Fuel Cells and Hydrogen Joint Undertaking

2013 Stakeholder General Assembly

Bert De Colvenaer, Executive Director
Brussels, 13 November 2013

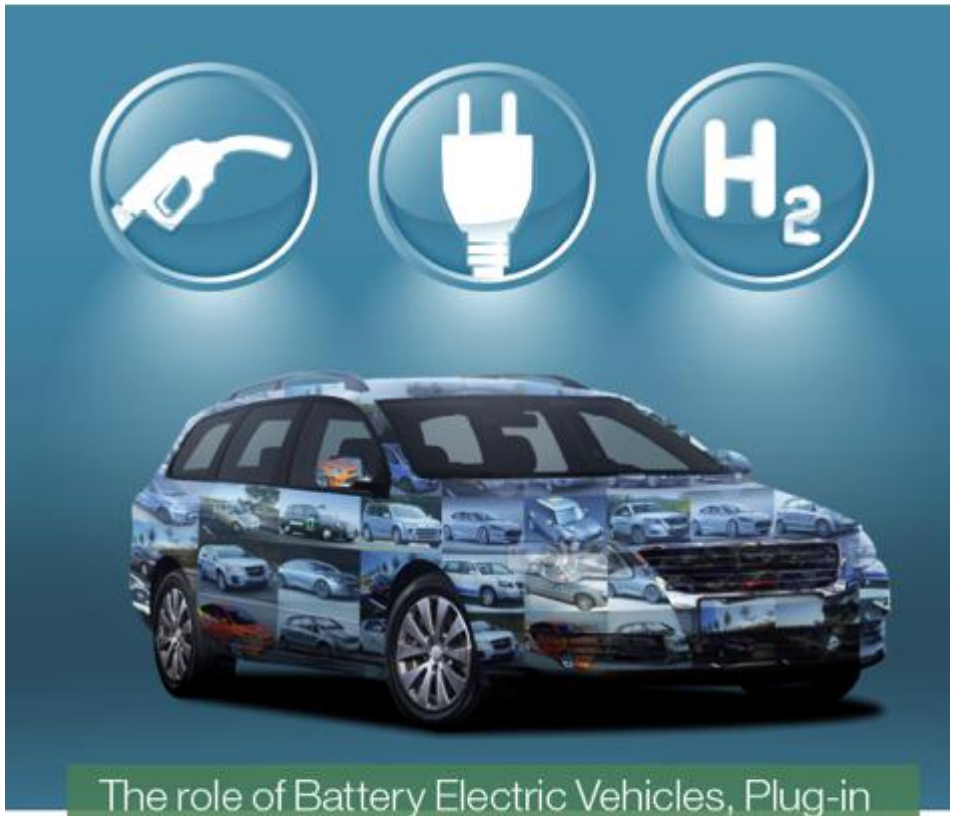
FCH JU main achievements

- **Transport sector :**
  - 49 buses, 37 passenger cars, 95 mini cars
  - 13 new refuelling stations
  - FC Bus H_2 consumption halved
  - H_2 cost < 10€/kg
- **Stationary sector :**
  - 1000 domestic Combined Heat & Power generators
  - Cost - 50%, efficiency 90%, lifetime up to 8 years
- **Early markets sector :**
  - 400 + material handling vehicles
  - 19 back up power units

- **The European FCH community :**
  - Strong, visible and coherent
  - Consensus strategy (MAIP/AIP)
  - Pre-competitive collaboration
  - 430 participants in 127 projects
  - SME participation 23%

A portfolio of power-trains for Europe

A portfolio of power-trains for Europe:
a fact-based analysis



Industry participants	
Car OEMs	DAIMLER, HONDA, HYUNDAI, KIA MOTORS, NISSAN, Ford, RENAULT, BMW, VOLKSWAGEN, TOYOTA
Oil and gas	Eni, OMV, Shell, TOTAL, galp energia
Utilities	EnBW, VATTENFALL
Industrial gas companies	AIR PRODUCTS, AIR LIQUIDE, Linde
Equipment OEMs	INTELLIGENT ENERGY, Powertech
Wind	NORDEX
Electrolyser companies	HYDROGENICS, PROTON ENERGY SYSTEMS, ELT Elektrolyse Technik, Hydrogen Technology
NGOs, GOs	European Climate Foundation, NOW, New Energy World

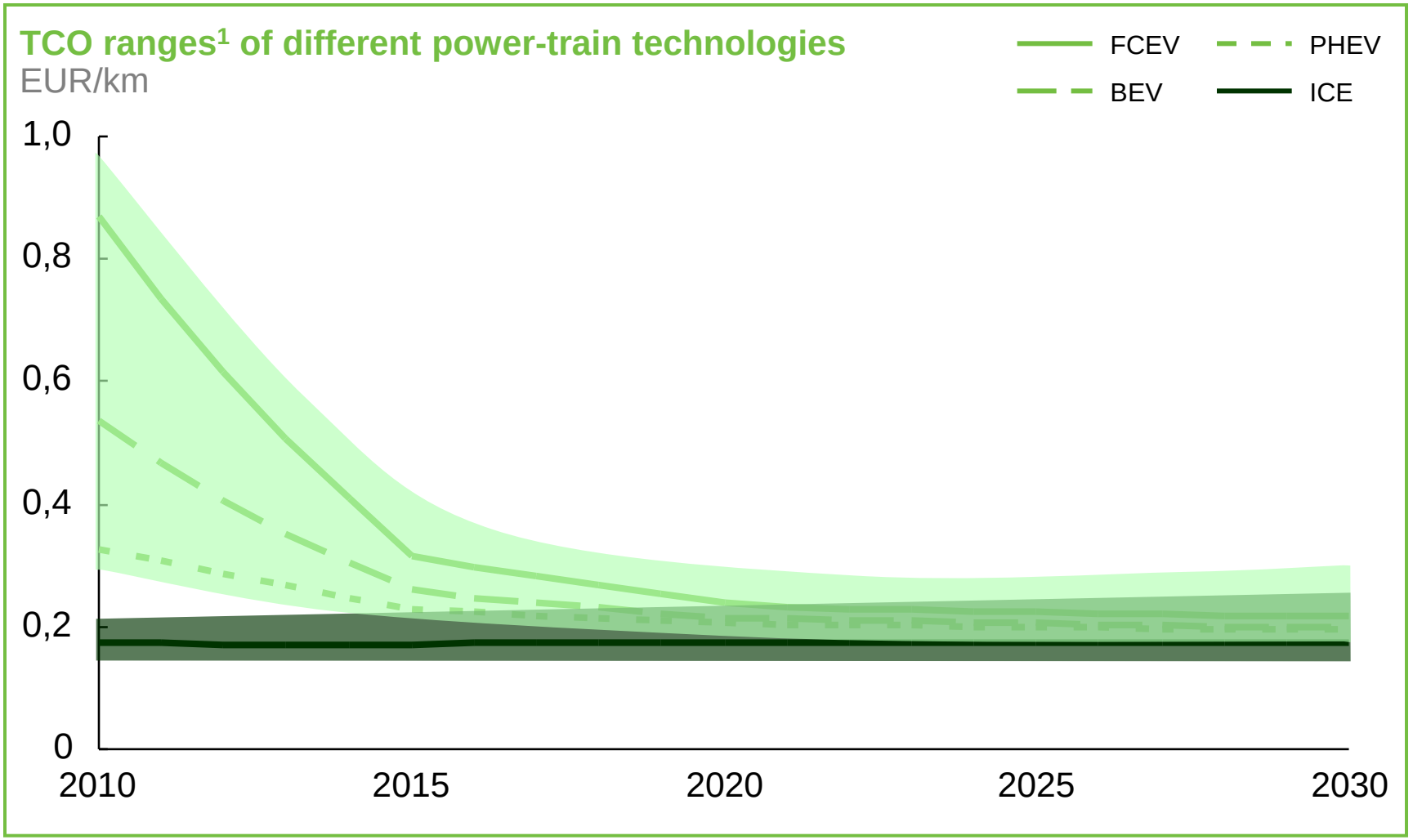
Publication: 8 November 2010

Available on **http://fch-ju.eu**

After 2025, costs of all power trains converge

TCO ranges[1] of different power-train technologies

EUR/km



H_2 Mobility in Germany

AIR LIQUIDE DAIMLER THE LINDE GROUP

NOW OMV TOTAL

H_2 Mobility initiative

Leading industrial companies agree on an action plan for the construction of a hydrogen refuelling network in Germany

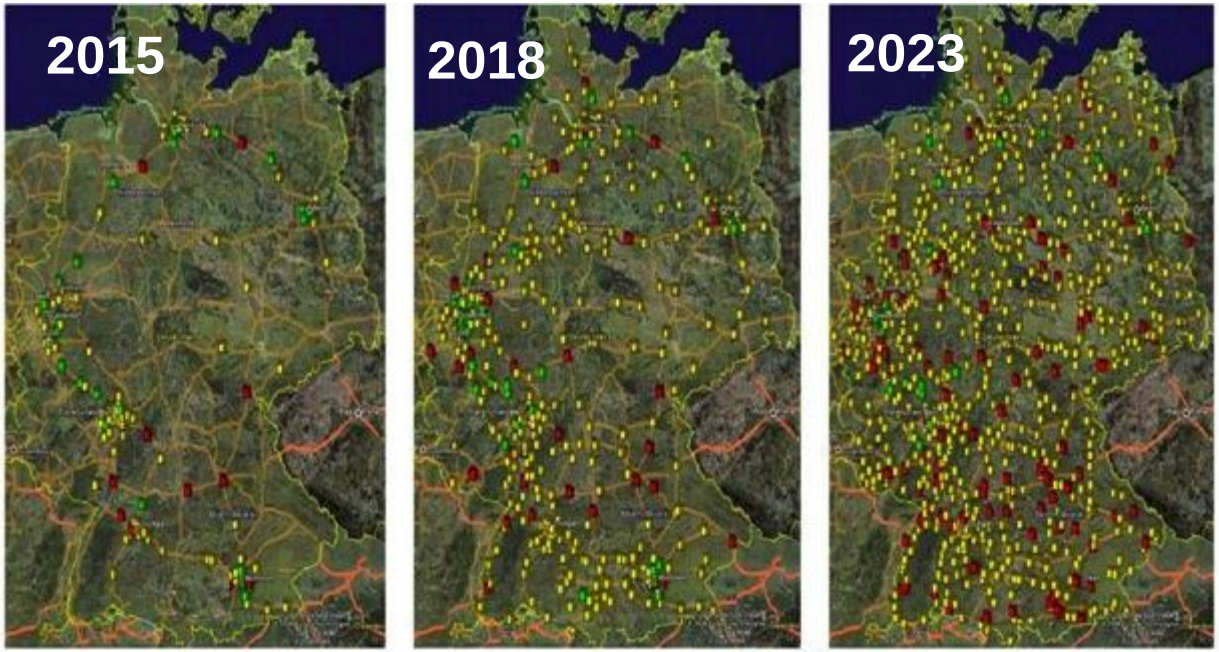
- **Hydrogen refuelling network to grow to about 400 filling stations by 2023**
- **Precondition for the market success of fuel cell powered electric vehicles initiated**
- **Overall investment of around €350 million planned**
- **Development plan represents the benchmark at international level**

Stuttgart, 30 September 2013 – The six partners in the "H_2 Mobility" initiative - Air Liquide, Daimler, Linde, OMV, Shell and Total – have set up upon a specific action plan for the construction of a nationwide hydrogen refuelling network for fuel cell powered electric vehicles. By the year 2023 the current network of 15 filling stations in Germany's public hydrogen infrastructure shall be expanded to about 400 H_2 filling stations. As a first step the deployment of 100 hydrogen stations in Germany over the next 4 years is intended. This would ensure a need-related supply for fuel cell powered electric vehicles to be introduced into the market in the next years. An agreement in principle has been signed by representatives of all the partners involved.

In addition to plans for a nationwide filling station network, the agreement includes the principles for the procurement and distribution of the necessary hydrogen and a request for support to the German Federal Government. Following the foundation of a joint venture (subject to necessary regulatory approvals), gradual expansion of the national filling station network will commence next year. This means that an H_2 supply suitable for everyday use shall be created not only for densely populated areas and main traffic arteries, but also for rural areas. The objective is to offer an H_2 station at least every 90 kilometres of motorway between densely populated areas. According to this plan in metropolitan areas, drivers of fuel cell powered vehicles will have at least 10 hydrogen refuelling stations available each from 2023. Thus zero tailpipe emission H_2-mobility is becoming increasingly attractive for customers. The "H_2 Mobility" initiative expects that a total investment of around €350 million will be required for this future-oriented infrastructure project.

The launch of fuel cell powered production vehicles on the German market has been announced by first manufacturers for 2015. In addition to attractive procurement and

- Initiative gathering the German government and 6 major industrial companies
- 400 hydrogen stations by 2023
- Investment of € 350 million
- Benchmark at international level



Clean Power for Transport Package

•Proposal for Directive on the deployment of alternative fuels infrastructure

- Build a competitive and resource efficient transport system.
- Establish long term fuel strategy.
- Remove technical and regulatory barriers.
- Facilitate a single market for alternative fuels vehicles and vessels.

- Associated costs:
  - Electricity = 8 M charging points = 8 B€
  - LNG Waterborne =139 refuelling points * 15 M€ = 2,1 B€
  - LNG trucks = 144 refuelling points * 0.4 M€ = 58 M€
  - CNG road = 654 refuelling points * 0.25 M€ = 164 M€
  - **Hydrogen = 77 refuelling stations * 1.6 M€ = 123 M€**

Financing H_2 infrastructure roll-out

1

Financing options, structures & partners – initial discussion with banks

- Typical financing structures and financier profiles
- Potential sources of subsidies, public partners and their expectations

2

Business case assessment, optimization, gap analysis

- Assessment of existing business cases
- Assess gap between business case and bankability
- Identify foreseeable risks and losses

3

Bankable/ Subsidy proposal

- Develop a bankable core
- Define elements that require state subsidies
- Ring-fence capital-intensive part that requires project financing
- Design guarantee mechanisms for technical risks, market risks
- Define required "firmness" of de-risking mechanisms

4

Test proposal with banks/ governments

- Test bankable parts and de-risking mechanisms with banks, industry partners and government partners
- Test proposed risk absorption with public stakeholders
- Evaluate feed-back from banks
- Refine proposals/ business case

5

Define way forward

- Summarize findings
- Identify next steps to address banks, public and industry stakeholders

Intermediate report

Final report

Urban buses: alternative powertrains for Europe

A fact-based analysis of the role of diesel hybrid, hydrogen fuel cell, trolley and electric powertrains

Urban buses: alternative powertrains for Europe

Bus manufacturers	Technology providers	Infrastructure providers	Operators	Other organizations
EvoBus	SIEMENS	AIR PRODUCTS	GVB	elementenergy
HESS MOTION & EMOTION	BAE SYSTEMS	Linde	RJK / HyCologne	EnergieRegion.NRW
MAN	NUCELLSYS	Shell	RET	NOW
VANHOOL	HYDROGENICS	HYDROGENICS	Transport for London	HyER
SOLARIS	VOITH	H2 Logic	HOCHBAHN	New Energy World JU
IVECO	Škoda	Ballast Nedam	SWS	
APTS / VDL	ENERDEL	AIR LIQUIDE	BVG TMB VRR	
	ZF BALLARD	BOMBARDIER	Ruter#	
	BOMBARDIER	ABB	MIVB STIB BOGESTRA	
	vossloh			
	PM			
	UTC Power			
	ABB			
7 70%[2]	14	6[1]	12	5

A fact-based analysis of the role of diesel hybrid, hydrogen fuel cell, trolley and electric powertrains

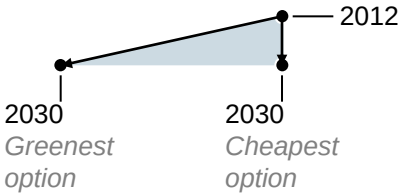
E-bus opportunity and hydrogen fuel cell expected to be the cheapest zero local-emission standard bus by 2030

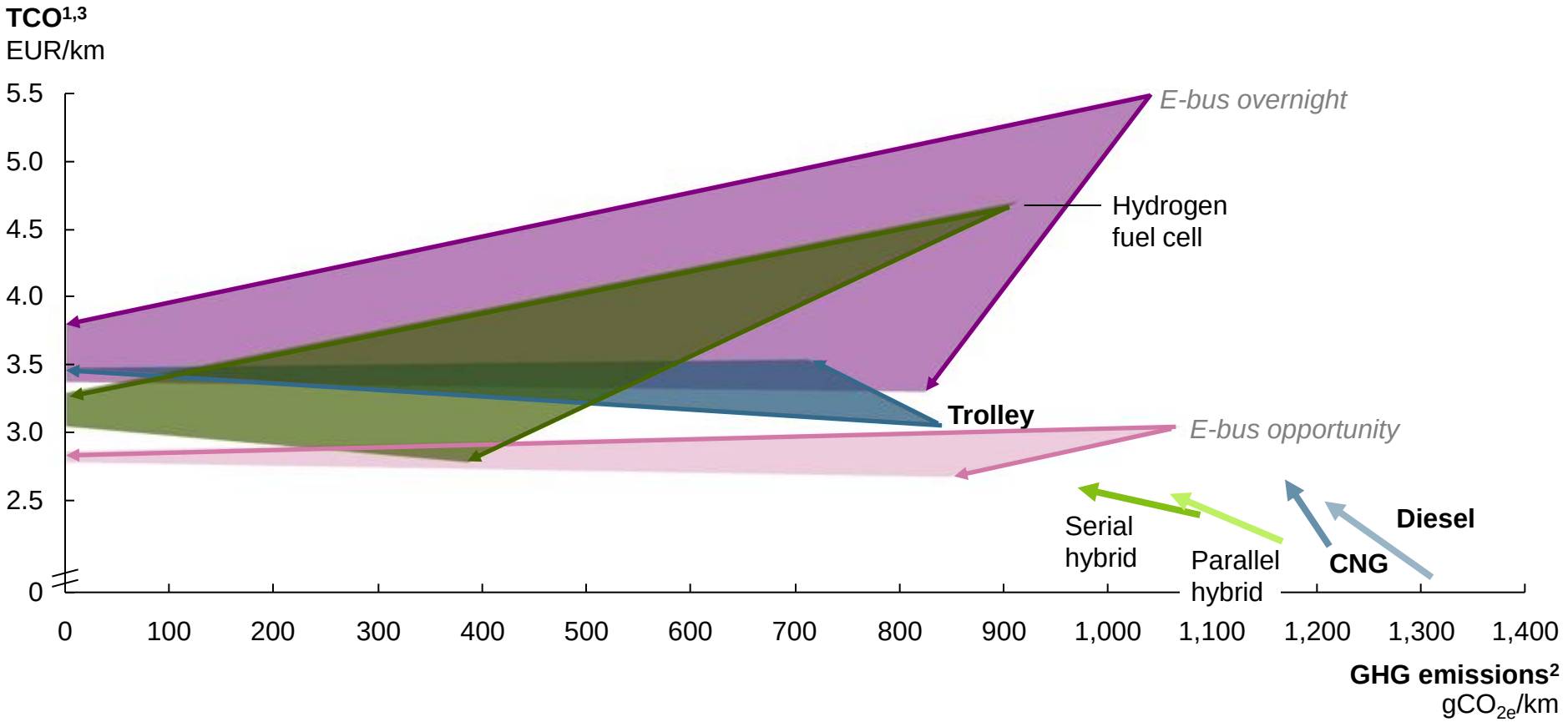
WELL-TO-WHEEL

STANDARD

Labeling of powertrain according degrees of operational experience (kilometers driven):

- **Commercial solution (>> 100 million km): Conventional, trolley**
- Test fleets (> 1 million km): Diesel hybrids, fuel cell
- *Prototype phase (< 10 thousand km): E-buses*





1 Total cost of ownership for a 12m bus including purchase, running and financing costs based on 60,000km annual mileage and 12 years bus lifetime – not all powertrains available for articulated buses therefore articulated buses not shown

2 Total CO_{2e} emissions per bus per km for different fuel types from well-to-wheel

3 Electricity cost for e-bus and water electrolysis part of hydrogen production based on renewable electricity price with a premium of EUR50/MWh over normal electricity

SOURCE: Clean team; working team analysis

Fuel Cell Urban Buses : next steps

Reason	Description/example
▪ **The total cost of ownership** of hydrogen fuel cell buses could be close to diesel hybrid after 2020	▪ With the announcement of H2 Mobility in Germany on 30 September, several car OEMs will start mass production of fuel cell vehicles enabling an accelerated decrease of the cost of fuel cell buses beyond 2020 ▪ After 2020, clean hydrogen could be offered as part of a "larger green bus deal" at a very competitive costs in a number geographically advantaged regions like Scotland, Schlesweig-Holstein, Belgium and the Netherlands
▪ Many cities are focused on the **implementation** of alternative bus power trains **over the next 10 years** to reduce local emissions	▪ London, Oslo, Hamburg, Stockholm, Brussels, Amsterdam, Cologne either have implemented restrictions on Diesel engines or asked for non-fossil power trains
▪ In order to achieve the EU GHG emission aspirations by 2050, **zero emission transport** needs be introduced in the coming decade	▪ The EU is committed to significantly reduce its GHG emission – by at least 80% by 2050 ▪ In order to meet this target, emissions in road transport sector may need to be cut by as much as 95%

Fuel Cell Urban Buses : next steps

Objectives

Accelerate the commercialization of Fuel Cell city buses in Europe by:

Aligning a coalition of private and public stakeholders to allow development of a large scale commercialization project

in a first phase,

- scoping city level Fuel Cell bus business cases
  + developing national ramp up scenarios

in a potential second phase, for whom it may concern,

- developing city level business cases for 400 – 800 buses
  + detailing national Fuel Cell bus roadmaps
    and an EU vision for zero emission public bus transport

in a potential third phase, for whom it may concern,

- implementing and funding selected local business cases
  + agreeing on a required regulatory framework

Coalition Studies

- A portfolio of power-trains for Europe, finished
  - ➥ H_2MOB D, UK, F, …, ongoing
  - ➥ Financing H_2 infrastructure roll-out: Bankability requirements and optimization levers, on-going
    - ➥ H_2MOB Europe, thinking
- Urban Buses: alternative powertrains for Europe, finished
  - ➥ FCH Busses phase 2, starting
- Commercialisation study for Distributed Generation technologies in Europe, starting
- Energy Storage portfolio for Europe, starting
  - ➥ Electrolyser, ongoing

Distributed generation technologies in Europe

Work streams

Coalition members and workstreams for the study → Analysis by benchmark

			
Technology segment	**Small CHP**	**Medium to large scale CHP**	**Large scale power generation**
Power ranges	< 50 kW	> 50 kW	>200 kW
	• Fuel cell	• Fuel cell	• Fuel cell
Technologies available for distributed generation	• Gas boiler • ICE / Stirling engine CHP • Thermal and PV solar • Heat pumps • District heating • Micro-wind • Biomass	• Gas CHP (engine, turbine) • Steam turbine • Heat pumps • Geo. heat • Biogas / biomass • AD • District Heating • Wind • PV • Micro-hydro	• CCGT • Wind (onshore / offshore) • PV • OCGT • Hydro • Tidal • AD • Biomass

Distributed Generation technologies in Europe

Aims

- A **characterisation of the benefits available** from each technology category under a range of future scenarios, both from an environmental and an economic point of view, and their competitive position compared to alternative technologies.

- A clear and consistent **categorisation of the most near-commercial and mass-market fuel cell distributed generation technologies**, at different points in time.

- A detailed assessment of the **barriers to full commercial rollout** of these target technologies, in terms of:
  - Economic barriers and required cost-volume thresholds, financial support, etc.
  - Technological readiness and improvements required to specific technology areas.
  - Market access and requirements for new business models, customer acquisition routes, etc.
  - End-user/consumer acceptance and any required consumer engagement work.

- Well-defined and **concrete recommendations for next steps** towards stimulating the commercialisation of fuel cells in distributed generation, aimed at:
  - European and national policy-makers
  - Specific European and national funding agencies
  - The fuel cell-related R&D community.

Structure of the coalition partners

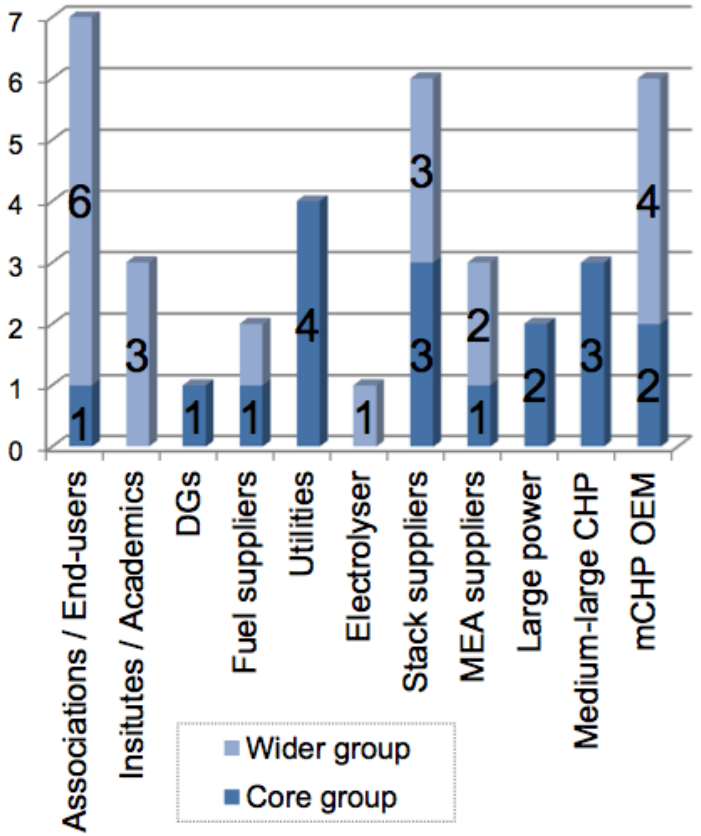
A **core group of stakeholders** has been set up to guide the coalition building process.

This will later form the basis for the **steering group** during the study phase and will include:

- Major fuel cell providers and OEMs from the three main categories:
  - Small CHP (<50kW)
  - Large CHP (>50kW)
  - Large power generation (>200kW)
- Energy utilities
- Other stakeholders

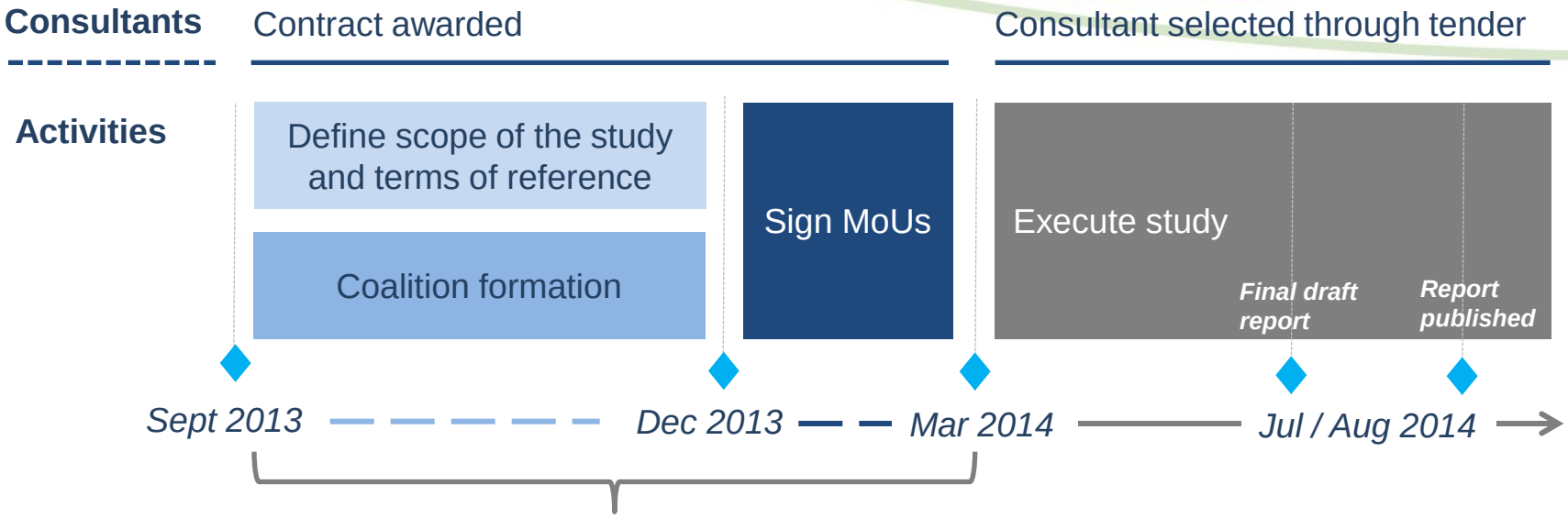
A **wider group** is also being formed including actors from all the subgroups shown on the right.

Current split of coalition partners (38)



Distributed generation technologies in Europe

Planning



	Sep	Oct	Nov	Dec	Jan	Feb
First description of project and outcomes						
First draft of project documentation (MoU + scope of works)						
Establish core consortium						
First consortium meeting			X			
Finalise project documentation						
Expand the consortium						
Second consortium meeting				X		
Sign MoUs						
Hand over to consultant and FCH JU						

Energy Storage Study: rationale

Rationale for the study	Description
Energy storage technologies can **provide value** to the European energy system	• Enable the deployment of intermittent renewable generation and variable demand • Avoid grid reinforcement costs • Provide balancing, response and reserve services
There is a high degree of **technological uncertainty** - A wide range of storage technologies exist for a variety of applications	• Batteries, Pumped hydro, CAES, liquid air, hydrogen for industry & transport, hydrogen to gas, flywheels • Demand side management, smart grids and other developments can both provide synergies with energy storage and also compete to deliver similar services
The **current market provides weak signals** to governments and investors	• Weak near term market demand and lack of business models • Future role of energy storage is unclear, especially for hydrogen • Competition in technology claims due to scarce investments
Action is required to create conditions under which energy storage technologies can develop towards commercialisation	• Clarify the market outlook for energy storage technologies • Clarify potential of the different technologies • Help ensure the right focus for policy support

Energy Storage Study: fact based

Objectives	Description
Fact based comparison of Energy Storage technologies and other options to provide services to the energy system	• A clear breakdown of ES services and products, and requirements for different functionalities and application areas • A clear and consistent categorisation of the relevant energy storage technologies. Positioned against each other and alternative options, at different points in time
Trajectories of **benefits and likely demand** for different Energy Storage technologies	• Overview of business models underlying these applications • Market potential for different applications and sensitivity analysis, for different markets and at different points in time
Insight in impact of **market arrangements** and regulations	• Overview of current market arrangements and regulations that inhibit the ability of storage technologies to capitalise on all possible value drivers
Well defined and **concrete recommendations for next steps** toward stimulating commercialisation of Energy Storage technologies	• Focal points for policy support, ensuring access to markets and level playing field • Focus for funding support to address cost related barriers • Most relevant areas for H_2 ES technologies to focus research and development efforts on

Energy Storage Study: the coalition

Structure of the coalition partners

A **core group of stakeholders** will be set up to guide the coalition building process.

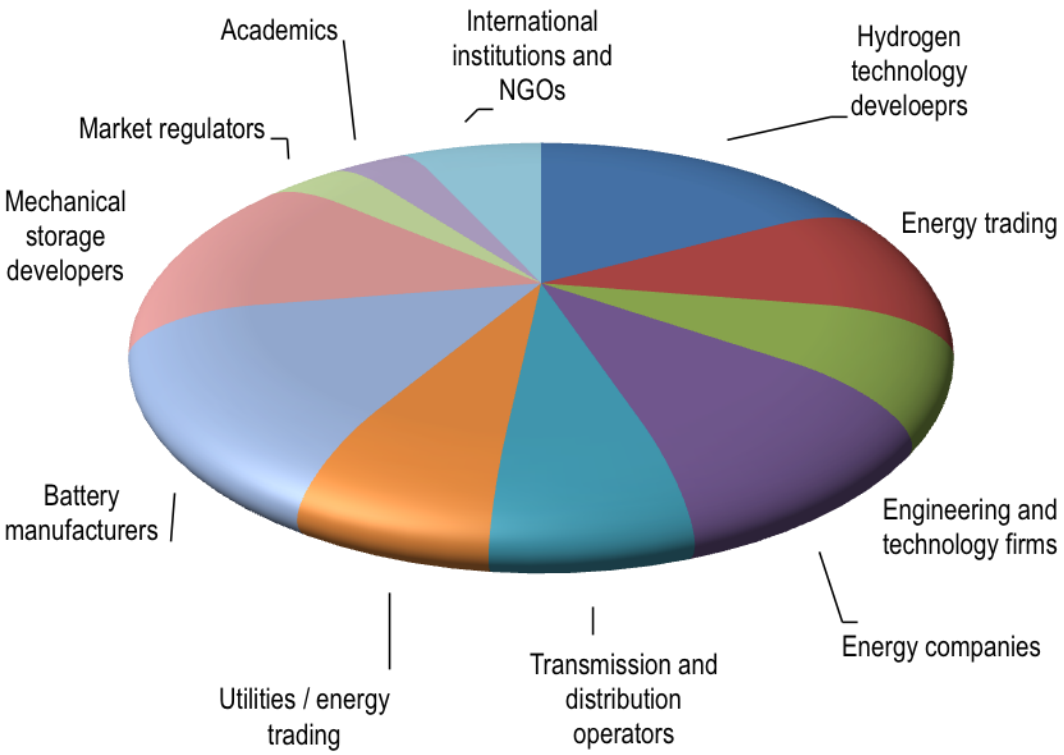
A **wider group** will later be formed including actors from all the subgroups shown on the right.

All coalition partners will be represented in the **project steering group**

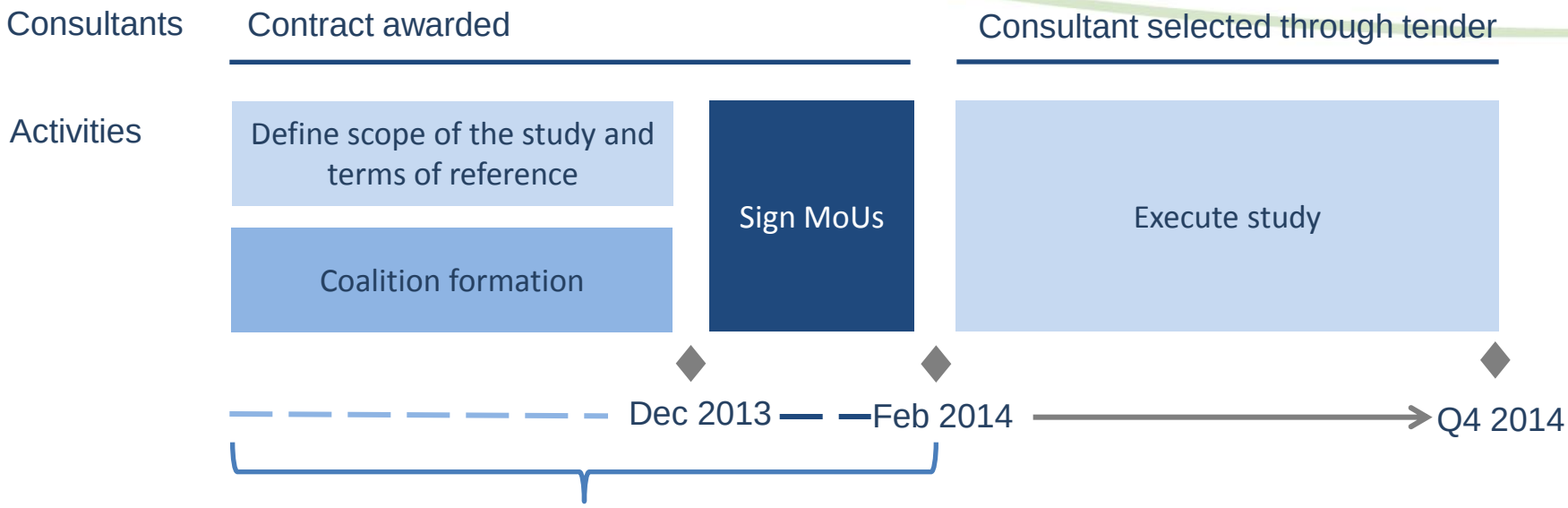
Workgroups of coalition members will be organised to provide input to the study for the following work streams:

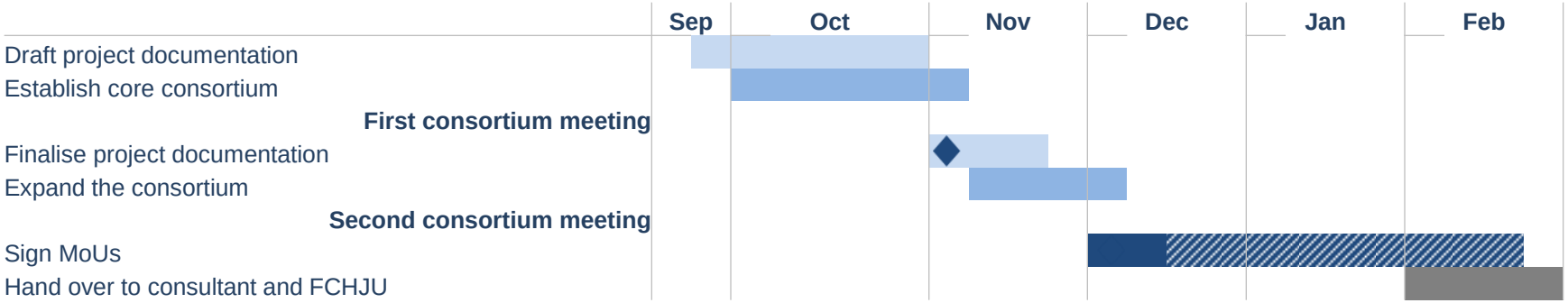
- All of the most relevant energy storage functionalities
- Market arrangements

Expected sub groups of coalition partners by activity



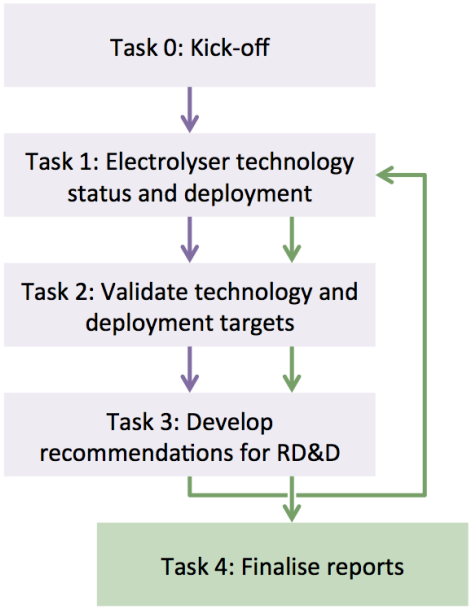
Energy Storage Study: planning

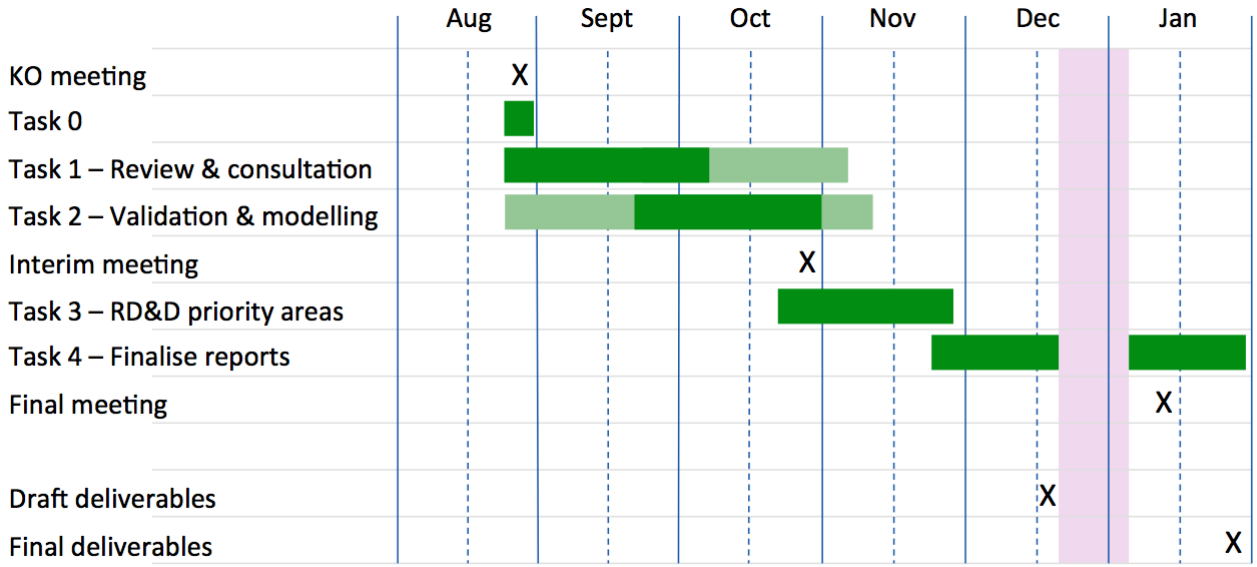




Development of electrolysis in Europe

- Short duration study on electrolysis (PEM, Alkaline, SOEC, …)
- State of the art and future trends; RD&D recommendations
- Small coalition with key stakeholders





Conclusions

- Steady technical progress
- Secure environment (FCH 2 JU, €, …)
- Fact based technical coalition studies
- Input for next Multi Annual Work Program (MAWP)
- Directions for new policy developments

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➢ Joint strengthen the FCH Community

➢ Take part !

Thank you for your attention !

Further info :

- **FCH JU : http://fch-ju.eu**
- **NEW-IG : http://www.new-ig.eu**
- **N.ERGHY : http://www.nerghy.eu**