

# Hydrogen Solutions and Technology

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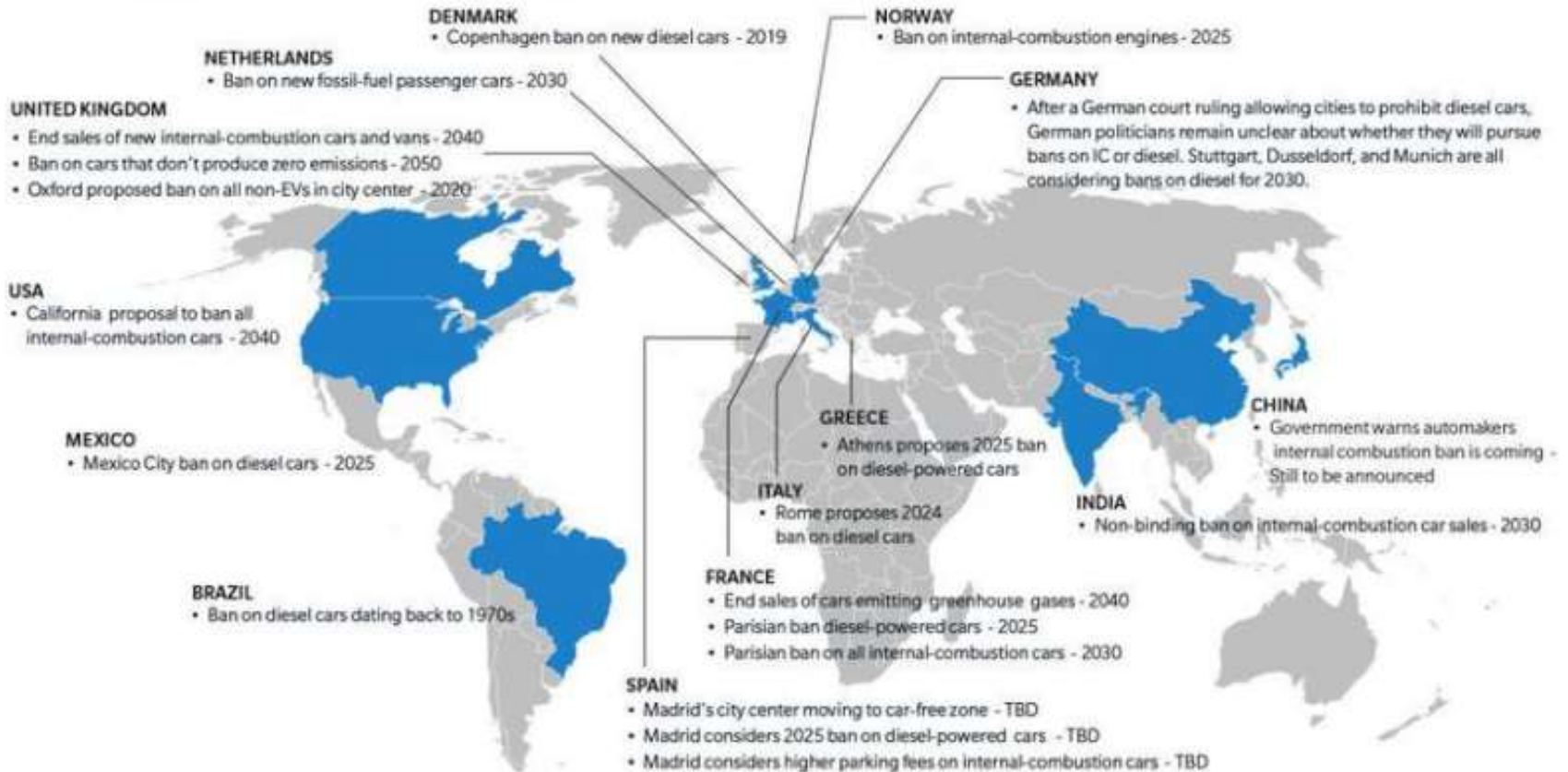
*12<sup>th</sup> March 2019*

# The world is changing...

## GOVERNMENTAL BANS THAT STEER CAR OWNERS TO ELECTRIC VEHICLES

A global snapshot of restrictions enacted or being considered to prohibit internal combustion-powered cars entirely or the sale of new ones

### COUNTRIES BANNING OR CONSIDERING A BAN ON INTERNAL-COMBUSTION (IC) VEHICLES



Source: Forbes/Oliver Wyman

# So why hydrogen?

- H<sub>2</sub> is an **energy carrier**, is converted to water which has minimal environmental impact
- H<sub>2</sub> is a **non-polluting fuel at use point** for transportation vehicles and power production
- H<sub>2</sub> allows **connection of the transportation and electrical infrastructure**
- H<sub>2</sub> can be used as a **mechanism for energy storage** both for intermittent renewables and larger systems
- H<sub>2</sub> can allow traditional energy production mechanisms to become **carbon capture ready**
- H<sub>2</sub> can be produced via multiple feedstocks meaning **local production** rather than importation is possible
- H<sub>2</sub> 'well-to-wheel' energy system analysis shows **more efficient** use of natural resources

# Hydrogen: a flexible, sustainable future



## Energy Source

- Natural Gas
- Biomass
- Crops
- Organic Waste
- Renewables
- Wind, Wave, Solar
- Waste Materials
- Coal, oil
- Nuclear



## Hydrogen Production

- Steam reforming
- Gasification
- Electrolysis
- Thermolysis
- Photolysis
- Off Gas



## Distribution

- Pipelines
- Compressed gas trailers
- Cryogenic liquid tankers
- Ship
- Rail



## Hydrogen Station

- Hydrogen Refuelling Station



## End Use

- Vehicle fuel cell
- Stationary fuel cell
- IC Engine
- Portable fuel cell

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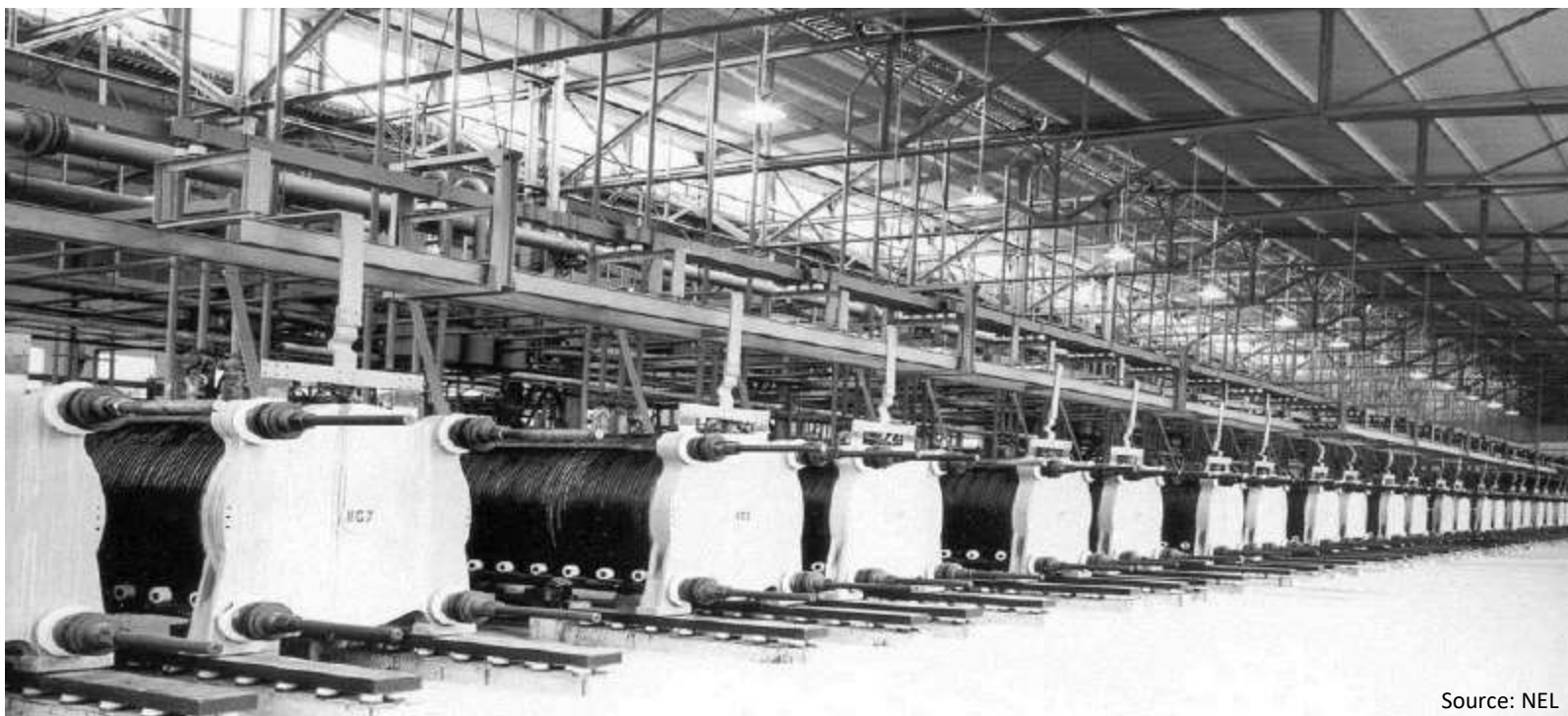
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# Rapid Response PEM Electrolyser



Modular to 2-10MW  
Bespoke to 60-120MW  
Responds in seconds  
Ramp to 200% output  
Compresses to 35 bar  
99.999% pure hydrogen

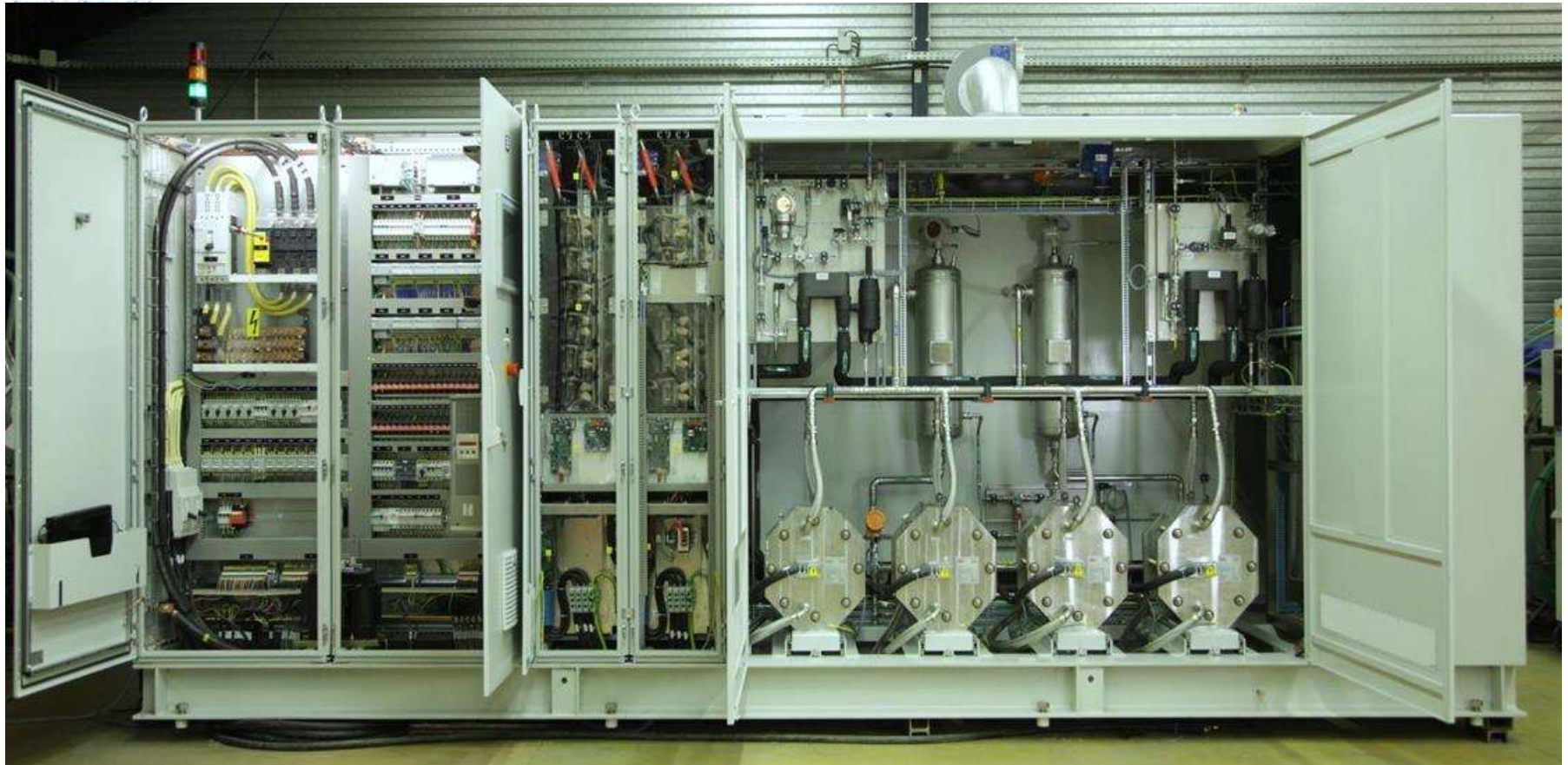
# Electrolysers: Not new for industry..



Source: NEL



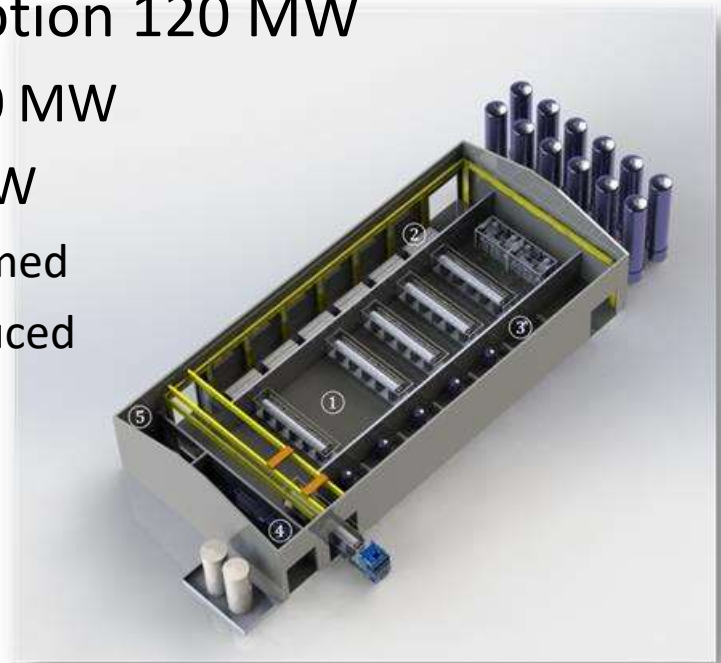
# Electrolysers: up to 10MW in one box



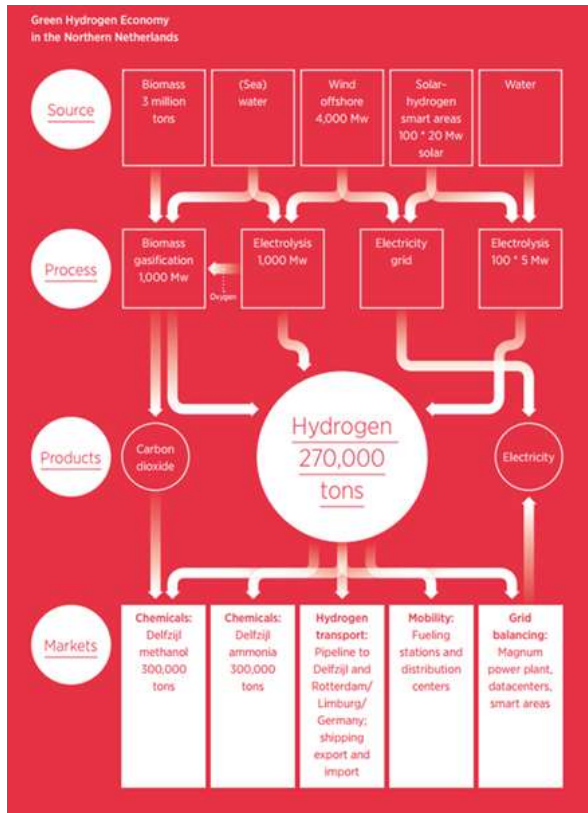
# Electrolysers: Bespoke designs up to 120MW

PEM Electrolyser, peak consumption 120 MW

- Primary storage capacity to 120 MW
- Standard operating mode 60MW
  - c.500 GWh/year of power consumed
  - up to 10500 MT/year of H2 produced

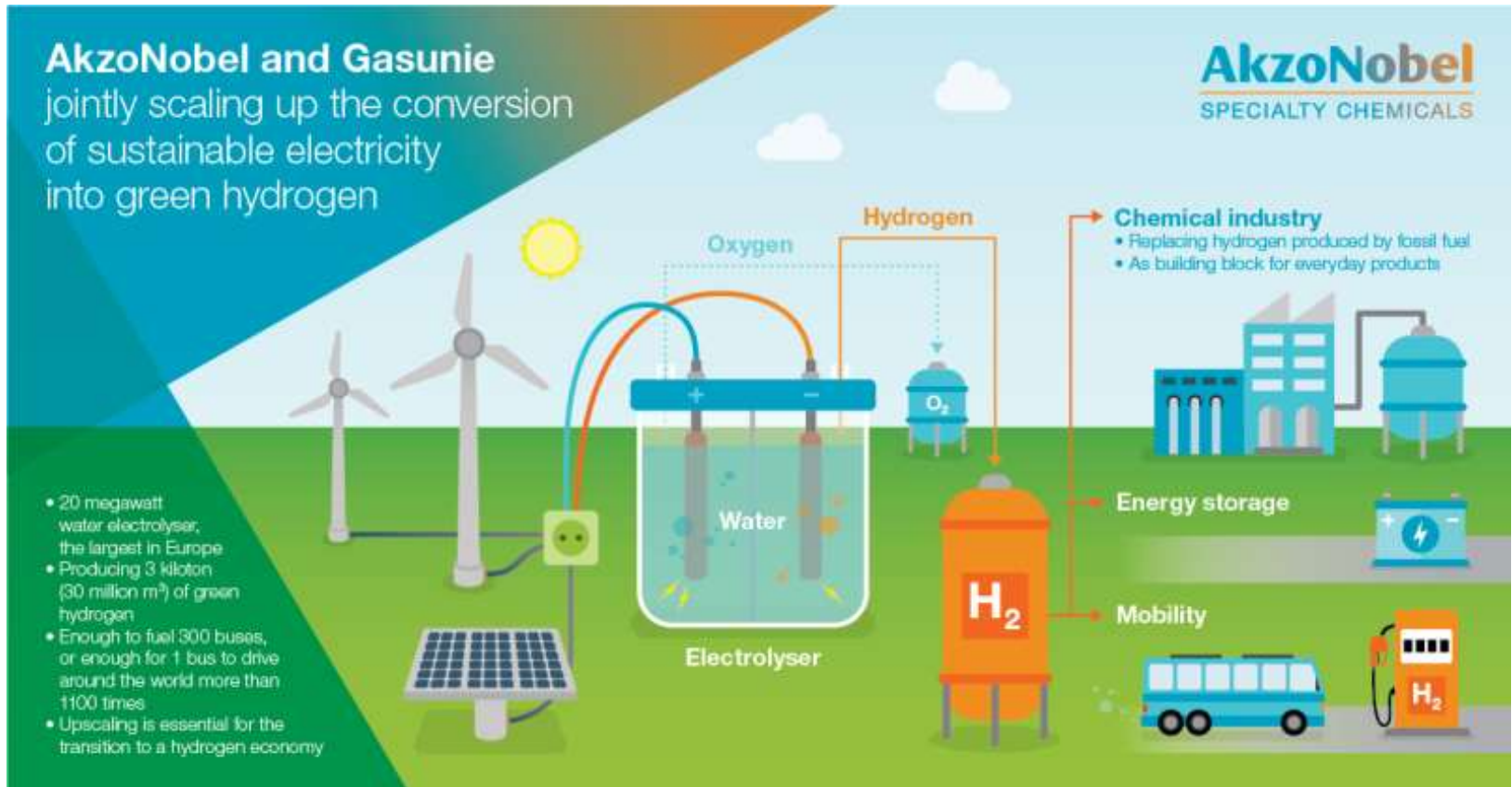


Source: Arevah2gen



Large scale systems required for future grid integration

# Electrolysers: Scaling up



Source: Nouryon

Source: Noordelijke Innovation Board

# Renewables to hydrogen



# Hydrogen station experience - the early days...



# Today's commercial hydrogen fuelling installations



# H2 Mobility Initiatives

Currently 200 H2 fuelling stations globally

## UK H2 Mobility

- 2020: 65 HRS.
- 2030: 150 HRS

## H2 Mobility Germany

- 2015: 45 HRS
- 2025: 400 HRS

## H2 Mobility France

- 2020: 15 HRS
- 2025: 139 HRS

## H2 Mobility Italy

- 2020: 20 HRS
- 2025 : 197 HRS

## H2 Mobility Scandanvia

- 2015: 10 HRS
- 2023 : 50 HRS





**Thank you for your kind attention**