



# HYDROGEN

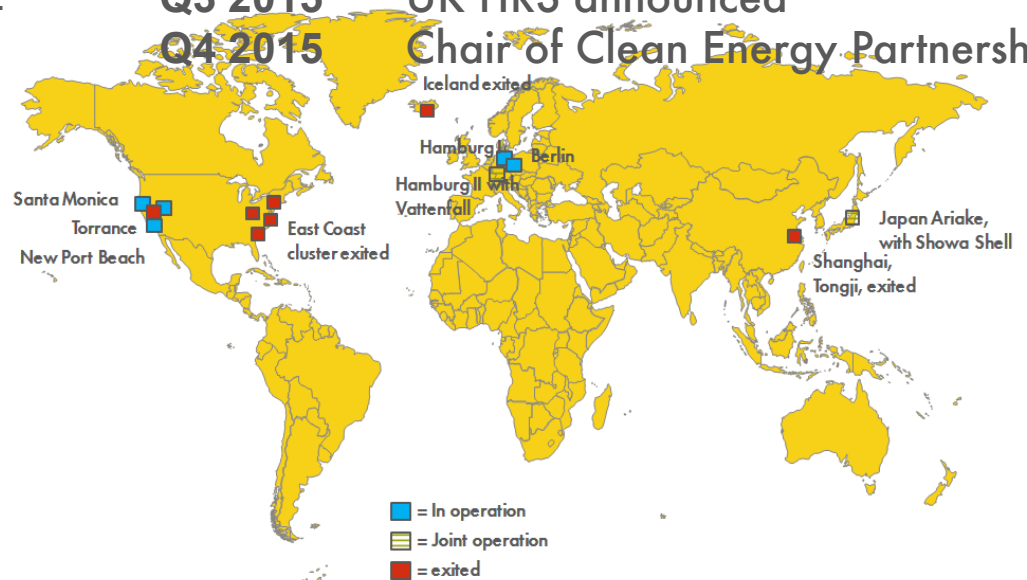
## PROVIDING INFRASTRUCTURE

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General Manager, Hydrogen



# SHELL HYDROGEN JOURNEY – OVER 15 YEAR HISTORY

1999	Shell Hydrogen founded	2011/12	Torrance and Newport Beach (CA) H <sub>2</sub> stations open
2003	H <sub>2</sub> project starts up in Washington DC with GM	2011/13	Berlin and Hamburg stations open
2005-08	5 more HRS introduced in NY and CA	Q4 2013	H <sub>2</sub> Mobility term sheet signed
2008	Increased focus on Germany and CA	Q3 2014	H <sub>2</sub> Mobility JV agreement signed
2009	Vehicle demand did not materialize. Closure of 5 H <sub>2</sub> Stations begins in East Coast	Q1 2015	Hamburg HRS opened (March 16)
		Q2 2015	H <sub>2</sub> Mobility JV starts
		Q3 2015	UK HRS announced
		Q4 2015	Chair of Clean Energy Partnership



# SHELL HYDROGEN ACTIVITIES

- Retail fuelling operations in Germany and the US (California)
- Stations demonstrate onsite SMR, electrolysis, compressed hydrogen gas delivery, liquid hydrogen, pipeline gas
- Extensive growth planned for German retail network
- Stations announced for United Kingdom market
- Investigating other European market opportunities e.g. France, Belgium, Luxembourg, Netherlands, Austria, Switzerland: key criteria is (i) Retail station ownership, (ii) financial risk sharing with governments, (iii) FCEVs
- R&D in flow metering, quality control, liquid hydrogen, dispensing and onsite production (electrolysis, SOFCs, SMR)
- New hydrogen lab in Amsterdam starting 2016



## ACHIEVEMENTS SINCE LAST IPHE MEETING (DECEMBER 2014)

- **H2 Mobility Germany JV (400 HRS program):** company founded, officially launched, first 7 stations are under permitting and construction
- **UK:** agreement reached with ITM and FCH-JU to deliver 3 refuelling stations in the Greater London Area; first station open mid 2016
- **Opened 3<sup>rd</sup> station in Germany in March (electrolyser station)**
- **Technology innovation funnel** filled with projects to support the commercial program: onsite production of hydrogen, quality sensor devices, safety, standards, cost reduction. Opening of H2 lab in Amsterdam
- **US:** successfully certified to sell hydrogen at New Port Beach. California remains a very important market.
- **Germany:** Chair of Clean Energy Partnership
- **Working closely with Partners (OEMs, IGCs, Governments, EC)**

...and pursuing new projects which have to remain confidential for

# WHY DOES H2 MOBILITY GERMANY JV WORK? IT SHARES RISKS AND COORDINATES STATION ROLLOUT WITH VEHICLES

## Hydrogen mobility – “chicken and egg” situation



- Full Cell Electric Vehicles (FCEVs) will only be bought by customer if there is refueling infrastructure
- Refueling infrastructure is only commercially attractive if there are FCEV customers



## Solution – aligned ramp-up of FCEVs and stations

Main objective of H<sub>2</sub> Mobility

- Coordinate activities for ramping up FCEV and hydrogen refueling infrastructure.
- Develop a basic hydrogen refueling infrastructure in Germany to enable the launch of series-produced FCEVs.
- Overcome risk of market failure through joint cross-industry action until infrastructure buildup is commercially viable.

H<sub>2</sub> Mobility is a success if...

- Hydrogen mobility is established in Germany and becomes a business opportunity beyond a first phase.
- A large number of coalition members jointly create this new market.

# HYDROGEN REFUELLING STATION CHALLENGES

## Technical

- HRS need to be integrated into existing network – (reduce footprint)
- Increased accuracy of flow meter needed (need to sell hydrogen!)
- Installation of HRS to be „plug and play“ (limit time on site!)
- Power requirements need to reduce (transformers & power in the road)

## Commercial

- Operational costs are still high (unreliable equipment)
- Communication to general public (urgent need to communicate more)
- Vehicles (remains the biggest risk).
- Permitting could be speeded up (work on communication, standards, etc)

*But – costs are coming down with more suppliers entering the market.*

*Good to see OEMs announcing vehicles. Nevertheless, the “eco-system” remains fragile*

# HOW CAN THE REGULATOR HELP?

## Considerations

- **(Joint) communication:** (i) an FCEV is an EV; (ii) de-mystify the technology to public in a fact based manner. (iii) explain the technology is safe
- **Financial support** (capex and opex) from regulator is required over a period of time (up to 10 years) to build the infrastructure ahead of FCEVs coming
- **Risk sharing** with partners is very important (OEMs, Retailers, Governments).
- **What incentives for early movers?** (first mover disadvantage).
- **Assist in speeding up permitting, initial waiver for metering hydrogen**
- **Public sector Fleets** – can local city councils procure vehicles?
- **Research & development support** – this remains crucial to reducing footprint, increasing reliability & performance of equipment.





# SHELL HYDROGEN STATIONS - GERMANY

Berlin



Hamburg Bramfeld



HH Schnackenburgallee



Gefördert durch:  Bundesministerium für Verkehr und digitale Infrastruktur  
 Koordiniert durch:  JNOW

	Berlin	Hamburg I	Hamburg II
Start up	2011	2013	Q1 2015
Supply	Liquid	Gaseous	PEM Electrolysis
Delivery pressure	350 / 700 bar	700 bar	700 bar
Capacity	1000 kg/day	70 kg/day	80 kg/day
Utilization	< 5%	< 5%	tbd



# SHELL HYDROGEN STATIONS - CALIFORNIA

**Torrance**



**Newport Beach**



	Torrance (Los Angeles)	Newport Beach
Start up	2010	2012
Supply	H2 Pipeline	On site reforming
Delivery pressure	350 / 700 bar	350 / 700 bar
Capacity	50 kg/day	100 kg/day
Utilization	70 %	10%

# THE NEW ENERGY FUTURE BY 2050

RISING ENERGY DEMAND, SUPPLY PRESSURE, CLIMATE CHANGE



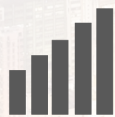
Population  
9 billion people,  
75% living in cities  
(2 billion more than today)



Vehicles  
2 billion vehicles  
(currently 800 million)



Rising standards  
Many millions of people will rise  
out of energy poverty; with higher  
living standards energy use rises



Demand  
Energy demand could double  
from its level in 2000...but CO<sub>2</sub>  
emissions must be half today's  
to avoid serious climate change



Efficiency  
Twice as efficient, using  
half the energy to produce  
each dollar of wealth



Renewables  
3 times more energy  
from renewable sources

# HYDROGEN: THE FUTURE FUEL FOR ZERO EMISSIONS?

## Drivetrain



Carriage



Steam Engine



CI SI  
Compressed & Spark Ignition Engine

**Fuel Cell Electric Vehicle**  
**Battery Electric Vehicle**  
**Plug-in Hybrid Elec. Veh.**  
**Gasoline Engine (SI)**  
**Gasoline (SI) Hybrid**  
**Diesel (CI) Hybrid**  
**Diesel Engine (CI)**  
**Mixed Combustion SI/CI**  
**Natural Gas Engine**



Fuel Cell Electric & Battery Electric Vehicle

1800

1840

1900+

**TODAY**

2030+ ?



Horse/Animal Feed



Coal



Petroleum: Gasoline & Automotive Gasoil (Diesel)



Renewable Electricity & Renewable H<sub>2</sub>

## Energy/Fuel

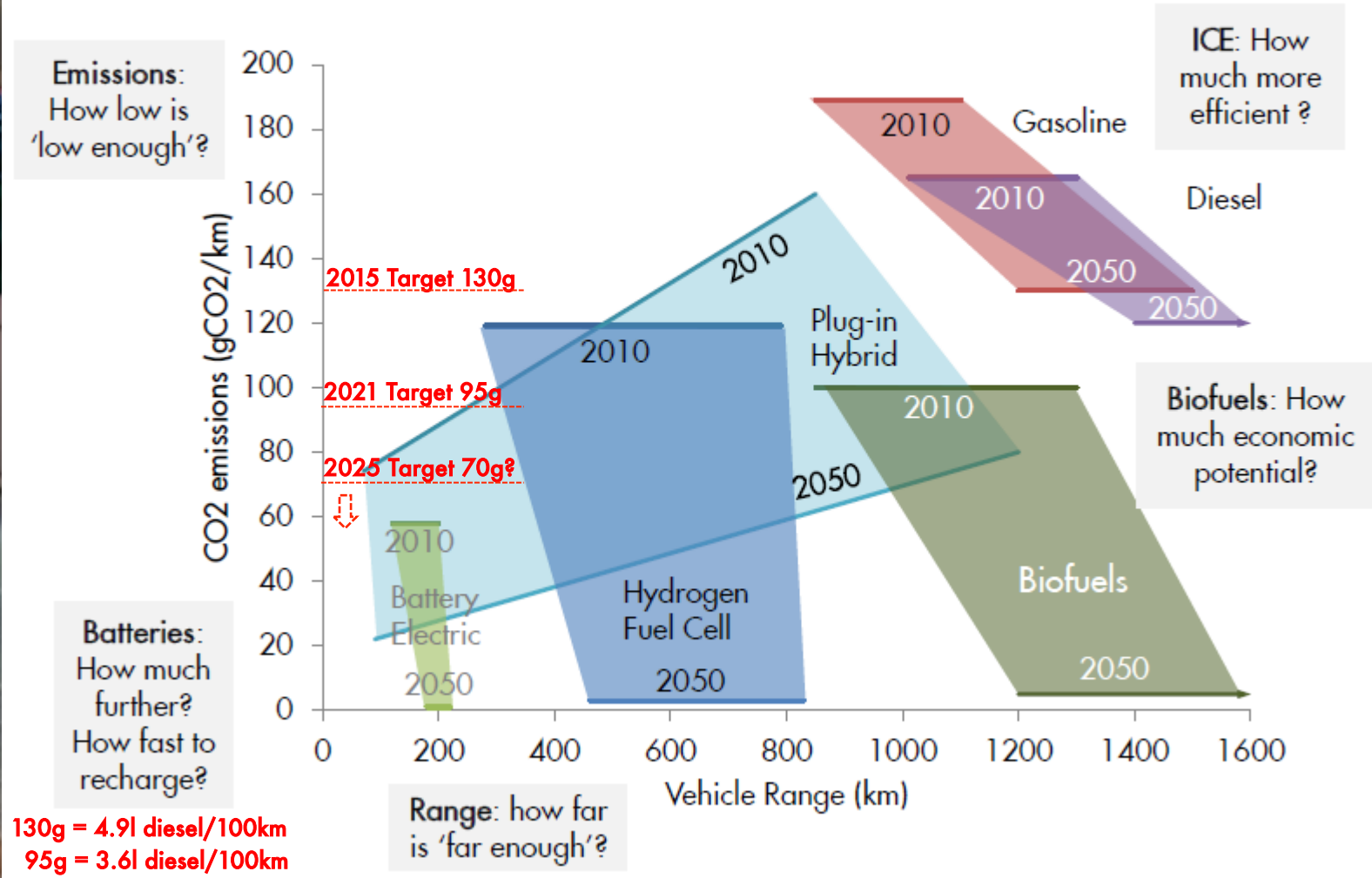
**Hydrogen**  
**Electricity**  
**LNG**  
**CNG**  
**LPG**  
**Biofuel 1G/2G**  
**HVO/GTL**  
**Gasoline**  
**Diesel**

**Renewable Electricity & Hydrogen?**



# H<sub>2</sub> OFFERS CO<sub>2</sub> REDUCTION PATHWAY

## Competing Fuel Technologies



# HYDROGEN REFUELLING STATION LEARNINGS

- Hydrogen stations provide important learnings and experience in consumer behaviour, safety, cost, and the dispensing and storage of hydrogen
- Hydrogen can be refueled safely in a consumer environment
- Various technologies have been tested
  - Forecourt electrolysis
  - Forecourt reforming
  - Gaseous trucked in, liquid trucked in, pipeline
  - 350 bar, 700 bar, liquid dispensing
- In order to make hydrogen affordable, hydrogen stations need to be standardized and lowered in cost
- Need higher reliability and utilization of stations