Fuel Cell and Hydrogen Sector

On the road to markets : Key Issues & early take aways

November 2011

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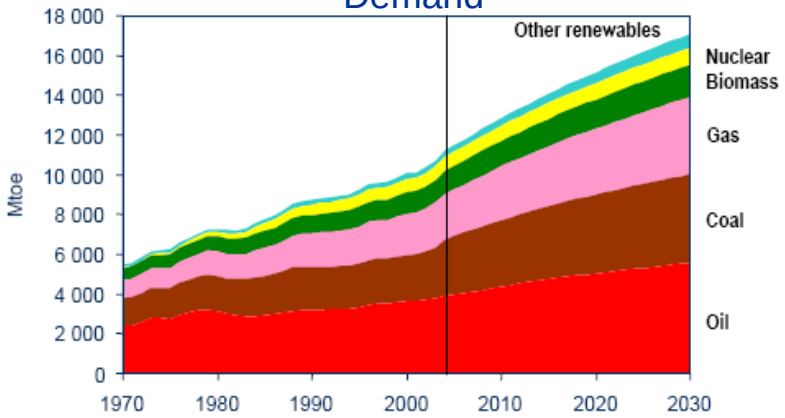
IPHE Meeting

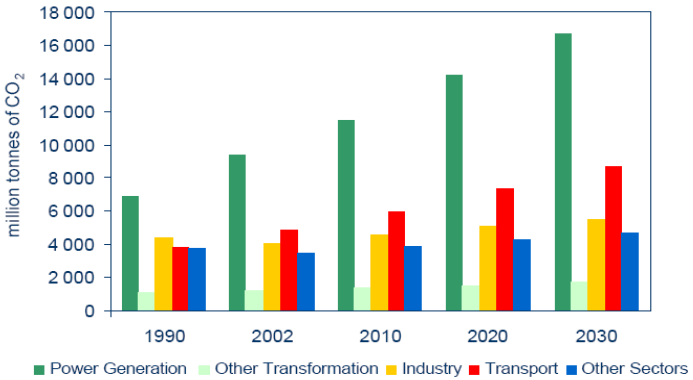
Pierre-Etienne Franc

Energy and Environment Challenges

Increase World Energy Demand



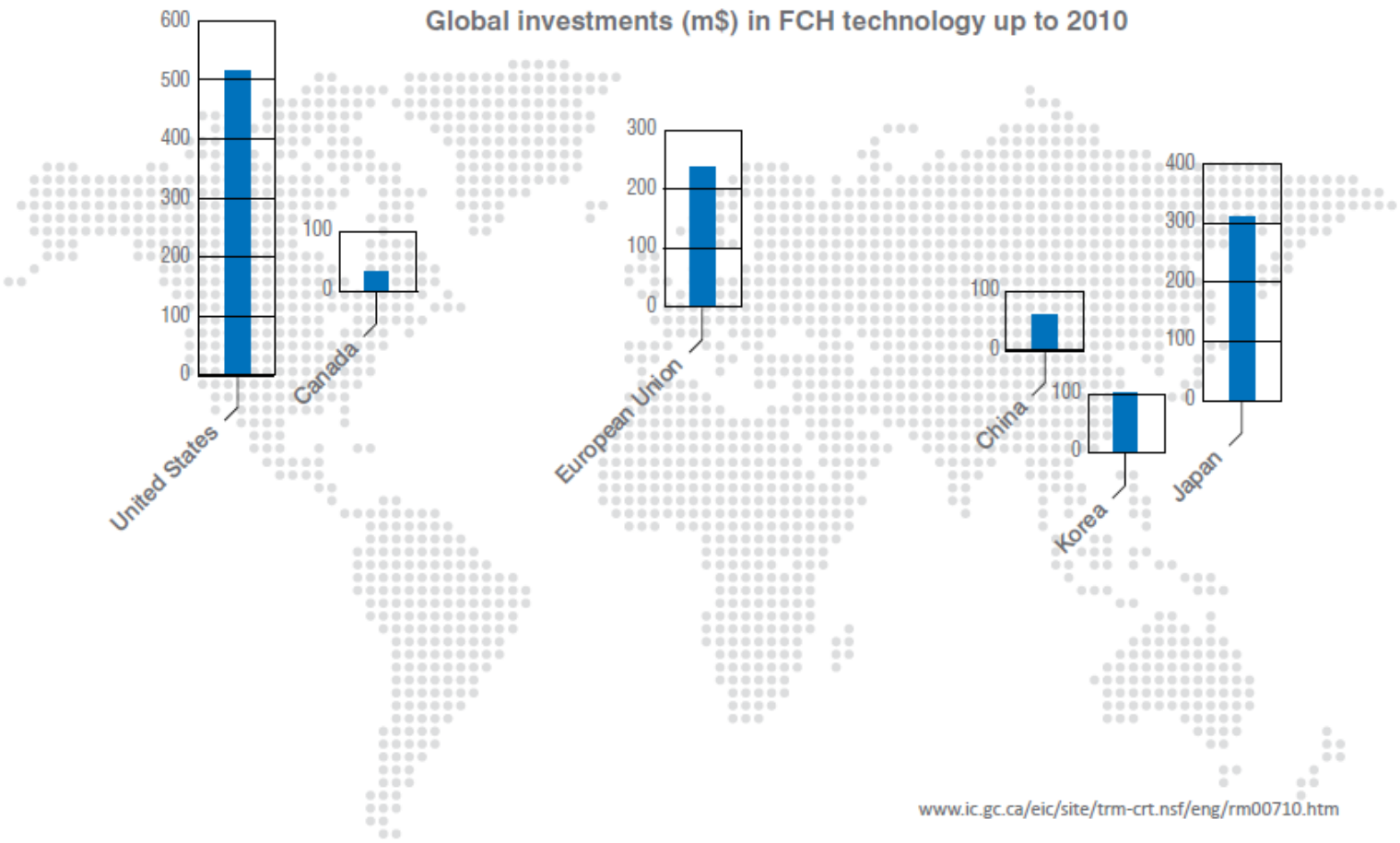
Increase of CO2 emissions By sector



Source : IEA

- ✓ **Europe Targets 20/20/20 : SET Plan 2020**
- ✓ **Targets - 80 % of GHG : 2050 Road Map « for a low carbon intensity Europe »**

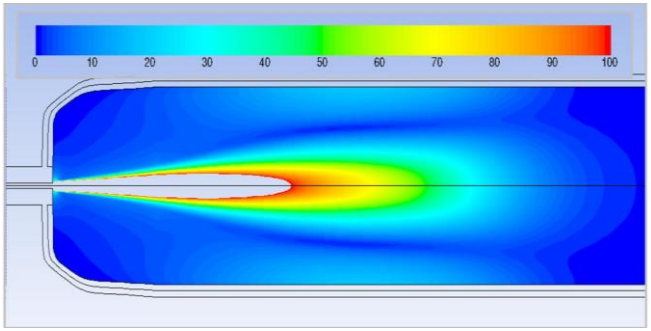
All continents have invested into the FCH technology



Huge technology achievements

Composite materials

Lab. tests



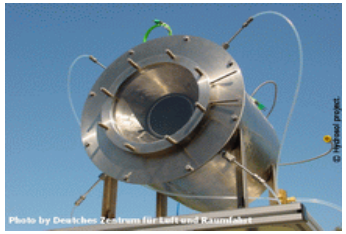
Fast Refueling modelisations

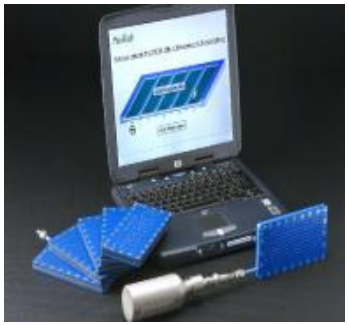
Quick connections

General Motors, Kapuskasing (Canada)

Stack assembly and volume manufacturing

Many types of projects supported





H2 Energy Applications reaching Market level

Early Markets

Chariot élévateurs électrique à hydrogène Walmart ravitaillé par une station Air Liquide

Mobility

Stationary

Antenne-relais Bouygues Telecom Pile à combustible Axane

Niche markets

Tournage de cinéma alimenté en électricité par une pile à combustible Axane

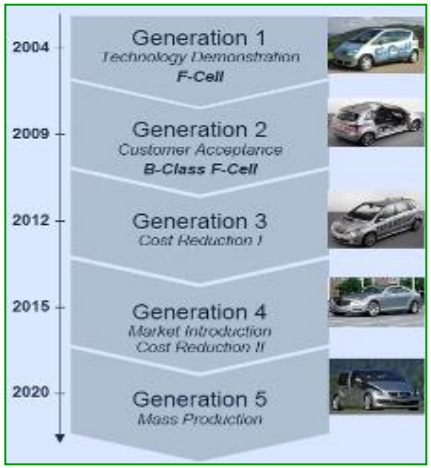
Volume deployments have started

- 200 HRS operational (WW)
- 50 buses & 300 demonstration FCV (WW)
- More than 5 000 stationary CHP systems (Japan)
- More than 2 300 Forklift (USA)

Marcoussis – Air Liquide

London – Bus à pile à combustible

France – Bouygues Telecom



Feuille de route de Daimler

USA – Chariot élévateur

Technologies and Companies ready to move…

- **TOYOTA - Chris Hostetter, Sales Group vice-president of strategic resources - 10/05/2011.**
  "Fuel cell technology is viable and ready for the mass market," "Toyota plans to bring a fuel cell vehicle to market in 2015 or sooner, and we will not be alone in the marketplace.
  Source : http://pressroom.toyota.com

- **GM-OPEL - Mark Adams, Vice President of Design - 04/07/2011.**
  "Fuel cell propelled electric vehicles can be commercialized by a 2015/2016 timeframe,"
  Source : http://media.opel.com

- **DAIMLER - Dieter Zetsche, CEO - 02/06/2011.**
  "We intended to go for volume production in 2015, but because of the experience of the world tour we have pulled forward." He said volume production would begin in 2014. "The product is ready for the market technically,"
  Source : http://www.insideline.com

Infrastructure deployment now required !

- **HYUNDAI-KIA - Byung Ki Ahn, General manager of Fuel Cell Group - 04/06/2010.**
  "Pilot-scale production of 1000 fuel cell cars a year will begin for us in two years,". "Our first cars (…) will allow us to make the final stages of development progress before we begin commercial production of around 10,000 hydrogen cars a year in 2015."
  Source : http://www.autocar.co.uk

- **Steve S. Yang, Hyundai President and Chief Executive – 11/09/2010.**
  "Our ultimate goal is to build fuel-cell vehicles and make them available from 2015. Of course, we need EVs and we need hybrids but these are an intermediate step for FC vehicles.
  Source : http://www.newsmail.com.au

- **HONDA - Takanobu Ito, CEO – 21/01/2010.**
  "I think the ultimate eco car is a fuel cell car."
  Source : http://www.detnews.com

  Takanobu Ito fully expects his company to offer a vehicle powered by hydrogen fuel-cells by the year 2018 (01/03/2007)

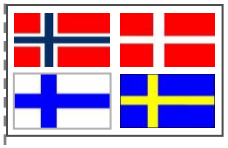
- **FORD - Alan Mulally , CEO – 26/06/2009.**
  Alan Mulally sees 2015 as the date that fuel cell cars would go on sale.
  Source : Edison Electric Institute conference

High momentum of H2 Mobility-related initiatives in several countries

Overview of selected countries

- Announcement by **13 companies** (3 OEMs and 10 energy and infrastructure providers) and the Ministry of Transport to commercialize FCEV
  - Mass production of **FCEV by 2015**
  - **100 HRS operational** in 4 four metropolitan areas and connecting highways planned, **1,000 HRS** in 2020, and **5,000 HRS** in 2030

- South Korea laid out **"Green Car Roadmap"** including action for EV, PHEV, HEV, FCEV, and bio diesel
- Plans to have **168 HRS** and **100,000 FCEV** deployed **by 2020**
- Announced **government support** for **EV** of **up to EUR 20,000** in rebates, tax exemptions, and bonus/malus
- Incentives for **FCEV** will be defined later but are **expected to be comparable** to EV



- Hyundai-Kia signed **MOU** with four **Scandinavian countries** (Norway, Sweden, Denmark and Iceland) for the provisional distribution of FCEV
- FCEV will be used to complement the **Scandinavian Hydrogen Highway Partnership (SHHP) fleet** of 26 FCEV and to be increased to 46 in 2011
- SHHP also plans to **increase number of HRS** from 7 to 15 by 2015

SOURCE: METI; Government of South Korea

H2 Mobility ahead of us

17 private companies and NOW jointly developed a business case for a hydrogen infrastructure and FCEVs

Participating companies

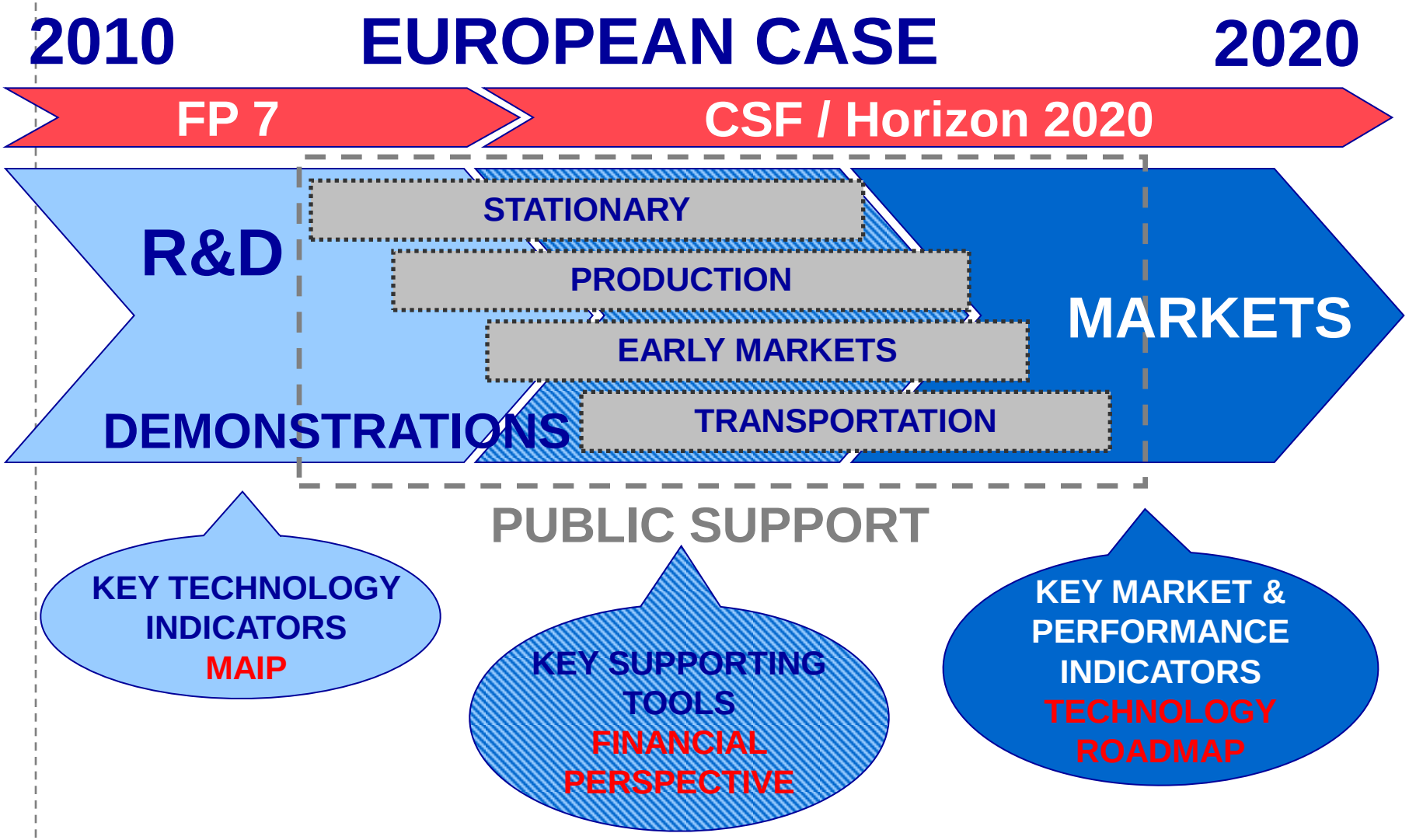
Car OEMs	DAIMLER, BMW, HYUNDAI, KIA MOTORS, GM, INTELLIGENT ENERGY, NISSAN, TOYOTA, VOLKSWAGEN
Industrial gas companies	AIR LIQUIDE, AIR PRODUCTS, Linde
Oil and gas companies	TOTAL, OMV, Shell, Eni
Utilities	EnBW, VATTENFALL
Govern-mental Org	NOW – Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

Main achievements

- Joint development of **consistent** infra-structure and FCEV **ramp-up scenarios**
- Development of **business case** for **hydrogen infrastructure** in Germany as pilot market
- Analysis of **sensitivities** and quantification of **risks and opportunities**

SOURCE: H_2 Mobility

Targets 2020: Reaching markets in all sectors

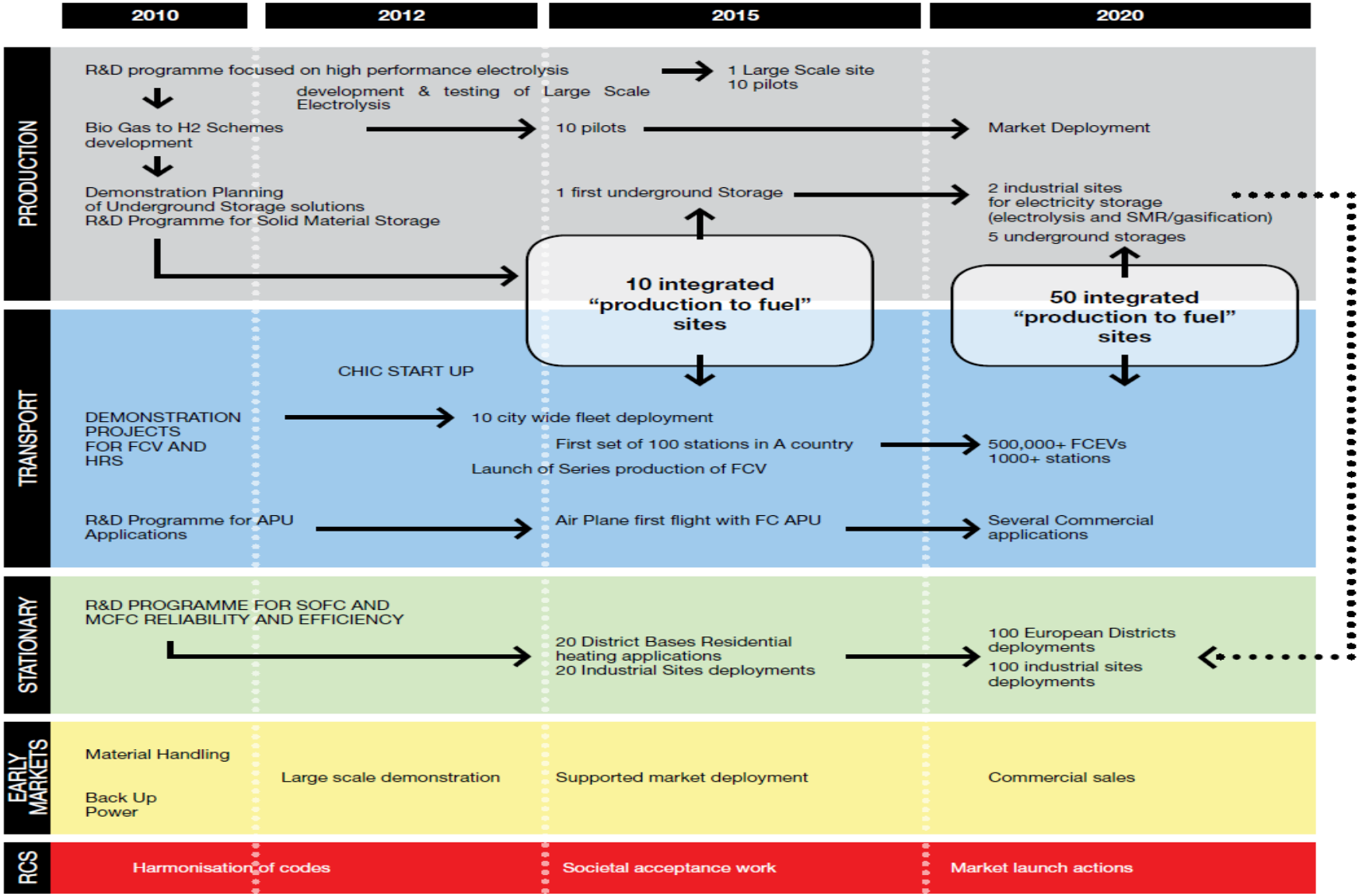


European Case : Industrial sectors objectives

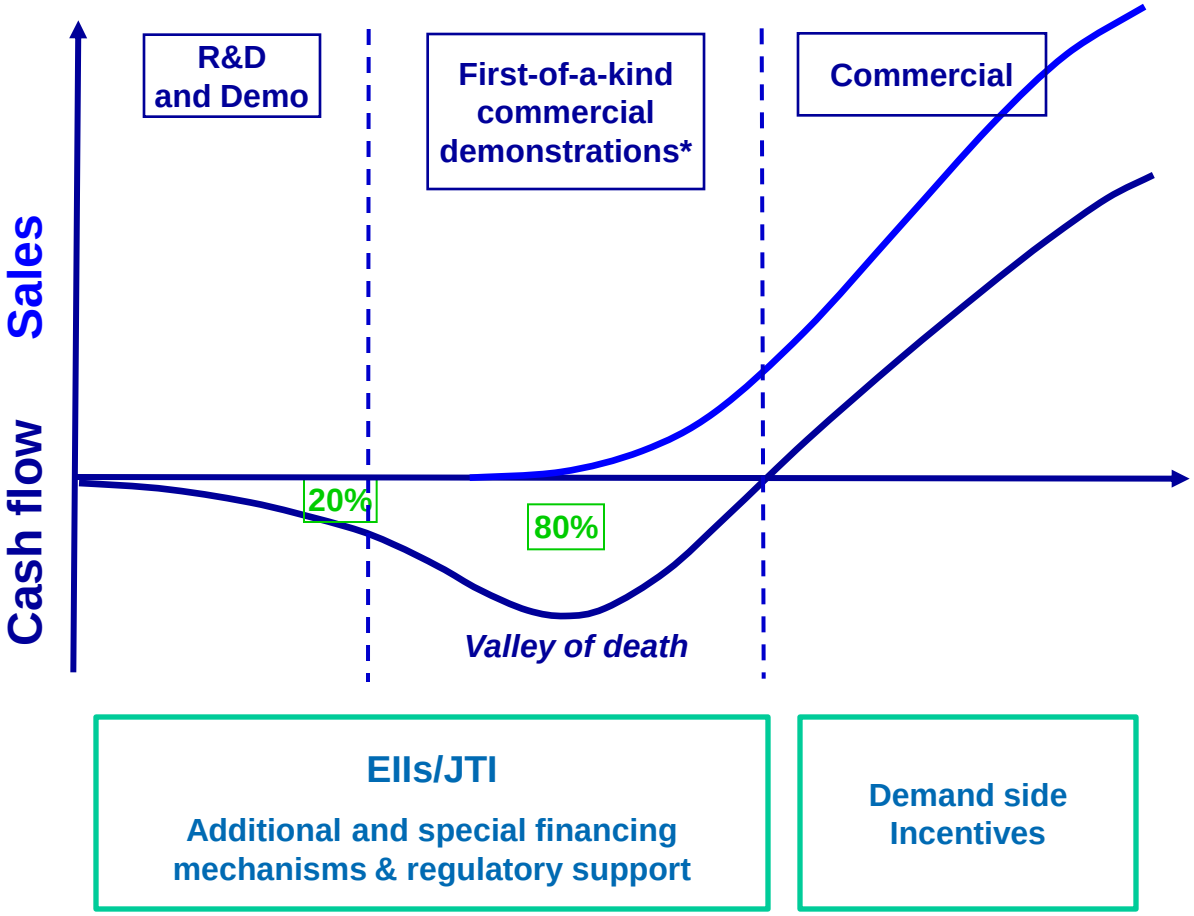
Deployment of FCH technologies across sectors:

Transport	• Contributing of 500,000 Fuel Cell Electric Vehicles (FCEVs) and 1,000+ hydrogen refuelling stations towards the transition of the transport sector towards electric drives
Energy production	• Contributing to the transformation of the European Energy mix by producing 50% of H2 used for these applications from renewable energies or from zero-CO2-emission sources
Energy storage	• Contributing to the integration of intermittent renewable energies (wind, solar) by applying hydrogen storage capacity up to 500 MW as part of a grid scalable storage
Early markets	• Contributing to the demonstration of cost-efficient solutions with clean and sustainable FCH technologies for material handling vehicles, back-up power and portable power applications
Heat & Power generation	• Contributing to the transformation of the energy sector by providing heat and power to more than 50,000 households using stationary fuel cell systems

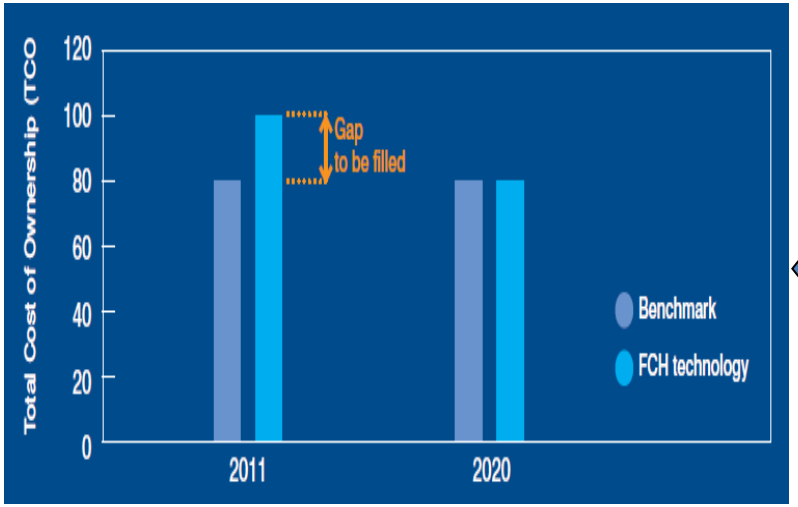
2010-2020 European Road Map : market at sight !



FCH technology innovation cycle: 80% of effort ahead

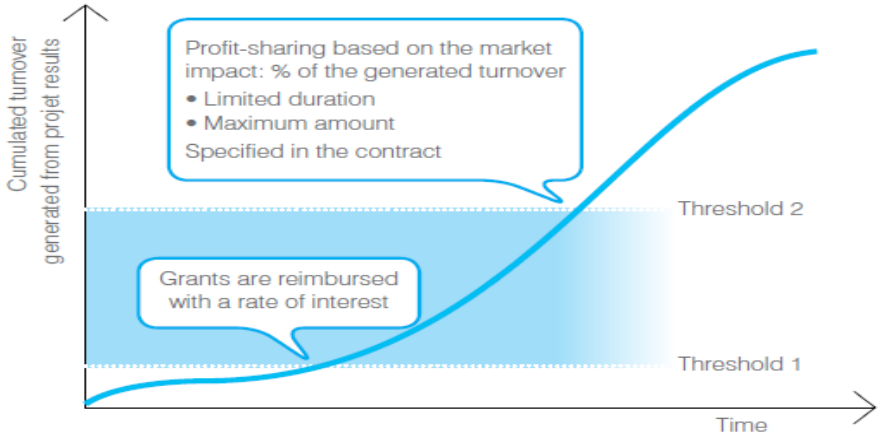


New Funding Mechanisms for Market introduction



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

Reimbursable grants: a new financial instrument to support EU political ambition



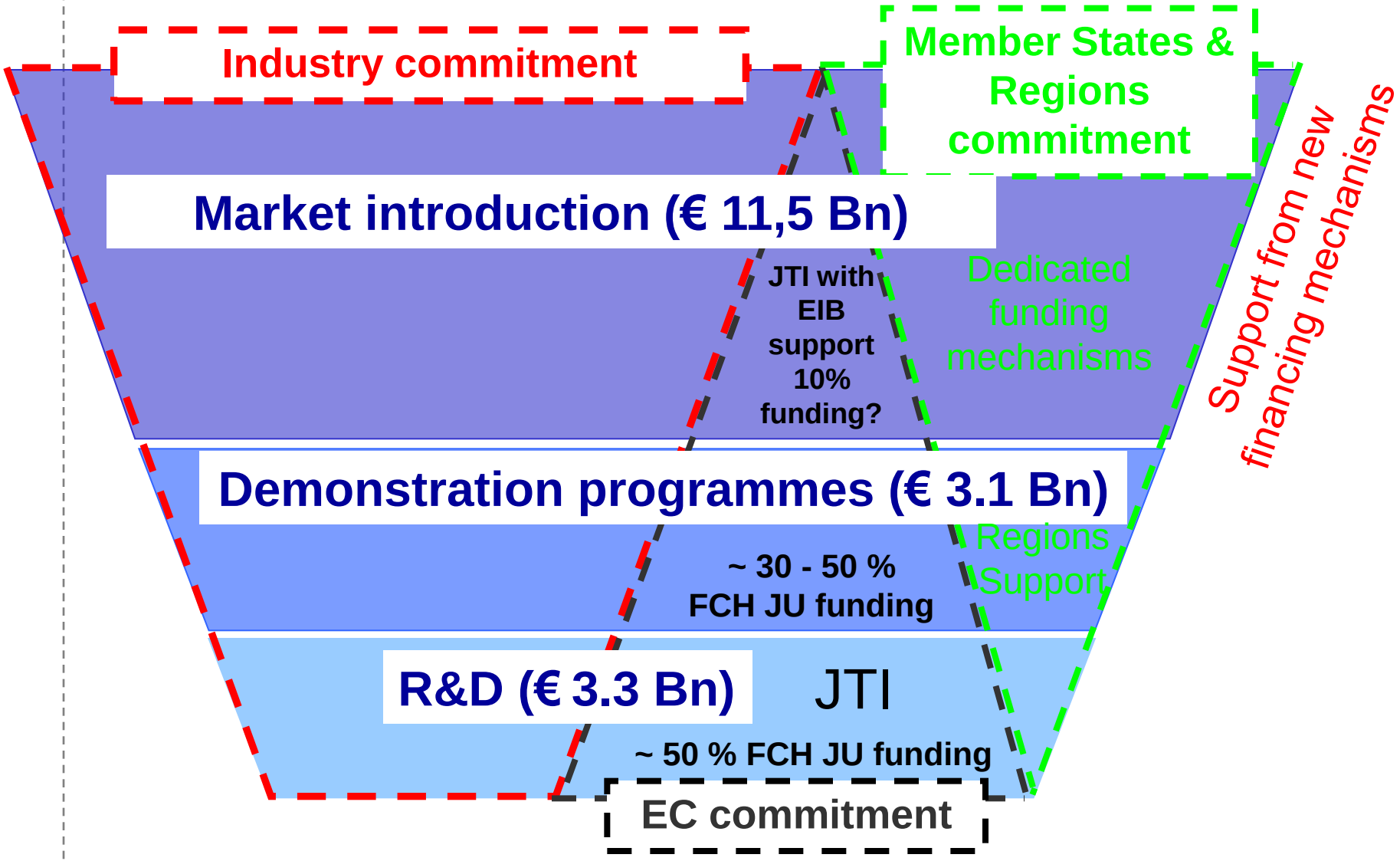
Grants are reimbursed when the cumulative turnover generated by the project reaches a first threshold.

In a second time, if the cumulative turnover crosses a second threshold, the profit can be shared between the funding agency and the grantee.

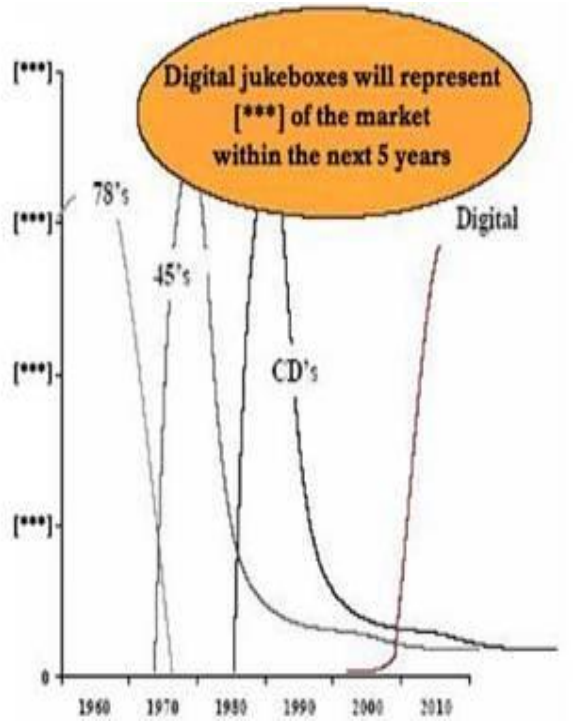
Typical Financing Schemes – Consortium Approach?

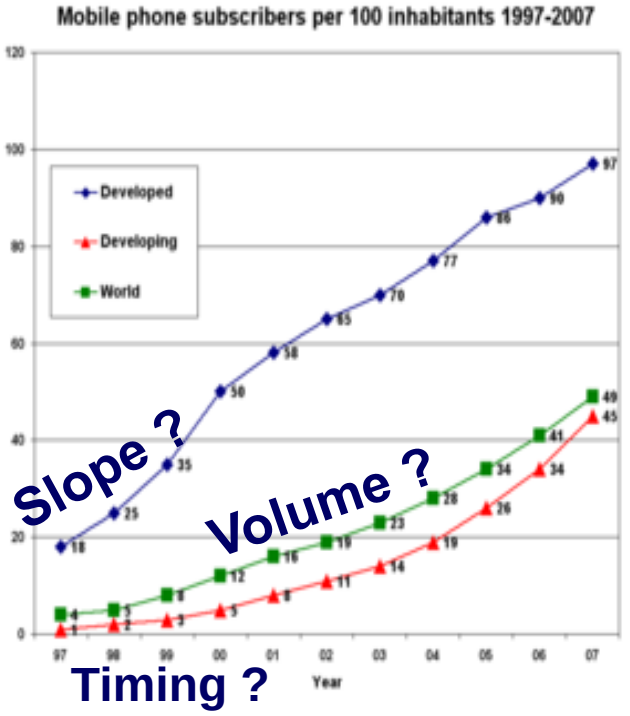
- Project Finance Structure
  - Infrastructure Investment Vehicle (Scope ?)
  - Industrial Partners to contribute in Equity (10-20% ?)
    - Financial Institutions to contribute Senior Debt (70-80%)
    - Public Institutions to provide Insurance packages for part of Loans against Market Failure (30-50% 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…
  - Structure also dependant on the political scope of deployment : European / Local / Regional

From Research To Markets…The European Case



Other past examples of techno revolutions…





Probably none comparable to what is at stake…

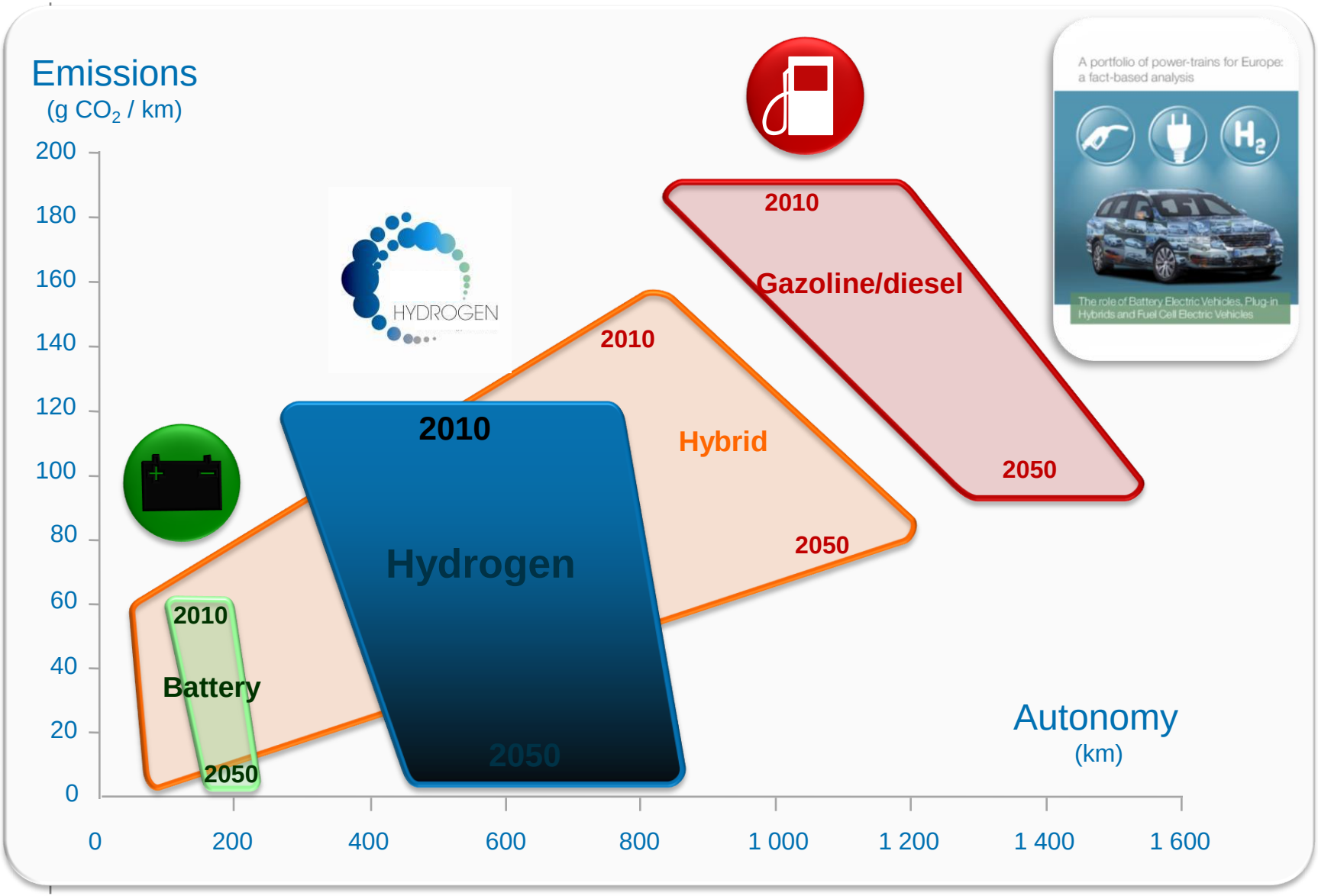
1. this is mainly a « substitution infrastructure » which needs to be built,
2. It is required to stop externalities partly created by the incumbent ones.

« Il faut que tout change pour que rien ne change » (Le Guepard)

Take aways and suggestions

1. **What about the End User ?**
   - Launch a dedicated societal acceptance survey ? World Wide ?
2. **What about lessons learnt from past techno introduction initiatives in the field of public acceptante and safety ?**
   - Launch a « benchmark » study ?
3. **Stability of Support schemes is critical for long term driven technology changes**
   - JTI type structures usefull for this.
4. **Risk Sharing Mechanisms to invent to pass the death valley : we are dealing jointly and severaly a paradigm change !**
   - Work around reinbursable grants or similar mechanisms.
5. **H2 Economy will not succeed if we do not engage now a road map to make it green :**
   - AL initiative « Blue H2 » tries to capture this.
6. **Need to support cooperative / collaborative scheme until break even level reached !!**
   - Need to protect early market introduction and consortia schemes
7. **2015 key date for first « volume » level FCV :**
   - Need of a dedicated infrastructure set up support project (not country base).

Back Up


Emissions
(g CO_2 / km)
200
180
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1 000
1 200
1 400
1 600
Autonomy
(km)
2010
Gazoline/diesel
2050
2010
Hybrid
2050
2010
Hydrogen
2050
2010
Battery
2050
HYDROGEN
A portfolio of power-trains for Europe: a fact-based analysis
The role of Battery Electric Vehicles, Plug-in Hybrids and Fuel Cell Electric Vehicles