BEVs and FCEVs for zero emission transport

November, 2016

H2 LOGIC
Hydrogen fueling solutions

Has changed name to Nel Hydrogen

nel

Number one by nature

About NEL Hydrogen

- **Pure-play hydrogen company listed on the Oslo Stock Exchange.**
- **Financially strong company with a market cap of €150 million.**
- **85 employees in Denmark, Norway and California.**
- **Three divisions offering hydrogen technology and solutions for industrial and energy applications.**
- **More than 850 hydrogen solutions delivered in 59 countries world wide since 1927.**
- **World #1 on hydrogen electrolysers and hydrogen fuelling – unrivalled performance and track-record.**

H2 LOGIC
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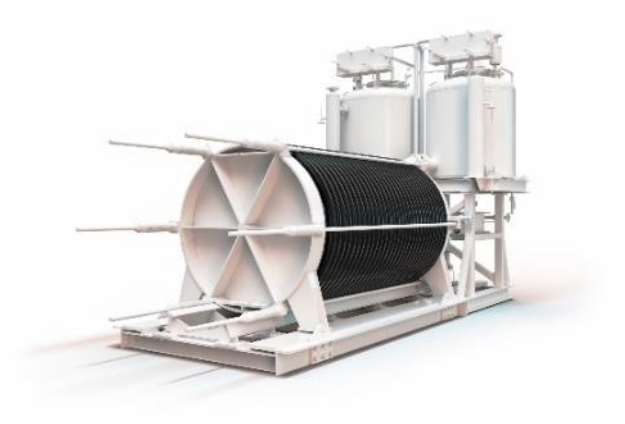
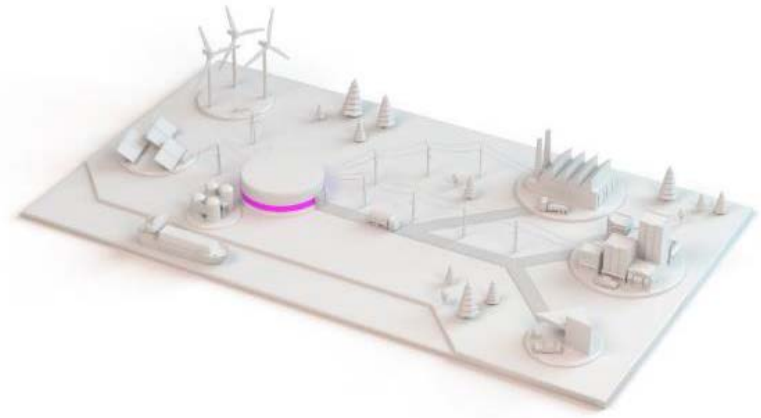
HYDROGEN ELECTROLYSERS



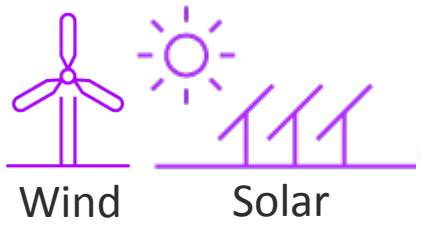
HYDROGEN FUELING

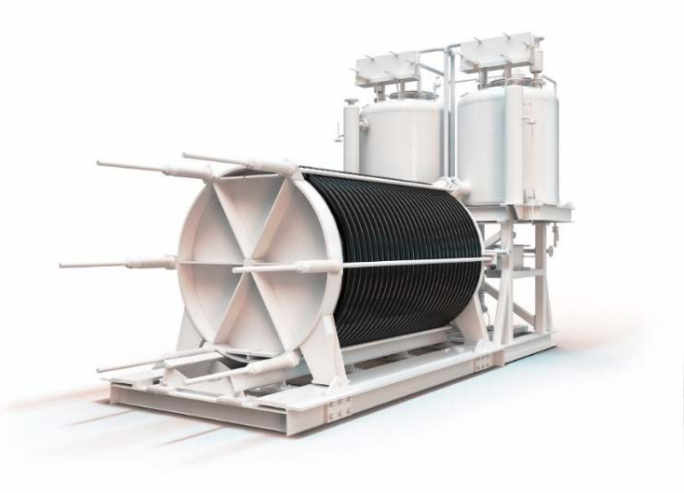
HYDROGEN SOLUTIONS



Nel Hydrogen – zero emission transport – no compromise

- Nel Hydrogen provides solutions for renewable production and fast fueling of hydrogen with long driving range.
- Enables zero emission transport based on renewable energy with the same convenience and performance as gasoline.





Electrolysers
Hydrogen production

H2Station®
Hydrogen fueling

Fuel Cell Electric Vehicle
<5 min. fueling 500+km range

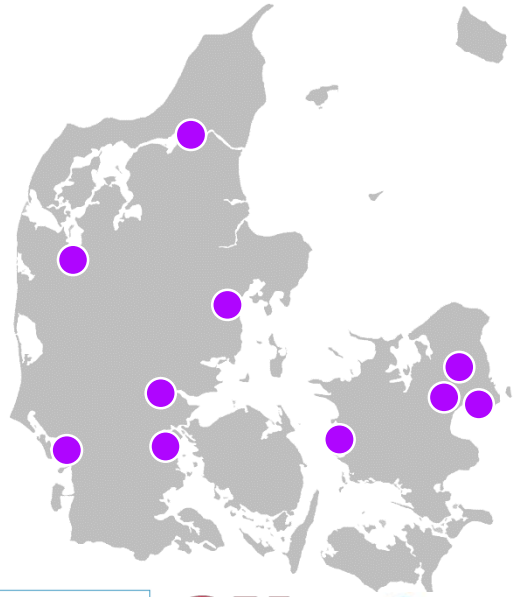
H2Station® for country-wide network roll-out

Nel Hydrogen has delivered more than 30% of 70MPa hydrogen fueling stations in Europe since 2011 – total 25 stations since 2003.

In Denmark and Norway Nel Hydrogen is deploying entire countrywide networks in collaboration with oil and gas companies.

DENMARK 2011-2016

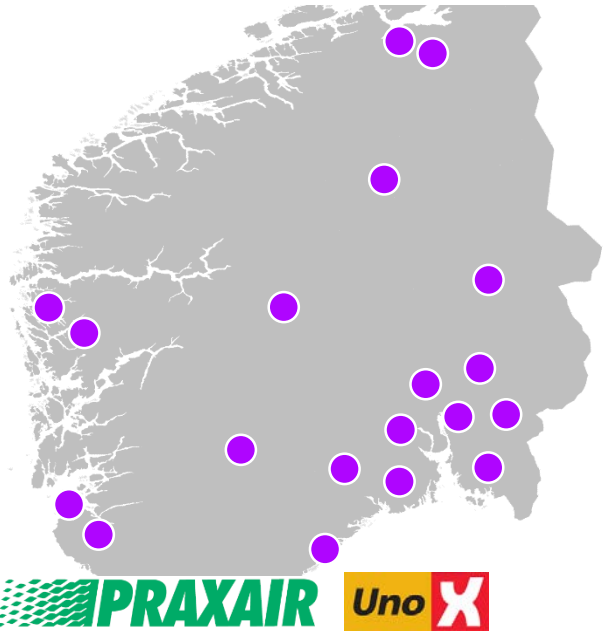
10 H2Station® &
Hydrogen production



AIR LIQUIDE OK STRANDMØLLEN

NORWAY 2016-2020

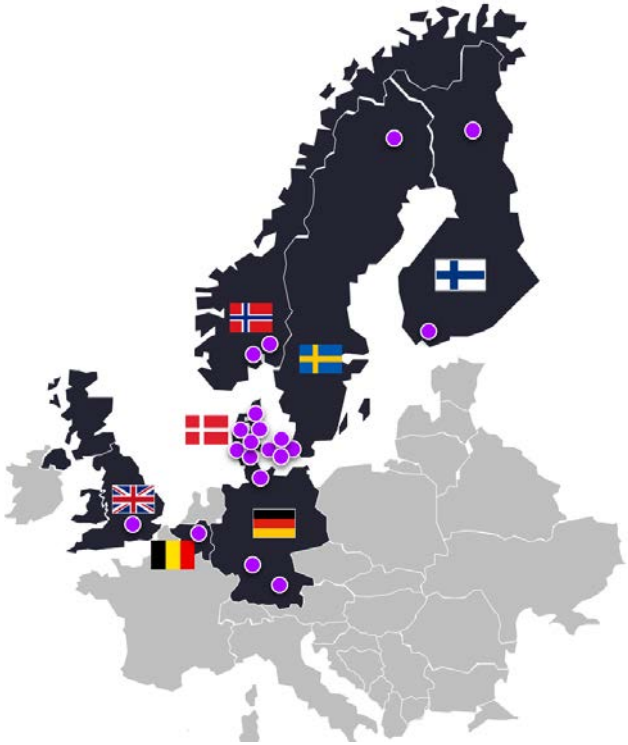
20 H2Station® &
Hydrogen production



PRAXAIR Uno X

EUROPE 30+% market share

More than 25 H2Station® since 2003



New H2Station® manufacturing facility – Herning DK

H2Station® manufactured at world's largest factory

300 H2Station® per year – sufficient for fueling 200.000 new FCEVs annually.

€9 million initial investment.

Renewables makes hydrogen competitive with gasoline

Renewables are undergoing substantial cost reductions.

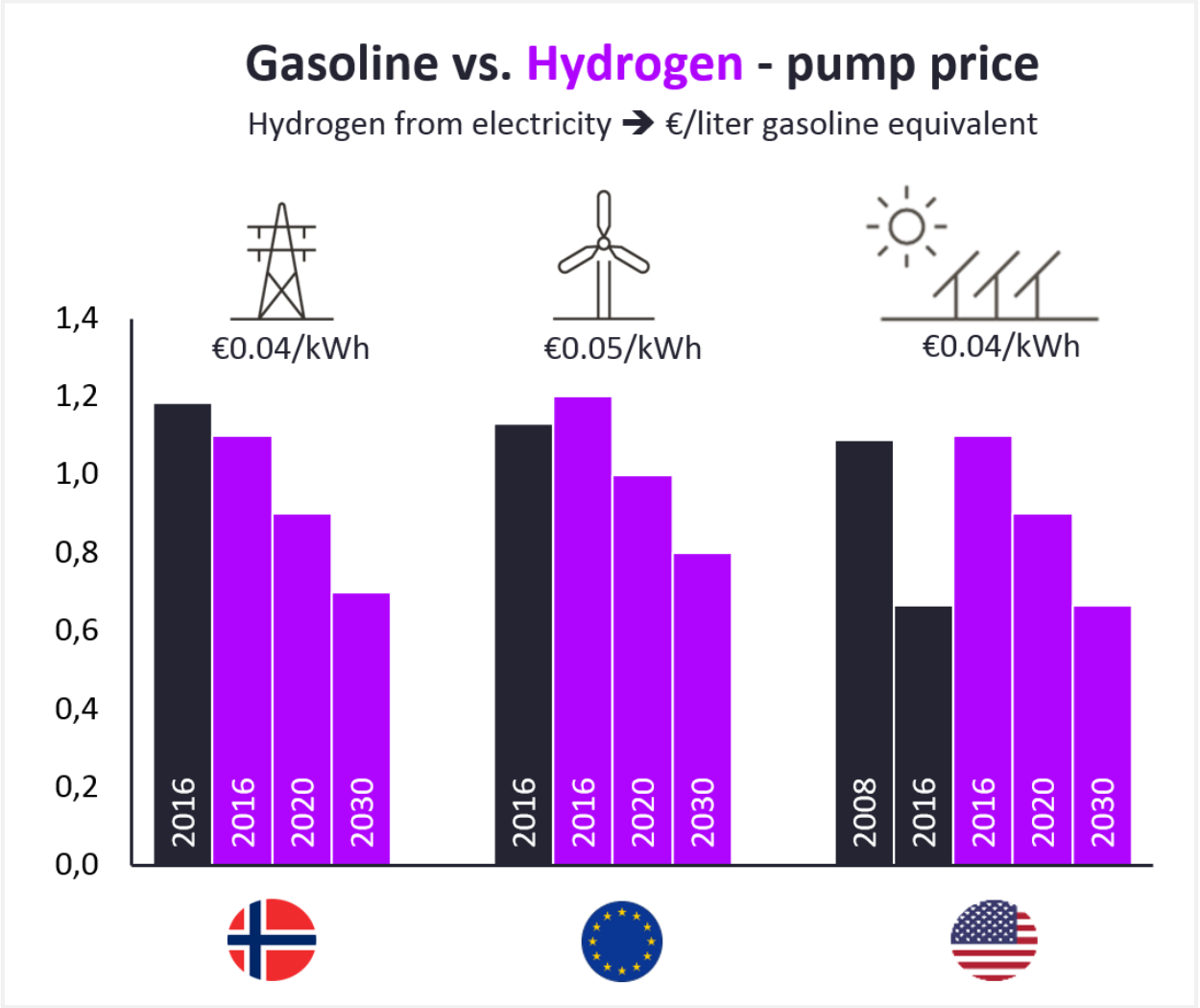
This makes hydrogen gradually competitive with gasoline:

- Norway: hydrogen based on grid electricity is 7% cheaper than gasoline at the pump already today (2016).
- Europe: hydrogen based on wind will be 11% cheaper than gasoline at the pump onwards 2020.
- California: hydrogen based on solar is on level with the peak gasoline price in 2008 and will gradually onwards 2030 close the gap towards todays low gasoline price.

The graph shows the achievable hydrogen pump price when covering variable and fixed costs including investments and excluding subsidies for centralized electrolysis, truck distribution and fueling equipment.

Achievable hydrogen pump price €/kg is converted to €/liter gasoline using fuel consumptions of 1kg H2/100km and 15km/liter gasoline – this represents price parity on a fuel cost €/km basis.

Electricity (used for hydrogen) and gasoline prices are including applicable energy taxes but excluding VAT and any subsidies. Electricity in Norway is average grid price and Wind (land based) in Europe and Solar electricity in California is Levelized Cost of Electricity (LCOE) excluding taxes.



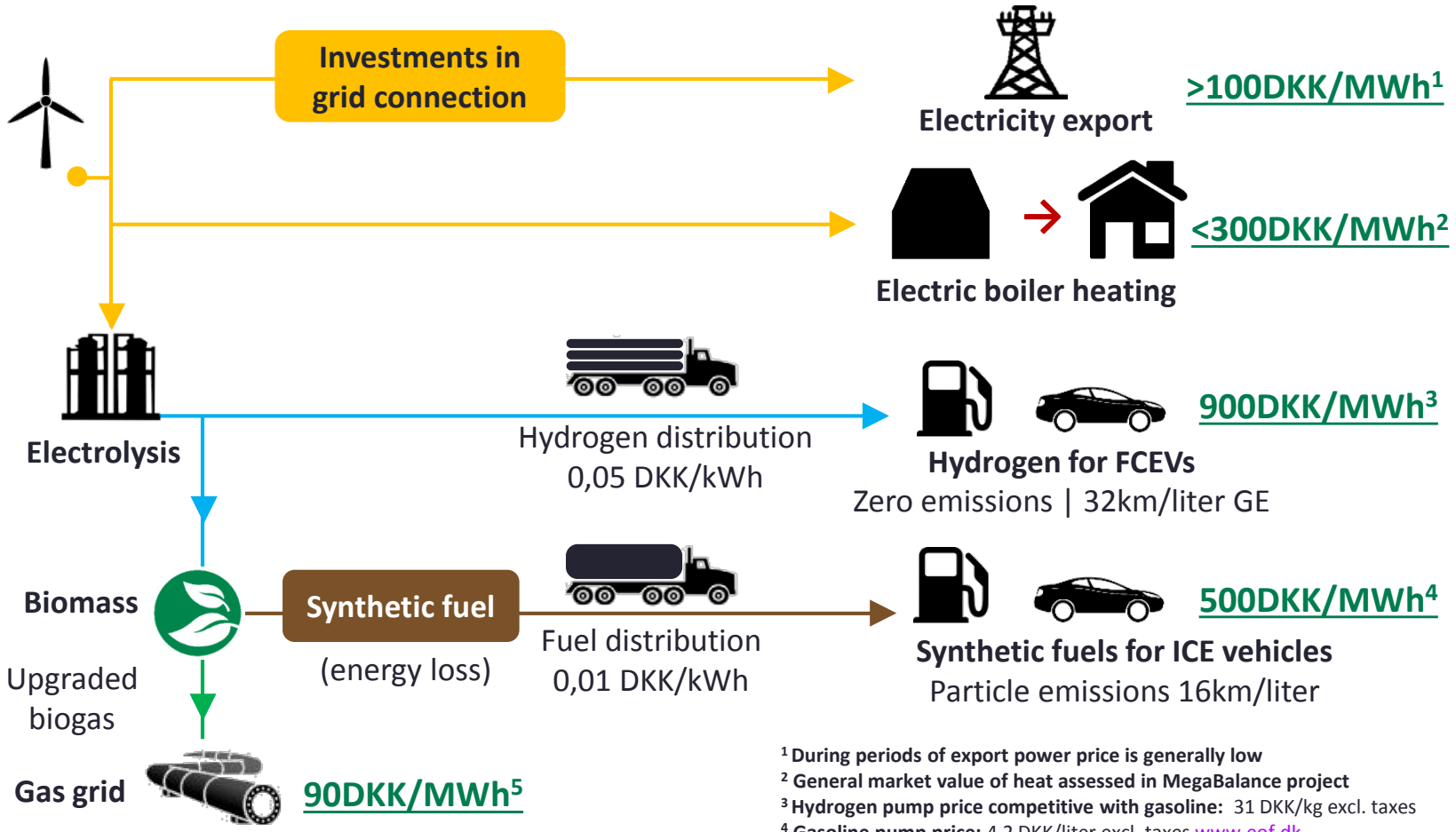
Renewable electricity will go for the highest bidder

Using renewable electricity for hydrogen fuel provides highest value.

- Export of electricity only achieves a low electricity price and requires investments in grid connections – similar to the cost of electrolysis.
- Heat: Only achieves a low value.
- Synthetic fuel vs. hydrogen:
  Using hydrogen in fuel production provides a lower value than direct use of hydrogen. Lower fuel distribution costs compared to hydrogen does not close the value gab. ICE vehicle efficiency is lower than FCEV and results in particle emissions.

Value of energy at consumption point - "Market willingness to pay"

DKK/MWh excluding taxes and subsidies – Denmark



[1] During periods of export power price is generally low
[2] General market value of heat assessed in MegaBalance project
[3] Hydrogen pump price competitive with gasoline: 31 DKK/kg excl. taxes
[4] Gasoline pump price: 4,2 DKK/liter excl. taxes www.eof.dk
[5] Natural gas grid price: 1,042 DKK/Nm3 www.gaspointnordic.com

New renewables to connect to grid or hydrogen?

New and unsubsidized renewable plants (RE) can avoid investments in grid connections when connecting directly to electrolysers.

Grid connections can account to up to 1/3 of the RE plant investment. The electrolyser investment is covered down-stream.

The higher value of hydrogen fuel compared to grid electricity – enables achieving of a higher electricity price for the RE plant.

CALIFORNIA

Investments in grid connection → **<$50/MWh**

Off-grid directly connected → **>$50/MWh**

DENMARK

Investments in grid connection → **<100-300 DKK/MWh**

Off-grid directly connected → **>300 DKK/MWh**

Fuel Cell Electric Vehicles are on the market

- **Major car manufacturers are developing Fuel Cell Electric Vehicles (FCEVs) and preparing market deployment.**
- **Hyundai, Toyota and Honda already started sales – more will follow in coming years among others Honda and Mercedes.**

- FCEVs run on hydrogen that is converted to electric power with zero emission.
- Hydrogen is fueled at conventional gas stations providing more than 400 miles range and fast fueling.
- Hydrogen can be produced from domestic natural gas or renewable electricity resources in the USA.

- **Learn more at: www.toyota.com/fuelcell or www.hyundaiusa.com/tucsonfuelcell or http://automobiles.honda.com/clarity**

Prices shown are for California, USA

$499/month lease

HYUNDAI

$349/month lease

TOYOTA

$369/month lease

HONDA

From 2018

Mercedes-Benz

Zero emission for the mass market without compromise

Zero emission has to match gasoline on price, range and fueling time to make it to the mass market.

Hyundai Accent $14.745
340 miles <5 min.

Audi A3 $31.200
530 miles <5 min.

Porsche Cayman $52.600
420 miles <5 min.

Market volume

VW E-Golf $28.995
83 miles >40 min.

Tesla 3 $35.000
215 miles >40 min.

Toyota Mirai $57.500
312 miles <5 min.

Tesla S-60 $66.000
218 miles >40 min.

Source: Vehicle prices in USA according to manufacturer website, excluding tax incentives to ensure fully societal commercial comparison – October 2016

Vehicle technology mass & performance is crucial for cost

Tesla Model S P100D

315miles 75 min.

100 kWh battery

~600kg

Toyota Mirai

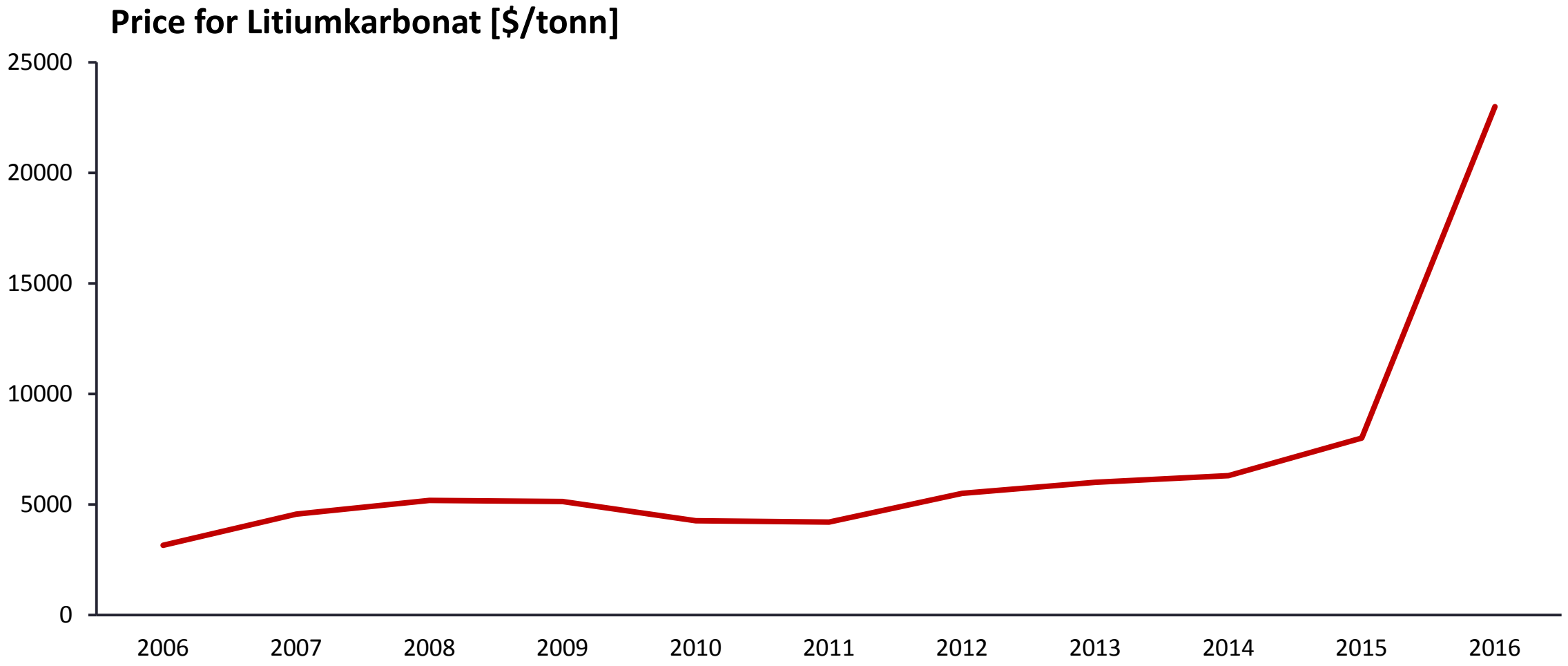
312miles <5 min.

Battery, Fuel Cell and Hydrogen tank

~200kg

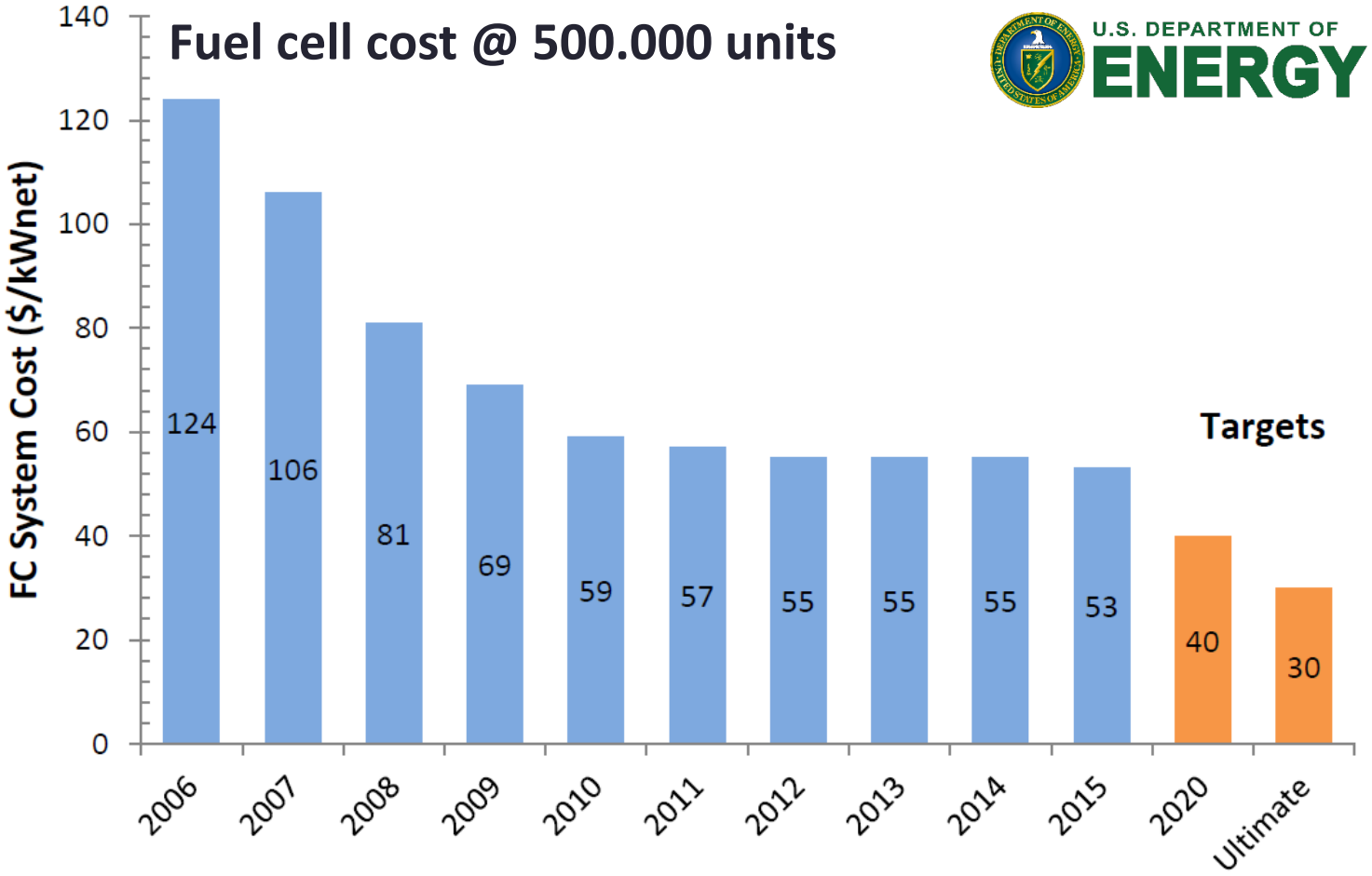
Source: Figures compiled based on public available specifications for the illustrated technologies

Technology mass is vulnerable to uncontrolled price fluctuation



Source: www.lithiumsite.com, Chilean lithium export prices, Asian Metal Inc.

Fuel cell cost reduction through scale and mass reduction



U.S. DEPARTMENT OF ENERGY

Source: https://www.hydrogen.energy.gov/pdfs/15015_fuel_cell_system_cost_2015.pdf

TOYOTA

2008 FUEL CELL STACK

1.4 kW/L

Weight	Volume	Power
-48%	-43%	+26%

2016 FUEL CELL STACK

3.1 kW/L

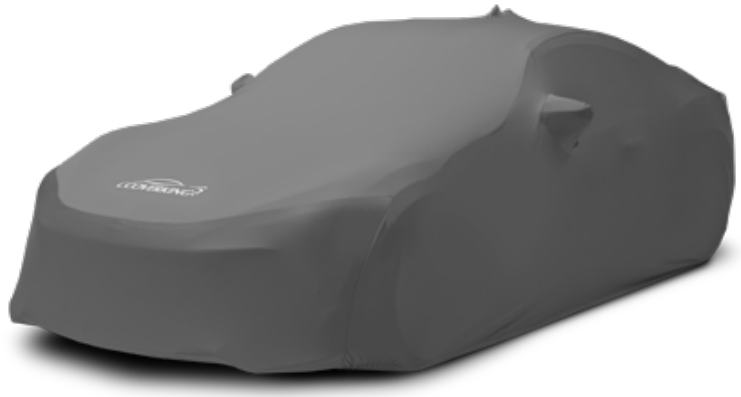
Making cheap zero emission vehicles – future best case

Batteries cheapest <200km range.

Hydrogen cheapest >200km range.

<u>Both technologies are relevant in each their market segment.</u>

Technology price & performance are the future best case for both batteries and hydrogen.



	Fuel Cell Electric Vehicle			Battery Electric Vehicle		
Fueling time	**5 min.**			**>40 min.**		
Driving range	**1.000km**	**500km**	**200km**	**1.000km**	**500km**	**200km**
H2 tank / battery size	8kg	4kg	1,6kg	120kWh	60kWh	22kWh
Base vehicle price*	€20.000	€20.000	€20.000	€20.000	€20.000	€20.000
Battery, fuel cell & H2 tank cost	€4.000	€3.000	€2.400	€10.800	€5.400	€2.000
Total vehicle price	**€24.000**	**€23.000**	**€22.400**	**€30.800**	**€25.400**	**€22.000**

**EU CONCAWE C-Segment vehicle*
Figures rounded for simplicity

55kW fuel cell @ €27/kW - US DOE target.
1kWh hybrid battery @ €525/kWh.
€240/kg H2 storage - US DOE target.

€90/kWh battery price - US DOE target.

Rate of turn-over makes the infrastructure business case

Hydrogen fueling achieves 3,5 x Sales turn-over as Battery charging during 12 hours – due to difference in fueling time.

Hydrogen achieves a full tank in 5 minutes – whereas Batteries achieve only 80% charge in 40 minutes.

The "convenience cost" of fast hydrogen fueling is an additional energy loss of 5% compared to fast charging.

	"NORMAL FAST" FUELING <5 minutes | 15% energy loss	**"SUPER FAST" CHARGING 80%** 40 minutes | 10% energy loss
Driving range	**312 miles (5kg H2)**	**252 miles (80kWh)****
Max. vehicles served in 12 hours	50	18
Time utilization of hose/plug	34% (50 fuelings of 5 minutes)	100% (18 charges of 40 minutes)
Pump price*	$6,24/kg	$0,315/kWh
12 hour $ turn-over	**$1.560**	**$453**

** Matching gasoline on fuel cost per driven mile in the US – compared to a gasoline vehicle with 28 miles per gallon and a gasoline price of $2,8 per gallon.*

*** 80% charging increases the potential turn-over – the remainder 20% charge takes more time.*

BEV vs. FCEV infrastructure for 1.500 vehicles in Denmark

BEV infrastructure requires more than 2 x investments of an FCEV infrastructure – due to cost of grid connections.

Connecting hydrogen production directly to renewables without grid connections – further reduces infrastructure costs.

1.500 vehicles / year

1.500 x

Home Charger
16Amps

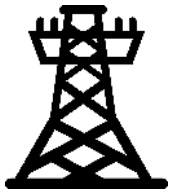
150 x

Public Charger
160Amps

Infrastructure cost: €1.000 / vehicle

€7,7 million
>40 min. fueling time

48.000 Amps



600-3.000 Amps

€130/Amps

1 x

Production
2400 Amps

Fueling
600 Amps

Infrastructure cost: €2.000 / vehicle

€3,1 – 3,4 million
<5 min. fueling time

Denmark – integrating **wind** with transport

100% fossil independence by 2050 | 50% BEVs and 50% FCEVs.

BEVs require 2,5 x the infrastructure investment compared to FCEVs.

Hydrogen production connected directly to wind (no grid connection).

Battery charging is both home (slow) and public (fast) charging.

Grid connection investment is fixed at €130/Amps across Denmark.

	Hydrogen <5 min.	Charging >40 min.
Car fleet	**1,5 million**	**1,5 million**
No. of stations / chargers	1.000	Home: 1.500.000 Public: 150.000
Grid connection required	0,6 million amps	48 million amps
Grid connection investment	€0,1 billion	€6,2 billion
Infrastructure investment	€3 billion	€1,5 billion
Total investment	**€3,1 billion**	**€7,7 billion**
	600Amps/Station. 1700MW Electrolysers are connected directly to wind. €2.000/car infrastructure cost €130/Amps grid connection	16A home charger 160A public charger €1.000/car infrastructure cost €130/Amps grid connection

California – integrating **solar** with transport

100% fossil independent transport: 50% BEVs and 50% FCEVs.

BEVs require 4 x the infrastructure investment compared to FCEVs.

Hydrogen production is connected directly to solar (no grid connection).

Grid connection cost in California is ~2 x that of Denmark (€/Amps).

Electricity cost in the city is 4 x that at solar plants in the dessert.

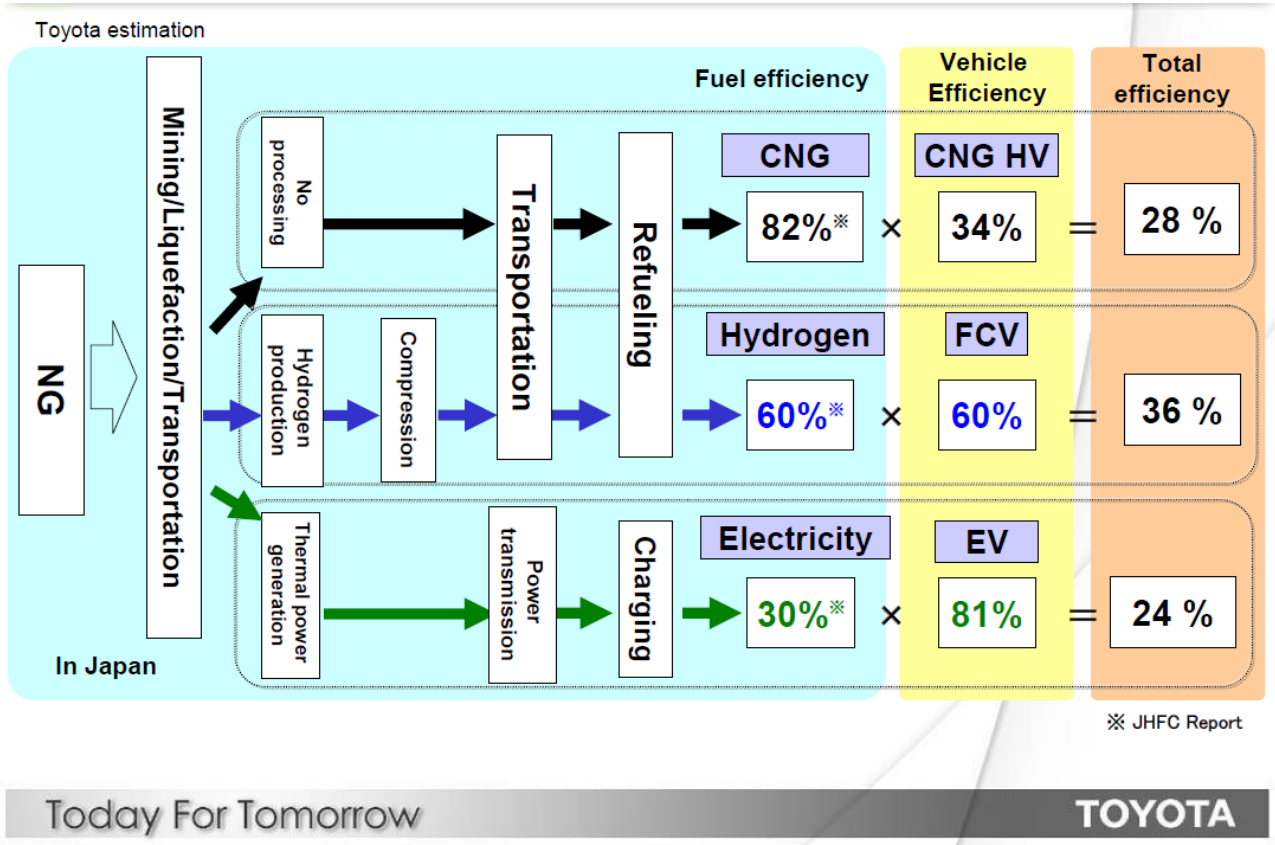
	Hydrogen <5 min.	Charging >40 min.
Car fleet	**15 million**	**15 million**
No. of stations / chargers	10.000	Home: 15.000.000 Public: 1.500.000
Grid connection required	6 million amps	480 million amps
Grid connection investment	€1,5 billion	€125 billion
Infrastructure investment	€30 billion	€15 billion
Total investment	**€31,5 billion**	**€140 billion**
	600Amps/Station. 17.000MW Electrolysers are connected directly to solar. €2.000/car infrastructure cost €260/Amps grid connection	16A home charger 160A public charger €1.000/car infrastructure cost €260/Amps grid connection

Japan – integrating **natural gas** with transport

Japan has limited potential for renewable electricity and nuclear is challenging.

Replacing imported oil with natural gas is needed if transport is to become cleaner.

Based on natural gas FCEVs are more efficient than BEVs - Well-To-Wheel.



Source: Katsuhiko Hirose, Toyota Motor Corporation, 2011

End of presentation

Thank you for your attention

Questions?

www.nelhydrogen.com

Number one by nature