Why hydrogen is important

Bjørn Simonsen
VICE PRESIDENT MARKET DEVELOPMENT AND PUBLIC RELATIONS

Next generation EV

800 km range
0 – 100% charge < 5 minutes
10 year | 160,000 km lifetime*
Excellent cold weather performance
Cleans the surrounding air**

nel

*lifetime defined as 10% degradation of fuel cell stack
**Filters around 500 liter air per km driven

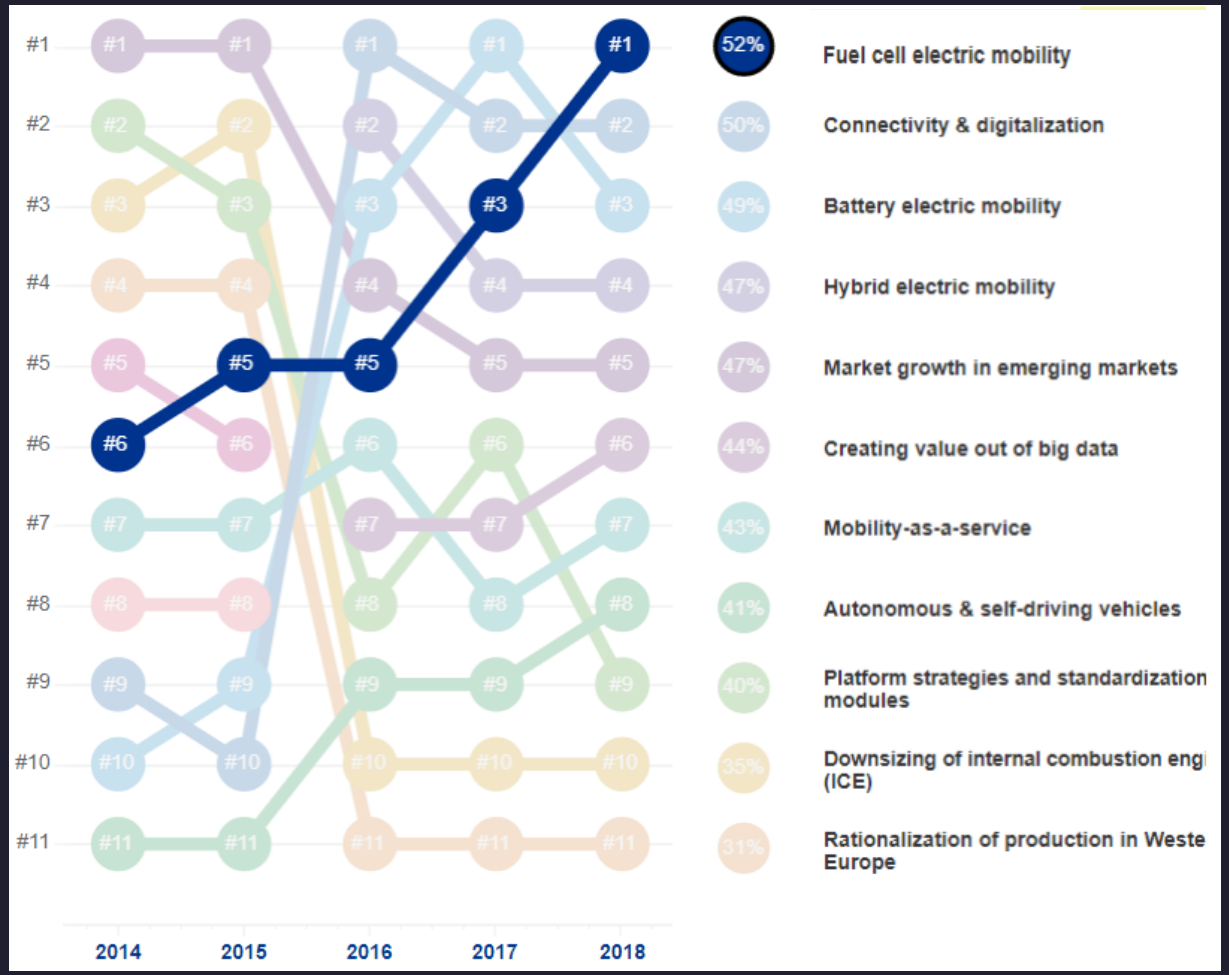
Next generation EV

H_2

nel

Photo: Hyundai

KPMB Global Automotive Executive Survey 2018



Compound input from 1000 executives from the automotive industry

KPMG

Fuel cell electric mobility is now the #1 trend until 2025

"There will not be a single solitary drivetrain technology: Executives project a split by 2040 for BEVs (26%), FCEVs (25%), ICEs (25%) and hybrids (24%)."

nel

Fuel cell development over the last decade

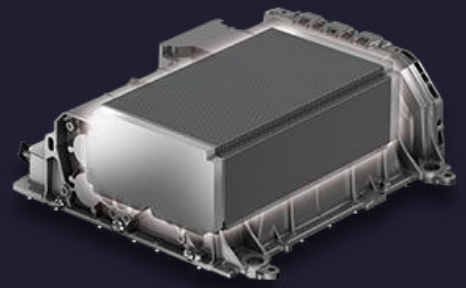
2008 FUEL CELL STACK (Toyota)
1.4 kW/l

WEIGHT
-48%

VOLUME
-48%

POWER
+26%

2014 FUEL CELL STACK (Toyota)
3 kW/l

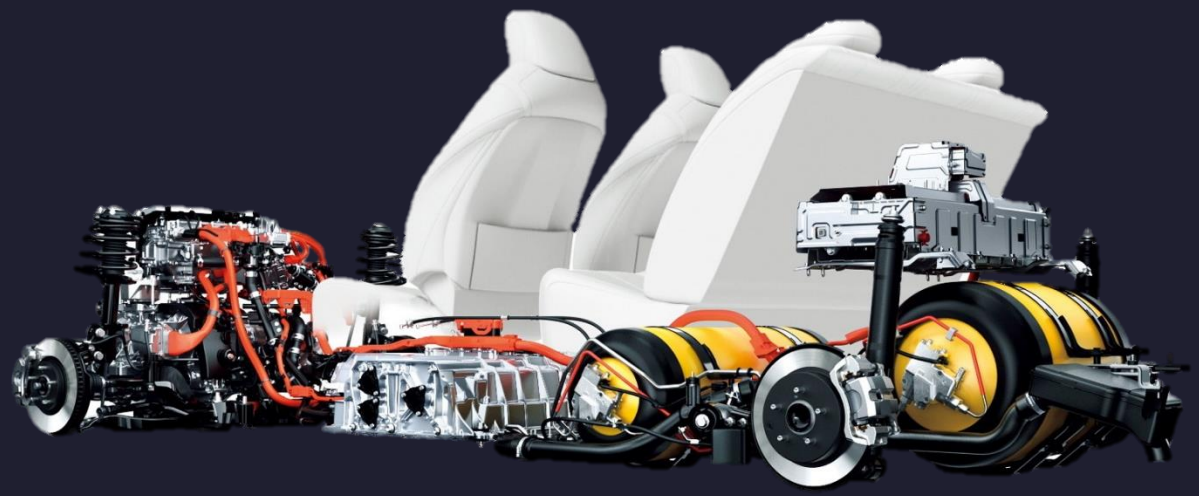


- Today, same size as an internal combustion engine – still large room for improvement
- **>90% cost reduction** between 2008 and 2014
- **Electrical efficiency >65%**
  - Produces heat – used to heat vehicle -> more weather-robust range
- Uses platinum, but levels are close to conventional catalytic converters
  - No other rare metals used

nel

Photo: Toyota

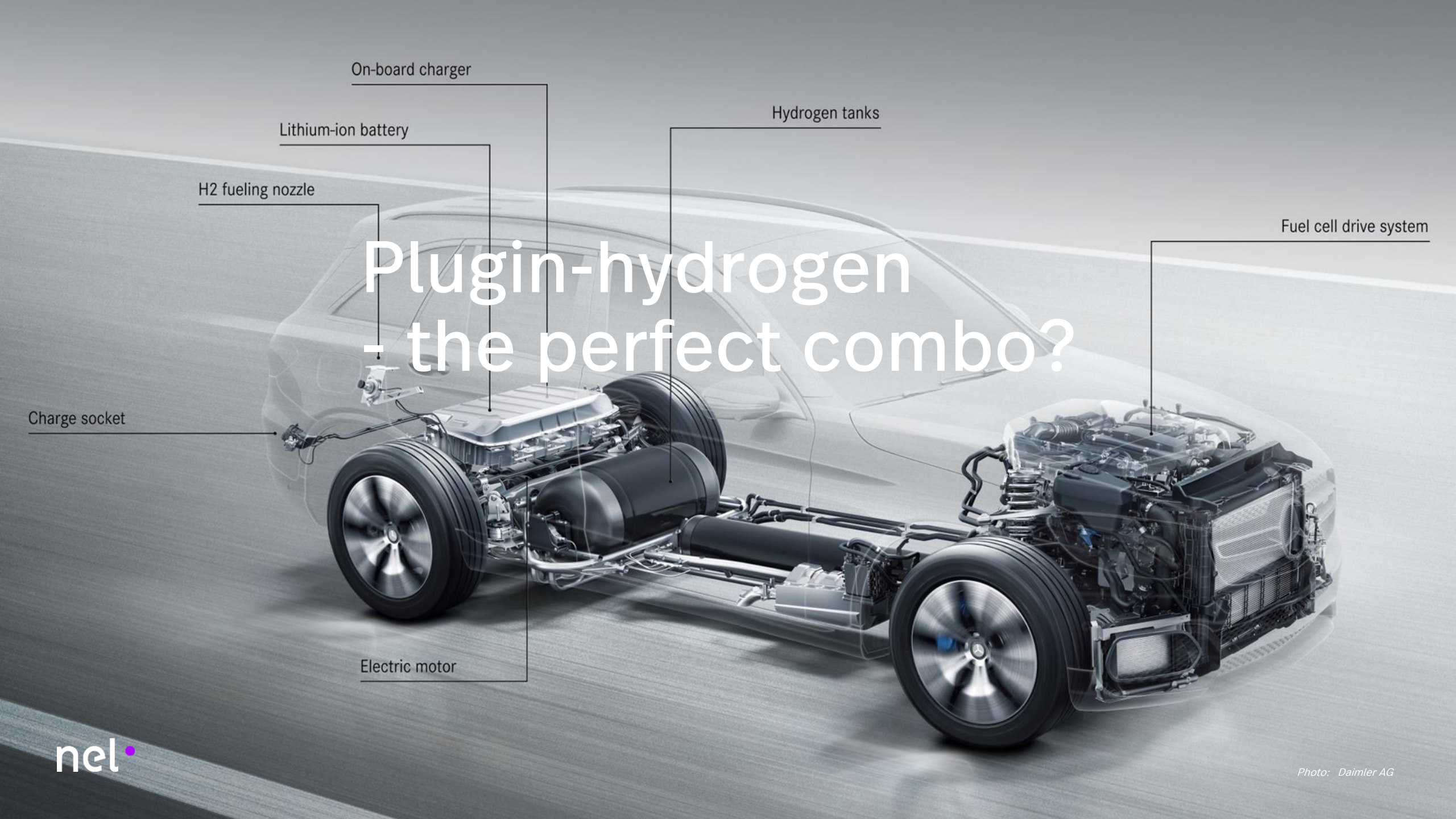
FCEV = Fuel Cell **Electric Vehicle**



- 500 - 800 km in 3 - 5 minutes (0 - 100% fill)
  - Equivalent to ~4000 kW (fast charging, ludicrous mode)
  - Does not draw power from the grid while filling/charging
- One, global standard for filling any fuel cell electric vehicle
- Total weight of battery, fuel cell and hydrogen tanks: ~200kg
- Target cost, system (fuel cell + tanks): ~5000 $/car

nel

Photo: Toyota



Plugin-hydrogen - the perfect combo?

nel

Photo: Daimler AG

6000 passenger FCEVs deployed by end 2017

Formidable cost reductions enable mass market introduction:

- Toyota foresees additional 50% cost reduction on key components for the launch of their next generation FCEV in 2020 while ramping up production to 30,000 units/year*
- By 2021, 10 brands will be selling FCEVs**

HYUNDAI

TOYOTA

HONDA

HYUNDAI

Audi

NISSAN

Ford

GM

BMW

2014 | 2015 | 2016 | 2018 | 2020 - 2025

nel

*Source: Nikkei Asian Review, jan'18
**Source: Information Trends, nov '17

Commercial introduction of BEVs and FCEVs

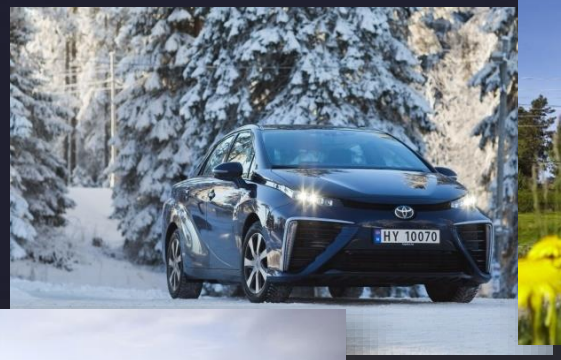
GM EV1 - 1996

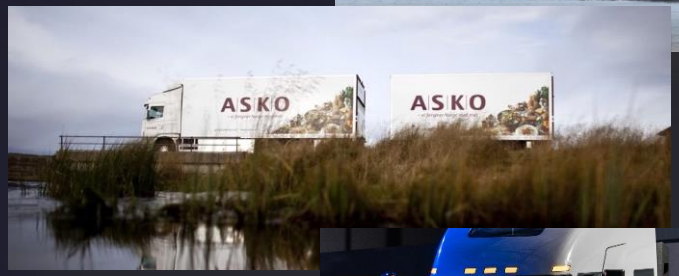
Hyundai ix35 - 2014

nel

Photo: GM and Hyundai

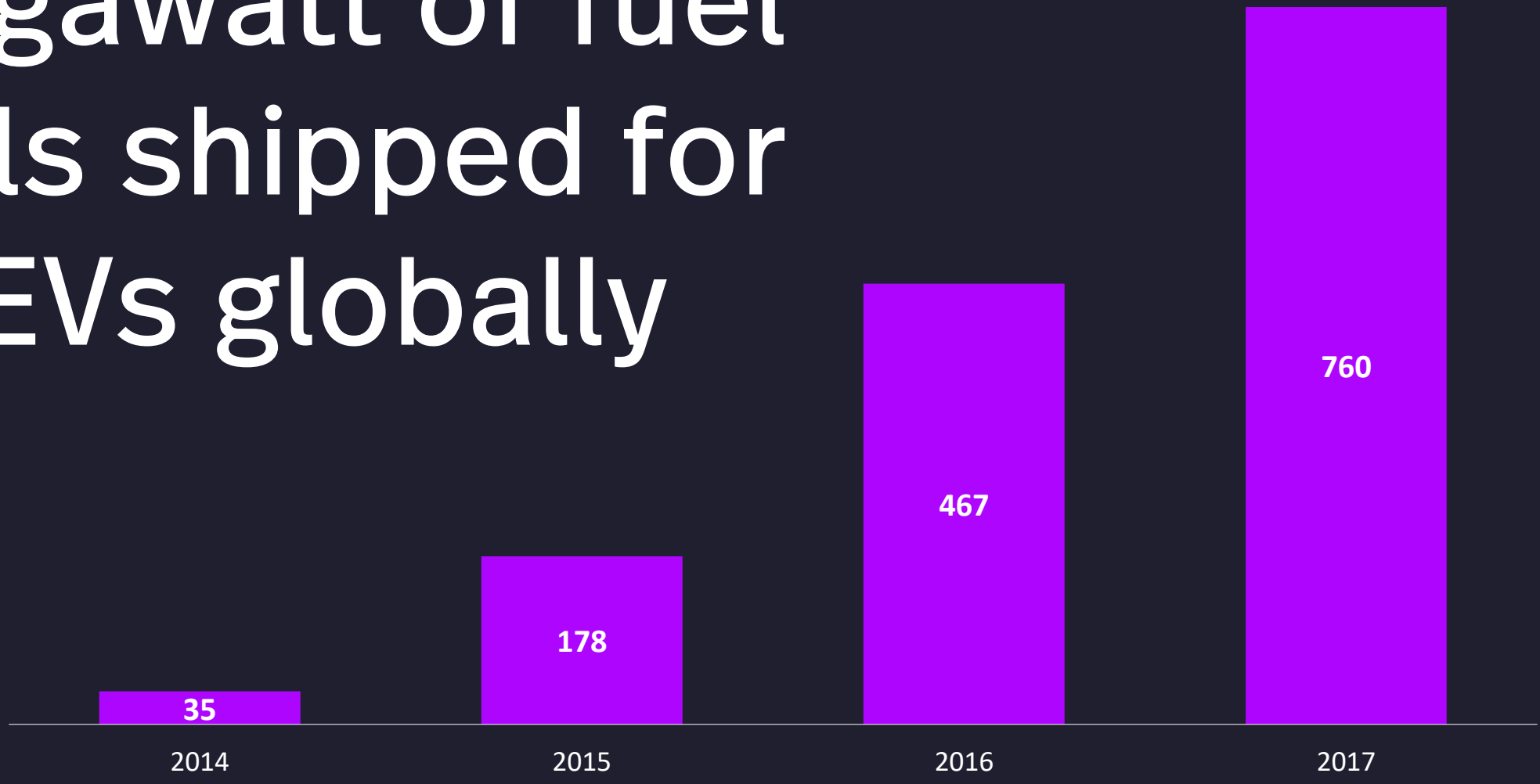
FCEVs come in all shapes and forms





nel

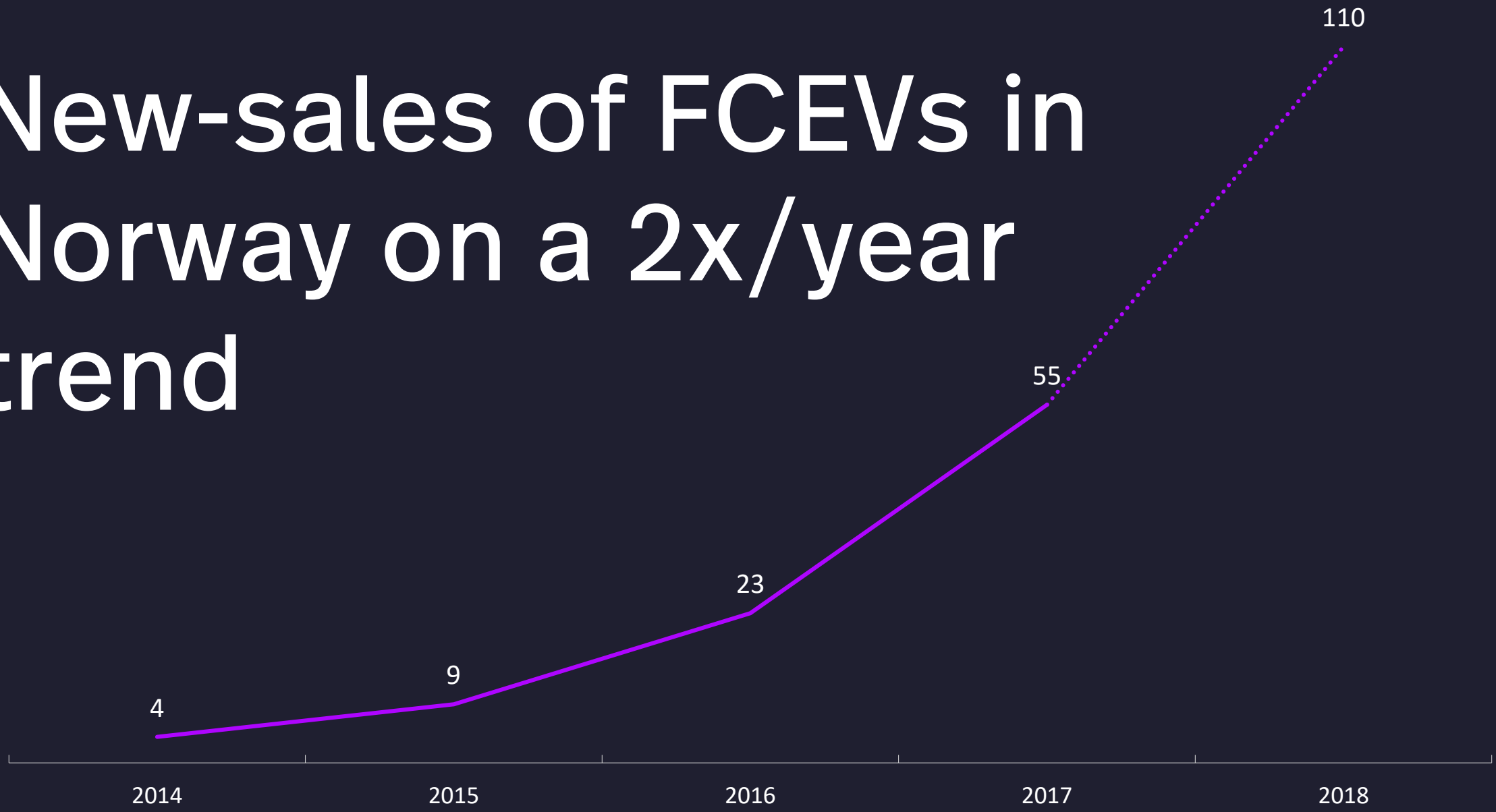
Megawatt of fuel cells shipped for FCEVs globally



A passenger FCEV typically has a 100 kW fuel cell

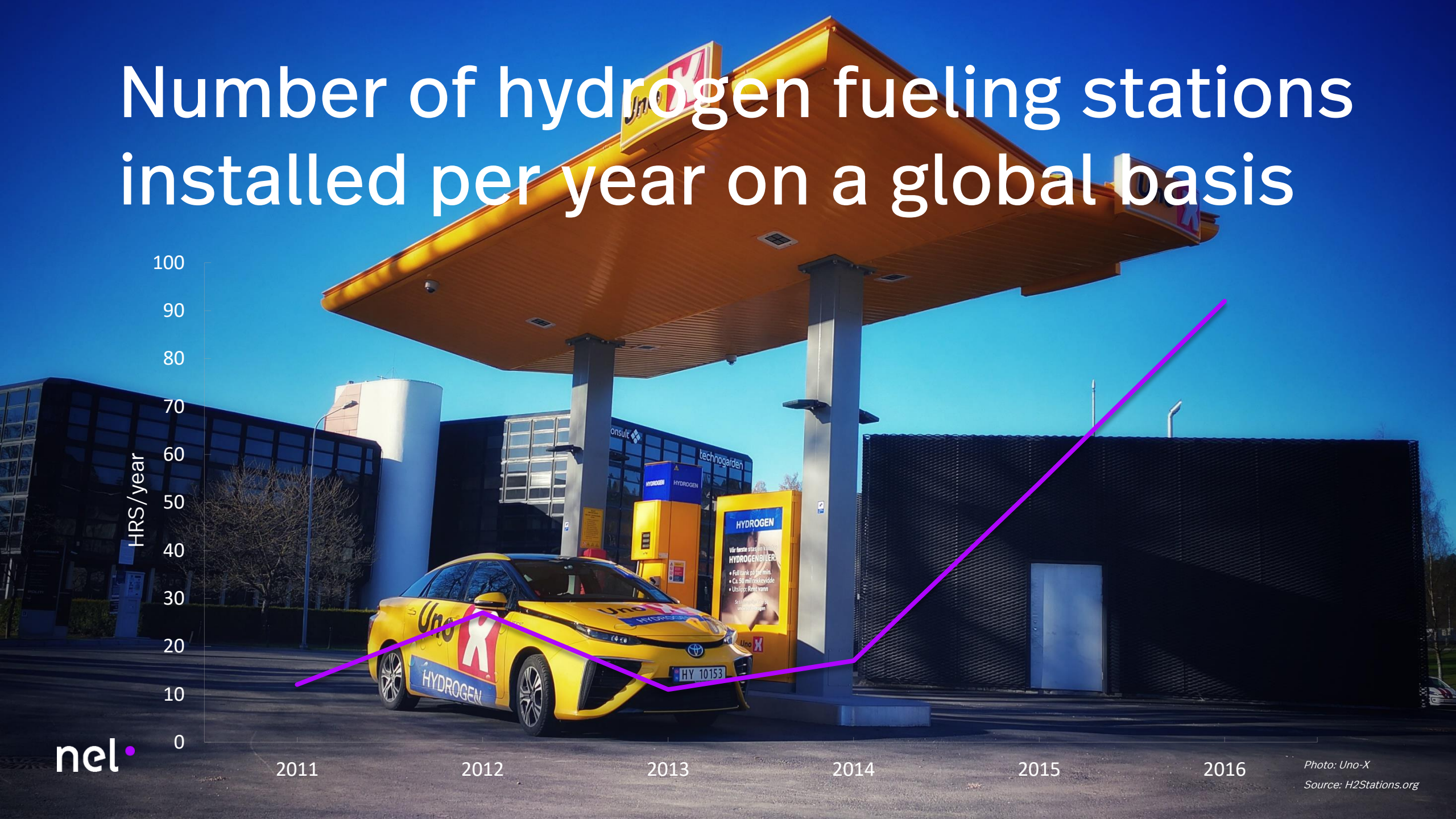
Source: 4th Energy Wave

New-sales of FCEVs in Norway on a 2x/year trend



Source: OFV.no for 2014-2017
Own estimate for 2018 based on current trend

Number of hydrogen fueling stations installed per year on a global basis

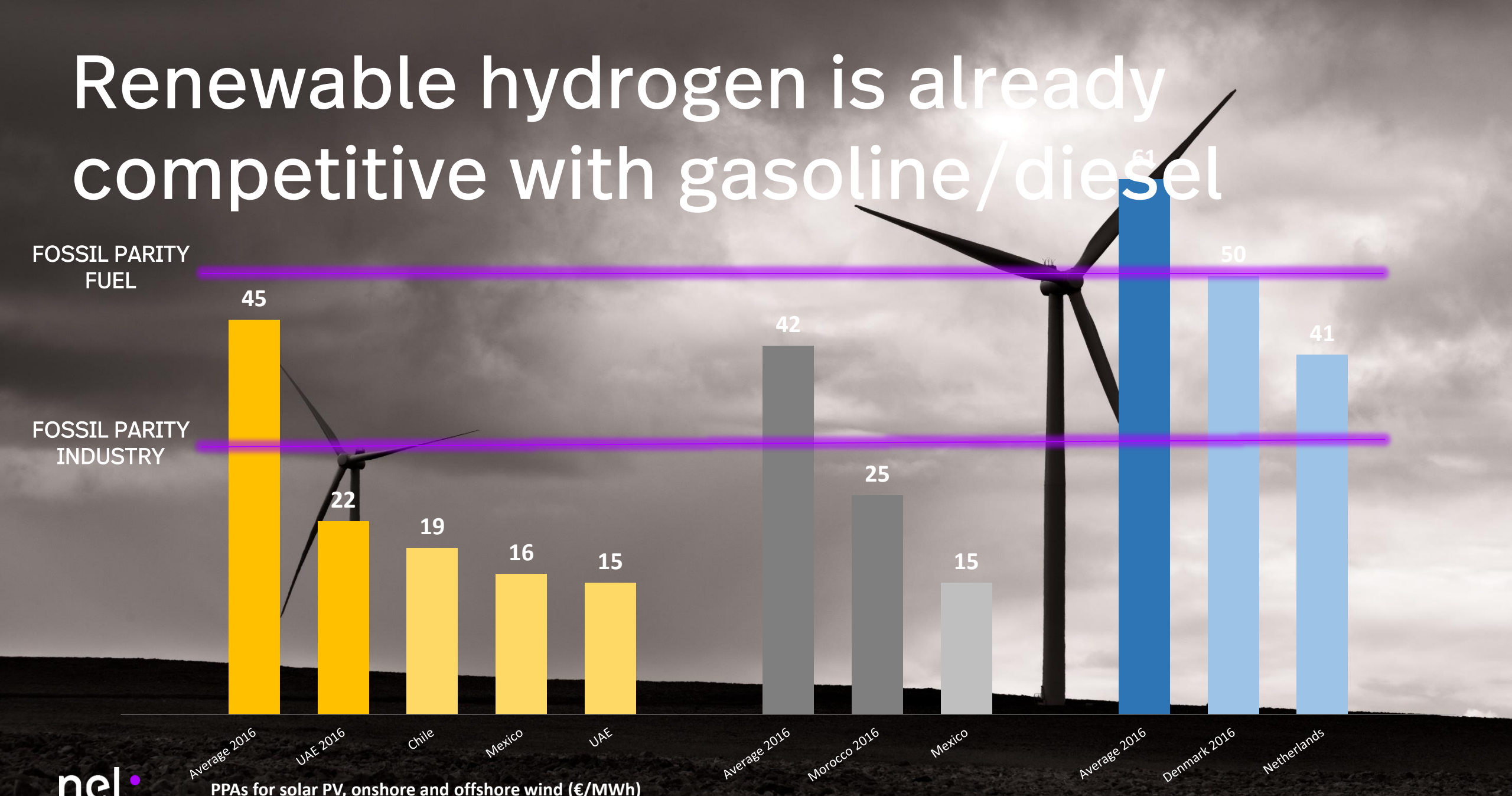


nel

Photo: Uno-X

Source: H2Stations.org

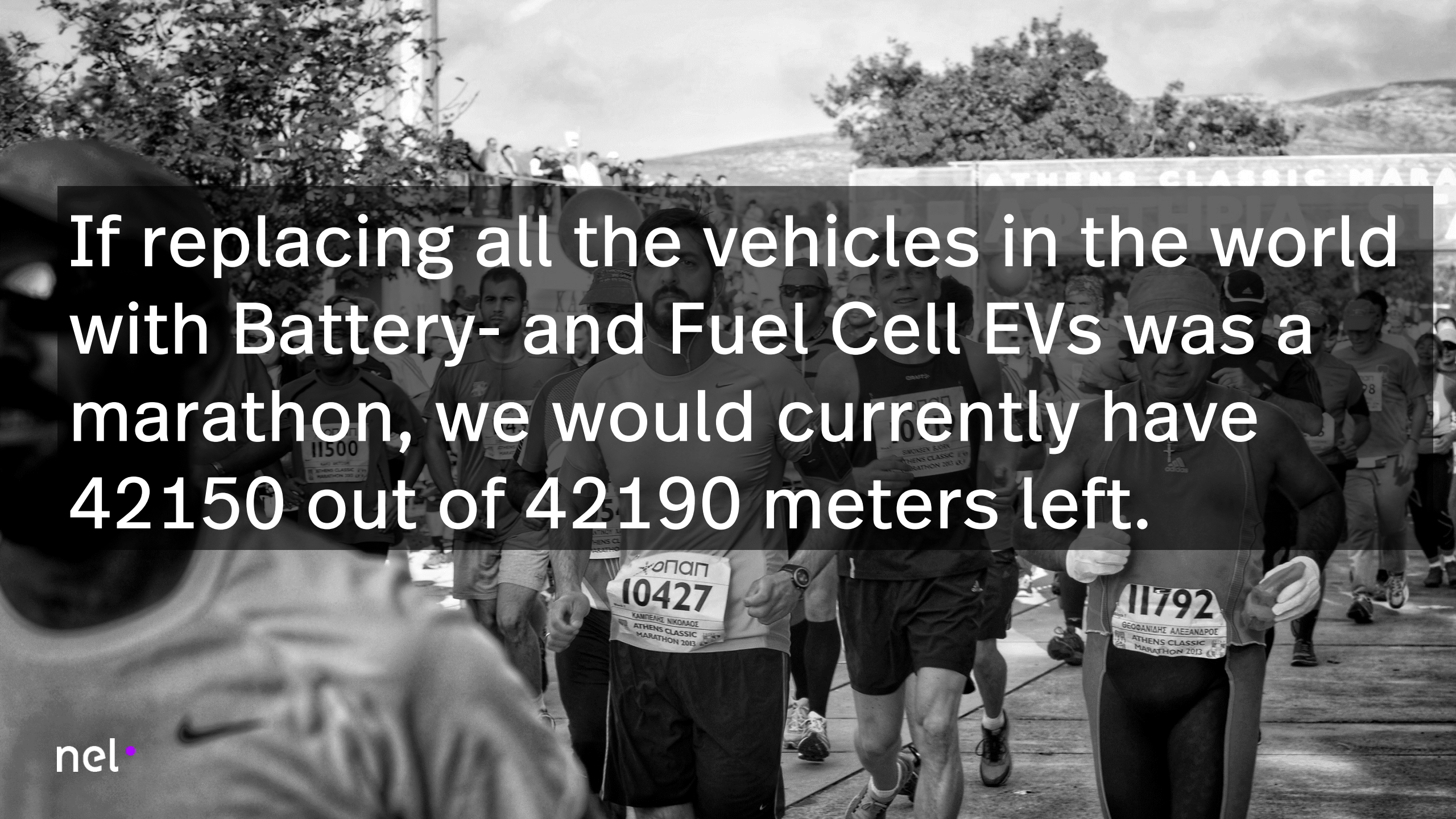
Renewable hydrogen is already competitive with gasoline/diesel



PPAs for solar PV, onshore and offshore wind (€/MWh)

At an electricity price of 30 €/MWh, hydrogen will be produced at 1.5 €/kg – one kg of hydrogen takes you at least 100 km

Photo: Varanger kraft AS



If replacing all the vehicles in the world with Battery- and Fuel Cell EVs was a marathon, we would currently have 42150 out of 42190 meters left.

nel

Summary

Tremendous technology development and cost reductions have triggered commercial introduction of FCEVs late 2014 – currently on a ~2x/year trajectory.

- Complements BEVs and enables exchanging all vehicles, small and large to EV technology
- FCEVs are currently #1 trend toward among car manufacturers toward 2025
  - Car manufacturers see equal shares of BEVs and FCEVs in 2040
- Hydrogen to fuel the FCEVs can be produced from renewable energy at a comptetitive price with gasoline and diesel today
- Presently 0.25% of passenger vehicles and 0.075% of vehicles in general have been converted to EVs

nel