is still TBC
2) Assuming production-at-scale scenarios for bus OEMs as per "Fuel Cell Electric Buses – Potential for Sustainable Public Transport in Europe" (FCH JU, 2015)
3) One FC stack or battery pack replacement during lifetime

Source: FCH2 JU, Roland Berger

The cost premium of hydrogen buses might decrease significantly in the medium run, emissions can be drastically reduced

Business case and performance overview in two scenarios

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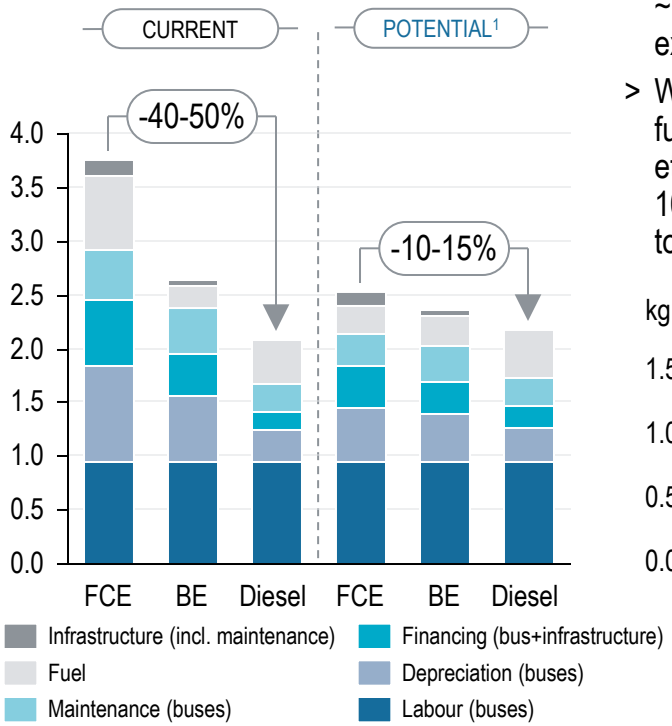
Economic

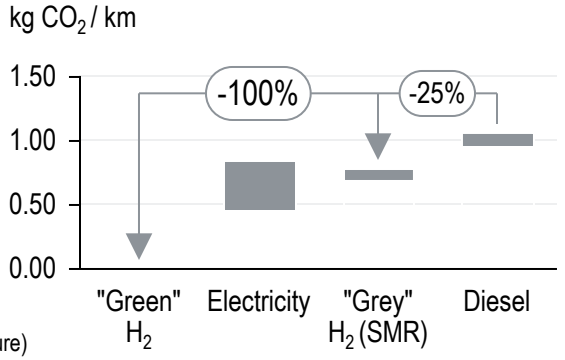
Total Cost of Ownership [EUR/km], annualised at 2017 prices



Environmental

> Zero tailpipe emissions of CO_2, pollutants (NO_X, SO_x) and fine dust particles, saving ~100 kg NO_X per bus a year (in this example)

> Well-to-wheel CO_2 emissions depend on fuel source (source of H_2, electricity mix, etc.) and vehicle efficiency, green H_2 or 100% green electricity would reduce well-to-wheel CO_2 emissions to zero



Technical/operational

> Fuel cell electric buses (full FC powertrain and FC range extender) are entering the commercial phase with large scale demonstration projects under way; besides, add. OEMs will launch vehicles in the short/medium run

> FC electric buses currently with availabilities of ~85% (longer down times), expected to reach ~95% in the medium run

> Range of FCH buses 250-450 km; (comparable to diesel buses), BE buses reaching 150-200 km max. guaranteed range

> Refuelling times of ~7-15 min per bus; comparable to diesel vs. BE bus several hours charging

1) The "POTENTIAL" scenario requires a number of FCE-related and other factors to fall in place in the medium/long run (please see previous slide)

Source: FCH2 JU, Roland Berger

Impact of TCO drivers varies, opening up several leverage points for reduction of hydrogen TCO compared to diesel & electric TCO

Determinants of the TCO[1)]

INDICATIVE

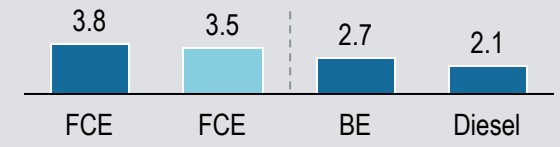
Key sensitivities considered (selection) …

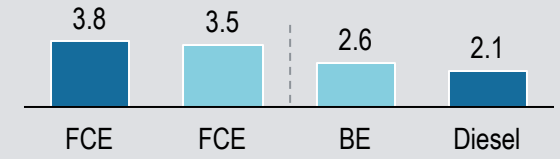
1 **Bus purchasing price:** reducing the bus purchasing price by 20% would lead to a reduction of the TCO of ~EUR 30 ct per km; total purchase price reductions to ca. EUR 400k per bus have been established by European studies ("POTENTIAL" scenario)

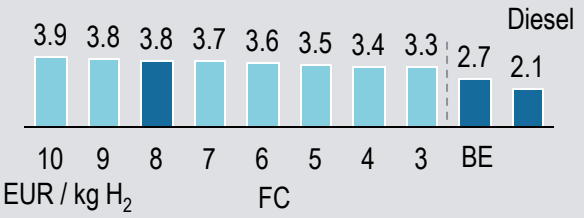
2 **Infrastructure costs:** setting attributable infrastructure investments for FC buses (as well as electric buses) to zero, results in a potential TCO decrease of ~EUR 30 ct per km for FC buses

3 **Fuel costs:** reducing hydrogen costs to the operator from 10 EUR/kg H_2 to 3 EUR/kg, results in a potential reduction of TCO per km of ~60 ct or ~15-20%

… estimated impact on TCO
[EUR/km]







TCO in EUR/km, base case TCO in EUR/km, adjusted variables

1) Unless otherwise stated, all statements shall be considered *ceteris paribus*, i.e. "all-other-things-equal"

Source: FCH2JU, Roland Berger

Please note the following:

- *This analysis shows one hypothetical example of a multi-dimensional performance comparison between FCE, BE and diesel buses. Real-life projects will differ based on regional circumstances and have to consider a range of additional factors (e.g. specific routes and schedules, individual bus-related requirements, national labour laws, additional cost items such as e.g. insurance and depot-related costs) that this high-level analysis omitted for simplification purposes*
- *Similarly, the scenarios shown above should be interpreted as potential combinations of key variables that affect the comparative technology performance*
- *Please note that a number of (industry-based) studies on FCE buses have been published under the auspices of the FCH2 JU over the past years. Please consult them for further reading:*
  - *"New Bus ReFuelling for European Hydrogen Bus Depots", 2017*
  - *"Clean Hydrogen in European Cities (CHIC) – Final Report", 2017*
  - *"Strategies for joint procurement of fuel cell buses", 2017*
  - *"Fuel Cell Electric Buses – Potential for Sustainable Public Transport in Europe", 2015*
  - *"Urban buses: alternative powertrains for Europe", 2012*

Source: Roland Berger

C

In the following, we summarize a set of general conclusions and comparative results of the preliminary business case analysis

Objectives and underlying premises of comparing FCH applications

Main objectives

- **Help participating Regions and Cities navigate** the large pool of applications – in terms of key decision-making dimensions
- **Identify common challenges and opportunities** – to start discussions about integrated deployment approaches
- **Provide first orientation for individual strategic fit** assessment
- **Identify further areas for detailed analysis** in Phase 2

Key premises for comparing FCH applications

- **Time horizon:** focus on the next 2-3 years – a realistic deployment timeline following this project
- **Alternative technologies:** benchmark FCH applications against conventional and/or other 0-emission technologies
- **Markets:** focus on Europe as market environment, e.g. in terms of commercial availability and regulation
- **Use cases:** attempt to abstract from specific use cases and consider a "representative" deployment context (e.g. operators' requirements, fleets, energy prices) – regionalisation in Phase 2
- **Financing:** exclude any specific public support schemes in the initial, general analyses

Source: Roland Berger

The FCH applications in scope are heterogenous – Different tech. readiness, economic competitiveness and deployment complexity

Evaluation of 10 FCH applications[1] across seven dimensions

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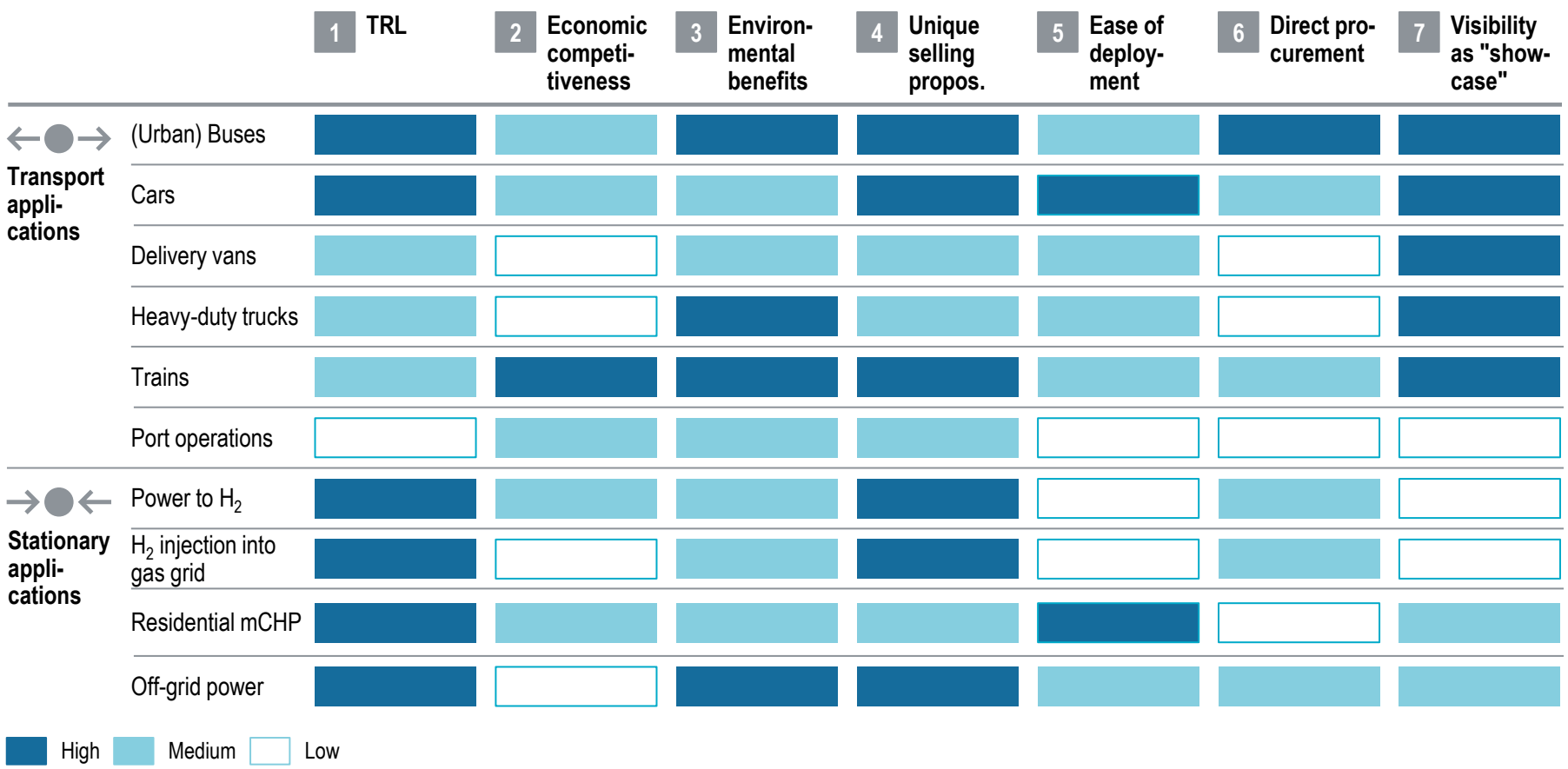


1) Please note that the selection only contains the ten top-ranked applications as stated by the Regions and Cities in the initial self-assessment survey
2) Results differ depending on location, time horizon, benchmark technology as well as specific use case under consideration

Source: Roland Berger

TRL range from 4 to 9 – Forklift trucks, cars and mCHPs have the highest TRL; they are fully commercially available

TRL and commercial availability compared to alternative technologies[1]

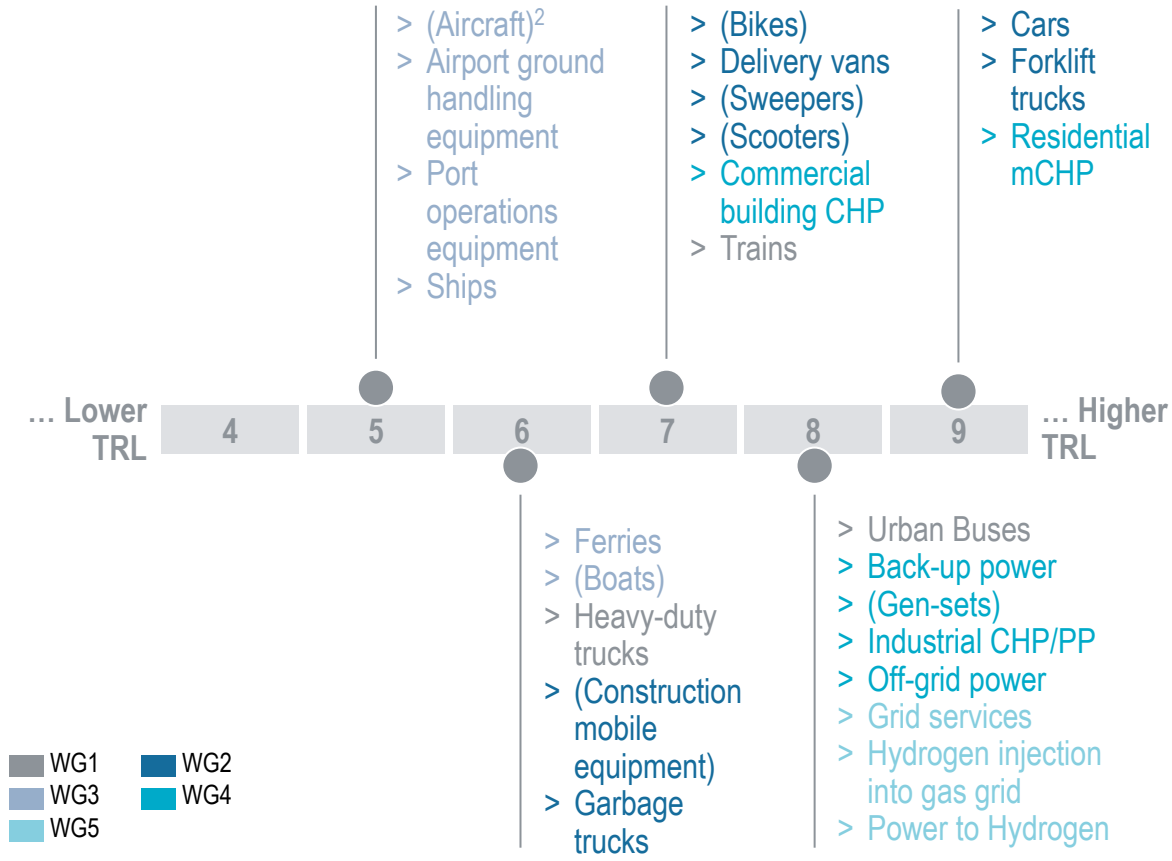
INDICATIVE

Key question

To what extent is the FCH application **technologically mature** and can be considered **commercially available** in Europe compared to competing technologies?

Key metrics

> Technology Readiness Level (TRL)
> Industrial capacities
> Deployable volumes
> …



1) Results differ depending on location, time horizon, benchmark technology as well as specific use case under consideration
2) Applications in parentheses are still to be discussed within Working Group Calls

Source: Roland Berger

Forklift trucks are among the few applications that can build a business cases on a stand-alone basis; trains are not far behind

Economic competitiveness compared to competing technologies[1]

INDICATIVE

Key question

How **economically competitive** is the FCH application from the user's/operator's perspective compared to key (0-emission or conventional) competitors?

Key metrics

> Total cost of ownership (TCO), levelized cost of energy (dep. on typical economic decision making process)
> Estimated cost of system / purchase price
> Cost premium
> ...

Low
Significant cost premium for FCH application [generally >100% TCO][3]

> Heavy-duty trucks [+150-200%]
> (Construction mobile equipment)[2]
> Delivery vans [+100-400%]
> (Scooters)
> Ships
> (Aircraft)
> (Back-up power)
> Comm. CHP [100-300%]
> (Gen-sets)
> Off-grid power

Medium
Moderate cost premium for FCH application [generally 30-100% TCO]

> Cars [+80-100%]
> Garbage trucks [+30-50%]
> (Sweepers)
> Urban buses [+60-80%]
> (Airport ground equ.)
> (Boats)
> Ferries [+40-60%]
> Port op's equipment
> Ind. CHP/PP [-30-200%]
> Res. mCHP [30-60%]
> Power to H_2 [-10-400%]
> Grid services (add-on)
> H_2 injection into gas grid (add-on)

High
Small or even no cost premium for FCH app. [generally <30% TCO]

> (Bikes)
> Forklift trucks [-5-15%]
> Trains [+10-20%]

WG1 WG2 WG3 WG4 WG5

Economic competitiveness

1) Results differ depending on time horizon (here short-term horizon of next 2-3 years, excl. public support schemes), benchmark as well as specific use case
2) Applications in parentheses "( )" are still to be discussed within Working Group Calls
3) Values in parentheses "[ ]" are based on results of the prel. business case anylsis; they indicate the relative TCO premium of the FCH application over the conventional benchmark

Source: Roland Berger

Environmental benefits differ, e.g. dep. on efficiency, fuel, size/scale of typical deployments and technologies that are replaced

Environmental benefits compared to competing technologies[1]

INDICATIVE

Key question

How significant are the **environmental benefits**[2] of a an FCH application in a typical use case / deployment compared to the main (conventional) competing technologies, considering both relative emissions savings and absolute abatement (e.g. vehicle fuel consumption, fleet sizes)?

Key metrics

> Greenhouse gas emission savings (especially CO_2)
> Pollutant emission savings (especially NO_x)
> Noise emission savings

Moderate Relatively moderate environmental benefits	**Significant** Significant environmental benefits	**Very strong** Very strong environmental benefits
> (Bikes)[3]	> Delivery vans [>50%]	> Cars [30-40%]
> (Construction mobile equipment)	> Forklift trucks [n/a]	> Heavy-duty trucks [>50%]
> Garbage trucks [25-35%][4]	> (Boats)	> Urban buses [20-30%]
> (Scooters)	> Port op's equipment	> Trains [15-25%]
> (Sweepers)	> (Back-up power)	> (Aircraft)
> (Gen-sets)	> Comm. CHP [5-35%]	> Ferries [15-30%]
> (Airport ground handling equipment)	> Ind. CHP/PP [5-65%]	> Ships [25-35%]
	> Res. mCHP [10-50%]	> Off-grid power [-20-30%]
		> Power to Hydrogen
		> Grid services
		> Hydrogen into gas grid

Please note: All hydrogen-fuelled FCH applications have zero local (TTW) emissions. When considering green hydrogen as medium-long term hydrogen supply options , local (TTW) and total (WTW) emissions fall to zero for all applications.

WG1 WG2 WG3 WG4 WG5

Environmental benefits

1) Results differ depending on time horizon (here short-term horizon of next 2-3 years, benchmark as well as specific use case
2) This indication is based on a typical use case for FCH applications, considering emissions savings of a typical use case (single unit or fleet), based on cons. of "grey" hydrogen
3) Applications in parentheses "( )" are still to be discussed within Working Group Calls
4) Values in parentheses "[ ]" are based on results from the prel. business case analysis and indicate the potential CO_2 emission savings compared to conventional (fossil-fuel) technologies

Source: Roland Berger

Several applications, e.g. forklifts, trains and buses, have already found a clear USP and focus on specific use cases

Unique Selling Proposition (USP) compared to alternative technologies[1]

INDICATIVE

Key question

Does the FCH application have a **unique selling proposition** (e.g. refuelling time, range, use case fit) compared to other low or zero emission technologies – from a user`s/operator`s point of view?

Key metrics

> Proven, tailored, viable use case
> Operational advantages
> New business models / opportunities
> Regulatory incentives
> …

Improvable
Application use case and USP still to be fully defined

> (Construction mobile equipment)[2]
> (Scooters)
> (Aircraft)
> (Boats)
> Ships
> Port operations equipment

Moderate
Application-specific use case, USP to be sharpened

> (Bikes)
> Delivery vans
> Heavy-duty trucks
> (Airport ground handling equ.)
> (Back-up power)
> Commercial building CHP
> (Gen-sets)
> Industrial CHP/PP
> Residential mCHP

Strong
Proven use case with distinct FCH USP

> Urban Buses
> Trains
> Cars
> Forklift trucks
> Garbage trucks
> (Sweepers)
> Ferries
> Off-grid power
> Grid services
> H_2 injection into gas grid
> Power to Hydrogen

WG1 WG2 WG3 WG4 WG5

Strength of USP

1) Results differ depending on location, time horizon, benchmark technology as well as specific use case under consideration
2) Applications in parentheses are still to be discussed within Working Group Calls

Source: Roland Berger

Implementation-related ease of deployment differs and depends e.g. on infrastructure requirements and necessary stakeholder buy-in

Implementation-related ease of deployment

INDICATIVE

Key question

How **easy** is the implementation of the application in comparison to competing technologies? Or in other terms – how complex is it?

Key metrics

> Setup time and cost
> Infrastructure requirements
> Number of stakeholders to be involved per project
> Project management requirements
> Completeness of FCH regulation
> Workforce training requirements

Low
Relatively complex deployment

> (Aircrafts)[2]
> Port operations equipment
> Ships
> (Back-up power)
> Grid-services
> Hydrogen injection into gas grid
> Power to Hydrogen

Medium
Moderate complexity

> Heavy-duty trucks
> Trains
> Urban buses
> Cars
> (Construction mobile equ.)
> Delivery vans
> Garbage trucks
> (Scooters)
> Sweepers
> (Airport ground handling equ.)
> Ferries
> Off-grid power

High
Straightforward implementation

> (Bikes)
> Forklifts
> (Boats)
> Commercial CHP
> (Gen-sets)
> Industrial CHP/PP
> Residential mCHP

WG1 WG2 WG3 WG4 WG5

Ease of deployment

1) Results differ depending on location, time horizon, benchmark technology as well as specific use case under consideration
2) Applications in parentheses are still to be discussed within Working Group Calls

Source: Roland Berger

Regions & cities have several options to engage directly in the deployment of FCH applications, e.g. in public transportation

Potential for Regions & Cities to act as direct customers, operators, etc.[1]

INDICATIVE

Key question

How are the possibilities for regions and cities to **implement** FCH applications as users/operators? Do they act as direct customers or are they rather indirect facilitators/enablers for private users?

Key metrics

> Owner of technology purchasing decision (public vs. private)
> Common operating model
> Potential of regions and cities as multiplier/facilitator
> …

FCH leads mainly private
Regions & cities act indirectly – as facilitators, enablers and promoters

> Heavy-duty trucks
> (Construction mobile equipment)[2]
> Delivery vans
> Forklift trucks
> (Scooters)
> (Aircraft)
> (Airport ground handling equipment)
> (Boats)
> Port operations equip.
> Ships
> (Back-up power)
> Industrial CHP/PP
> Residential mCHP

FCH leads private and public
Regions have direct lines to buyers / can in some cases be direct customers

> Trains
> (Bikes)
> Cars
> Ferries
> Commercial building CHP
> (Gen-sets)
> Off-grid power
> Power to Hydrogen
> Grid services
> H_2 injection into gas grid

FCH leads mainly public
Regions & cities can act (more or less) directly as customers

> Urban buses
> Garbage trucks
> (Sweepers)

WG1 WG2 WG3 WG4 WG5

Potential for direct implementation

1) Results differ depending on location, time horizon, benchmark technology as well as specific use case under consideration
2) Applications in parentheses are still to be discussed within Working Group Calls

Source: Roland Berger

Public transport applications are particularly visible to the public and hence have a great potential to act as FCH "showcases"

Visibility as public "showcase" to promote overall FCH technology[1]

INDICATIVE

Key question:

How **visible** is the application in the every day life of European citizens? How large is its impact in promoting the acceptance of fuel cell and hydrogen technologies?

Key metrics:

> Degree of usage in public space and by European citizens
> Role in public infrastructure provision
> Location and size of application
> …

Limited Relatively limited visibility	**Moderate** Moderate public visibility	**Strong** Strong public visibility
> Forklift trucks	> (Construction mobile equipment)	> Heavy-duty trucks
> (Airport ground handling equipment)[2]	> (Aircraft)	> Trains
> Port operations equipment	> (Boats)	> Urban buses
> Ships	> (Back-up power)	> (Bikes)
> Industrial CHP/PP	> Comm. building CHP	> Cars
> Grid services	> (Gen-sets)	> Delivery vans
> Hydrogen injection into gas grid	> Off-grid power	> Garbage trucks
> Power to Hydrogen	> Residential mCHP	> (Scooters)
		> (Sweepers)
		> Ferries

WG1 WG2 WG3 WG4 WG5

Visibility

1) Results differ depending on location, time horizon, benchmark technology as well as specific use case under consideration
2) Applications in parentheses are still to be discussed within Working Group Calls

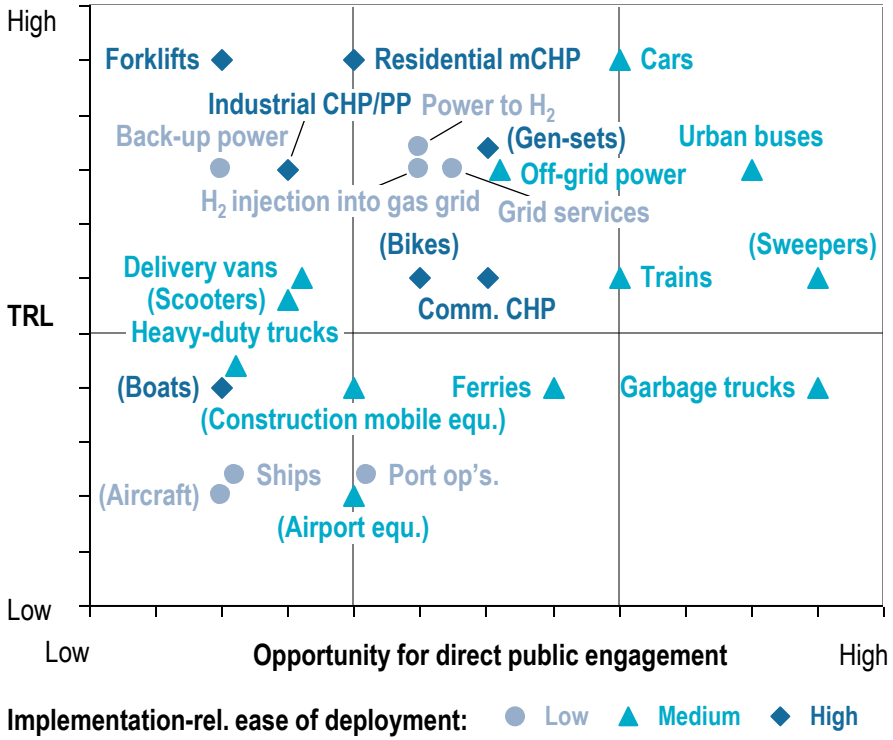
Source: Roland Berger

Some app. can be directly ordered/deployed as they are available at OEMs and implementation lies within in the public domain

Short-term deployment opportunities for Regions and Cities

INDICATIVE

What applications can I deploy tomorrow?



Key considerations

> In the short term, Cities and Regions can look for **applications with high TRL** for actual deployment projects

> **Public infrastructure sectors** are well suited for deployment of applications because of direct control of public authorities (e.g. publically-owned local/regional transport operators or utilities)

> Cities and Regions can reduce complexity in multi-stakeholder settings by acting as **direct customers** of industry

1) Results differ depending on location, time horizon, benchmark technology as well as specific use case under consideration
2) Applications in parentheses are still to be discussed within Working Group Calls

Source: Roland Berger

Regions and Cities have various short term project opportunities – Three main archetypes of projects are feasible in the short term

Typology of short-term FCH projects for Regions and Cities (incl. examples)

INDICATIVE

1 Further definition of use case / potential

Joint industry & Regions/Cities projects for the identification of clear cut FCH use cases (incl. buying centre), product definition and prototype development – e.g.:

> Constr. mobile equipment
> Ferries
> Ships
> Boats
> Port operations
> …

"Concept and product design"

2 Real-life prototype testing / demo project support

Joint lighthouse demonstration projects in real-life environment, with regional/ municipal platform – e.g.:

> Heavy-duty trucks
> Bikes
> Delivery vans
> Garbage trucks
> Sweepers
> Comm. CHP
> Off-grid power
> Delivery vans
> …

"Demonstration project"

3 All-out FCH deployment projects

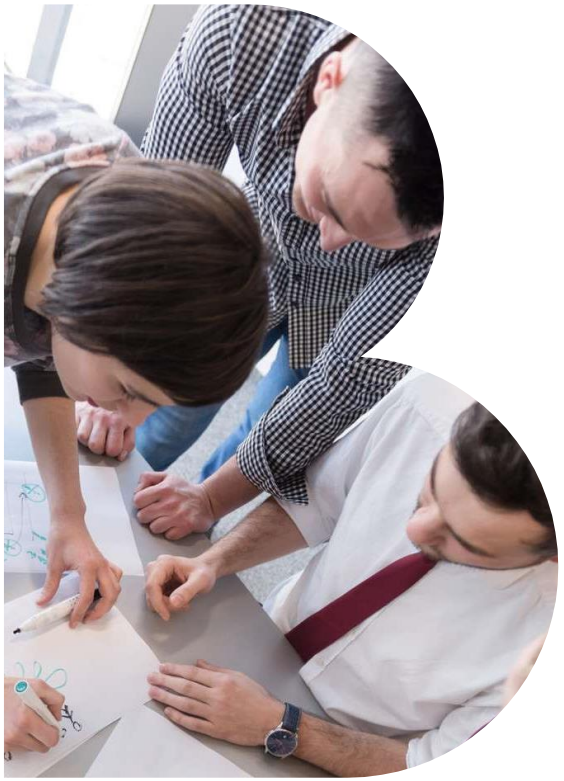
> Public procurement processes for deployment – e.g.:
  – (Urban) buses
  – Cars
  – Trains
  – …

> Support for local private deployment, assistance along the hydrogen value chain – e.g.:
  – Forklift trucks
  – Residential mCHP
  – Industrial CHP/PPP
  – Power to Hydrogen
  – …

"Commercial deployment"

Source: Roland Berger

D. Break-out sessions in smaller groups: prel. business case analysis (cont'd)



D

In the next +/-75 min, we would like to discuss the preliminary business cases further in small groups

Break-out sessions in smaller groups

Group discussions

- > **Three groups of Regions and Cities, one industry group in separate rooms**; split of Regions and Cities by level of experience/ambition acc. to self-assessment
- > **+/-75 min discussion time, moderation by SteerCo members and RB team** with common guiding questions
- > **Subsequent presentation of key discussion results** to entire GA

Our main objectives

- > **Reflect on and discuss results** of prel. business case analyses
- > **Exchange views on attractiveness** of different FCH applications (for Phase 2)
- > **Start conceptualising projects**, bounce around first ideas
- > **Network with peers** across Europe

Source: Roland Berger

D

The groups of Regions and Cities are based on previous FCH experience and ambitions as per the Self-Assessment Survey

Composition of break-out groups and moderators (RB team, SteerCo)

FIRST IDEAS

1. Access FCH projects

V. Alvarez (ESP)
F. Barbir (HUN)
Y. Bonin (FRA)
K. Cavell (GBR)
M. Deligiannakis (GRE)
J. Dodds (FRA)
S. Dumenieu (FRA)
M. Nogueira (PRT)
S. Pedro (PRT)
F. Pingault (FRA)
L. Rubio Bremard (ESP)
B. Vanhecke (BEL)
D. Vladikova (BGR)
V. Willmann (BEL)

Niko Natek (SteerCo)

Yvonne Ruf

Johannes Pfister

2. Advance FCH projects

C. Abbott (GBR)
V. Analytis (GRE)
Z. Buyle-Bodin (FRA)
P. Dermol (SVN)
M. De Juan (ESP)
A. De Nardi (FRA)
C. Funez Guerra (ESP)
R. Godoy Garzon (BEL)
F. Guaspare (FRA)
V. Kovacic (SVN)
B. Krajnc (SVN)
M. Lewis (GBR)
I. Mori (SVN)
A. Otten (NLD)
F. Pfeffer (GER)
E. Stamatakis (GRE)
E. Steenhuis (NLD)
C. Werquin (FRA)

Mark Lewis, Frederic Pfeffer (SteerCo)

Felix Heieck

3. Build FCH ecosystems

A. Arnaud (FRA)
H. Bouma (SWE)
F. Da Col (ITA)
M. Dear (GBR)
T. Johansson (SWE)
J. Jordan (HyER)
F. Koch (GER)
U. Lindahl (SWE)
V. Lindner (GER)
A. Martens (BEL)
A. Merino (ESP)
Y. Ratnayeke (GBR)
A. Venema (NLD)
D. Wentzlaff (GER)
F. Wiedemeyer (GER)

Heinrich Klingenberg (SteerCo)

Markus Kaufmann

Prof. Detlef Stolten

4. Grow role of industry

H. Bekkers (VDL Bus & Coach bv)
R. Brons (Holthausen)
A. Castro (H2B2)
D. Chatzikyriakou (Toyota Europe)
C. Dunn (Ferguson Marine)
B. Fournel (CEA LE Ripault)
Y. Laperche Riteau (Ballard Power)
B. Madden (Element Energy)
K. Müller (Daimler Buses EvoBus)
C. Ratinet (Calvera Maquinaria S.L.)
F. Schwarz (Uniper)
D. Thomas (Hydrogenics)
G. Ville (Atawey)
N. Zandonà (Symbio)

TBD

Source: Roland Berger

D

We intend to discuss a set of general questions in all groups – looking back (and ahead) on the project

Key questions for the discussions across all break-out groups

FIRST IDEAS

Key questions for Regions and Cities

1. How happy are you overall with the project? Is it **meeting your expectations**? What could be improved?
2. What are your key **takeaways** from the preliminary business case analysis?
3. Which FCH applications appear currently **most attractive** to you, in the short-medium term?
4. What are the **cornerstones** of new FCH projects re. stakeholders, applications, technology, H_2 supply?
5. Which **synergies** between FCH applications could be relevant and facilitate integrated deployments?

… plus any further questions you might want to discuss …

Add. questions for industry

- Which applications can see visible and large-scale deployments in the short term?
- Which partnership models with Regions & Cities have been successful in the past?
- Which roles of industry players are most important for joint project development with other – esp. regional public - stakeholders?

Source: Roland Berger

D

The individual focus of each break-out group is slightly different – With specific topics depending on experience/ambition

Detailed focus topics of break-out groups

FIRST IDEAS

1. Access FCH projects

How to …

> Identify **local use cases** for hydrogen

> Identification of **enabling stakeholders** and engagement strategies

> Drafting of **hydrogen strategies and roadmaps** (key dimensions, questions, must-haves, winning political and industry support, etc.)

2. Advance FCH projects

How to …

> Elaborate on **local synergies** of hydrogen application use cases

> Grow FCH activities beyond first application(s) or even create a **strategic concept** for a hydrogen valley

> Engage in **demo projects** and real life prototyping to gather experience and insights with applications

3. Build FCH ecosystems

How to …

> Define **strategies for hydrogen valleys** in line with existing policies

> Initiate **public procurement** processes for first sizable fleets/applications

> Conduct **lighthouse project** financing and share knowledge amongst FCH stakeholders

4. Grow role of industry

How to …

> Consider learnings from prelim. business cases and **implications for future deployment** projects

> Shape the **role of industry** in future hydrogen valley concepts

> Define **new business models** for hydrogen supply/storage to make local ecosystems more attractive

The discussion should freely evolve as it unfolds – you can try to steer it with the help of the focus topics of the respective break-out group (if necessary)

Source: Roland Berger

E. Framework for strategic-fit-assessment, FCH application ranking

E

To complete Phase 1, we will finalise the business case analysis and facilitate a strategic fit-assessment and ranking process

Objectives and approach for the remainder of Phase 1

Wrap-up of prel. Business case analysis 1

- Discussion of **remaining applications** (at high level)
- Summary of **key findings** per working group and implications for Regions and Cities

Strategic fit assessment 2

- Summary of **next deployment/project opportunities** ("archetypical next project") typical for different FCH applications
- Critical **requirements** per application
- Guidance how to check for local **use cases** and potentially interested stakeholders
- **Check-list** with favourable conditions, list of key questions

Ranking/prioritization of applications 3

- **Outside-in ranking** of applications by RB team
- **Inside-out ranking** by Regions and Cities via **online survey**
  - Update of self-assessment
  - Criteria-based scoring model
  - Justification/details with concrete use case
- Consolidation of ranking to **crystallise up to 10 applications for Phase 2**

Phase 2

WG conference calls	WG conference calls	Online survey
2-3 weeks	2-3 weeks	4th GAM November 16, 2017

Key interaction format with Regions and Cities

Source: Roland Berger

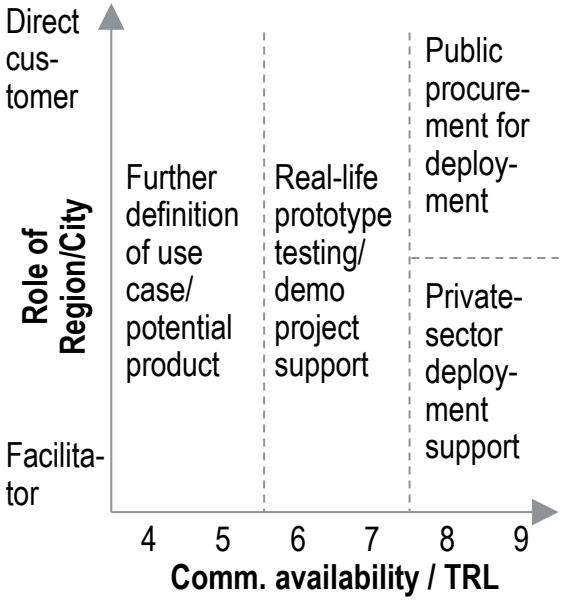
E

After the prel. business cases, we will first support Regions and Cities determining their strategic fit with different FCH applications

Deep dive re. #2: Strategic fit assessment

A Archetypical short-term projects re. applications

What type of project is implementable in the short-term, for a given app.?



B Critical requirements for applications

What "must-haves" need to be in place for deployment?

- > Use case requirements
- > Regulatory framework
- > Hydrogen supply/logistics (infrastructure availability)
- > Energy system context
- > Public acceptance, essential stakeholder support
- > Available funding
- > …

… specification per FCH application

C Success factors / favorable conditions

What local conditions make an application particularly attractive?

- > Energy prices, e.g. marginal cost of electricity, spark spread
- > Drivers of major TCO components
- > Regulatory support schemes, particularly favourable provisions
- > Synergies with other applications
- > Local policy framework
- > External financing opportunities
- > …

… specification per FCH application

Source: Roland Berger

E

The survey will build on the main content of the project so far in order to prepare for an informed ranking process for best results

Deep dive re. #3: Key elements of the survey

A Partial update of the self-assessment

> Topic 1 – Question 1
> Topic 2 – Question 2
> …
> Examples:
> How interested is your Region/City in actively pursuing the **future deployment** of FCH applications?
> Within your Region/City, which **hurdles and challenges** currently pose obstacles to the deployment of FCH applications?

B Multi-criteria scoring model

	C1	C2	C3	…
App 1				…
App 2				…
App 3				…
App …	…	…	…	…

C Top-down ranking with key reasoning

1.	App 1	Concrete use case description
2.	App 2	Concrete use case description with some deployment details
3.	App 3	…
4.	App 4	…
5.	App …	…

One integrated online survey – similar time requirements as for self-assessment survey

Source: Roland Berger

E

We will combine the Cities' and Regions' ranking with a RB perspective to select the most promising applications for Phase 2

Deep dive re. #3: Ranking of FCH applications for Phase 2

Inside-out ranking by Regions & Cities via online survey:

> Scoring model

> Use-case specification

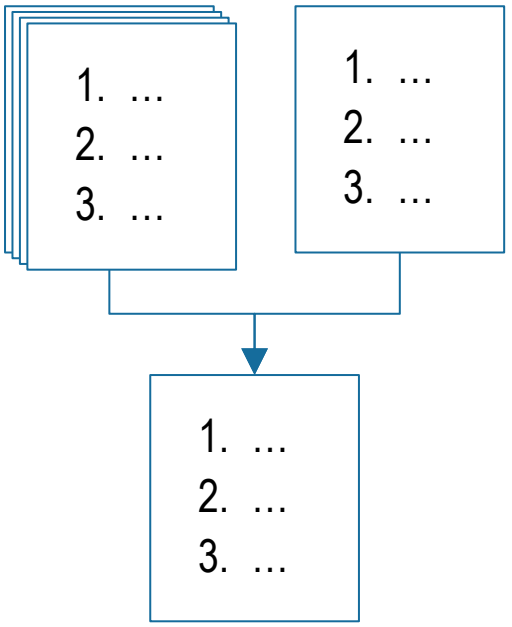
Outside-in ranking by RB team with focus on:

> Technology readiness

> Commercial availability

> Business case / USP

Consolidation of rankings by RB team



Discussion of finalization of up to 10 applications for Phase 2 in 4th GAM

1. …
2. …
3. …
4. …
… …
9. …
10. …

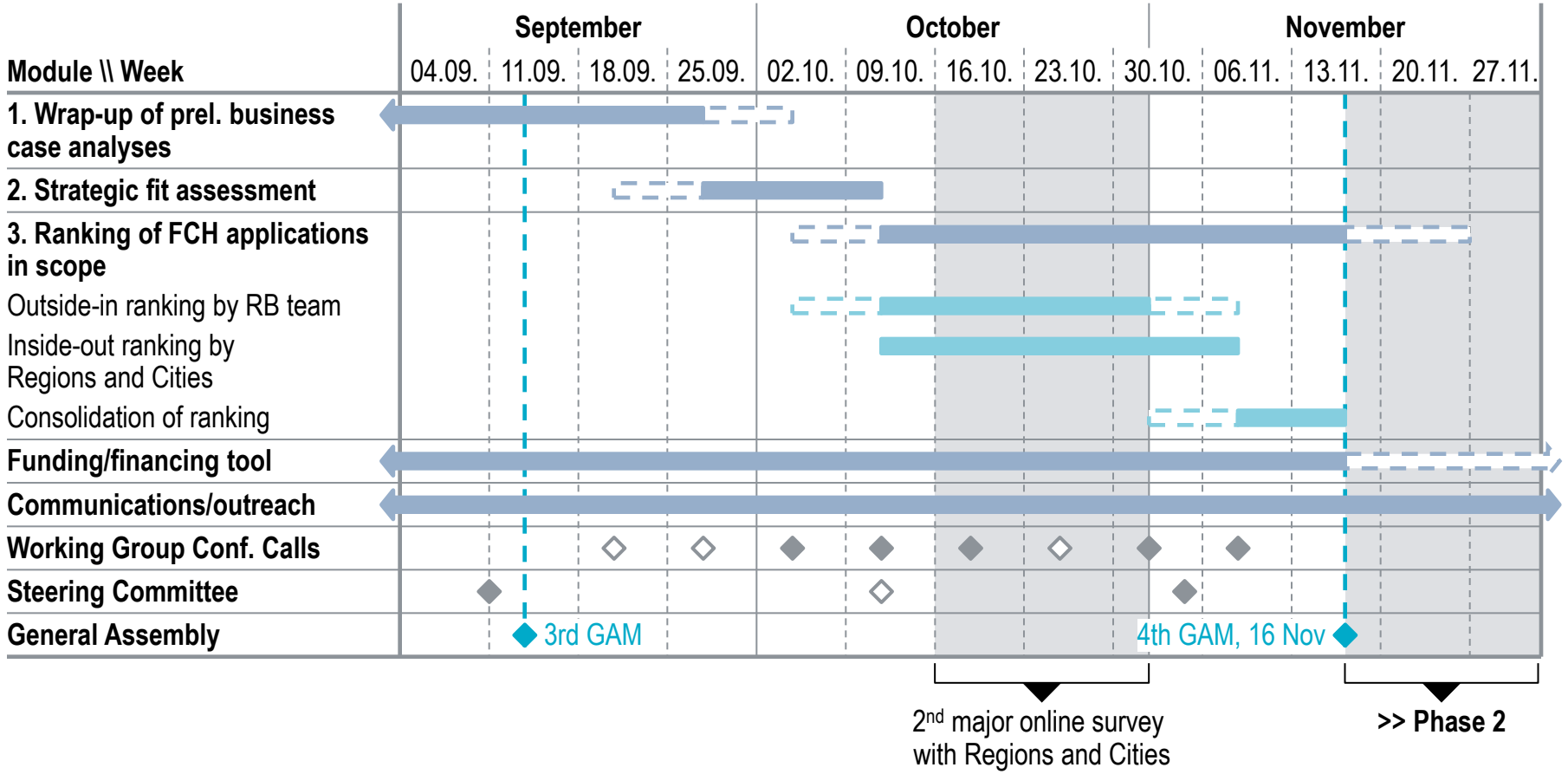
… final agreement in Steering Committee (if necessary)

Source: Roland Berger

E

We will complete the remaining project modules in Phase 1 until the 4th GAM on 16 November

High-level project plan for the remainder of Phase 1



Scheduled WG Conf. Call Buffer / time for follow-up (no WG Conf. Call unless necessary)

Source: Roland Berger

F. Excursus: EU support for FCH bus deployment in Europe

G. Financing FCH projects: new navigation tool for Regions and Cities

G

The main focus of mapping funding instruments will be on public sources as most relevant support for FCH projects in the short run

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

Deep-dive at 4th GAM in November

1) Technological Readiness Level

Source: Roland Berger

G

The funding tool allows for detailed analysis of existing grant funding opportunities on a simple and user-friendly platform

The funding and financing navigation tool

60+ funding programmes included …

… 30+ countries and 270+ individual regions covered

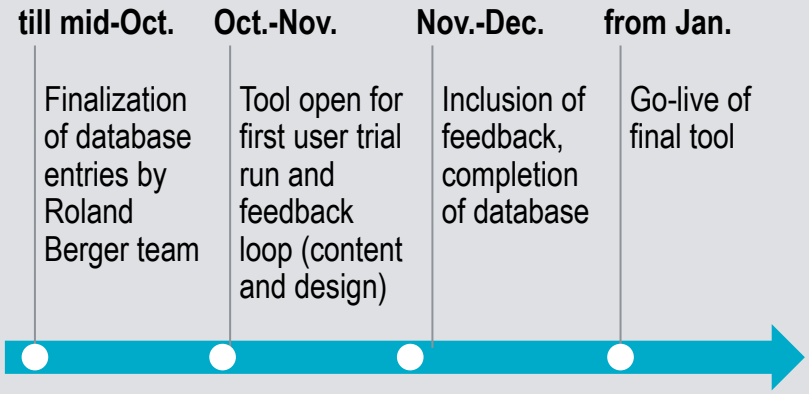
… on average EUR 1.96 m potentially accessible per project and programme[1]

Scope and content

> Focus on **non-repayable grant funding** opportunities on national and European level
> Detailed content regarding the available **budgets and funding conditions**
> Custom search filters to achieve maximum **fit with individual needs** of Cities and Regions

Tool format and timeline for implementation

> Funding and financing navigation tool set up in MS Excel, for user friendly access
> Easy to navigate between "funding programme fact sheets" for detailed insights into available sources
> Possibility to search via filter or open text to assure customization of search requests



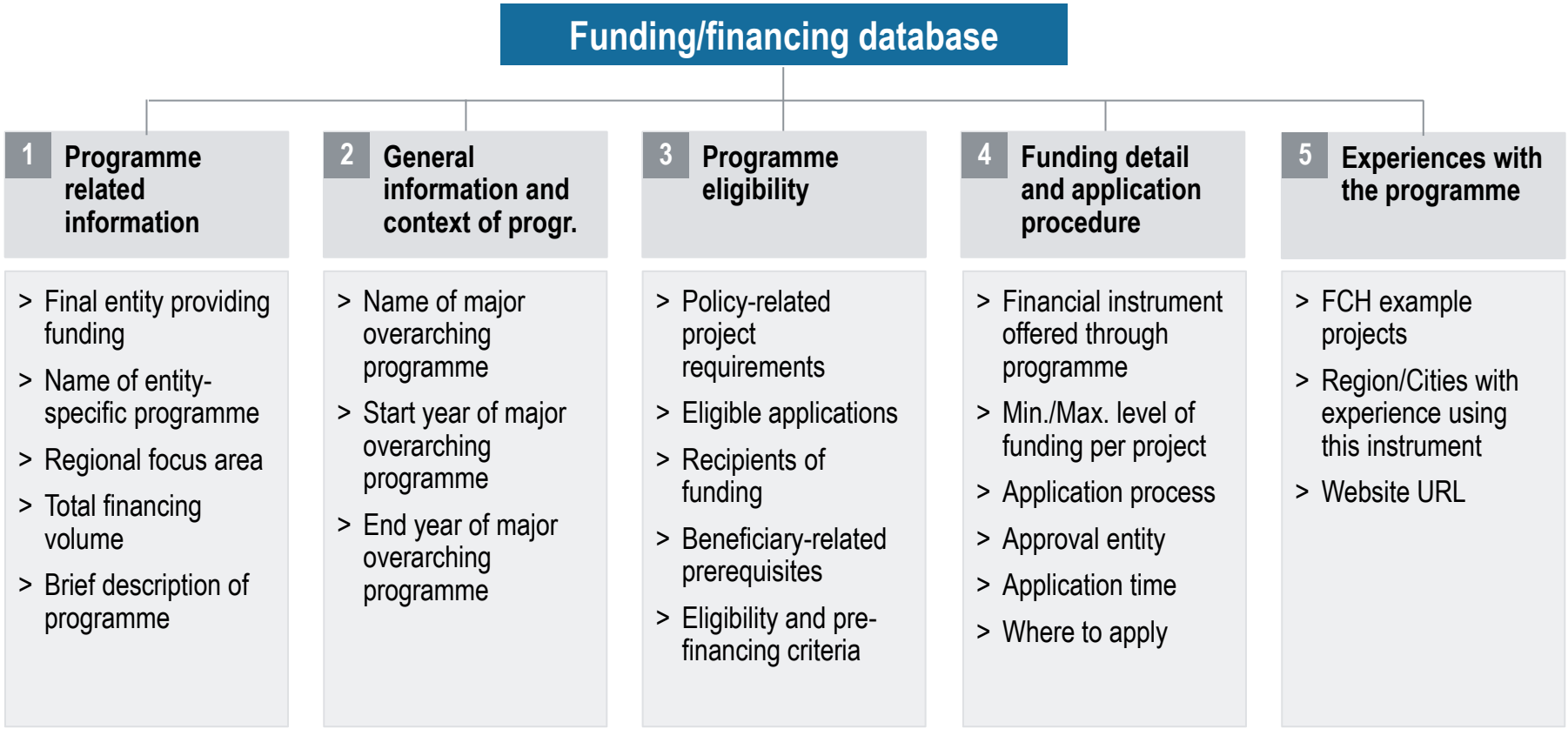
1) Avg. amount of mean funding volume per project and funding programme

Source: Roland Berger

G

The database covers information on 5 different thematic categories and enables the identification of funding instruments

Database structure per source of funding/financing



Source: Roland Berger

The cockpit of the funding and financing navigation allows you to set the right filters to identify potential sources for local FCH projects

First glance (1/2): cockpit

Funding and Financing Navigation Tool

Cockpit

Your Filter

Country*: United Kingdom

Region*: Cornwall and Isles of Scilly

Project beneficiary:
- [ ] Commercial business
  - [ ] SME[1)]
- [x] Public entity[2)]
- [ ] NGO
- [ ] Academic insitution
- [ ] Other (incl. PPP)

Desired funding[3)]:
- < EUR 2 m
- EUR 2 m – EUR 5 m
- EUR 5 m – EUR 10 m
- > EUR 10 m

Co-funding required: [x] Yes [ ] No

FCH application/sector: Light- and medium duty transport

Open search: zero emission

Get results

Get results

1) Specialized SME grants are available
2) incl. state-owned entities
3) Hint: select higher range (when in doubt) to increase pool of potential instruments displayed

Your Results

Name	Total entity-based
ManagEnergy	n.i.
NER400	-
Cohesion fund	63.400,00 EUR m
Connecting Europe Facility - Transport	24.050,00 EUR m
Connecting Europe Facility - Energy	5.350,00 EUR m
European Institute of Innovation & Technology (EIT)	2.700,00 EUR m
Innovate UK	2.063,41 EUR m
Financial Instrument for the Environment (LIFE) - Action Grants	373,00 EUR m
Urban Innovative Actions	372,00 EUR m
Interreg Europe	359,00 EUR m
CIVITAS 2020	250,00 EUR m
FCH2 JU	116,00 EUR m
URBACT III	96,30 EUR m
Low Carbon Infrastructure Transition Programme	87,12 EUR m
Financial Instrument for the Environment (LIFE) -NGO	38,60 EUR m
ELENA EIB	20,00 EUR m
LIFE operating grants	18,00 EUR m
European Maritime and Fisheries Fund	340,00 EUR m

Search options

> Searching the database is possible either via filter criteria or via open text
> Country and regional filter are mandatory (important sources for funding are regionally-earmarked EU structural funds)
> For easy of reference, the technology/application fit is categorized along the Working Groups of the project
> A defined project beneficiary, the amount of desired funding and the requirement for co-funding can be chosen selectively
> **Please note:** The more specific your filtering criteria, the higher the possibility of missing out on potentially interesting funding opportunities

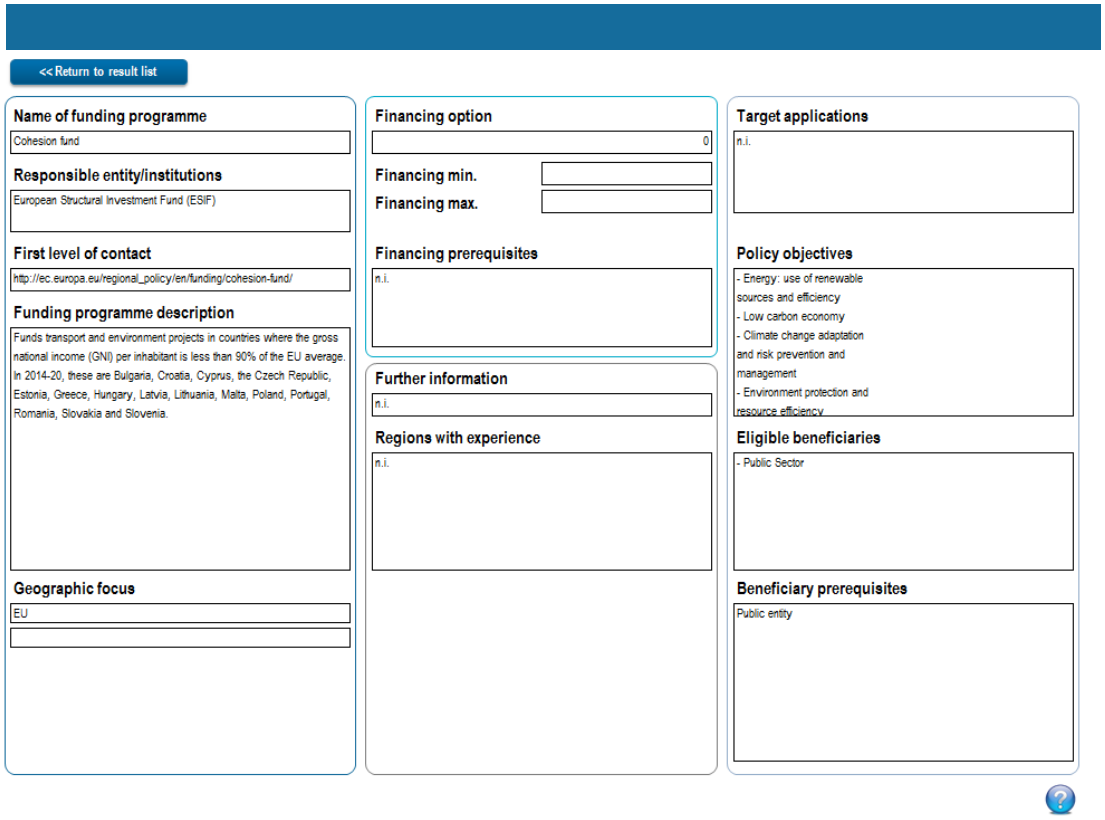
Source: Roland Berger

As search result, comprehensive fact sheets summarize information on the individual funding programmes

First glance (2/2): fact sheet

Funding programme

Fact Sheets



Short introduction to the funding programme fact sheets

- The fact sheets gather the most relevant information about each funding programme
- Besides information on potential funding contributions and funding eligibility, the fact sheets list first-level contacts to the responsible funding institutions
- Regions with experience: The initial self assessment has shown that many Regions already successfully financed a project. These should be a first point of contact to share experiences
- **Please note:** The initial information portrayed offers guidance in the vast European funding landscape. However, individual project eligibility should always be bilaterally discussed with the responsible contact at the funding institution

Let's have a look

Source: Roland Berger

H. Conclusion and next steps

H

Next steps

Key activities:

> Incorporation of GAM feedback from dial-in participants
> Distribution of updated GAM presentation to the coalition
> Invitation and presentations for next Working Group Conf. Calls
> Wrap-up of prel. business case analysis in the Working Groups
> Continuation of populating funding/financing tools database

Upcoming events:

> Next Working Group Conf. Calls: Wednesday, 20 or 27 September 2017
> **4th General Assembly Meeting: Thursday, 16 November in Brussels**

Source: Roland Berger

Please do not hesitate to get in touch with us

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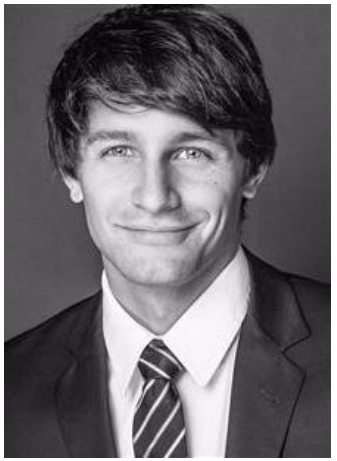

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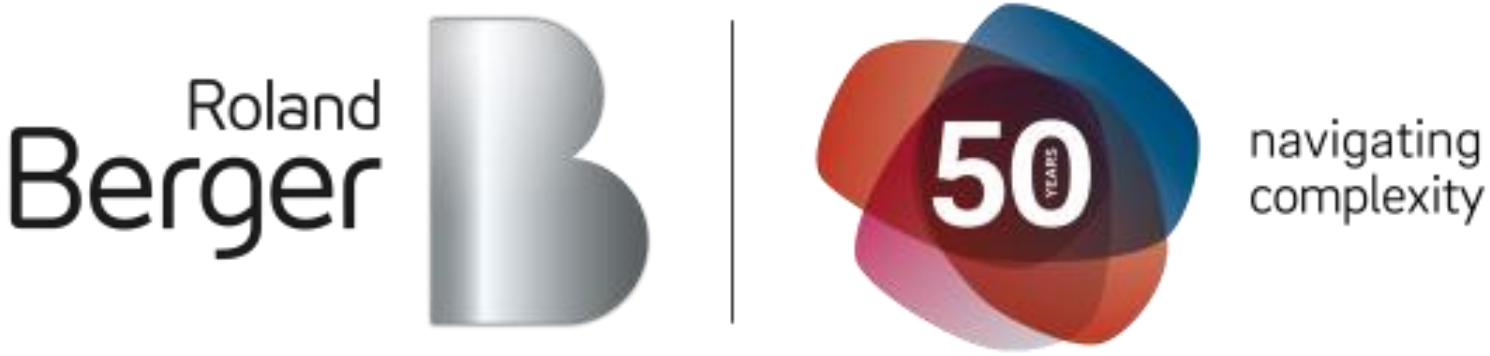
Source: Roland Berger


Roland
Berger
50
YEARS
navigating
complexity