Fuel Cells and Hydrogen Joint Undertaking

Achievements and Outlook to the Future

Bert De Colvenaer, Executive Director
Brussels, 10 September 2013

The FCH JTI in the SET plan

EU targets :

20 % increase in renewables
20 % increase in efficiency
20 % decrease in emissions

Fuel Cell and Hydrogen Joint Undertaking

- FCH JU : community body
- Budget : 940 M €
- FCH JU Programme Office

450 = RTD : 315 ENER : 120 MOVE : 15

Public-Private Partnership

Fuel Cells & Hydrogen Joint Undertaking

Industry Grouping
Over 60 members

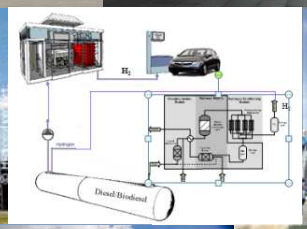
European Union
represented by the European Commission

Research Grouping
Over 60 members

Both the Industry Grouping and the Research Grouping are non-profit organisations with open membership

To accelerate the development of technology base towards **market deployment of FCH technologies** from 2015 onwards

FCH JU portfolio127 projects

TRANSPORTATION & REFUELLING INFRASTRUCTURE	**25 projects** 8 demo 14 research 3 CSA	       
HYDROGEN PRODUCTION & DISTRIBUTION	**28 projects** 4 demo 24 research	   
STATIONARY POWER GENERATION & CHP	**36 projects** 9 demo 26 research 1 CSA	   
EARLY MARKETS	**21 project** 13 demo 8 research	     
CROSS - CUTTING	**17 project**	RCS, Safety, Education, PNR, …

Clean Hydrogen in European Cities

CHIC

Objectives

- Operation of **26 fuel cell buses** in 5 cities in Europe (**Aargau, Bolzano, London, Milano, Oslo**) and the respective infrastructure for a period of 5 years
- Transfer of learning from cities with experience in operating buses and infrastructure (Hamburg, Berlin, Cologne, Whistler; ~ 30 fuel cell buses) to the 5 cities
- Assessment of the technology with focus on environment, economy and society
- Dissemination to the general public and to cities preparing for the technology in the next step
- 2 filling stations per city
- Demonstration phase 2010-2016
- **Cost 82 M€, 26 M€ funding**










Main Partners

25 partners from cities, consultants and industry:

ATM, BC Transit, BVG, hyCologne, hySOLUTIONS, infraserv höchst, London Buses, Postauto, Ruter, STA, element energy, Euro Keys, HyER, PE International, PLANET, Spilett, University of Stuttgart, Air Liquide, Air Products, Daimler, Linde, Shell, Total, Vattenfall, Wrightbus

Hydrogen Transport in European Cities (2010)

The HyTEC project will expand the existing European network of hydrogen demonstration sites into two of the most promising early markets for hydrogen and fuel cells, Denmark (Copenhagen) and the UK (London)

30 new hydrogen vehicles (taxis, passenger cars and scooters

16 partners
5 countries

2 refuelling stations:
-London
-Copenhagen

FCH JU Achievements Transport

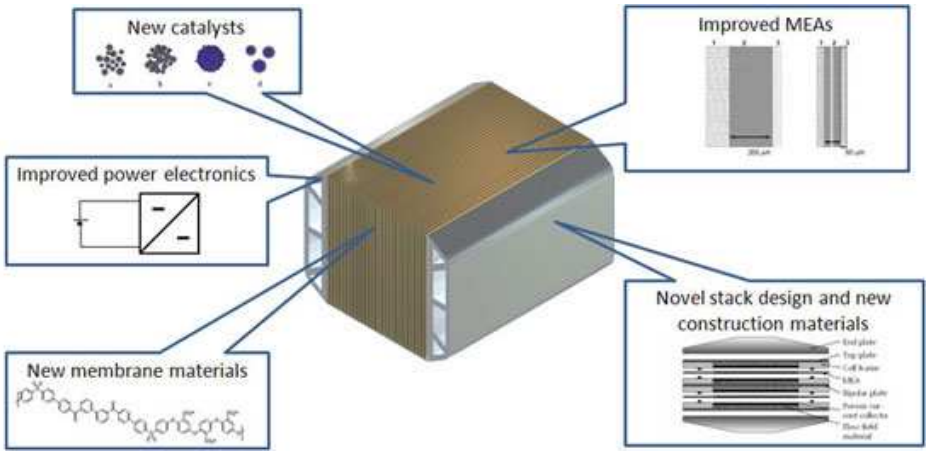
- 49 FCH busses, 37 passenger cars, 95 mini cars (range extender)
- 13 new refueling stations (98 % availability)
- H_2 cost < 10 €/kg
- Reduction in H_2 consumption : bus 22 ➔11 kg/100 km
- MEA improvement : 5000h, Pt reduction (-30 %)
- Co-funding with MS (DK, NO)

Next-Generation PEM Electrolyser For Sustainable Hydrogen Production

An efficient PEM electrolyser integrated with Renewable Energy Sources (RES) will be constructed and demonstrated.

Goals: improvement of components, reduce cost and improve stability.

Advanced stack design using components suitable for mass production and highly efficient power electronics.



fumatech
Funktionelle Membranen und Anlagentechnologie

Fraunhofer ISE

cea

HELION HYDROGEN POWER

Statoil

SINTEF

FCH JU Achievements Hydrogen

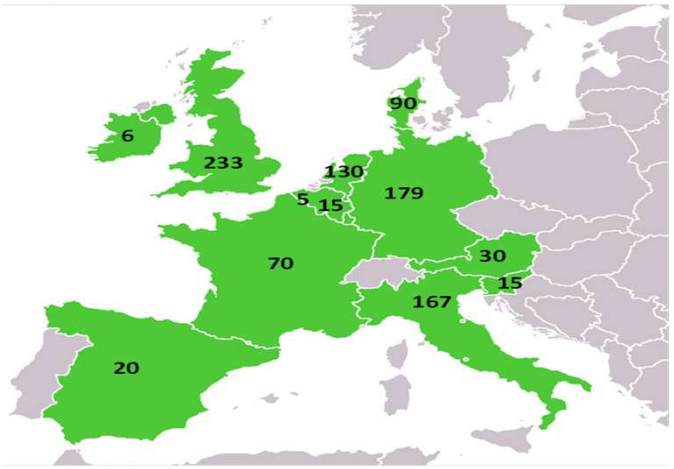
- Polymeric Electrolyte Membrane (PEM) water electrolysis
- Alkaline electrolysis coupled with renewable energy source
- Intermediate temperature steam electrolysis
- Photo electrochemical water decomposition
- Solar thermochemical production
- Hydrogen production from biomass
- Steam reforming of fuels
- Reforming of (bio)diesel

- The purification of hydrogen and its separation from other gas mixtures

- Solid-state storage
- High pressure gas storage and delivery
- Liquid phase storage

Ene.field project

- Demonstration of up to 1000 residential fuel cell µCHP (1-5 kW) units from 9 manufacturers in 12 EU member states
- Establish supply chains, validate new routes to market, stimulate cost reduction for final commercial deployment



FCH JU Target	State of the Art	Expected performance
Electrical efficiency (min) 35%	30 %	35 % – 50 %
Overall efficiency > 85% (LHV)	70 % – 85 %	Up to 90 %
Lifetime : of 8 - 10 years	3 years	Up to 8 years

Technical characteristics	JTI Call	Summary table of products by manufacturer								
		Baxi	Bosch	Ceres	Dantherm	Elcore	Hexis	RBZ	SOFCP	Vaillant
IMAGE										
FC technology	All	LT PEM	SOFC	IT-SOFC	SOFC+LT PEM	HT PEM	SOFC	LT PEM	SOFC	SOFC
kW electrical	micro-CHP	1 kW	1kW	0.8kW	1kW (both)	300W	1kW	5kW	2.5kW	1kW
kW thermal	micro-CHP	1.8 kW	20kW	25kW	1.4kW		2kW + peak heater 20 kW	10kW		
System efficiency (LHV)	>85% (LHV)	91% Target 96%	>85%	80-90%	90% LHV (SOFC) and (PEM)	>90%	≤95%	>85%	Target 90%	>85%
Electrical efficiency (LHV)	Min 35%, target >40%	Target 35% (32%in Callux)	>40%	39%	45% (SOFC) and 35%(PEM)	35%	32–35%	>30%	35–50%	35%
System type	N/A	Floor		Wall	Floor	Wall	Floor	Floor	Floor	Wall or Floor
Certification	N/A	CE–0085BU0371	CE in progress	CE	CE	CE(in progress)	CE	CE	CE	CE
Manufacturer's Previous trials	N/A	CALLUX	-	BRITISH GAS TRIAL	DKmicro-CHP (both)	NIP program (planned)	CALLUX	NIP program 2010	Local Trials & lab test	CALLUX

Table 4 – Products to be deployed under ene.field.

FCH JU Achievements Stationary

- Ene.field : 1000 mCHP, 12 MS, 9 suppliers : cheaper (- 50 %), higher system efficient (up to 90 %), longer lifetime (8y)
- 1 MW system, electric efficiency 48 %, 2500 €/kW
- Research oriented : cheaper, longer lifetime/improve degradation, increased electric efficiency, improved fluid and thermal mgt, improved control, modeling & diagnostic for PEM & SOFC.

HyLIFT DEMO

HyLIFT
Clean Efficient Power
For Materials Handling
www.hylift.eu

European demonstration of fuel cell powered materials handling vehicles including infrastructure

Objectives

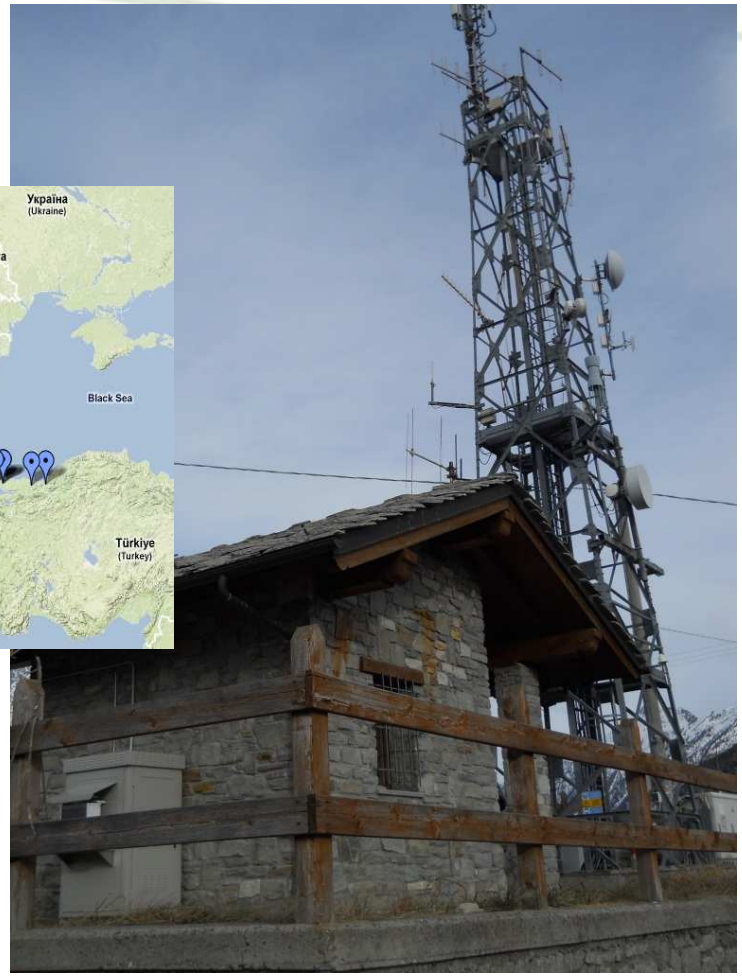
- demonstration of 30 fuel cell forklifts
- demonstration of hydrogen refuelling infrastructure
- performance of accelerated durability tests
- preparation of market deployment from 2013 on

ludwig bölkow systemtechnik
DanTruck
DTU
EHA EUROPEAN HYDROGEN ASSOCIATION
FAST Federazione delle associazioni scientifiche e tecniche fondata nel 1897
HyRaMP
H2 Logic
JRC EUROPEAN COMMISSION
ie Institute for Energy
Linde
SINTEF
TÜV

FITUP

Fuel cell field test demonstration of economic and environmental viability for portable generators, backup and UPS power system applications

- 19 units, 3 countries
- Availability > 95 %
- Lifetime > 1500 h
- Cycles > 1000

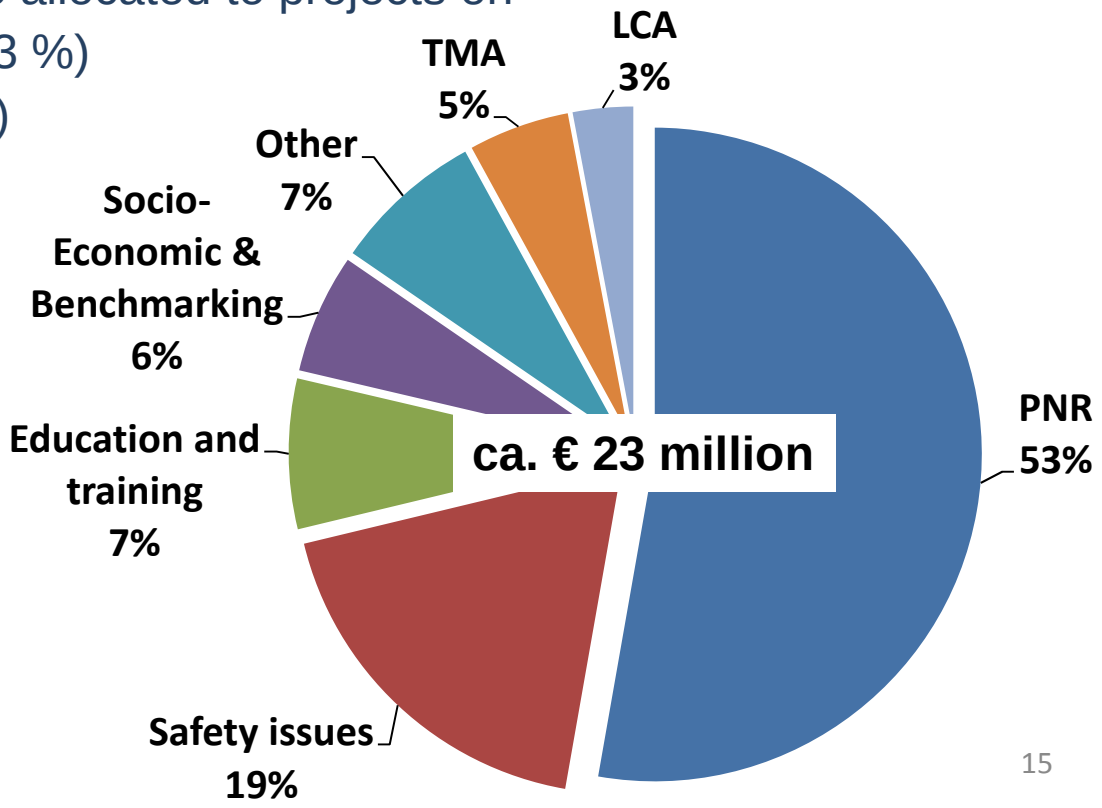


FCH JU Achievements Early markets

- FCH material handling : forklifts, tow trucks, refilling
- 19 back up power units in Italy, Swiss and Turkey
- FCH power for Unmanned Areal Vehicle
- Hybrid systems : battery, FCH, PV
- DMFC, micro FC, …

FCH JU projects on cross-cutting issues

- Up to call 2012 **22** projects are funded on cross-cutting issues :
  = € 23 million or 6% of the total FCH JU budget
- Out of these more than 70% are allocated to projects on
  - Pre-Normative Research (53 %)
  - Safety-related issues (19 %)



Pre-Normative Research Projects

Material testing

•**HyCOMP** - Enhanced Design Requirements and Testing Procedures for Composite Cylinders intended for the Safe Storage of Hydrogen (01/01/2011 - 31/12/2013; €1.4 million FCH JU funding)

•**StackTest -** Development of PEM Fuel Cell Stack Reference Test Procedures for Industry (01/09/2012 - 31/08/2015; € 2.9 million FCH JU funding)

•**MATHRYCE** - Material Testing and Design Recommendations for Components exposed to Hydrogen Enhanced Fatigue (01/10/2012 - 30/09/2015; € 1.3 million FCH JU funding)

•**FireComp** - Modeling the thermo-mechanical behavior of high pressure vessel in composite materials when exposed to fire conditions (01/06/2013 - 31/05/2016; € 1.9 million FCH JU funding)

•***Forthcoming projects (call 2013)*** : (1) Resistance to mechanical impact of composite overwrapped pressure vessels and (2) Uniform and industry wide test procedures for high temperature solid oxide cells (SOEC and SOFC)

Fast transfers of compressed hydrogen

•**HyTransfer** - Pre-Normative Research for Thermodynamic Optimization of Fast Hydrogen Transfer (01/06/2013 - 30/11/2015; € 1.6 million FCH JU funding)

Safe indoor use of H2 and FC

•**HyIndoor** - Pre Normative Research on the indoor use of fuel cells and hydrogen systems (02/01/2012 - 01/01/2015; € 1.5 million FCH JU funding)

Key projects focused on safety issues

First responders

•**HyResponse** - European Hydrogen Emergency Response training programme for First Responders (01/06/2013 - 31/05/2016; €1.9 million FCH JU funding)

Safety knowledge assessment

•**H2Trust** - Development of H2 Safety Expert Groups and due diligence tools for public awareness and trust in hydrogen technologies and applications (01/06/2013 - 30/11/2014; € 0.8 million FCH JU funding)

Assessment of best practices in use of CFD for safety analysis

•**SUSANA** - Support to Safety Analysis of Hydrogen and Fuel Cell Technologies (01/09/2013 - 31/08/2016; € 1.2 million FCH JU funding)

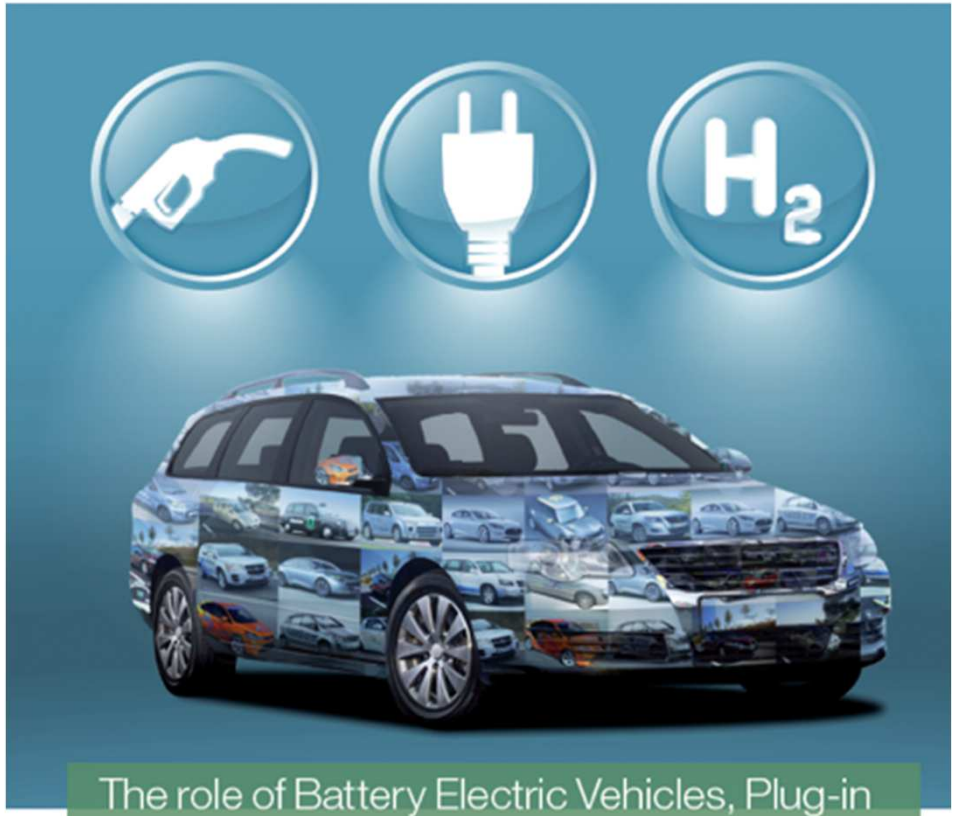
Hydrogen safety sensors (first FCH JU/US DoE common project)

•**H2Sense** - Cost-effective and reliable hydrogen sensors for facilitating the safe use of hydrogen (01/06/2013 - 31/05/2014; € 0.4 million FCH JU funding)

A portfolio of power-trains

for Europe

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



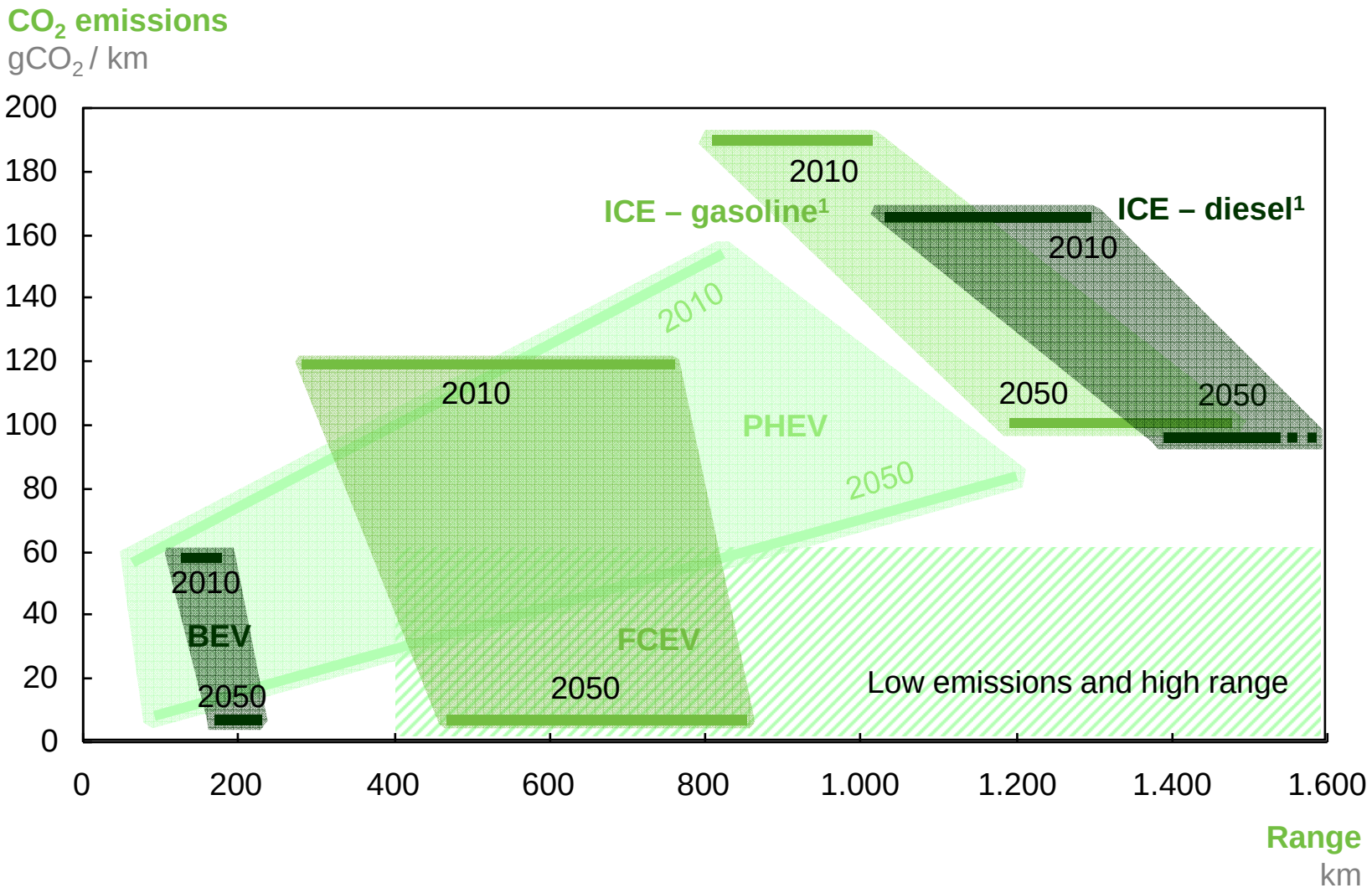
Industry participants	
Car OEMs	DAIMLER, HONDA, HYUNDAI, KIA MOTORS, GM, NISSAN, Ford, RENAULT, VW, BMW, TOYOTA
Oil and gas	Eni, OMV, Shell, TOTAL, galp energia
Utilities	EnBW, VATTENFALL
Industrial gas companies	AIR PRODUCTS, AIR LIQUIDE, Linde
Equipment OEMs	INTELLIGENT ENERGY, Powertech
Wind	NORDEX
Electrolyser companies	HYDROG(E)NICS, PROTON ENERGY SYSTEMS, ELT Elektrolyse Technik, Hydrogen Technology
NGOs, GOs	European Climate Foundation, NOW Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie, New Energy World HQ

Publication: 8 November 2010

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

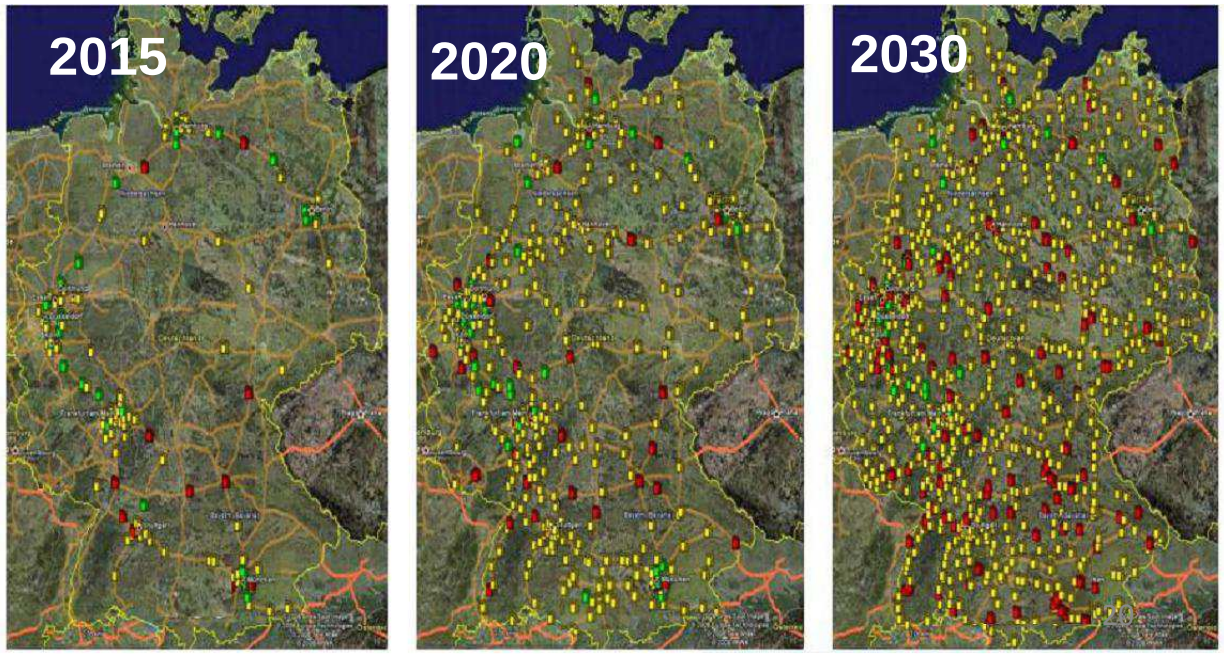
Battery and fuel cell vehicles can achieve low emissions

C/D SEGMENT



H2 mobility in Germany

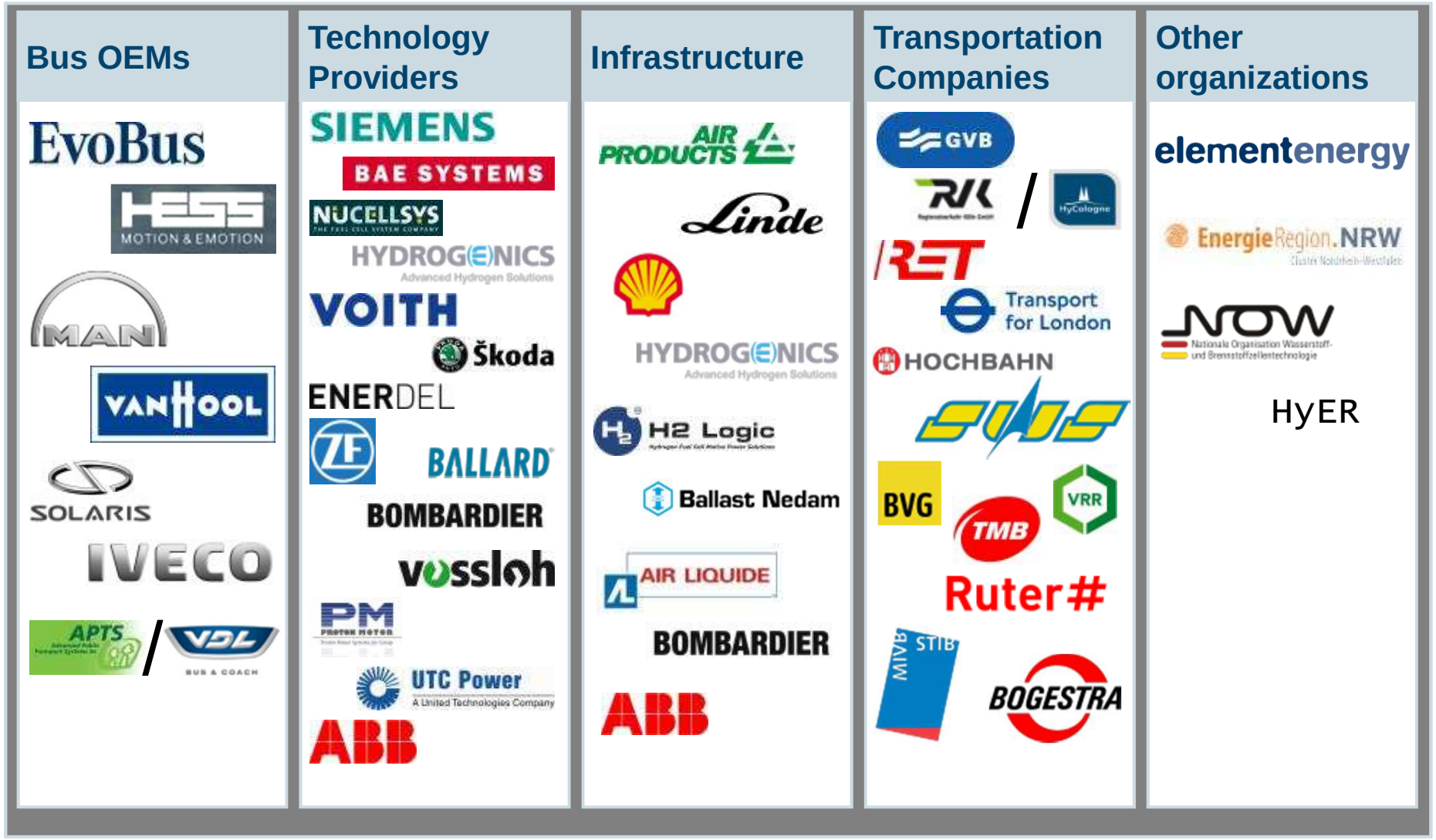
- Initiative gathering the German government and industrial companies
- 200 to 500 hydrogen refuelling stations in 2020, distributed all over the country
- 150 000 to 500 000 FCEVs on the roads in 2020



Urban buses: alternative powertrains for Europe

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

The coalition of more than 40 industrial companies and organizations



1 Bombardier, Hydrogenics and ABB participate in both the Technology Providers and the Infrastructure working groups

SOURCE: FCH JU; McKinsey

In depth analysis of 8 different powertrains for standard and articulated bus

1. Diesel powertrain

- **Conventional** diesel combustion engine

2. CNG powertrain

- **Conventional** CNG combustion engine

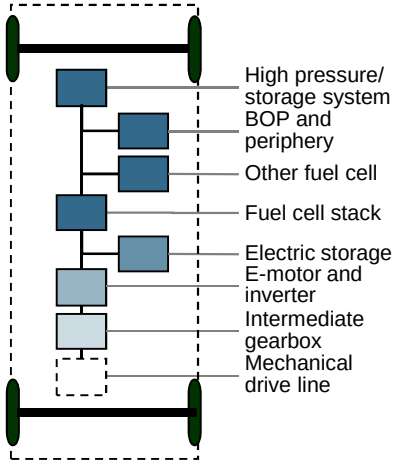
3. Parallel hybrid powertrain

- **Parallel** hybrid configuration of electric and ICE drive
- Fully electric driving for **smaller distances** (<2 km)

4. Serial hybrid powertrain

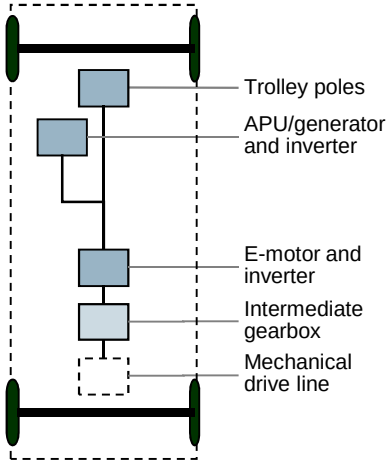
- **Serial** hybrid configuration of dominating electric system
- Fully electric driving for **smaller distances** (<10 km); larger range possible depending on capacity of battery

5. Hydrogen fuel cell powertrain



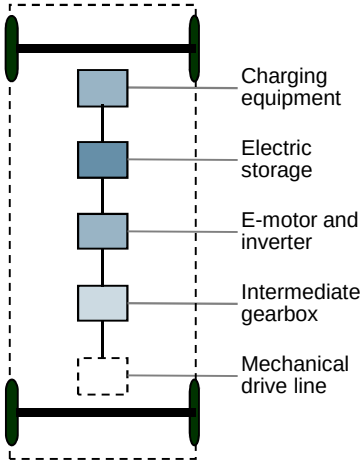
- **Serial hybrid** configuration of fuel cell system and electric drive
- Hydrogen tank pressure typically 350 or 700 bar

6. Trolley powertrain



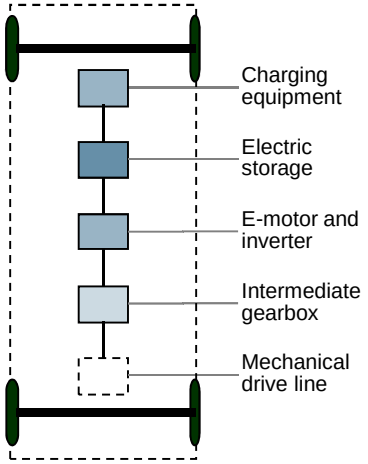
- **Purely electric** drive
- Electric energy taken **from the overhead wiring** while driving

7. Opportunity e-bus



- **Purely electric** drive
- Only charging of battery **from the grid** while stationary at intermediate stops (e.g. via an overhead catenary system)

8. Overnight e-bus



- **Purely electric** drive
- Only charging of battery **from the grid** while stationary at the depot

ICE powertrain | Transmission | Electric powertrain | Battery or supercaps | FC powertrain

SOURCE: Study analysis

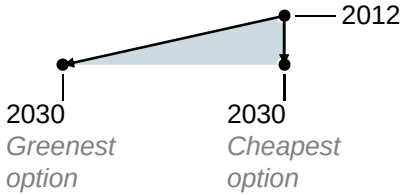
E-bus opportunity and hydrogen fuel cell expected to be the cheapest zero local-emission standard bus by 2030

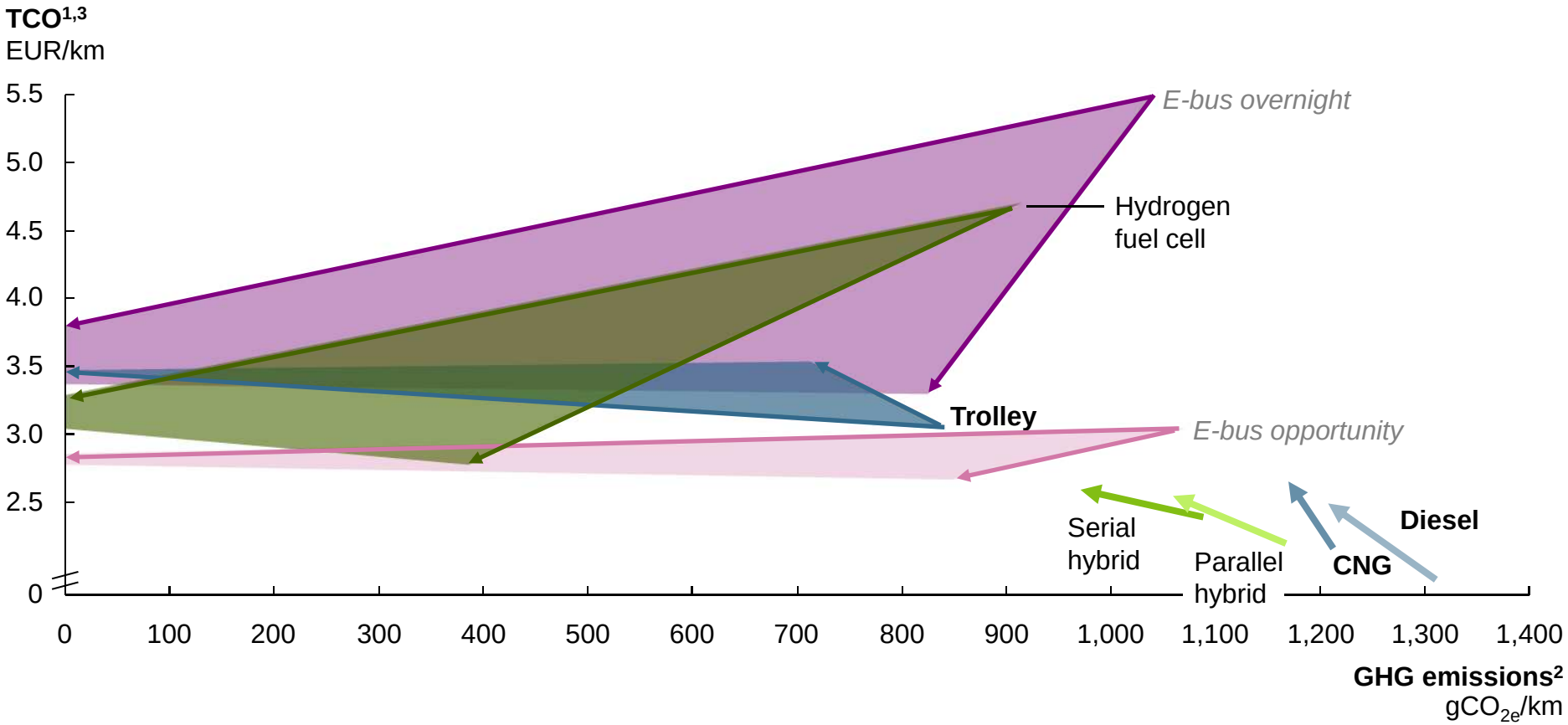
WELL-TO-WHEEL

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

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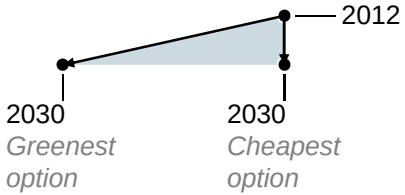

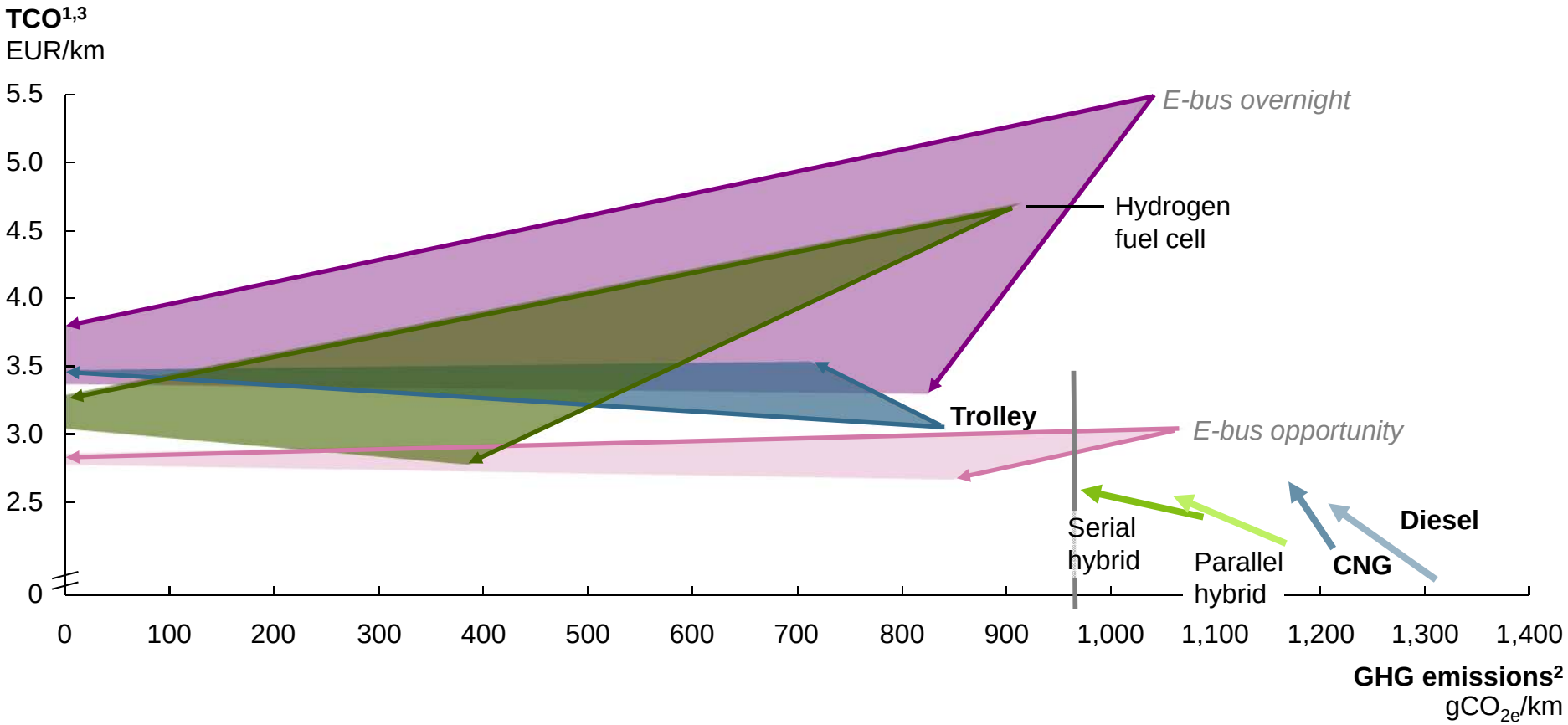

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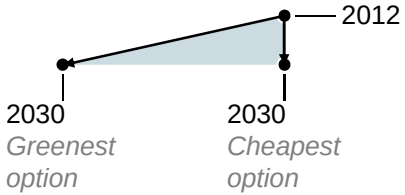

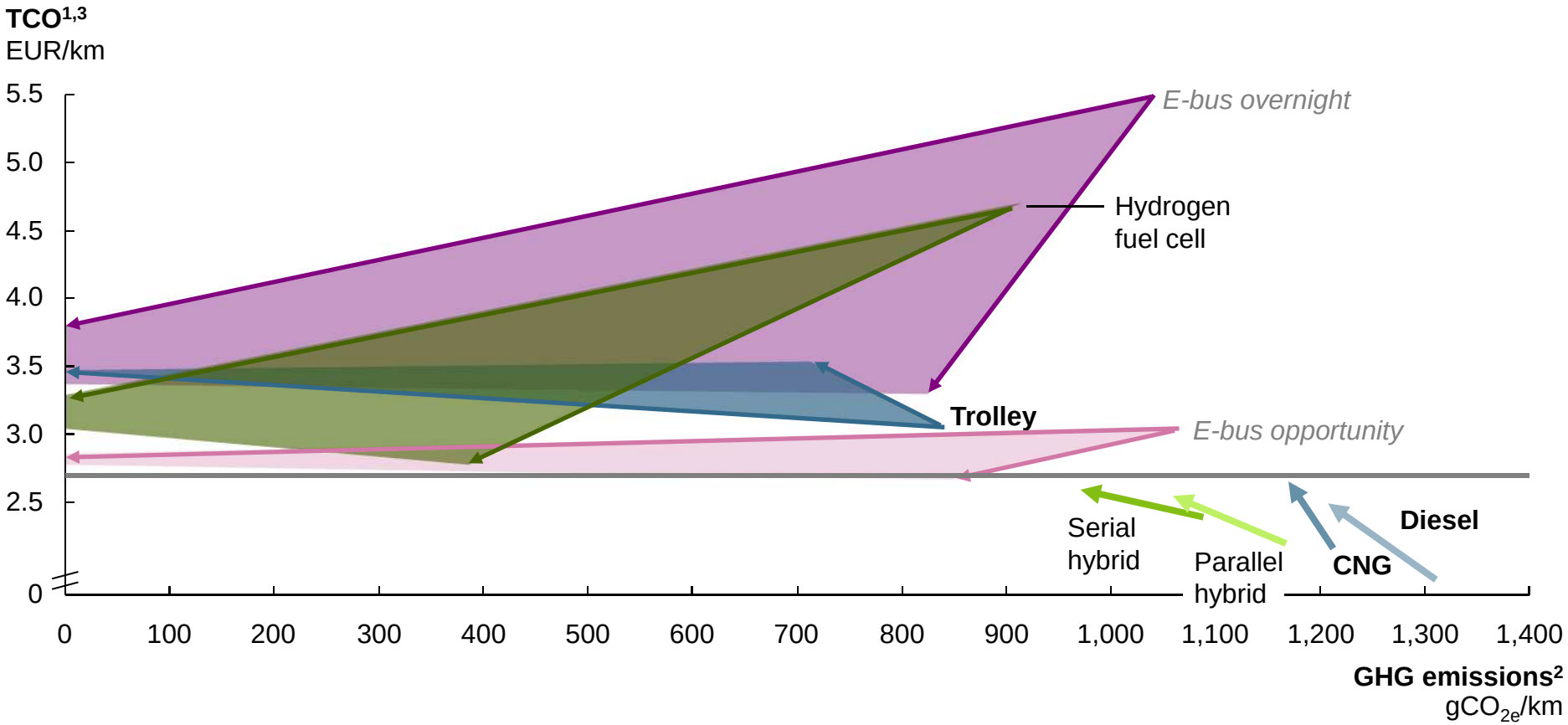

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SOURCE: Clean team; working team analysis

Clean Power for Transport package

Objectives :

- Build a competitive and resource efficient transport system in the EU
- Establish a long term fuel strategy
- Remove technical and regulatory barriers across the EU
- Facilitate the development of a single market for alternative fuels infrastructure and alternative fuel vehicles and vessels.


FCH JU Policy Achievement

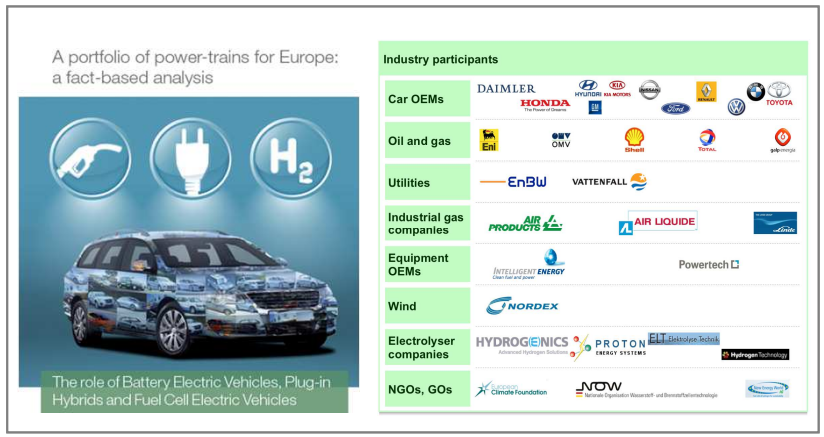
Clean Power for Transport Package

- Proposal for Directive on the deployment of alternative fuels infrastructure
  - Framework (minimum infrastructure)
  - Common EU standards
  - Consumer information

- 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€**

FCH JU Achievements General

- A strong FCH platform/hub/community in Europe
- Put FCH technology back on the agenda
- An EC, IG & RG consensus plan (MAIP 2008 - 2013)
- Interest from European Institutions (EC, Parliament, Council)
- (Industrial) Cooperation before competition



FCH JU under Horizon 2020

- **Horizon 2020** is the Framework Programme for Research and Innovation (2014-2020) of the European Union
- The European Commission proposes to continue the activities on Fuel Cells and Hydrogen technologies using the **public-private partnershi**p approach of the current FCH Joint Undertaking
- **Main Scientific & Technical objectives** are already defined – Detailed scope and budget are under elaboration/discussion
- Main priorities will be: Hydrogen based solutions for **storing renewable electricity** and **road transport** (+ infrastructure)
- RTD programme will be structured around two main innovation pillars: "**Energy**" and "**Transport**"

FCH JU under Horizon 2020

Two key activity pillars

TRANSPORT

- Road vehicles
- Non-road mobile vehicles and machinery
- Refuelling infrastructure
- Maritime, rail and aviation applications

ENERGY

- Fuel cells for power and combined heat & power generation
- Hydrogen production and distribution
- Hydrogen for renewable energy generation (incl. blending in natural gas grid)

CROSS-CUTTING ISSUES

(e.g. standards, consumer awareness, manufacturing methods, studies)

Strategic objective

By 2020, fuel cell and hydrogen technologies will be demonstrated as one of the pillars of future European energy and transport systems, making a valued contribution to the transformation to a low carbon economy by 2050.

Budget of €1.4 billion in 2014 - 2020

Strong industry commitment to contribute inside the programme + through additional investment outside, supporting joint objectives.

Invitation Drive ‘n’ Ride

Invitation General Assembly

Fuel Cells and Hydrogen
Joint Undertaking

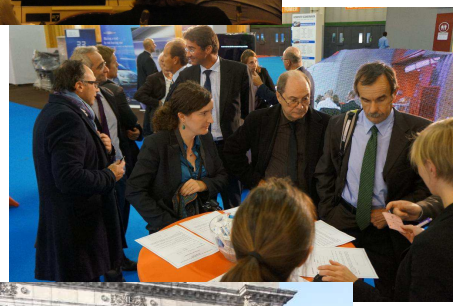
New Energy World JU
fuel cells & hydrogen for sustainability

6th Stakeholder General Assembly
of the European Partnership for Fuel Cells and Hydrogen

"Fuel Cells and Hydrogen:
Towards a competitive, sustainable Europe"

13 November 2013 / Brussel, Belgium

Leading speakers from the fuel cell and hydrogen community will meet on the occasion of the 2013 Stakeholder General Assembly of the Fuel Cells and Hydrogen Joint Undertaking. This high-level forum will mark the 10th anniversary of a European FCH strategy and take stock of exciting new developments in the sector. Importantly, it will set out the strategic vision of how fuel cells and hydrogen can help achieve EU 2020 targets.



Summary

- For operational activities (National – European – Internationally) generate a **closer and stronger research cooperation** (sharing info, data, results, best practice, …) and aligning operational strategies.
- A **strong(er) emphasis on safety and PNR** related issues in all hydrogen related activities and projects towards proactive dissemination and awareness.

Thank you for your attention !

Further info :

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