AIR LIQUIDE
Creative Oxygen

Advanced Business & Technologies

Hydrogen – Transporting the future

May 2016 I advanced Business & Technologies

Accelerating Energy Transition – Agenda

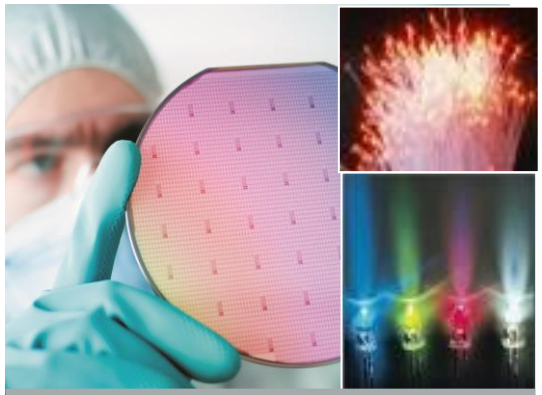
1. Hydrogen at Air Liquide -> industrial applications
2. Energy Transition: Hydrogen in transportation
3. Air Liquide's Hydrogen strategy 2020
4. What opportunities or hurdles lie ahead?

1. Hydrogen at Air Liquide -> Industrial Applications

Hydrogen, many existing applications…

Heat Treatment

Glass



H2 Ultra pure <1ppb

Chemicals & Petroleum refining

Rockets

Fuel cell vehicle

40 years of global investment in Hydrogen

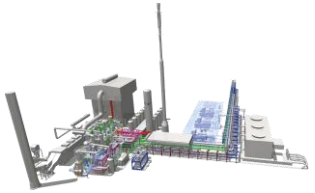
> 14 bn m^3/yr
> 1,850 km H_2 pipeline
> 46 large H_2/CO plants
> 2 bn € sales

year 2015

Hydrogen
Oxygen
Nitrogen
Synthetic gas

Hydrogen and or/carbon monoxide facility and hydrogen source
Oxygen and nitrogen facility
Cogeneration facility
Synthetic gas facility

Production



Distribution

Applications

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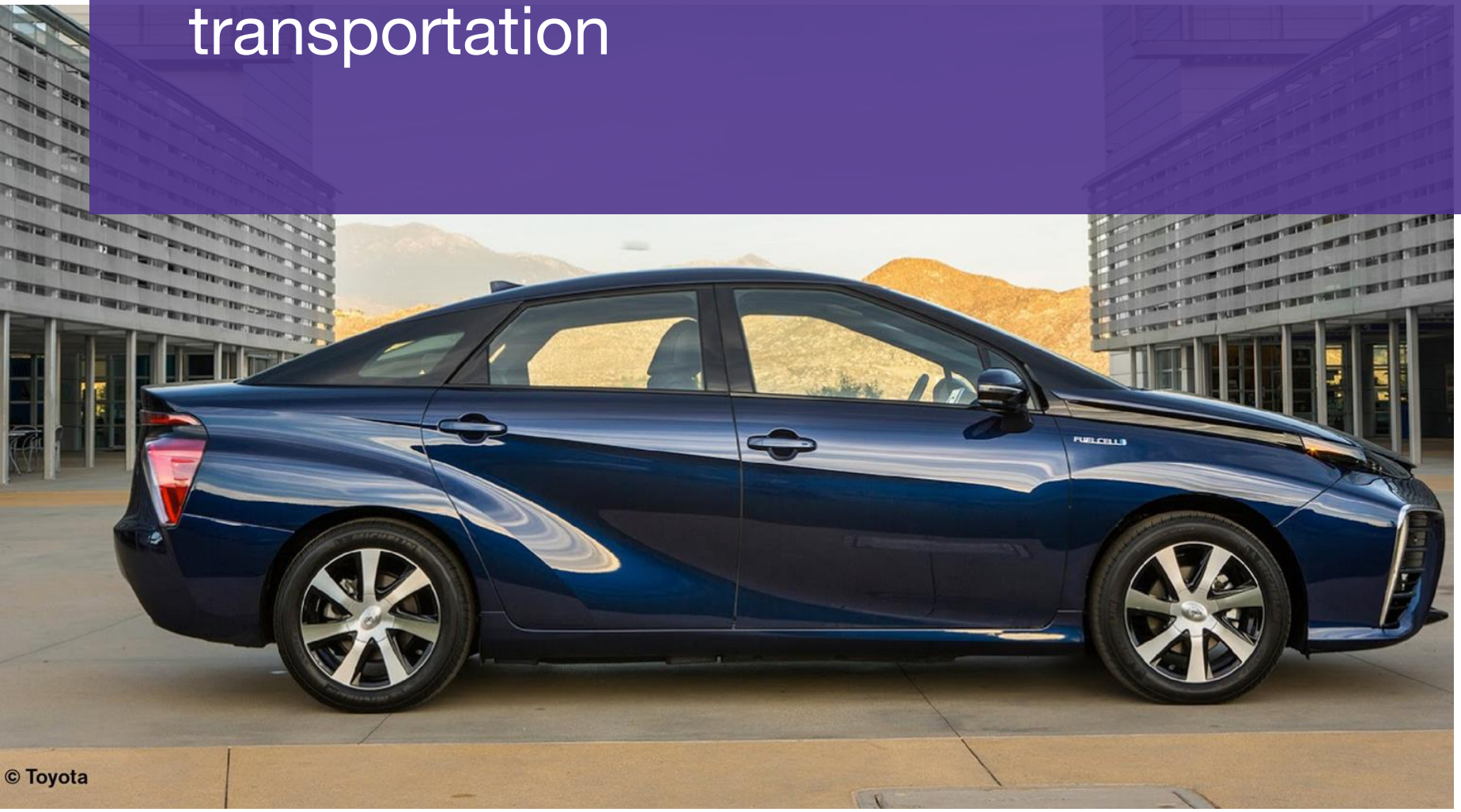
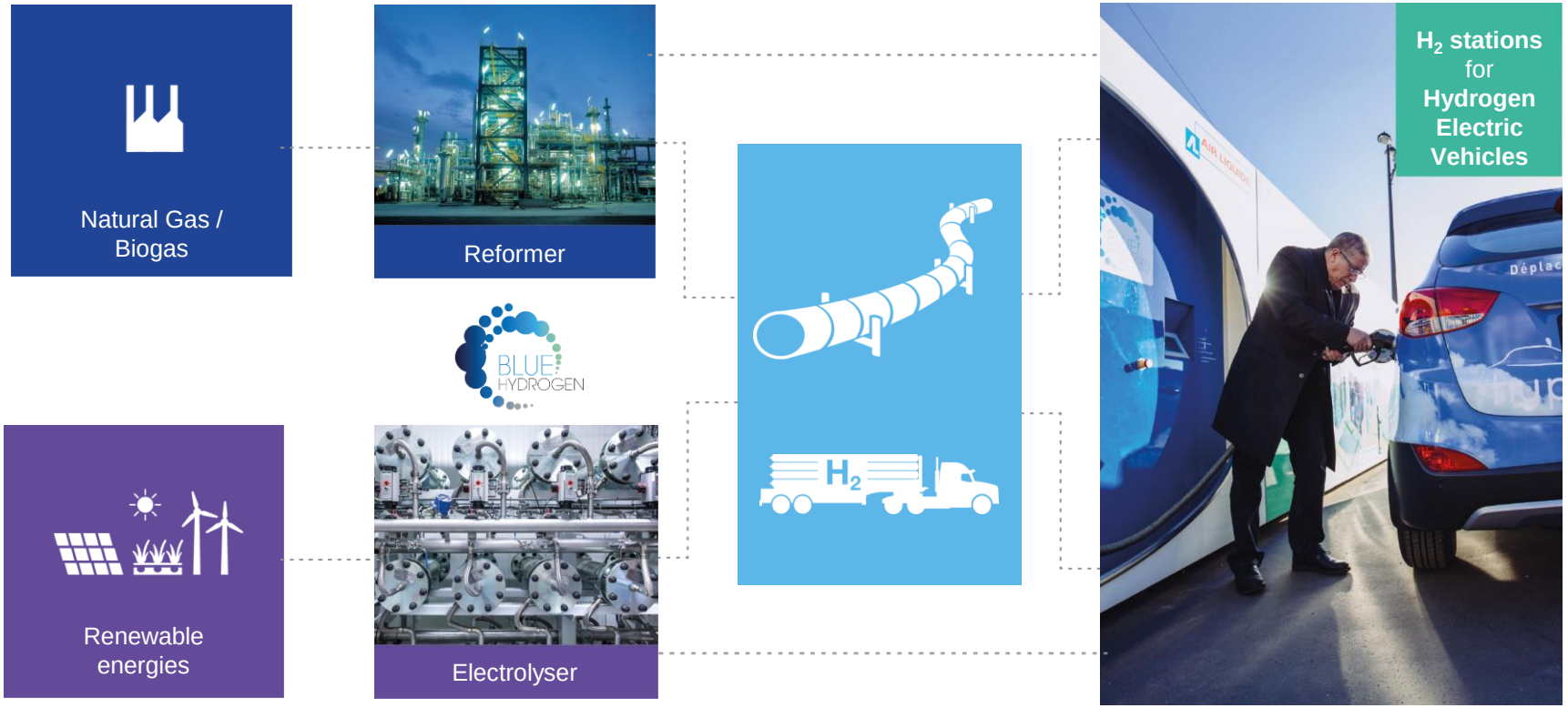
2. Energy Transition: Hydrogen in transportation



Hydrogen delivers dramatic transportation solutions

- H_2 produces zero emissions, just water
- H_2 enables energy storage



People 'get' Hydrogen – and are expecting it

Arnie's Hydrogen Highway

Jay Leno, Honda Clarity

Death Valley test 2014

Emissions scandal 2015

H_2 saves valuable fuel 2016

Tokyo 'Hydrogen Olympics' 2020

Hydrogen out performs the alternatives

PETROL

EMISSIONS

Vehicle	150 g/km
Well to wheel	180 g/km
With Hybrid	← ZERO

HYDROGEN

	ZERO
	120 g/km
	ZERO

With Green H2

ELECTRICAL

AUTONOMY

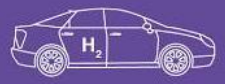
100 > 300 km

CONVENIENCE

Recharging
30 min < 8 hours

HYDROGEN

500 > 700 km



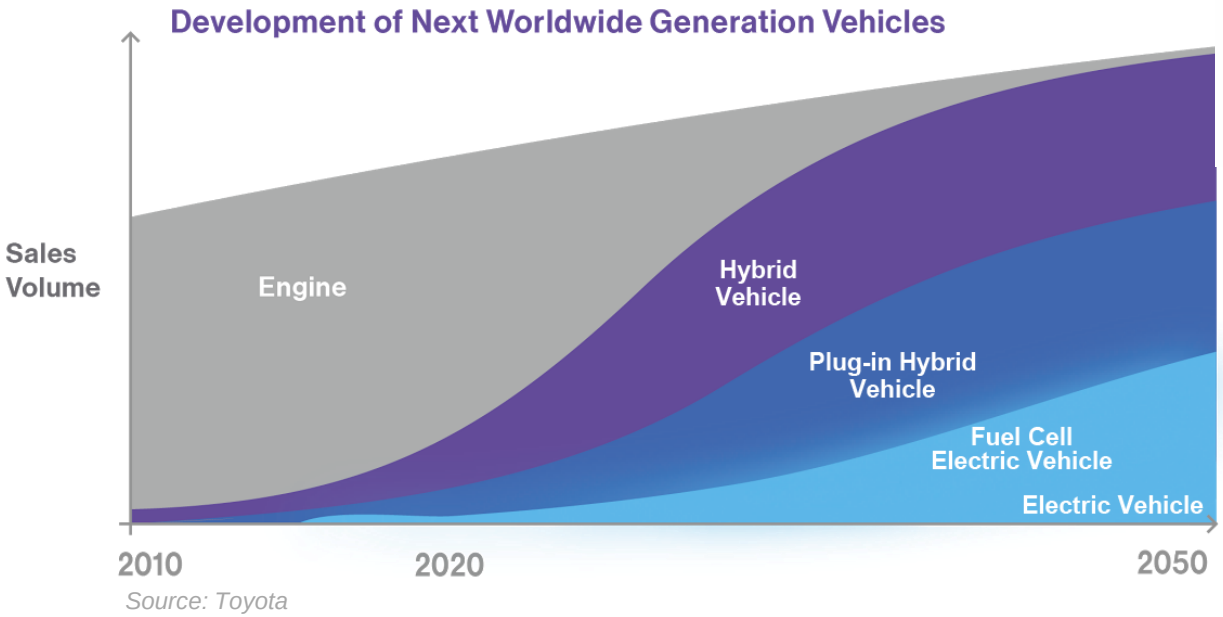
Refueling
3 < 5 min

Source : Mc Kinsey, 2011, EU Powertrain Report

The engine revolution favours H_2…

By 2050, 1 out of 4

will already be driving a Hydrogen energy car.
Hydrogen will be on every corner like petrol is today.



Source: Toyota

TOYOTA HONDA HYUNDAI DAIMLER

Electrification of vehicles will help transitioning towards Hydrogen FCEVs

3. Air Liquide's Hydrogen strategy to 2020

Our ambition: leadership in H_2 Mobility

- Leadership role in development of **of H_2 Energy Markets**
- **Be Major Mobility player**
  Maintain leadership across the full value chain
  from H_2 production to delivery at the pump

Towards leadership in H_2 Mobility – 3 pillars

1
TECHNOLOGY

2
INVESTMENT

3
CUSTOMER EXPERIENCE

Technology leveraged at every step in the chain

Efficient
Sustainable
Safe
Reliable
Competitive

Everything we do leads to CO_2- free H_2 mobility

50% of H_2 energy
from carbon-free processes by 2020

A commitment to meet
both **environmental requirements**
and **economic constraints**

Achieving "Blue H_2"

1. Natural gas reforming + CCS
2. Water electrolysis
3. Biomass gasification
4. Biogas reforming

BLUE HYDROGEN

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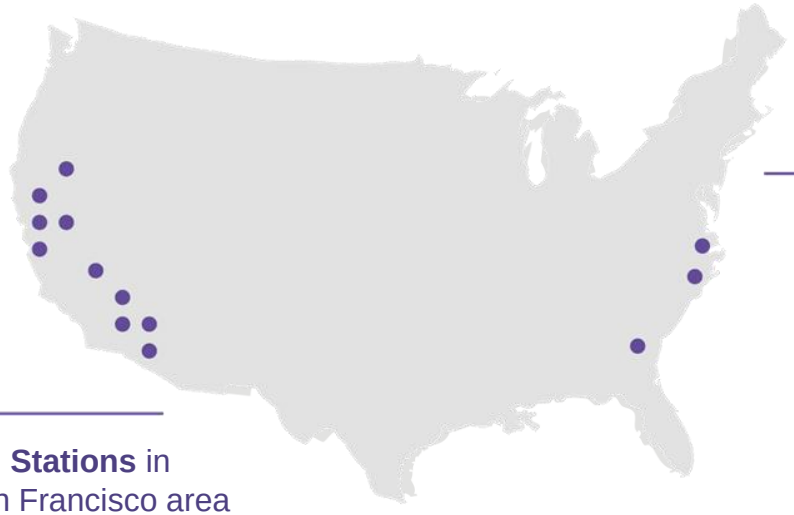
U.S. – California & 'Zero Emission Vehicles' States



4 Hydrogen Stations in
L.A. and San Francisco area
More under development

Collaboration with TOYOTA

12 Hydrogen Stations in
New York City, Boston,
New Jersey, Connecticut
and Rhode Island

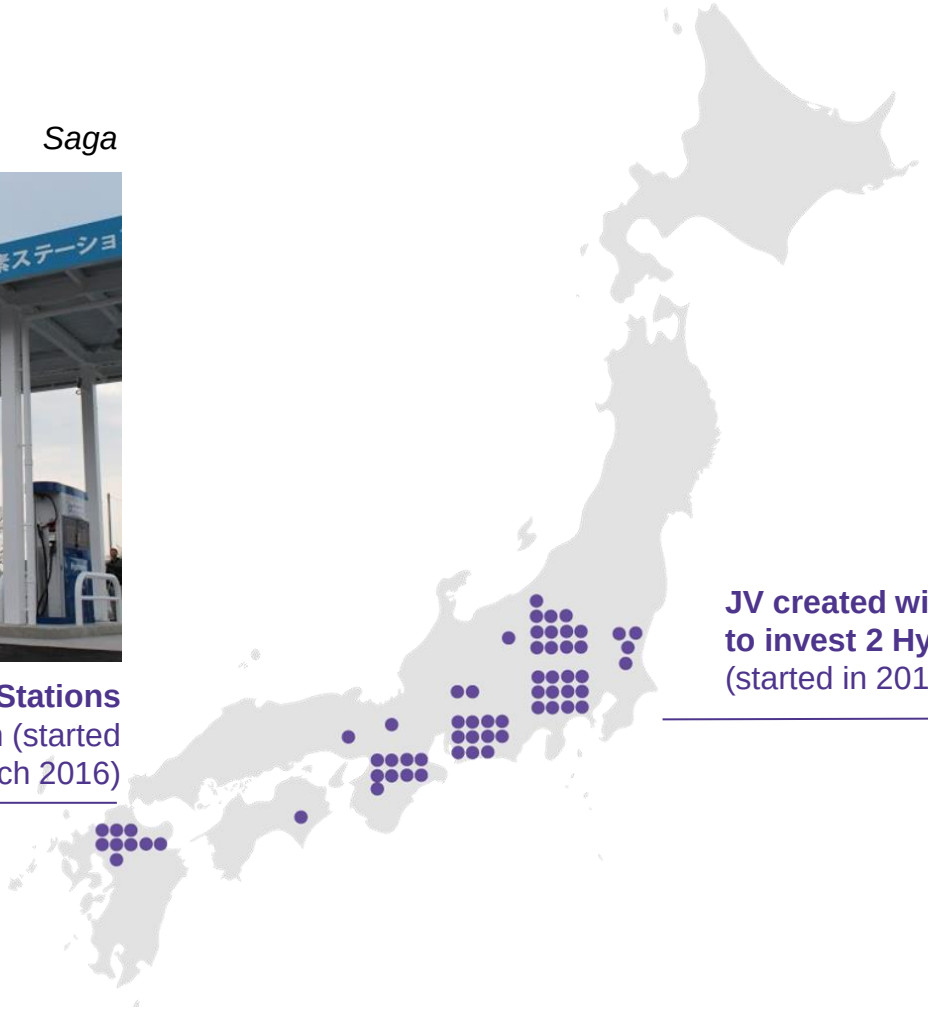
1st Hydrogen Station start-up Q1 2017

Dedicated H_2 supply chain implemented by Air Liquide for Toyota's roll-out of the Mirai

Japan – Deployments through the National Plan

Saga

2 Hydrogen Stations
in Kyushu region (started march 2016)



JV created with Toyota Tsusho to invest 2 Hydrogen Stations
(started in 2015)

Hydrogen Station

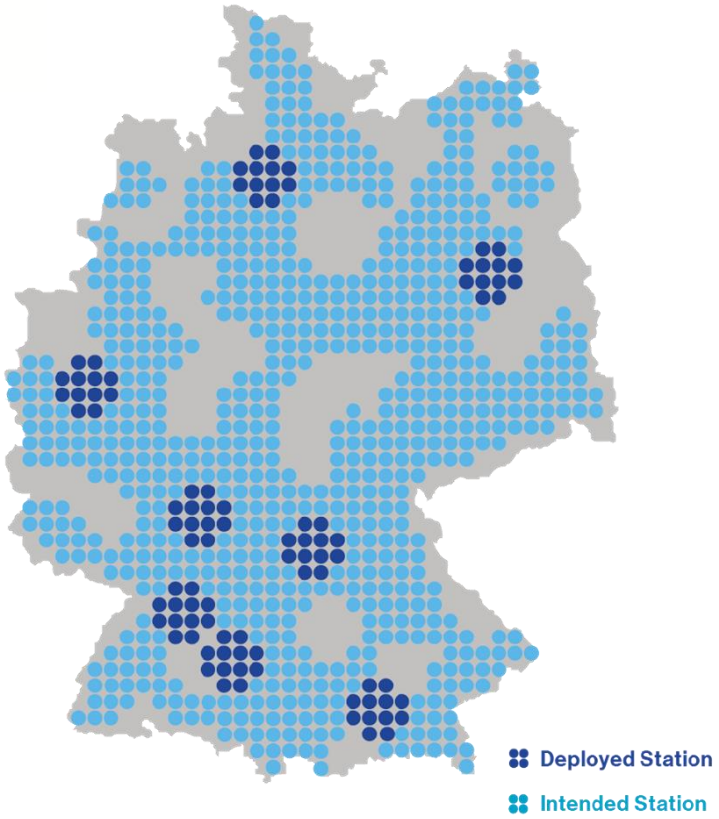
Nagoya Atsuta

Germany – H_2 Mobility Consortium

H_2 MOBILITY
FUELLING HYDROGEN

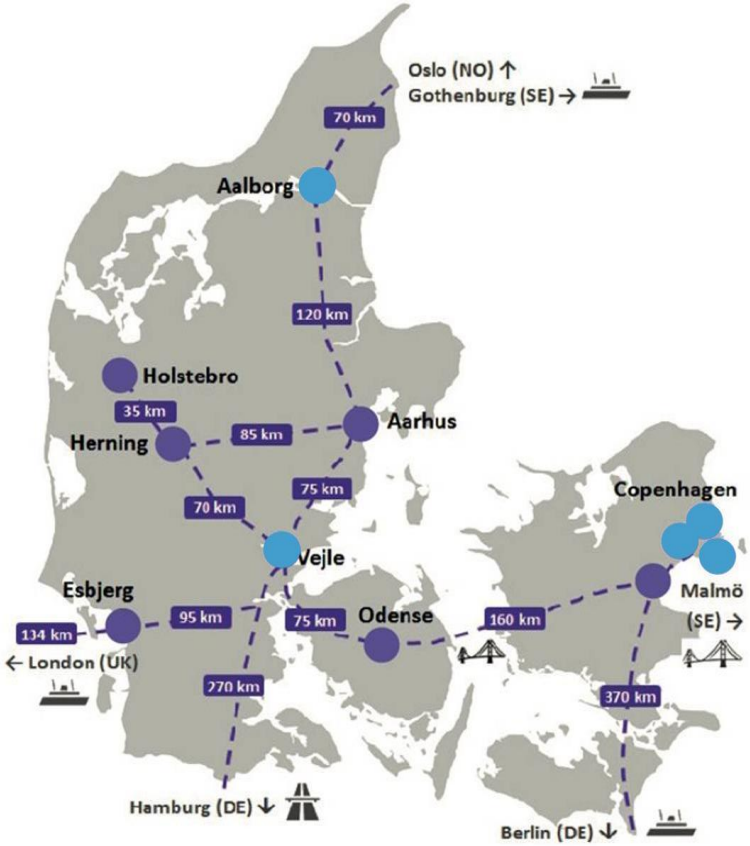
Air Liquide, Daimler, Linde, OMV, Shell and Total have agreed an action plan for the construction of a hydrogen station network in Germany

- **400 Hydrogen Stations by 2023** (100 by 2017)
- **350m €** investment
- **Max. 90 km distance between each station on motorways**
- **10 Hydrogen Stations** in each metropolitan area



Denmark – Copenhagen Hydrogen Network (CHN)

- **5 Hydrogen Stations** owned by Air Liquide
- Hydrogen to be produced from renewables : HyBalance "**Power to Hydrogen**" project



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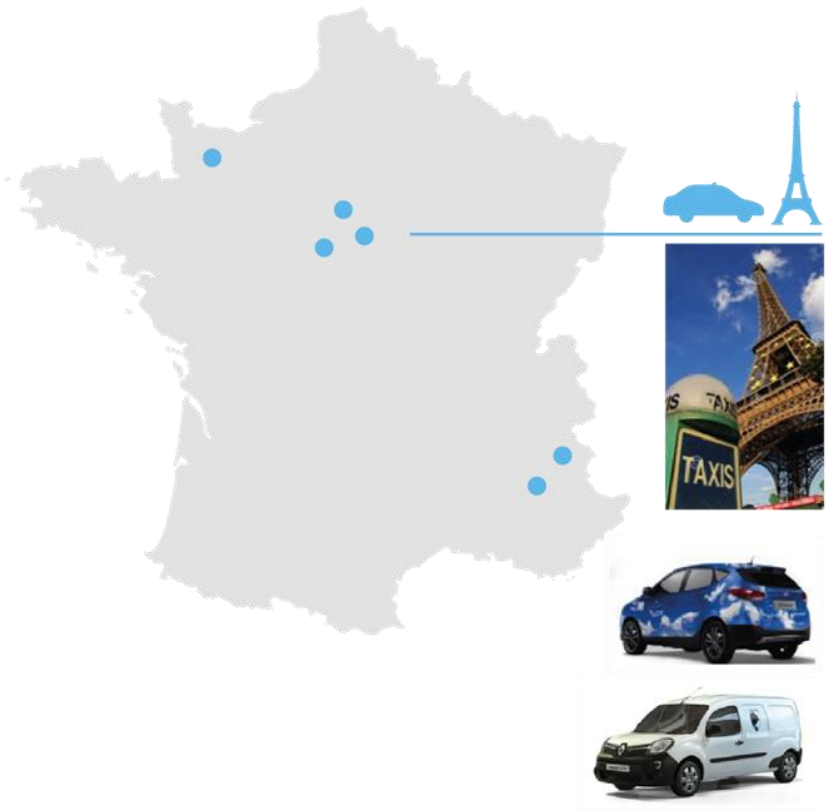
France - H_2 Mobility initiative



H_2 Stations Network under development to supply Range Extender Electric Vehicles (REEV)

- St-Lo (1) → 10 REEV & 5 Hyundai ix-35
- Hyway (3) → 50 REEV in Lyon & Grenoble
- H2ME1 (3) → 100 REEV
- Eas-Hymob (15) → in Normandy
- H2ME2 (9) → up to 1,000 REEV & 20 FCEV

Current Air Liquide developments

- Hyway - Grenoble (2)
- **Hype - Paris**
  - H2ME1 (1) → South Paris
  - H2ME2 (2) → North & West Paris

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Towards leadership in H_2 Mobility – 3 pillars

1
TECHNOLOGY

2
INVESTMENT

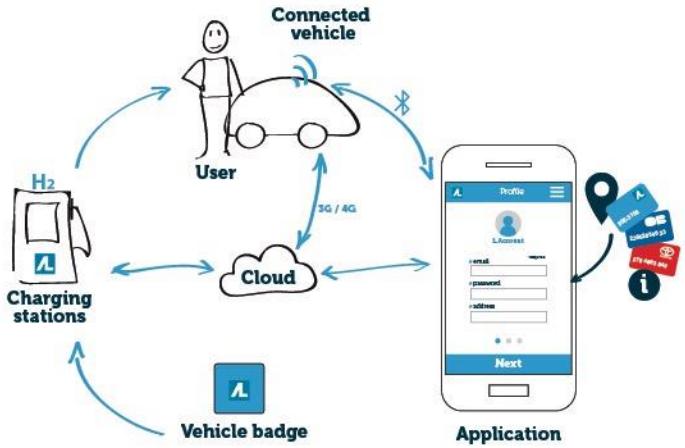
3
CUSTOMER EXPERIENCE

Delivering a new mobility experience…

Enhancing every experience to create a clean and hassle-free future for customers

Critical aspects of the experience we deliver

- Reliability
- Accessible and ergonomic stations
- Fast charging time
- Network density
- Convenient payment
- Better experience than today's alternatives
- A totally connected experience

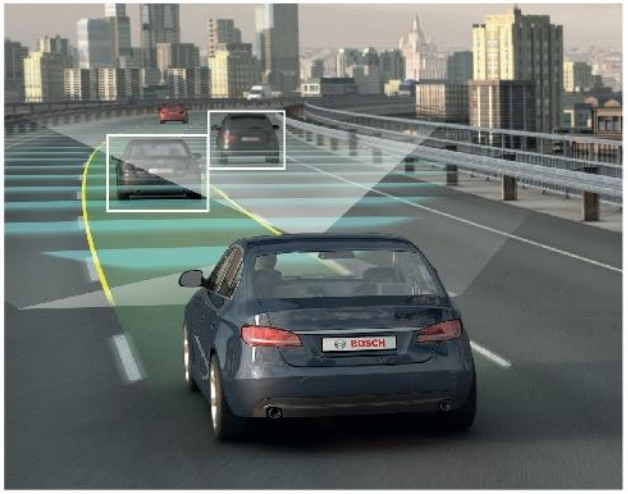


4. What opportunities or hurdles lie ahead?

Sustainable mobility is within our grasp

Transition evolving at unprecedented pace

- **Car electrification** (hybrids, battery electric, FCV, e.g. Prius, Mirai…)
- **New mobility models** (Uber, car sharing…)
- **Autonomous vehicles**



Political and economic initiatives are accelerating transition…

Gov. Yoichi Masuzoe – "demotorization" 2020 Olympics

Clear signs of support around the globe

- Japan: M. Abe's commitment towards a H_2 Society
- Korea: New Green Car roadmap (Dec. 2015)
- Europe: EU-funded programs (FCH JU, TEN-T)
- ZEV Allianz : US (California, NE) , Germany, Netherlands

"I have no doubt that Japan comes to the 'Front runner' of hydrogen energy race. I commit to promote hydrogen innovation much harder." - Prime Minister Abe (April 2015)

But need to further incentivize <u>Demand</u> and <u>Offer</u> to accelerate the transition

- Customers
- Car OEMs
- Infrastructure developers

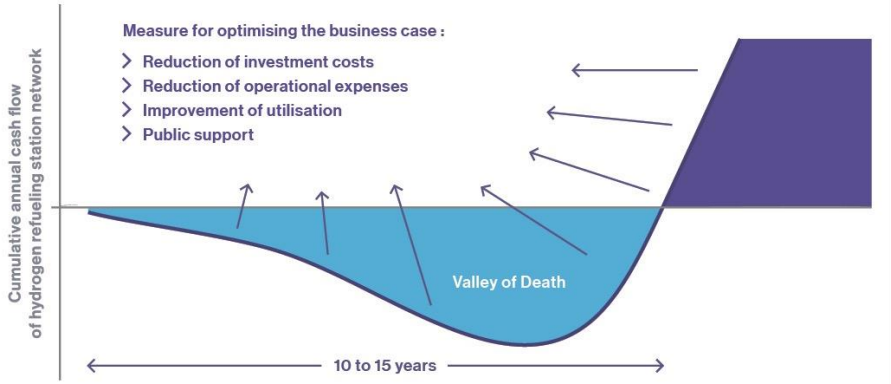
PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

We are identifying financial solutions...

Main issue

- Under-utilization of Hydrogen Stations and **“Valley of Death” periods**

H2 Station – cash flow curve



Source : IEA, H2 roadmap 2015

Example:

- **Guarantee mechanism** from Governments to attract Private Debt and secure lenders against FCEV ramp-up risk
- Managed through issurance and buy-back of Carbon Tickets**, based on station performance**

Possible outcome:

- **Attract private capital** into H_2 infrastructure development (banks, funds)
- Convergence of interests between **project promoters and Governments**
- Limited impact on budget/public debt → Strong leverage effect

Innovative business models to accompany new usages…

Captive fleets are catalysts for take-off

Captive fleet niches: buses, light commercial vehicles, taxis

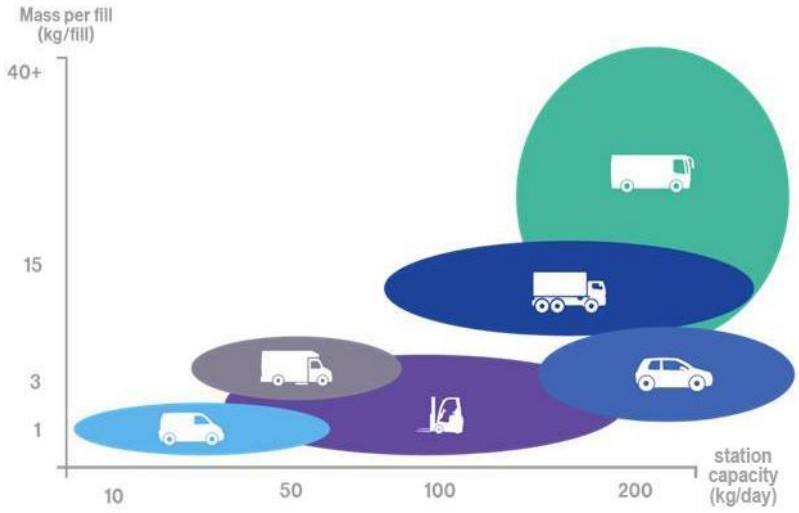
hype The «taxi of tomorrow»

An emission-free Paris

Targeting 70 taxis
by the end of 2016

and 600
within 3 years

Speeding-up energy transition for taxis



Value is created by mutualising Hydrogen Stations infrastructure with private users

The Hydrogen Society is closer than we think…

Acting now, we can rapidly accelerate a long overdue energy transition

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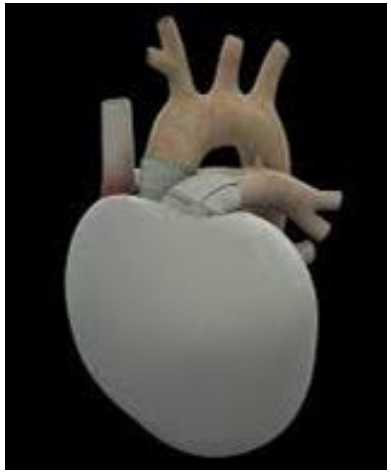

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As we advance towards an emission-free Hydrogen Society, we may just be solving the ultimate sustainability challenge...

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Thank you

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