# Hydrogène et piles à Combustibles
# Initiatives publiques:
# européenne, nationales et locales

*Paul Lucchese*

**CEA**

# Chronologie de la dynamique H2 en Europe et en France

ANR

HYPAC

Feuille de route ADEME

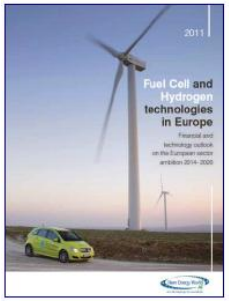
3 AMI Investissement Avenir

H2 mobility in France

H2 mobility in UK

H2 mobility in Germany

Power Trains Comparison « Mac kinsey study »


Needs for 2014-2020 By Industry

Démarrage JTI

4 calls—for proposals

2 call for proposals

2007 2010 2011 2012

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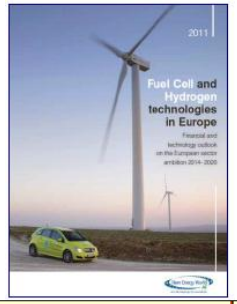


***Needs for 2014-2020 By Industry***

Démarrage JTI

***4 calls—for proposals***

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# Le cadre européen

# EC support for FC & $H_2$ R&D

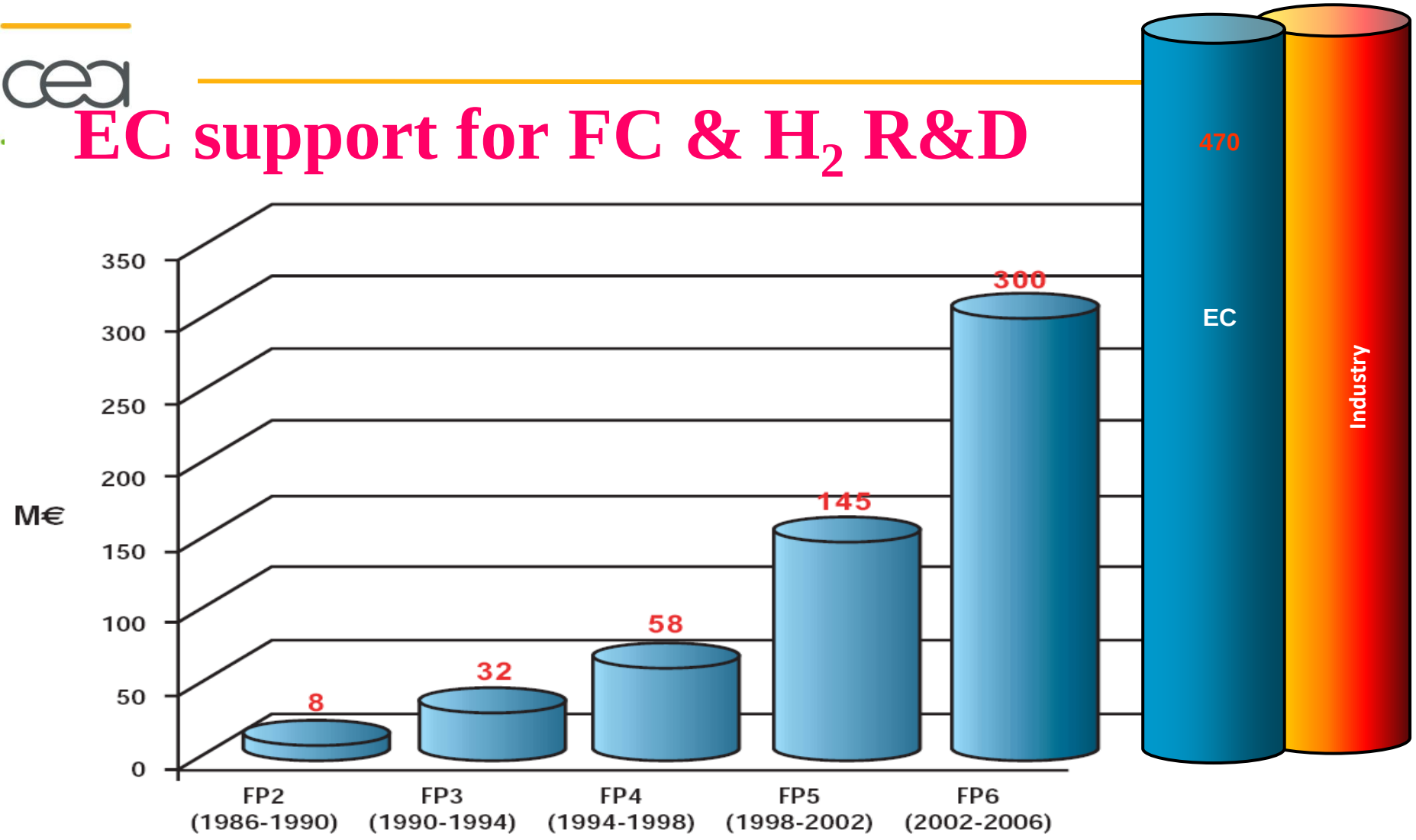



Figure 2 – EC funds to Hydrogen and Fuel Cell research in the various FPs

# Hydrogen and Europe: an old love story …


**VISION**
Hydrogen Energy
And Fuel Cells
(2003)

**STRATEGY**
Strategic Research Agenda
Deployment Strategy
Strategic Overview
(2005)

**100 Stakeholders invested more than € 10 m€ for the JTI preparation**

**FCH JU**
Officially operative
since September 12, 2008
0,94 B€

**IMPLEMENTATION**
Implementation Plan
(March 2007)
7,4 B € 10 years

# UN PROGRAMME PERENNE ET STRUCTURANT

## *LE JTI FCH*

# JTI Hydrogène

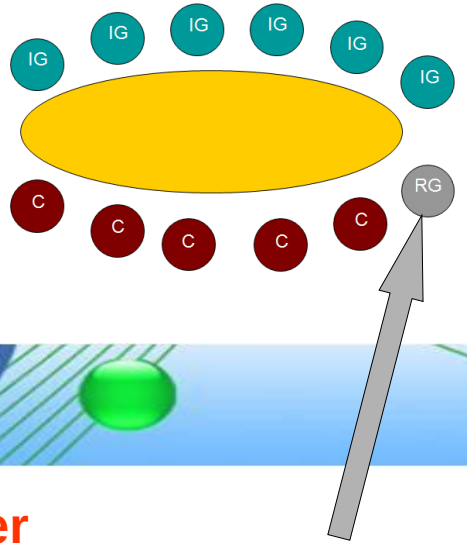
## Une priorité européenne: discours en accord avec les actes

**Une première réussie dans le domaine de l'énergie**

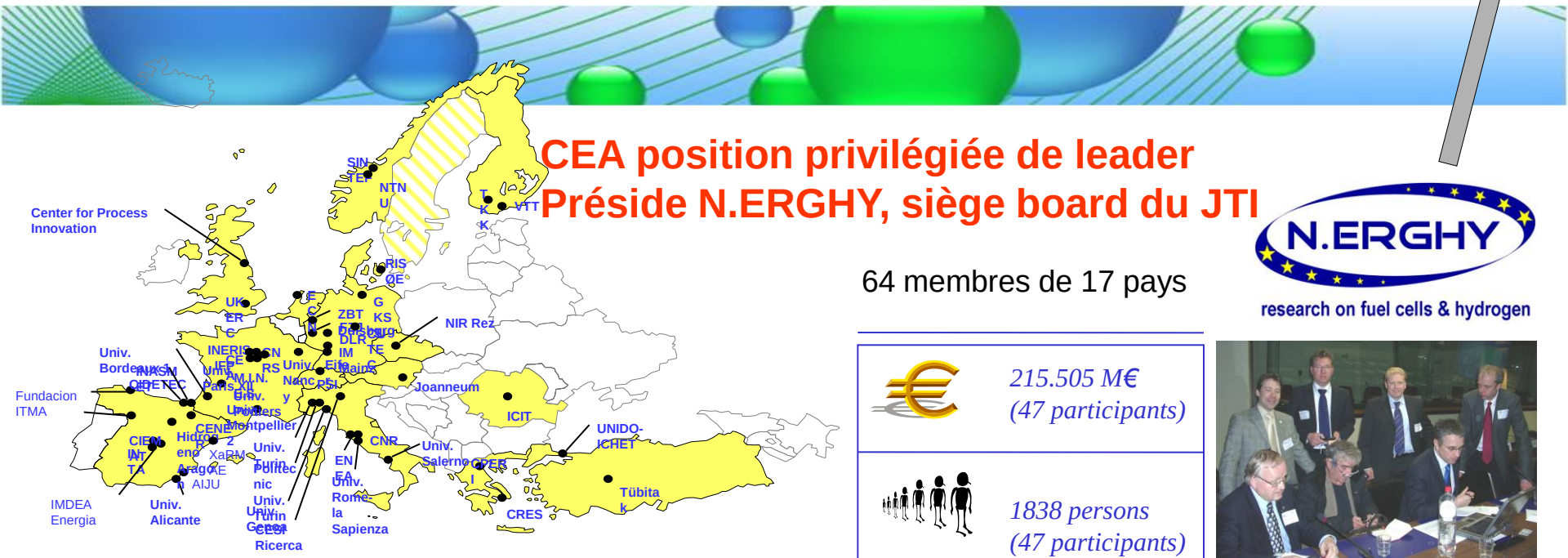
**Partenariat public/privé perenne approuvé par EC, Parlement, Etats Membres**

**Objectif:** accélérer déploiement technologies H2 et Pac Transports, Stationnaire production et marchés précoces

***7 années 2008-2013, 940 M€, 50 % industrie***




**Organe de décision: Governing Board**




**CEA position privilégiée de leader**
**Préside N.ERGHY, siège board du JTI**

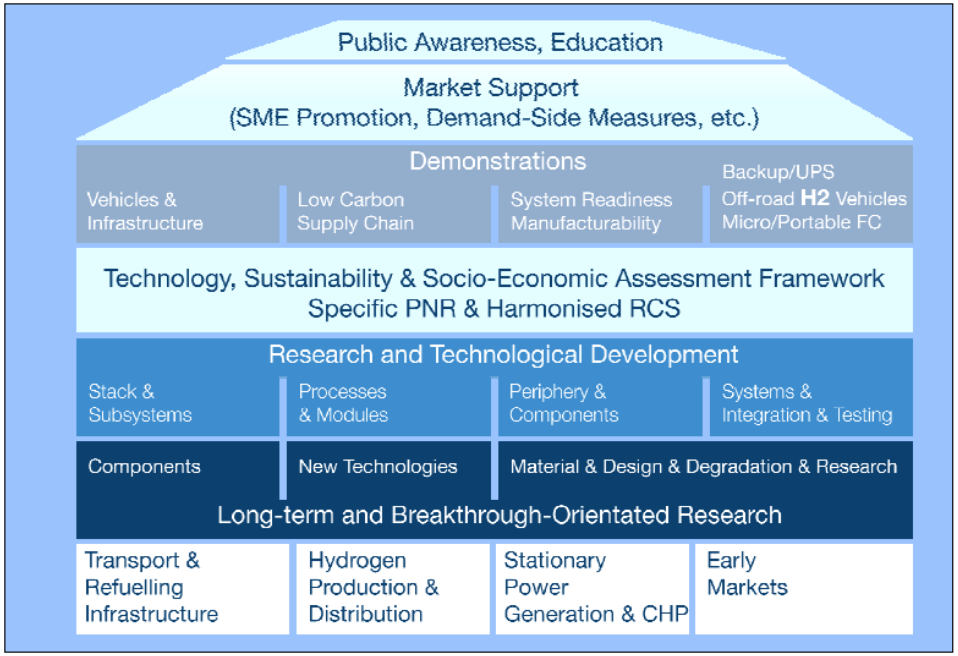
64 membres de 17 pays

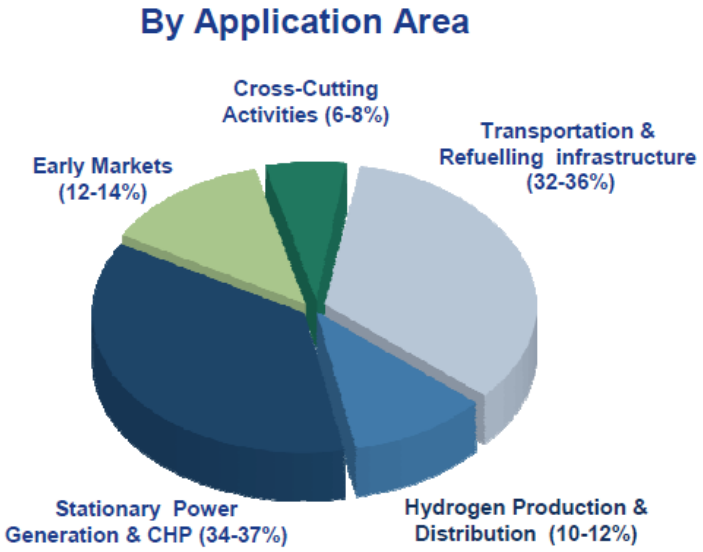
N.ERGHY
research on fuel cells & hydrogen

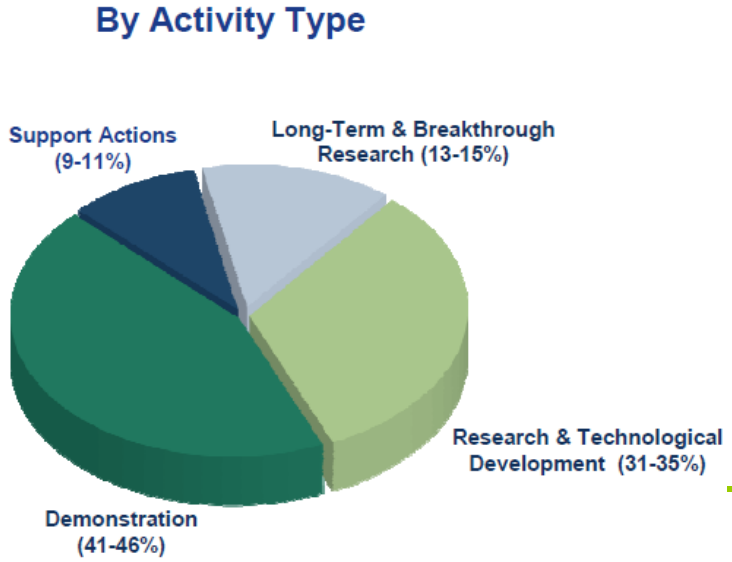
| | |
|---|---|
| *215.505 M€ (47 participants)* | |
| *1838 persons (47 participants)* | |

# Mise en place des outils de planification stratégique

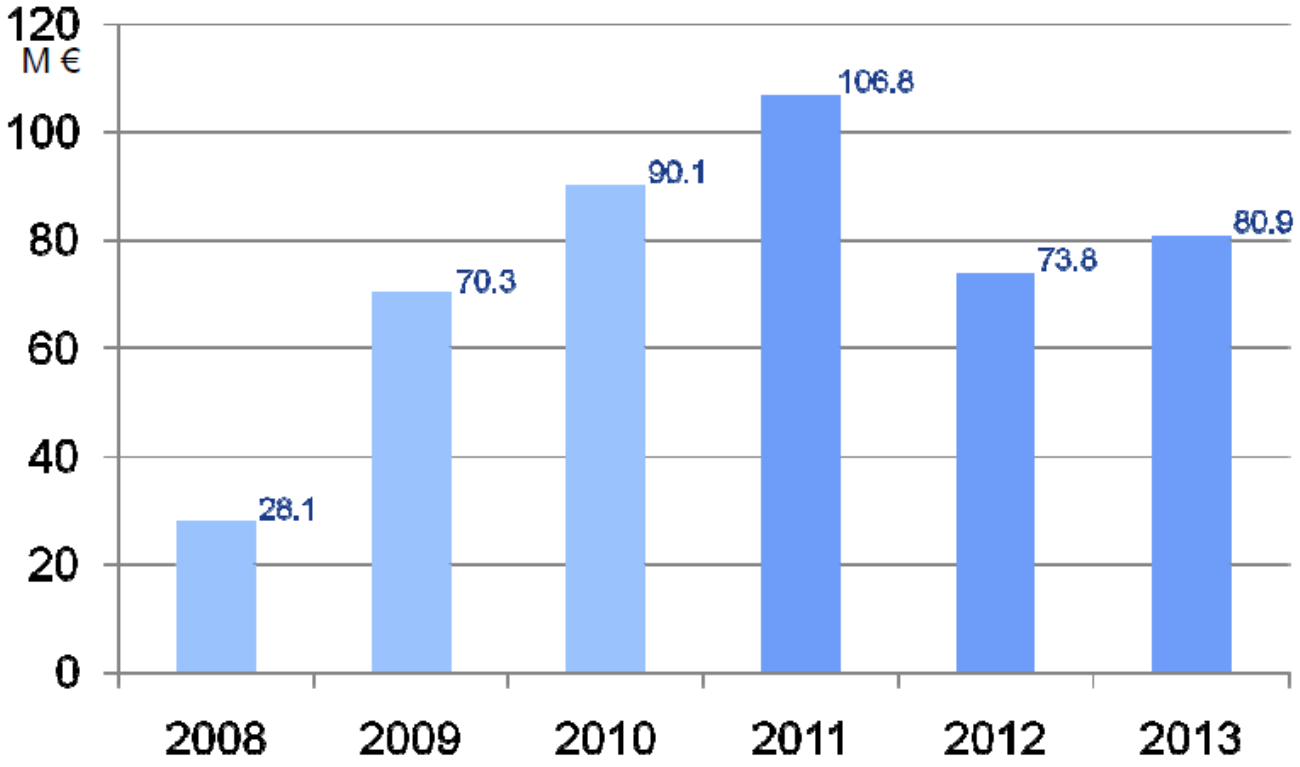
- Définition et mise à jour des plans de réalisation annuels (AIP) et multi-annuel (MAIP)
  - Consultation IG/RG/EC
  - Consultation du comité scientifique et du groupe des Etats Membres



# Répartition temporelle des calls



# Exemple Appel 2008

## Focus on demonstration projects : H2moves Scandinavia

***Gaining customer acceptance for fuel cell vehicles in Scandinavia***

- Roll-out latest state-of-the-art hydrogen fuel cell vehicles operated by customers
- Consolidate existing hydrogen-fueling hub in southern Norway and add one new station of latest design in Oslo (70 MPa, capacity min. 200 kg/day)
- Carry out five European vehicle road tours (extended vehicle fleet) supported by mobile refueler.
- Communicate on project performance
- Actively link Scandinavian Hydrogen Highway Partnership (SHHP) to European network

***Participating vehicles:***

10 Daimler B-Class F-CELL | 2 Alfa Romeo Mito FCEV | 5 Th!nk FC city cars

- Refueling stations
  - 1 refueler with 70 MPa, pre-cooling (-40°C)
  - 1 mobile refueler for EU demo tours
- Certification & project safety
  - Improvements in regulations, C&S
  - Safety relevant emergency mechanisms
- Project key data :
  - Budget ~20 M€ ( ~8 M€ EU + ~2 M€ (DK, NO))
  - Start 1 Jan 2010, duration 36 months

CRF CENTRO RICERCHE FIAT DAIMLER H2 Logic Hydrogen Sweden HYDROGEN LINK ludwig bölkow systemtechnik TÜV SÜD SP

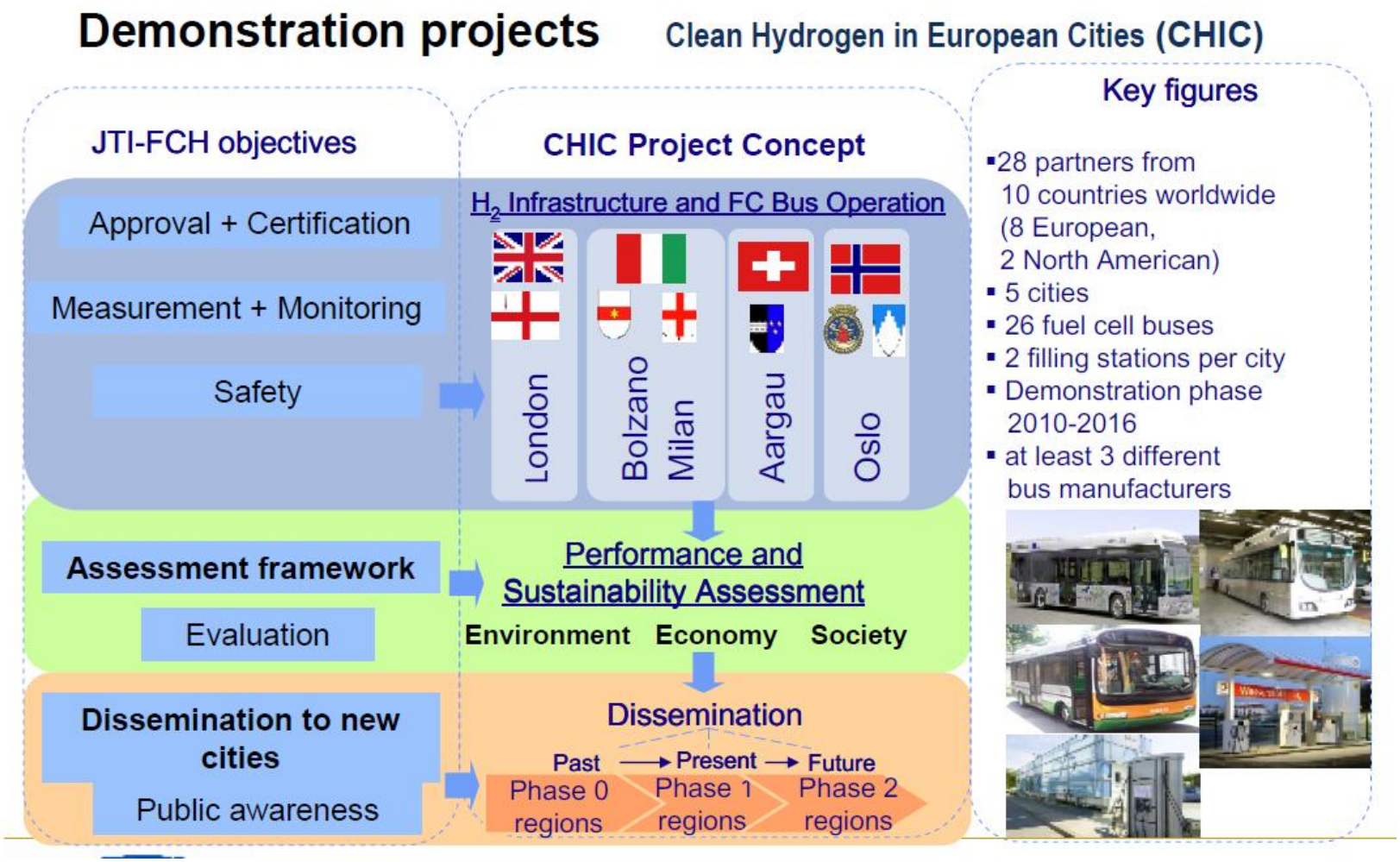
# Exemple Appel 2008

# Appel 2009

## 71M€, 26 projets en fin de négociation,

| | |
|---|---|
| Transportation & refuelling infrastructure (26,4M€) | *Large-scale demonstration of road vehicles and refuelling infrastructure (1)*<br>*Development of electric driven turbocharger for fuel cell (1)*<br>*Development and optimisation of PEM FC electrodes and GDLs (1)*<br>*Pre-normative Research (PNR) on composite storage (1)*<br>*Pre-normative Research (PNR) on fuel quality (1)* |
| Hydrogen Production & distribution (5,7M€) | *New generation of high temperature electrolyser (1)*<br>*Improved solid state hydrogen storage systems (1)* |
| Stationary power Generation & CHP (25,9M€) | *Degradation and Life time Fundamentals (2)*<br>*Materials development for cells, stacks and balance of plant (BoP) (4)*<br>*Operation diagnostics and control (3)*<br>*Component improvements (1)*<br>*Proof-of- concept fuel cell systems (3)*<br>*Validation of integrated fuel cell systems readiness (1)*<br>*Application specific targets and related technology benchmark (1)* |
| Early markets (10,3M€) | *Demonstration of fuel cell-powered materials handling vehicles and infrastructure (3)*<br>*Portable generators, backup and UPS power systems (1)* |
| Cross-cutting issues (3M€) | *Development of educational programmes (2)*<br>*Training initiatives for regulators (1)*<br>*Development of a framework for Life Cycle Assessment (LCA) (2)* |

# Exemple Appel 2009



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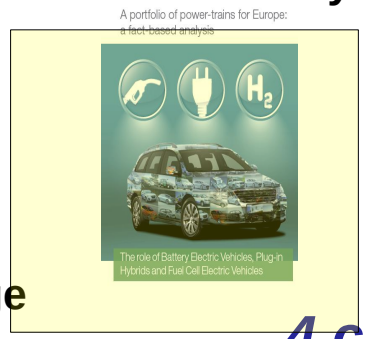


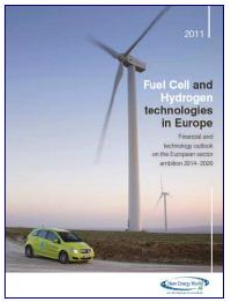


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# L'étude de référence sur les motorisations du futur

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

# A broad coalition shared performance estimates on different power trains

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


## Industry participants

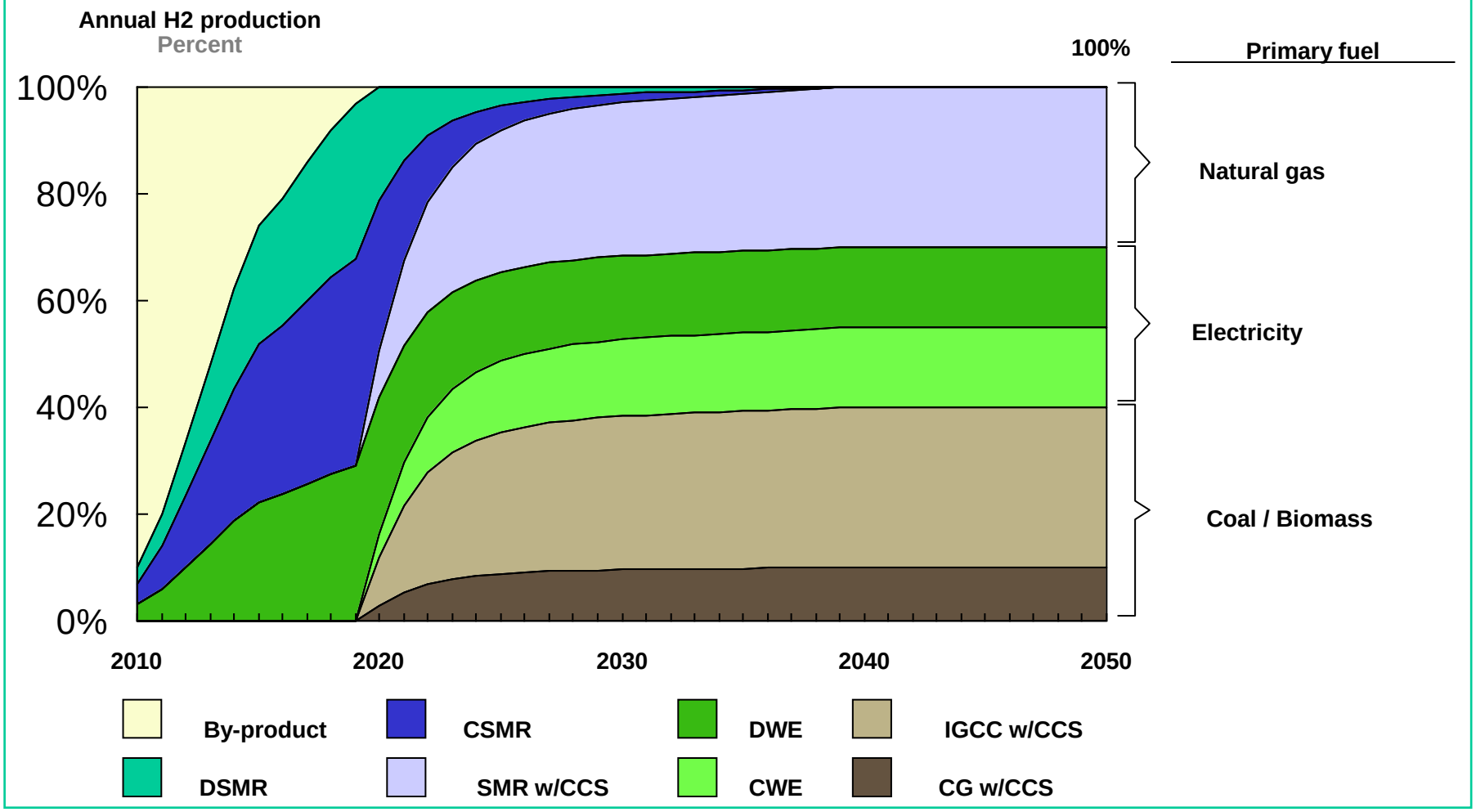
| | |
|---|---|
| Car OEMs | DAIMLER, HONDA The Power of Dreams, HYUNDAI, KIA MOTORS, GM, NISSAN, Ford, RENAULT, VW, BMW, TOYOTA |
| Oil and gas | Eni, OMV, Shell, TOTAL, galp energia |
| Utilities | EnBW, VATTENFALL |
| Industrial gas companies | AIR PRODUCTS, AIR LIQUIDE, Linde |
| Equipment OEMs | INTELLIGENT ENERGY Clean fuel and power, Powertech |
| Wind | NORDEX |
| Electrolyser companies | HYDROGENICS Advanced Hydrogen Solutions, PROTON ENERGY SYSTEMS, ELT Elektrolyse Technik, Hydrogen Technology |
| NGOs, GOs | European Climate Foundation, NOW Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie, New Energy World HG |

## Approach and principles

- All relevant powertrains (ICE, BEV, PHEV, FCEV)
- 3 reference car segments
- Cost, emissions, energy efficiency, driving performance
- Well-to-wheel
- >10,000 company data in a “clean room” environment

# Production after 2020 is split between electrolysis, coal/biomass and natural gas






SOURCE: Coalition workshops, Working team analysis

# Overview – Distribution technologies

Distribution method

| Transmission pipeline | tonne H2/day |
|---|---|
|  | 10<br>100<br>1,000 |

| Liquid trucks | tonne H2/truck |
|---|---|
|  | ~3.5 |

| Gaseous trucks | tonne H2/truck |
|---|---|
|  | ~0.4 (250 bar)<br>~0.8 (500 bar) |

| Distribution pipeline | tonne H2/day |
|---|---|
|  | 0.1<br>1<br>10 |

| Liquefier | tonne H2/day |
|---|---|
|  | 10<br>100<br>1,000 |

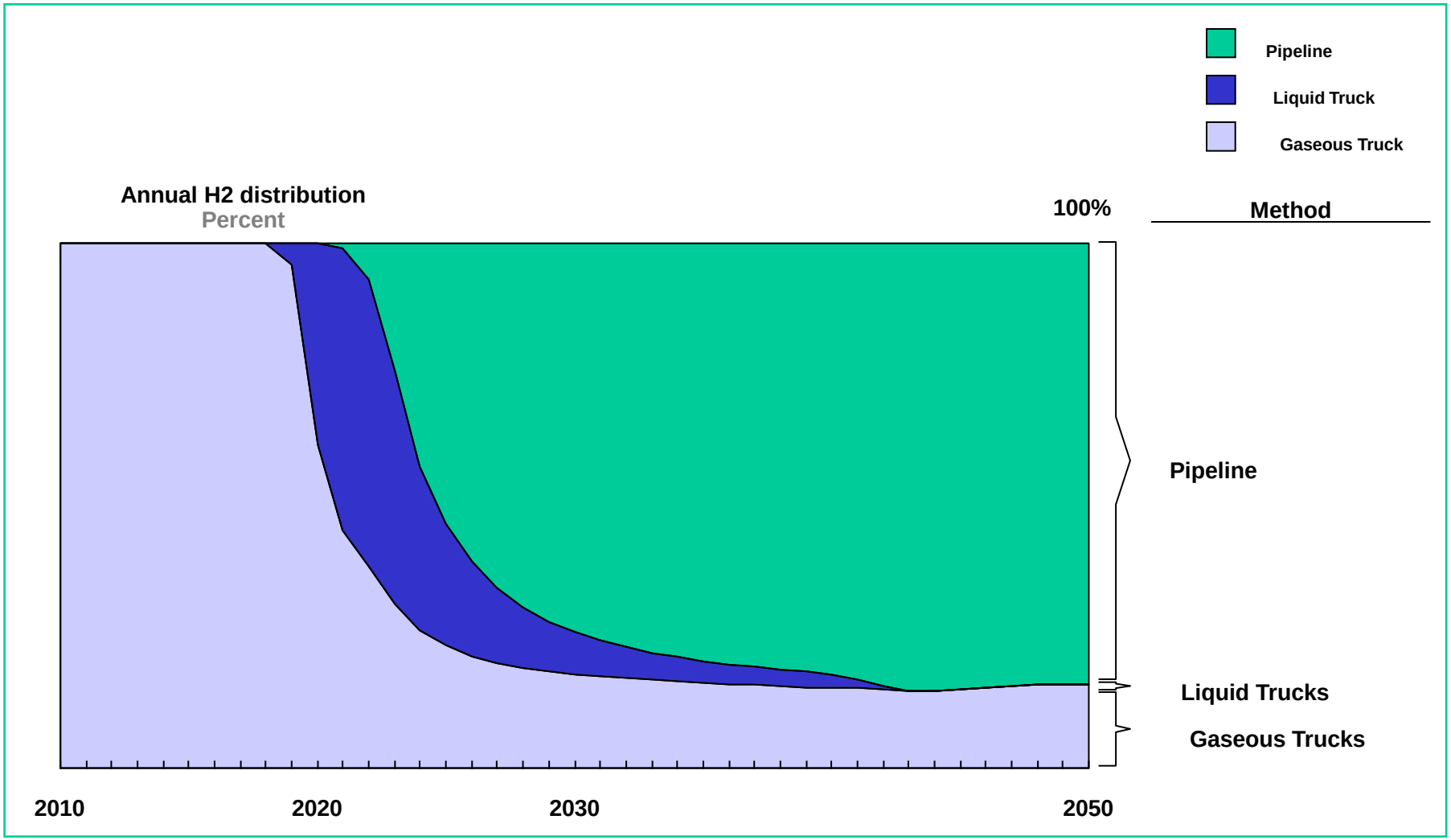
| Compressor | tonne H2/day |
|---|---|
|  | 1<br>10<br>100 |

- **Assumptions**
  **30 bar received H2 pressure**

SOURCE: Coalition workshops, Working team analysis

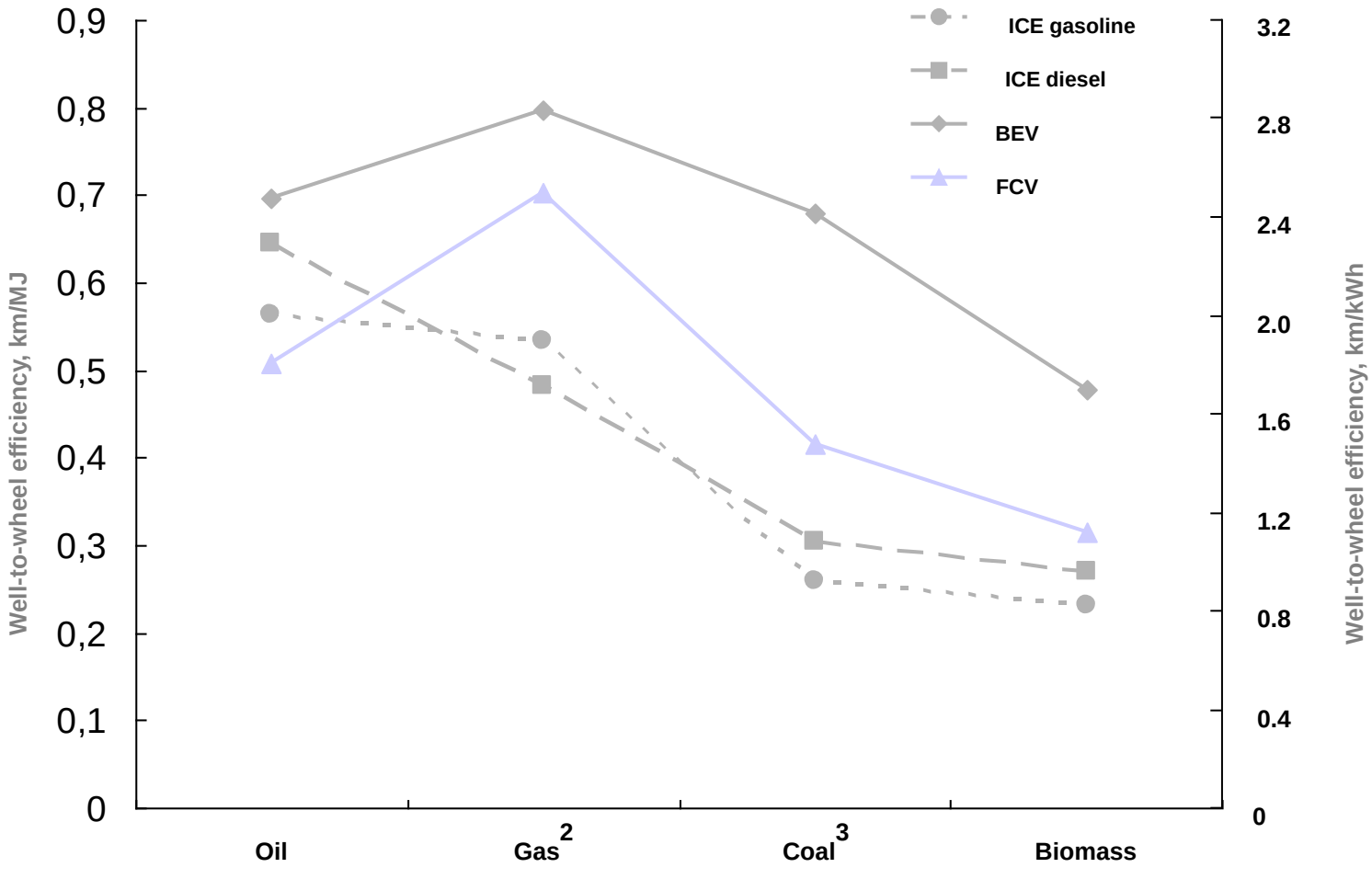
# Gaseous trucks are most important at the beginning with liquid trucks bridging the gap to pipelines



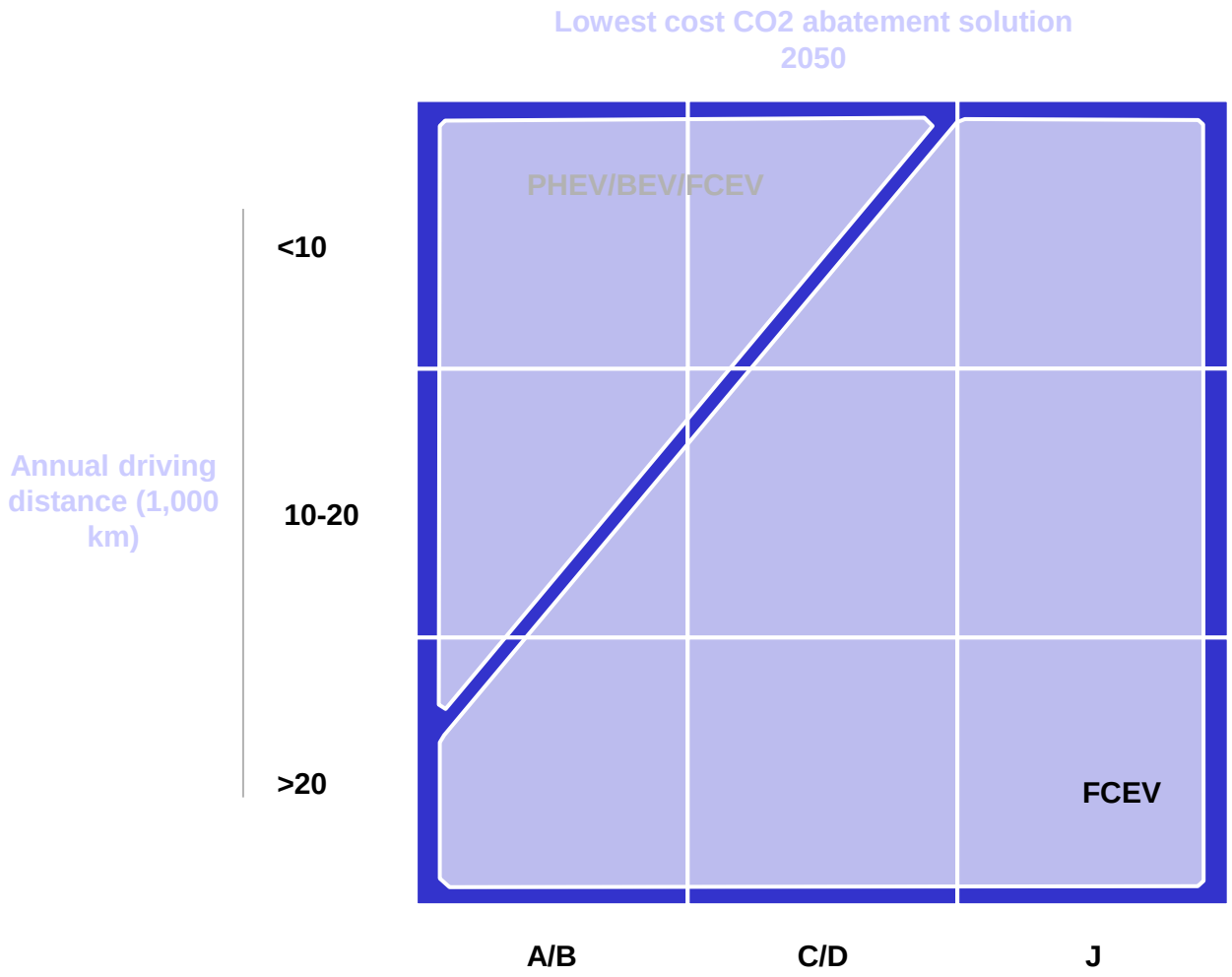



SOURCE: Coalition workshops, Working team analysis

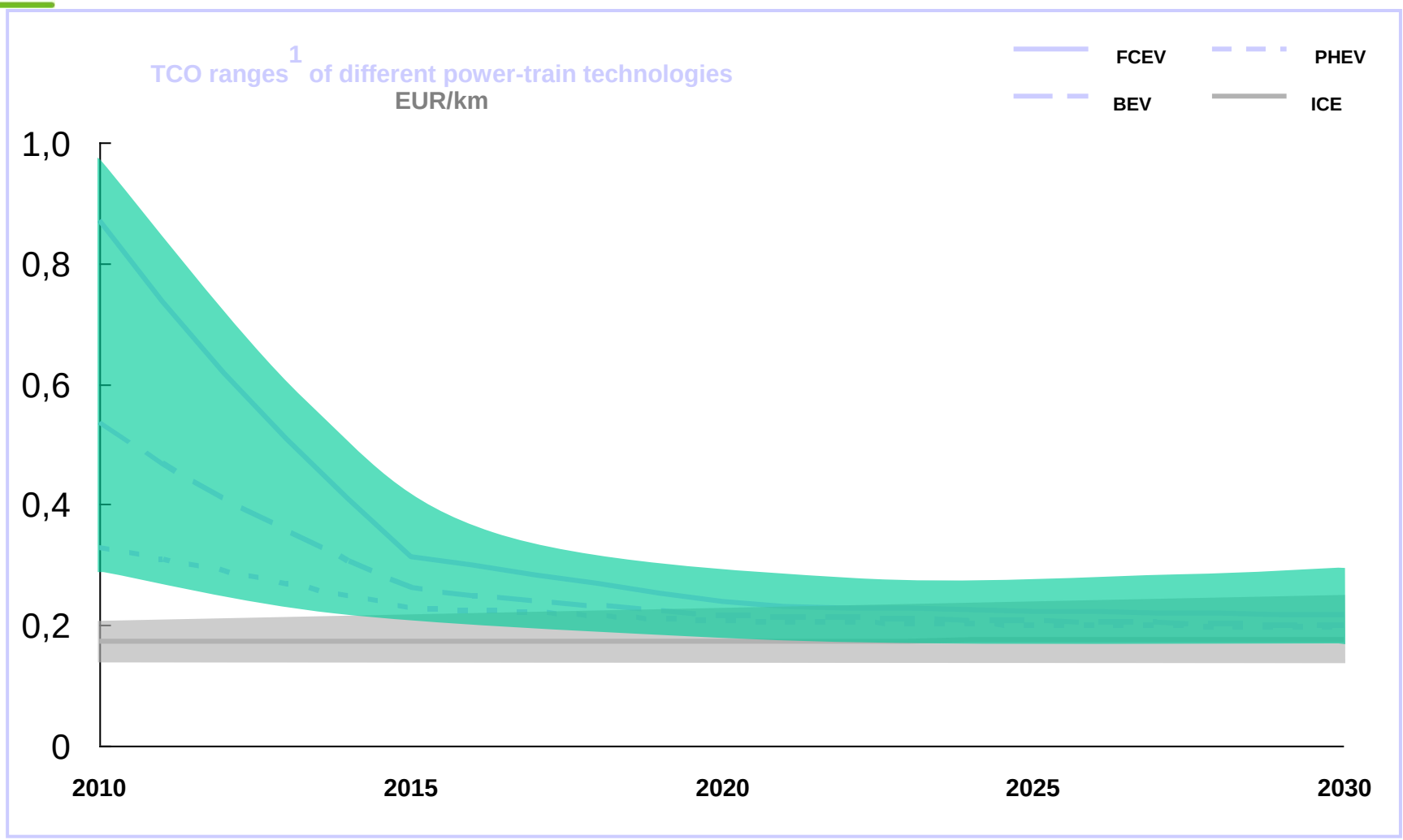
# Electric driving is more efficient and allows primary energy diversification



# FCEVs are specifically suited for larger cars, that represent 70% of CO2 emissions

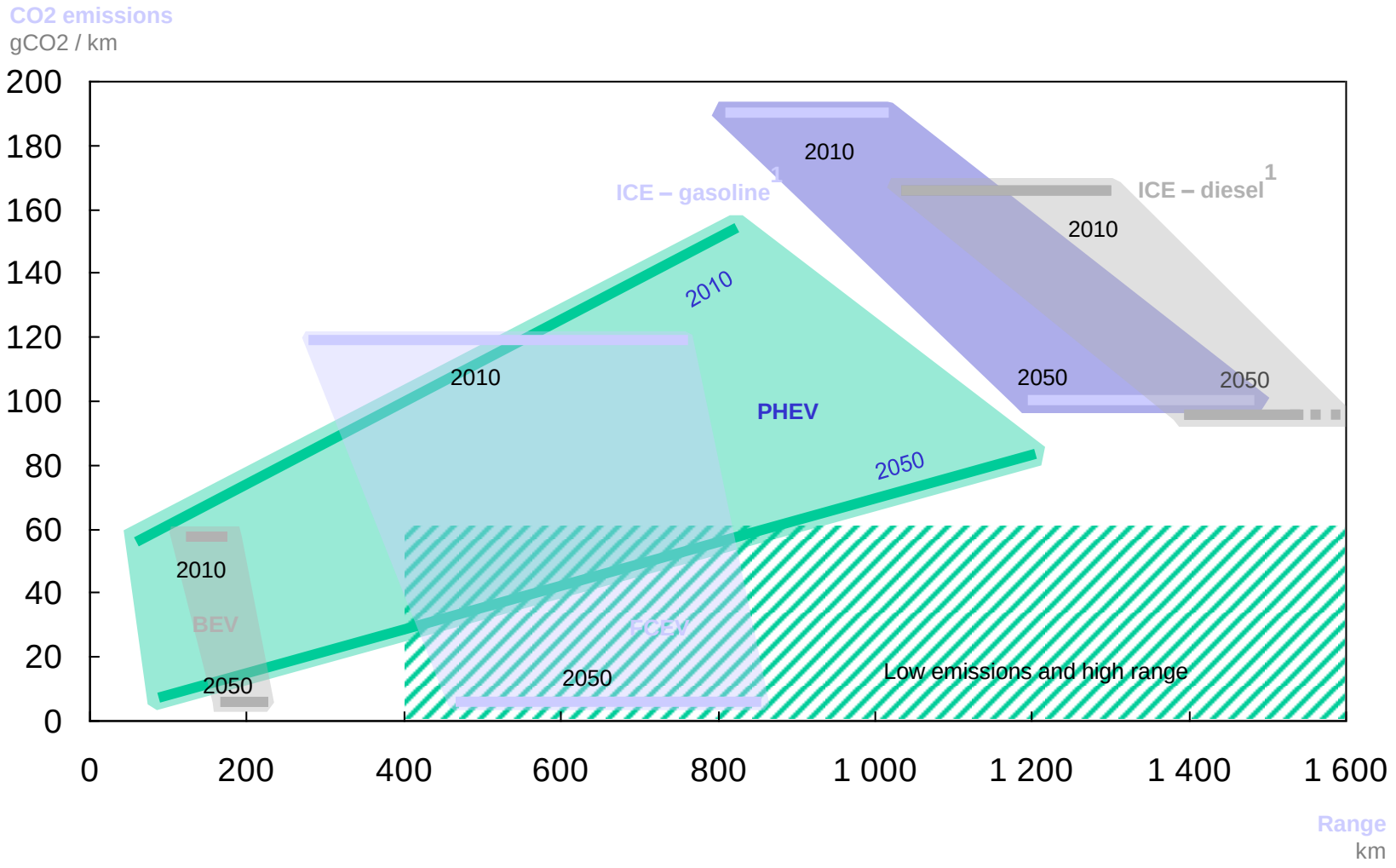


# After 2025, costs of all power trains converge

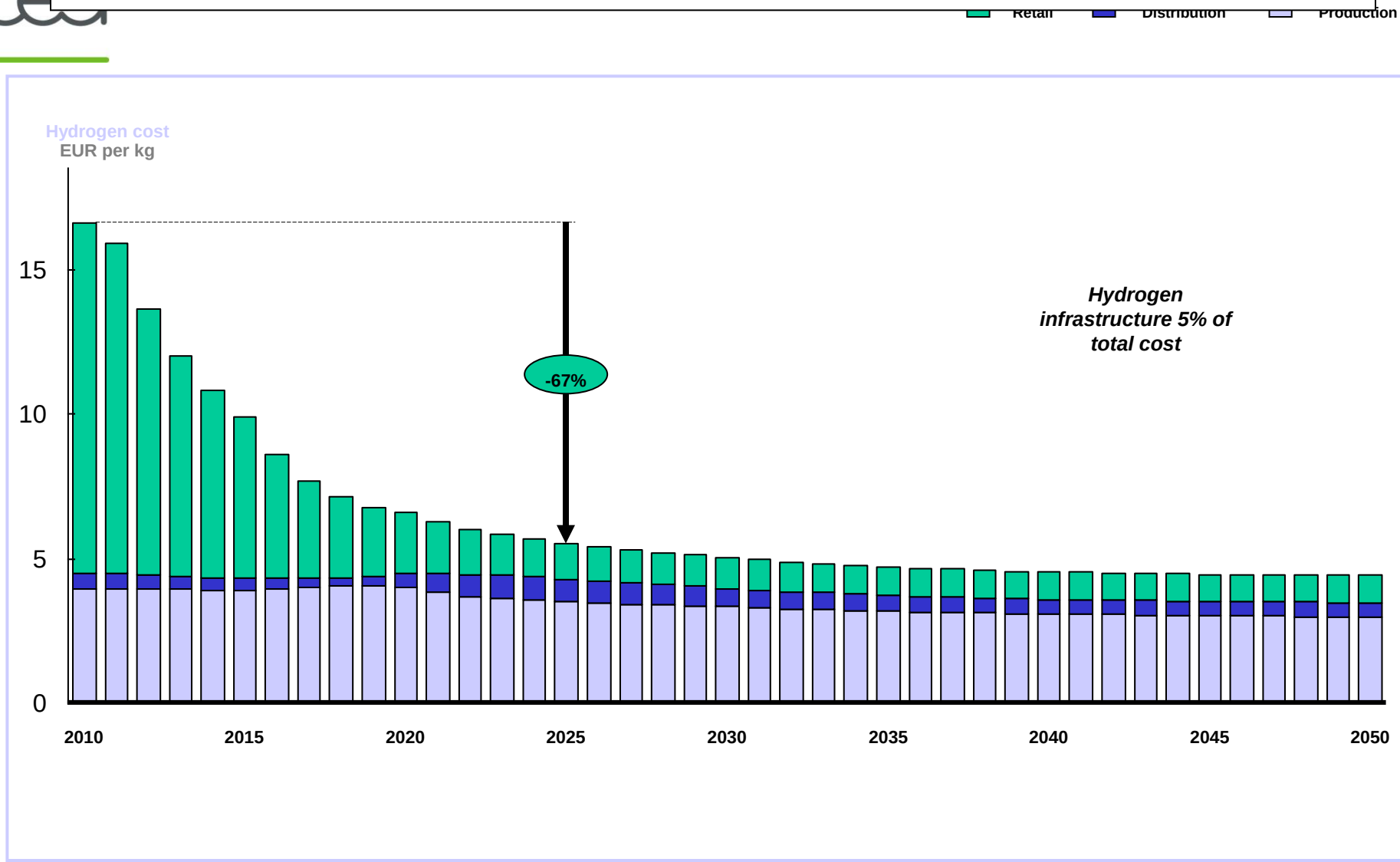


# Battery and fuel cell vehicles can achieve low emissions

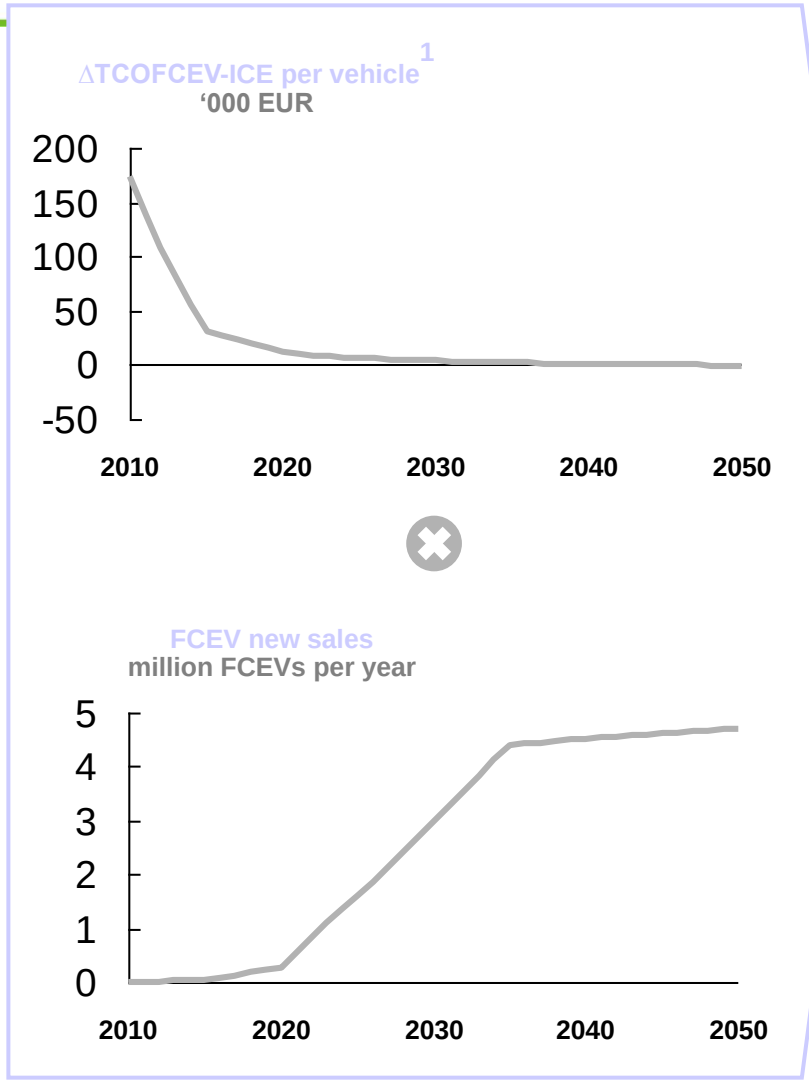


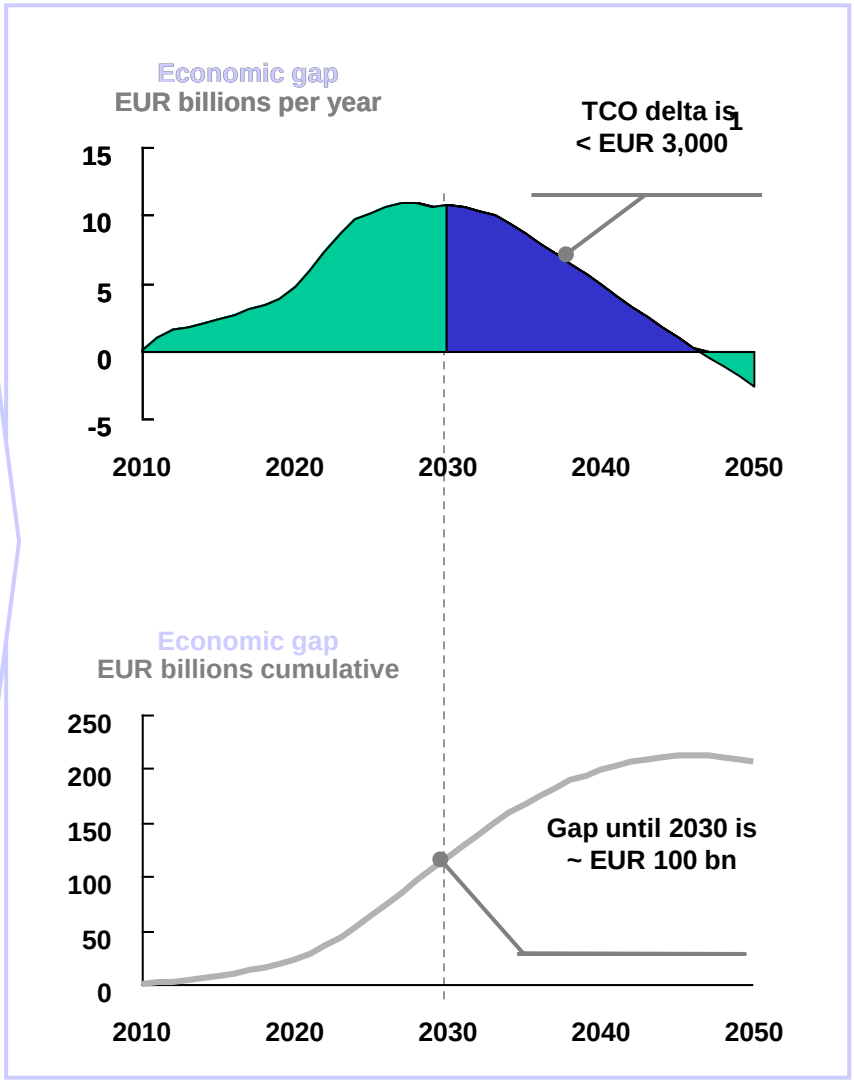


# Retail costs are inefficient in the first 15 years



# An economic gap of about Eur 100 billion remains for the next 20 years to develop FCEVs globally



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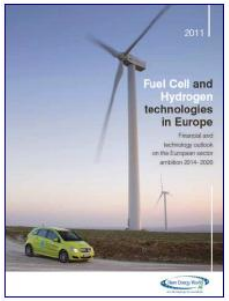


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*4 calls—for proposals*

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# "$H_2$ Mobility" Initiative – Overcoming the Chicken and Egg Dilemma

- Memorandum of Understanding for "$H_2$-Mobility" signed Sept. 10th 2009 in Berlin
- Ten key stakeholders from industries (OEM, oil, utility & industrial gas) and NOW as public-private-partnership
- Intention to build up hydrogen fueling infrastructure and establishing Germany as lead market


DAIMLER EnBW THE LINDE GROUP AIR LIQUIDE NOW OMV AIR PRODUCTS TOTAL eni VATTENFALL

# Four sizes for HRS were defined and Capex/Opex data investigated

## Overview of HRS sizes

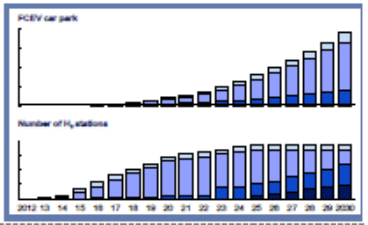
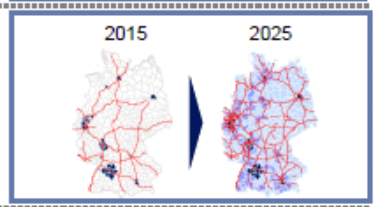
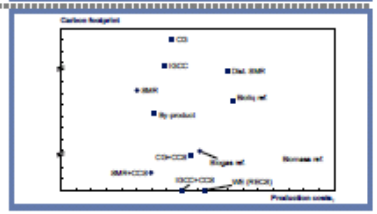
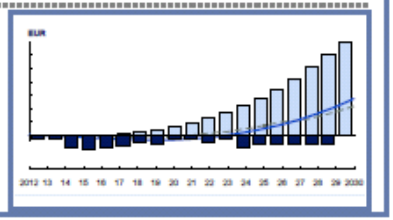



| Specification | Very small (XS) (mobile) | Small (S) | Medium (M) | Large (L) |
|---|---|---|---|---|
| Number of re-fueling positions | 1 | 1 | 2 | 4 |
| Number of re-fuelings per hour (per position) | 2.5 | 6.0 | 6.0 | 10.0 |
| Average / maximum number of fuelings per day | 10 / 20 | 30 / 38 | 60 / 75 | 125 / 180 |
| Average / maximum $H_2$ throughput per day (in kg) | 56 / 80 | 168 / 212 | 336 / 420 | 700 / 1,000 |
| Approximate number of cars per station | 100 | 400 | 800 | 1,600 |

In addition data for was investigated for three HRS delivery types: gaseous $H_2$ trucked-in, liquid $H_2$ trucked-in, and pipeline/on-site delivery (see next section for more details)

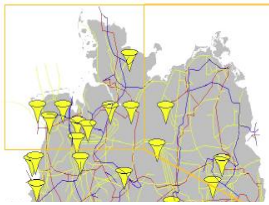
SOURCE: $H_2$ Mobility

# Main achievements and selected end products for pilot market Germany

| | | |
|---|---|---|
| **Roll-out scenarios for $H_2$ station network and FCEVs** | • Development of **FCEV roll-out** scenarios with car OEMs via "clean team" based on assumptions (e.g., incentives, market environment)<br>• Assessment of **$H_2$ station rollout** and network requirements (e.g., density, sizes) |  |
| **Roll out regions and timing** | • Analyses of German **regions** on traffic density, income per capita, car registrations, etc.<br>• Definition of **"focus regions"** and connecting highways |  |
| **$H_2$ production and supply road map** | • Assessment of **$H_2$ production technologies** on cost and $CO_2$ emissions (water electrolysis, steam methane reforming, etc.)<br>• Definition of $H_2$ **production and supply mixes** focusing on $CO_2$ abatement, sustainability, and economic efficiency |  |
| **Holistic roll-out cases** | • Description of consistent **rollout case** for Germany<br>• **Financial assessment** of roll-out cases including NPV, investment, payback time<br>• Evaluation of **risks** and **sensitivities** |  |

# Des plans précis de déploiement des infrastructures en Allemagne et au Japon à partir de 2015

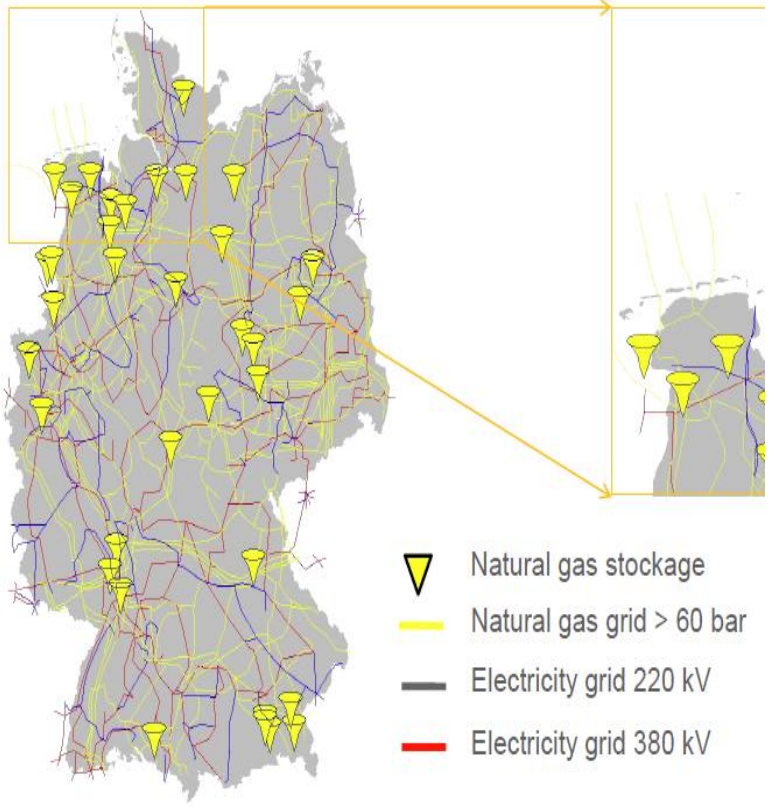
Utilisation du réseau gazier comme stockage





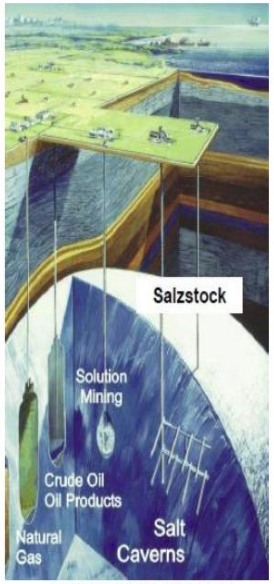
# Coupler ENR (Eolien et biomasse) et Hydrogène

## Utilisation du réseau gazier comme stockage



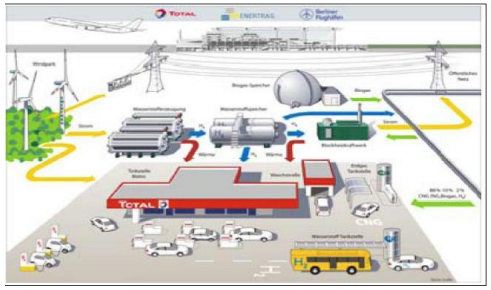

Source: DVGW e.V. 2011






source: KBB Underground Technologies

## $CO_2$ free HFS at Berlin Brandenburg International Airport BBI



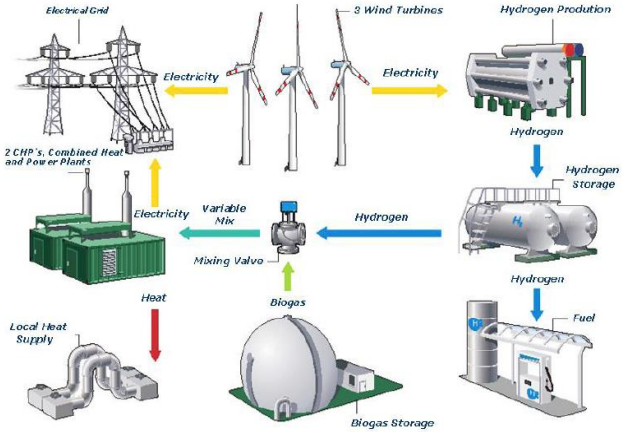
ENERTRAG

TOTAL

Berliner Flughäfen

## Hybrid Power Plant

ENERTRAG




NOW
Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

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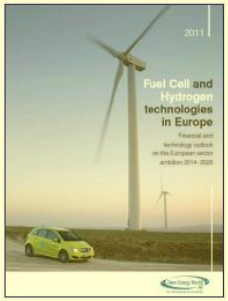


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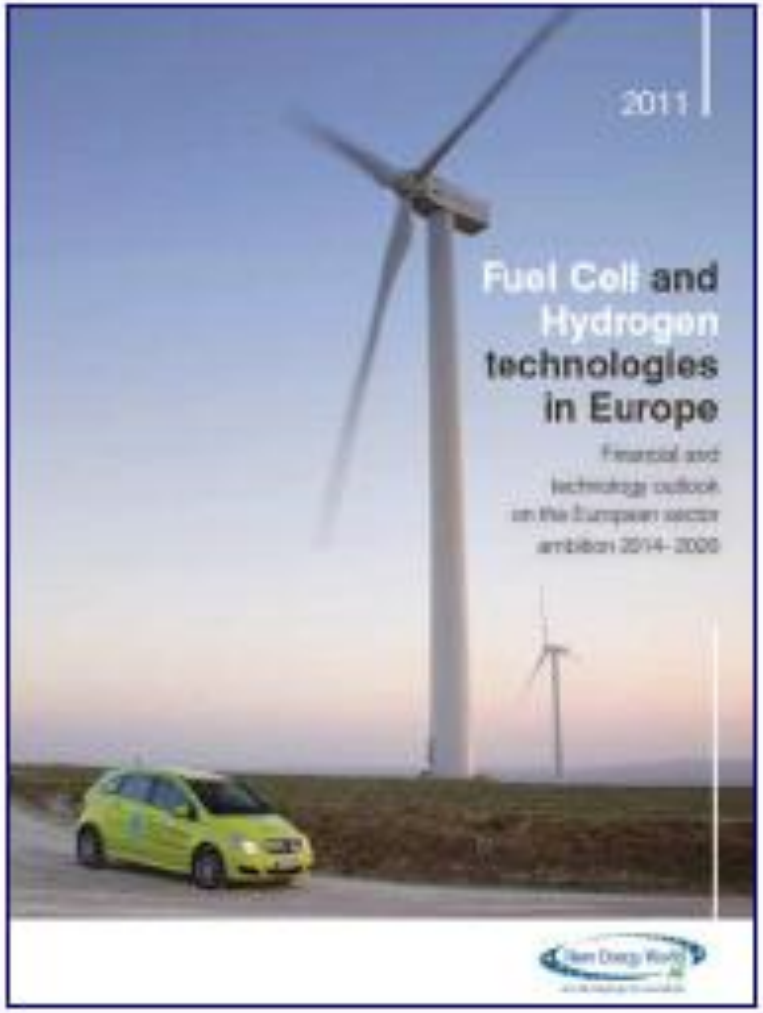
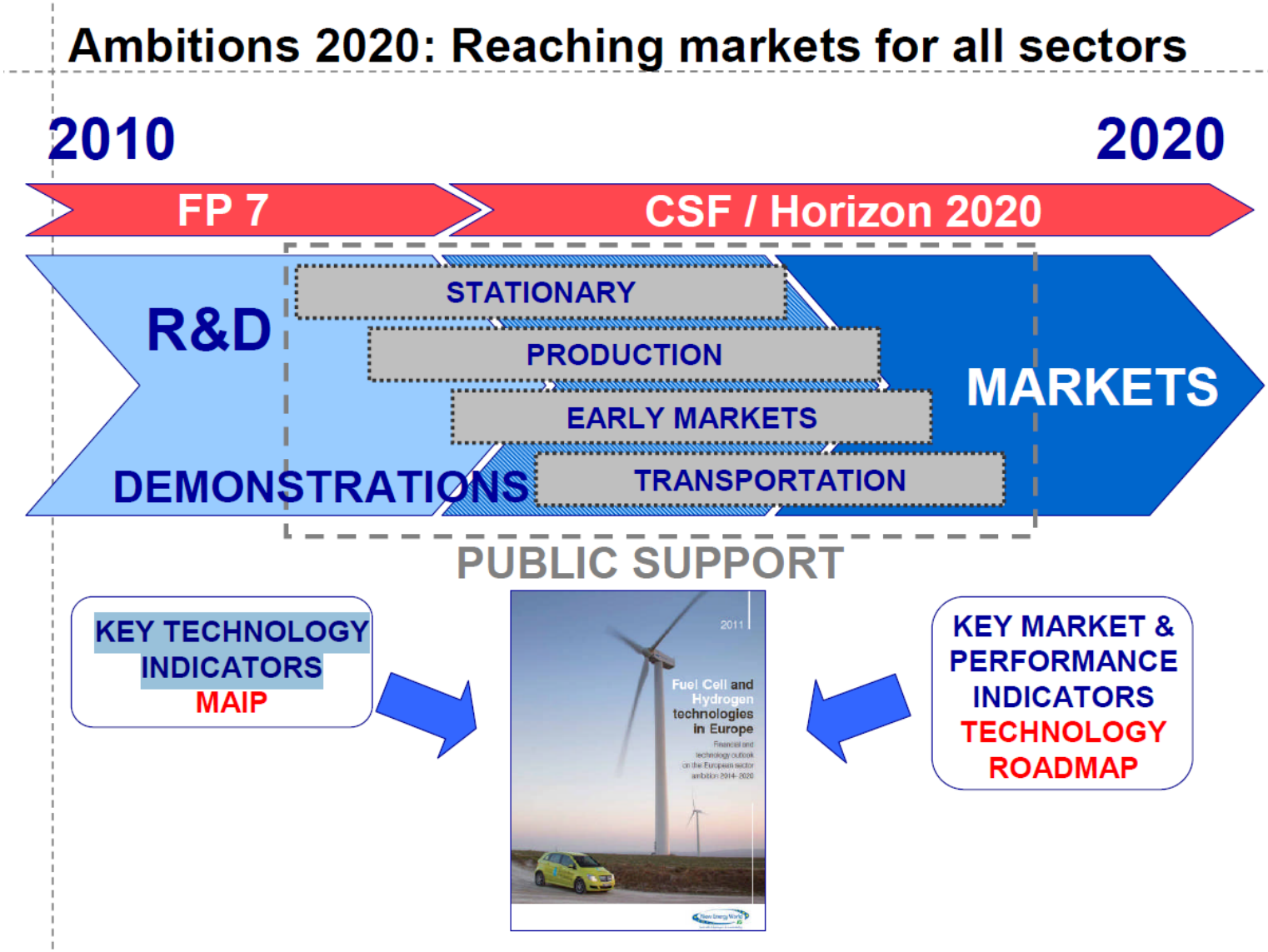
# LE PLAN DE DÉPLOIEMENT EN EUROPE

## 2014 2020

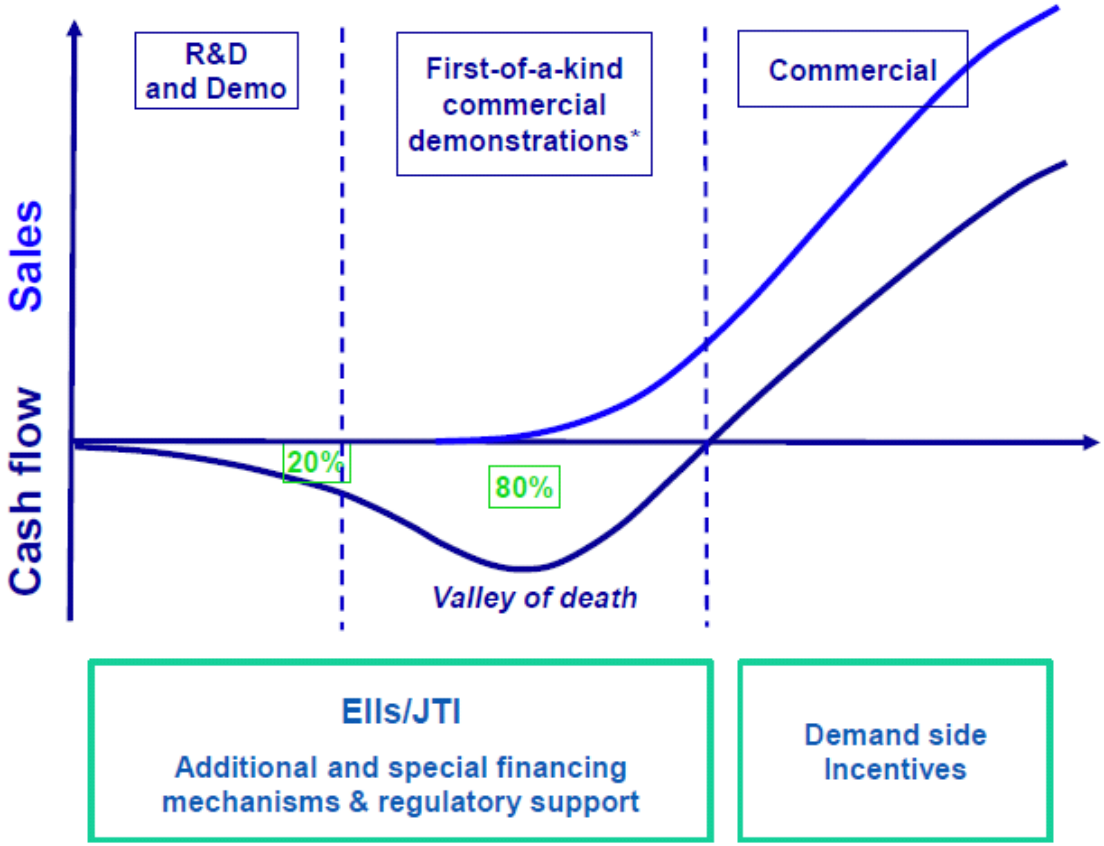



- Un programme ambitieux de plus de 17 milliards €
  - Volonté de déploiement 2014-2020 pour les industriels de l'automobile, de l'infrastructure et la production H2
- Pour la recherche :
  - 3,3 milliards d'€ de besoins industriels
  - Priorité de l'effort de R&D : segments stationnaire et marchés précoces

# Un programme aligné sur le formalisme Set-Plan



# FCH technology innovation cycle: 80% of effort ahead



# Industry needs 2014-2020

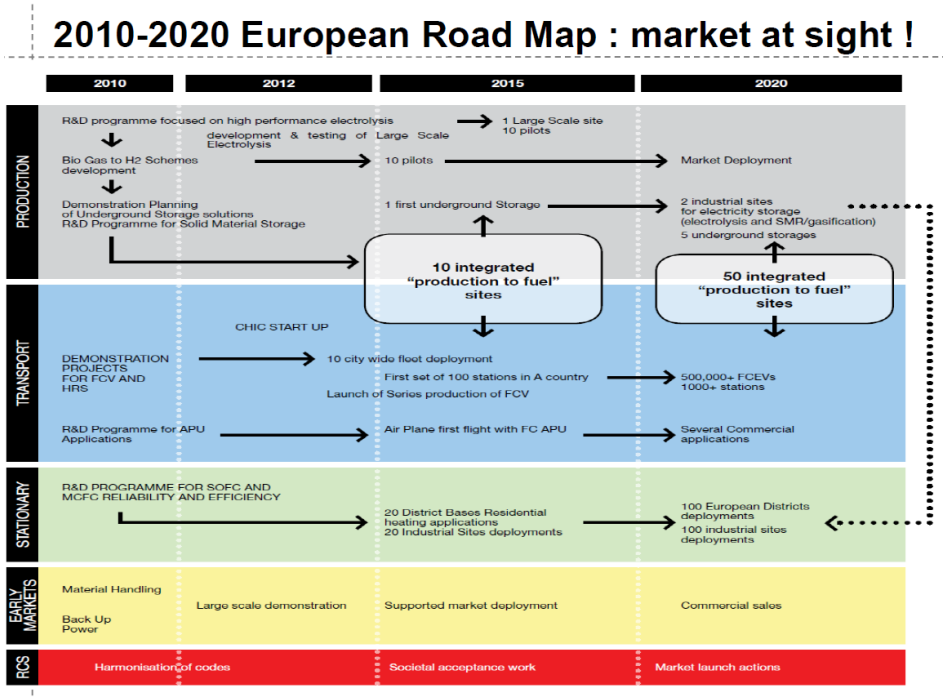
- A near 18 B € programme
  - JTI 2.0 part of the programme
  - Including a 3 B€ applied R&D part

| Sector Financial Effort | | | | |
|---|---|---|---|---|
| | R&D | Demonstration Programmes | Market Introduction Support | **Total** |
| Transport & Refueling | 500 | 2 171 | 9 429 | **12 100** |
| Production | 330 | 492 | 984 | **1 806** |
| Stationary | 1 465 | 135 | 659 | **2 259** |
| Early Markets | 830 | 178 | 409 | **1417** |
| RCS | 150 | 150 | 0 | **300** |
| Total | 3 275 | 3 126 | 11 481 | **17 882** |

# Approbation de la roadmap à 2020

## Les objectifs confirmés et intégrés dans le Set-Plan :

- Un déploiement de 500 000 véhicules électriques piles à combustible en Europe et environ 1 000 stations service hydrogène pour la transition du secteur des transports vers les véhicules électriques
- 50 000 logements utilisant des systèmes de piles à combustible stationnaires
- Une intégration des énergies renouvelables intermittentes (éolien, solaire) par des systèmes de stockage d'hydrogène allant jusqu'à 500 MW
- Une introduction sur le marché des premières applications : systèmes de back-up, applications portables…
- 50 % de l'hydrogène utilisé pour ces applications produite à partir de sources renouvelables ou sources zéro-émission de CO2.



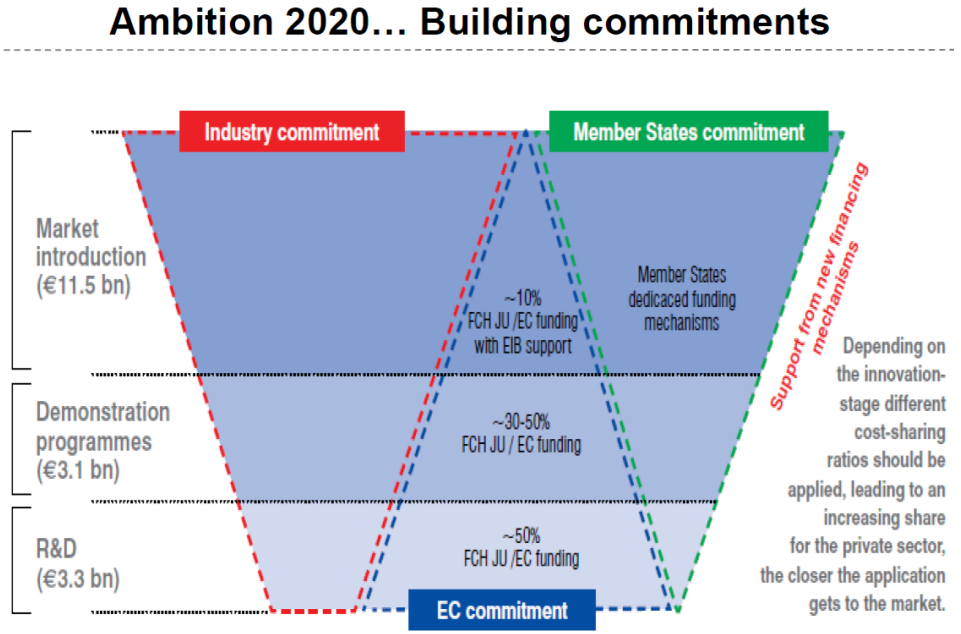

**Pour atteindre ces objectifs donnés par le secteur industriel, des objectifs technologiques sont définis par domaines d'application (production & stockage, applications transport, applications stationnaires, marchés précoces, réglementation/normes/ codes/acceptabilité sociale).**

# 3 phases de travail 2014-2020

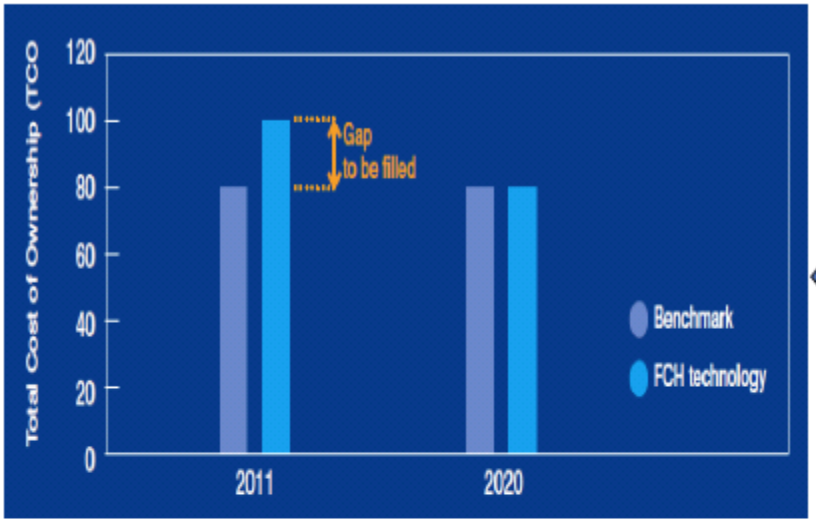
**JTI 2.0 :**

- Une phase Recherche,
- Une phase démonstration
- Une phase Introduction sur le marché

- Les types d'outils de financement associés sont en cours de discussion

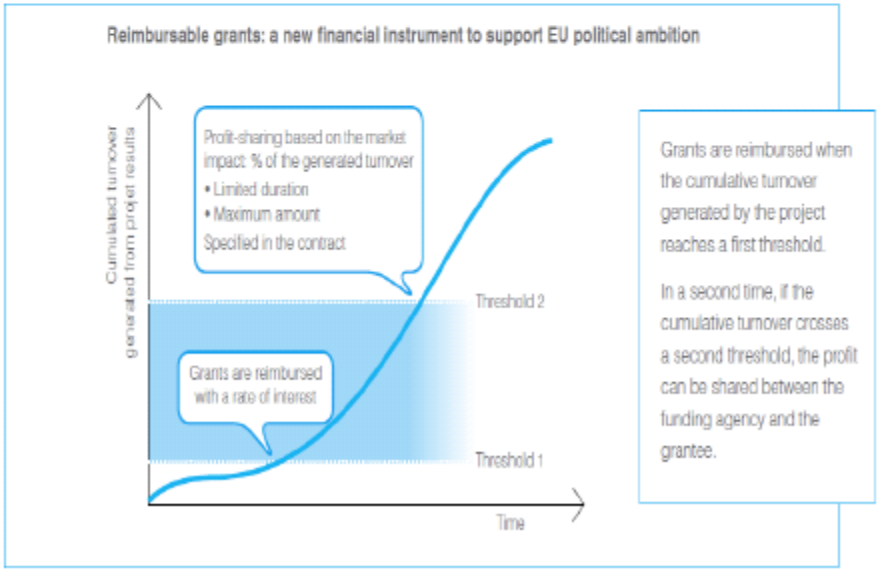


# New Funding Mechanisms required




| Benchmark technologies used for the estimation of market introduction costs | |
|---|---|
| Fuel Cell Hydrogen Technology | 'Benchmark' Technology |
| FCH Vehicles | Internal Combustion Engine Vehicles |
| Hydrogen Refuelling Stations | Gasoline Refuelling Stations |
| FCH Auxiliary Power Units | Diesel Auxiliary Power Units |
| Fuel Cell Systems for combined heat and power generation | Traditional natural gas boilers |
| FCH forklifts | Diesel forklifts |
| FCH Back-up power and Uninterruptible Power Supply | Diesel power generators |

## EARLY MARKETS AND STATIONARY : REIMBURSABLE GRANTS ?




## FCV : THE CONSORTIUM APPROACH ?

Infrastructure Investment Vehicle (Scope: Infrastructure ?)

Industrial Partners to contribute in Equity (10-20% ?)

- Financial Institutions to contribute Senior Debt (70-80%)
- Public Institutions to provide Insurance packages for part of Loans against Market Failure (30-50% of Total Debt ?)

Member States to support Infrastructure Consortium:

- Direct Subsidies in Consortium (10-20%)
- CO2 credits / stations ?
- Auctionning principles for Station space allocation with reverse values at start ?

Dedicated OEM « TCO Gap » costs support :

- Tax credits
- CO2 Allowances
- Direct subsidies…

# Chronologie de la dynamique H2 en Europe et en France

ANR

oseo

HYPAC

Feuille de route ADEME

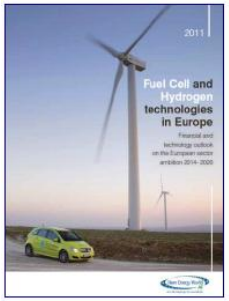
3 AMI Investissement Avenir

**H2 mobility in France**

**H2 mobility in UK**

**H2 mobility in Germany**

**Power Trains Comparison « Mac kinsey study »**


***Needs for 2014-2020 By Industry***

**Démarrage JTI**

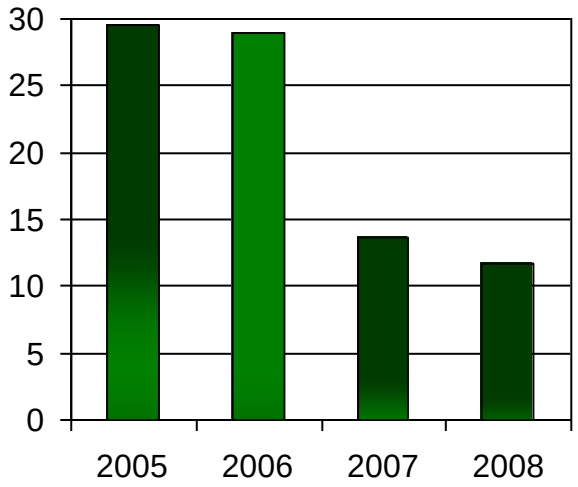
***4 calls—for proposals***

***2 call for proposals***

**2007** **2010** **2011** **2012**

# LA FRANCE: BAD NEWS…

AGENCE NATIONALE DE LA RECHERCHE
ANR



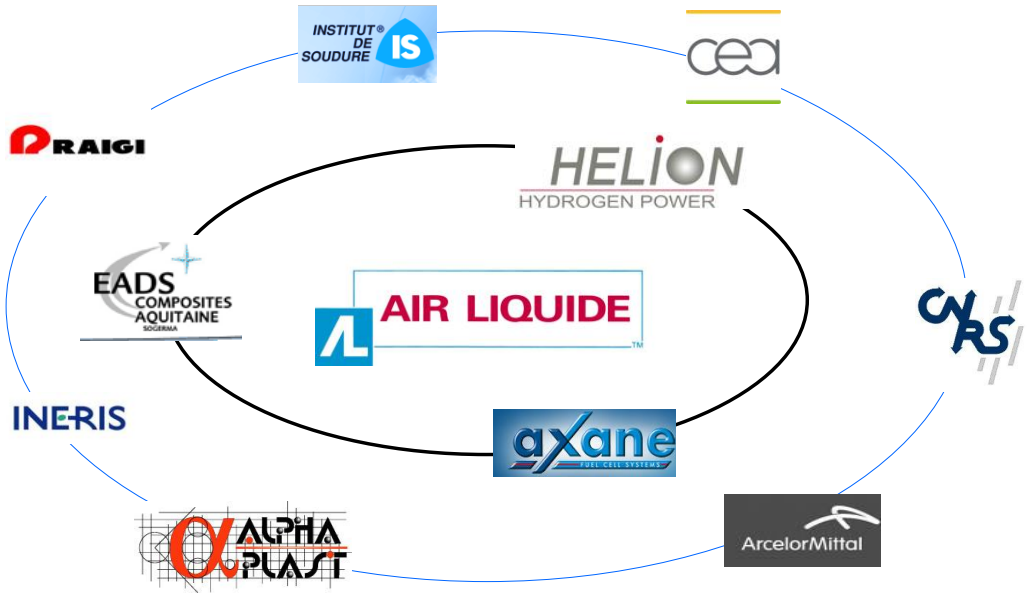

**73 projects out of 235 proposals were funded following Calls in 2005, 2006, 2007 and 2008.**
**50 are still running. 61 Patents have been obtained.**
**84 M€ sur 4 ans**

**2009-2011 moins de 5 M€ par an**
**Thématique non reconnue à l'échelle du programme Energie**

# Good news: H2E: Horizon Hydrogen Energy

**An ambitious deployment program of 200 M€ coordinated by Air Liquide**
**A Public-Private-Partnership federating national competencies**

AIR LIQUIDE


*19 partners, 150 FTE*

*7 years, 2009 - 2016*

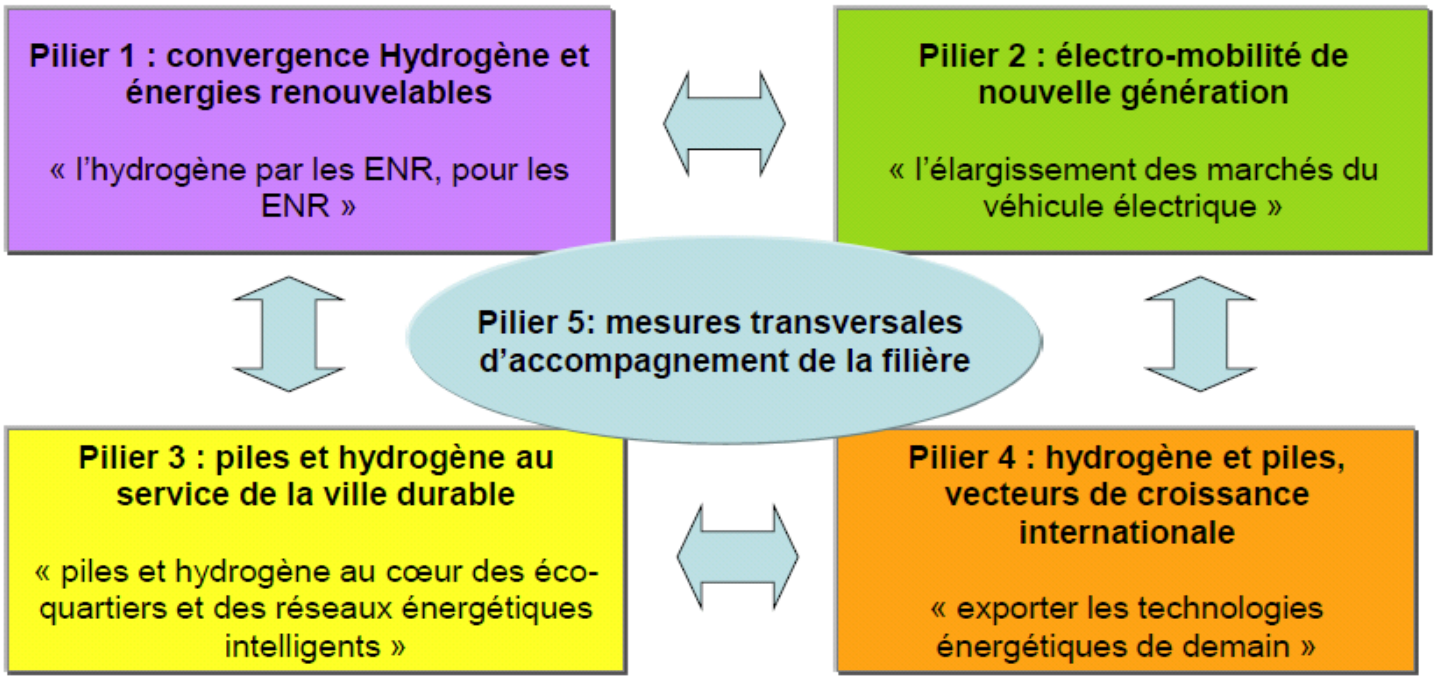
*Funding: Private - 123 M€ & Public via Oseo Innovation- 67 M€*

*TheH2E program aims at markets with wireless energy needs not met by any current solutions.*

*For example, captive vehicle fleets, portable generators or the supply of backup energy*

# Good news: Feuille de route ADEME

## Objectifs de la France



# Good news: 3 AMI Ademe 2011 et 2012

- 2012: **AMI dédié aux véhicules routiers à hydrogène** a pour objectif de soutenir des projets de recherche industrielle, des démonstrateurs de recherche ou des expérimentations préindustrielles ayant pour but : d'augmenter significativement les performances technologiques (optimisation des données de densités, du rendement, du système de stockage) et économiques (coût total du système, durée de vie, fiabilité) des véhicules routiers actuels grâce à l'utilisation du vecteur hydrogène
- de valider les performances obtenues sur véhicule en conditions réelles de fonctionnement (intégration véhicule, définition de cycles de roulage, mesures de performances, analyse de résultats)
- de traiter l'aspect sécurité et sûreté de fonctionnement des solutions proposées (sécurité active et passive, vieillissement)
- **2011: AMI « Hydrogène et piles à combustible »** dont l'axe thématique n°2 concerne l'expérimentations de flottes captives utilisant l'hydrogène comme source énergétique
- **2011: AMI « Chaîne de traction électrique »** dont l'axe thématique n°1 concerne l'utilisation de piles à combustible comme prolongateur d'autonomie.

- Plus hydrogène et piles présents dans AMI
  - Bateau du futur
  - Batiments intelligents
  - biocarburants

# Good news: création d' Afhypac

Les missions de l'association

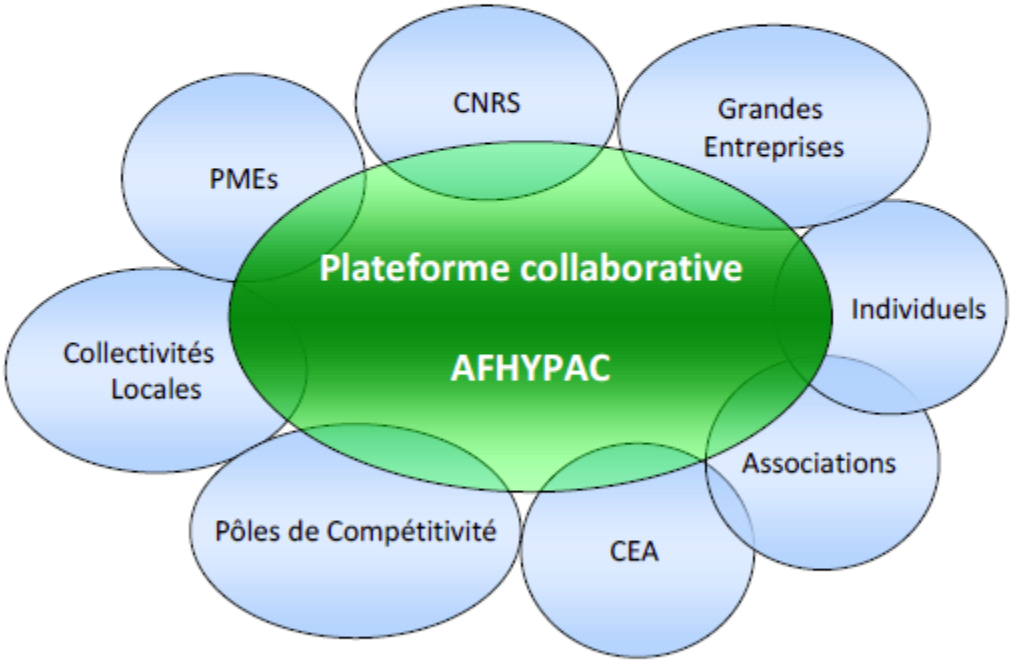
Promouvoir **les usages des technologies** de l'hydrogène énergie et des piles à combustible…

- ☒ Alimenter des véhicules électriques
- ☒ Fournir de l'électricité hors réseau électrique
- ☒ Valoriser l'électricité ENR
- ☒ Cogénération Batîment et Eco-quartiers

….En animant des **initiatives communes** aux acteurs de la filière Française

- ☒ Observatoire H2 et PAC
- ☒ Groupe travail réglementations
- ☒ H2 Mobilité France

# Coopérer pour accélérer l'adoption des technologies et des produits




Commission parlementair

DGEC

Autre syndicat professionnels
ENR, Hydro, ATEE

DREAL Lyon

# Mettons nos moyens en commun

- Rassembler et diffuser les informations clés
  - Usages
  - Technologies et Fiches techniques
  - Projets
  - Sources et infrastructure ?

Observatoire H2

- Adapter le cadre réglementaire français

- Initiative H2 Mobilité France

H2Mobilité France

# Contacts

www.afhypac.org

## Bureau

| | | |
|---|---|---|
| Présidente | Marianne Julien | – Air Liquide |
| Vices Présidents | Claude Derive | |
| | Paul Lucchese | – CEA |
| | Pascal Mauberger | – McPHY |
| Secrétaire | Hélène Pierre | – GDFSUEZ |
| Trésorier | Pierre Derozier | |

## : Membres du conseil d'administration

Jérôme Gosset – Helion
Michel Gugenheim – CETH2
Patrick Bouchard – Cap Energies
Michel Junker – Alphéa
Claude Lamy – CNRS

Benno Weinberger - Ineris
Bruno Mansuy – ERH2-Bretagne
Didier Grouset - EMAC
Antoine Feral - Michelin
Pierre Picard – WH2

# MERCI POUR VOTRE ATTENTION

Paul.lucchese@cea.fr