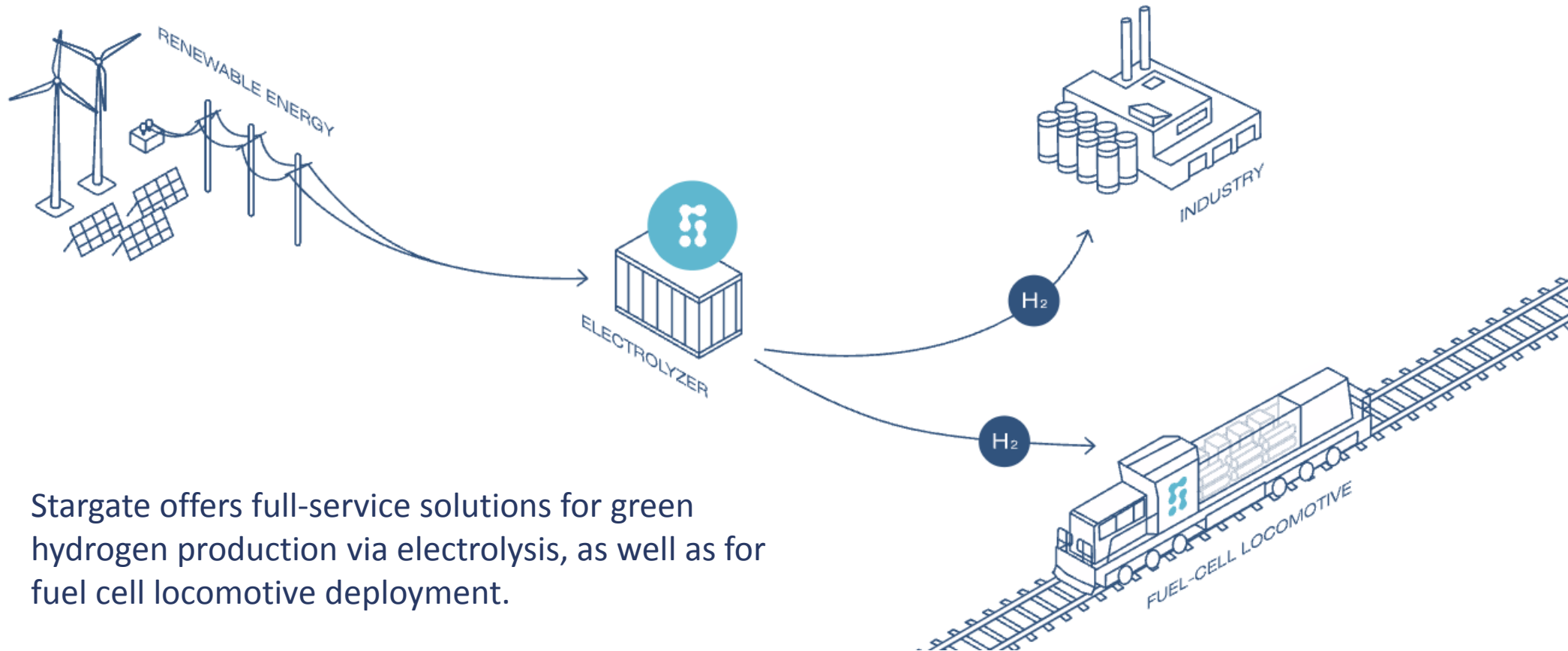


Alkaline Electrolyzers for Green Hydrogen Production

Brief introduction



Stargate = electrolyzers + fuel cell locomotives



Stargate offers full-service solutions for green hydrogen production via electrolysis, as well as for fuel cell locomotive deployment.



Decarbonization of rail is inevitable

Problem

Electrification would help to decarbonize the sector, but:

- In EU, only ~60% of the track is electrified and much less in Eastern European countries.
- Electrification via catenary lines is highly capital intensive.

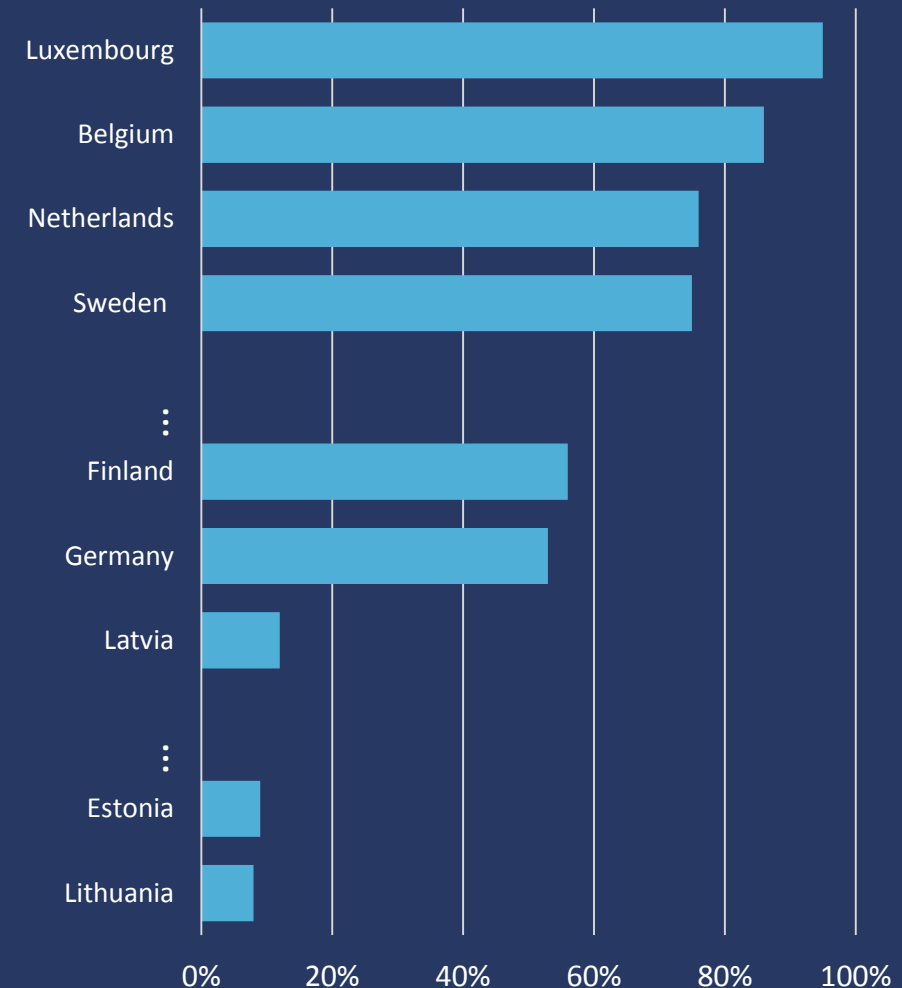
Solution

“**Wireless electrification**” with batteries and fuel cells:

- Batteries alone do not provide enough range
- Fuel cells provide higher energy density, but availability of H₂ may be an issue
- Combination of batteries and fuel cells = optimal range + attractive TCO

Stargate brings world-class technical expertise for compact, efficient hydrogen powertrains, allowing for **modular and scalable freight locomotive retrofit solutions** combined with fueling infrastructure.

Overall percentage of electrified railway network by EU country as of 2019

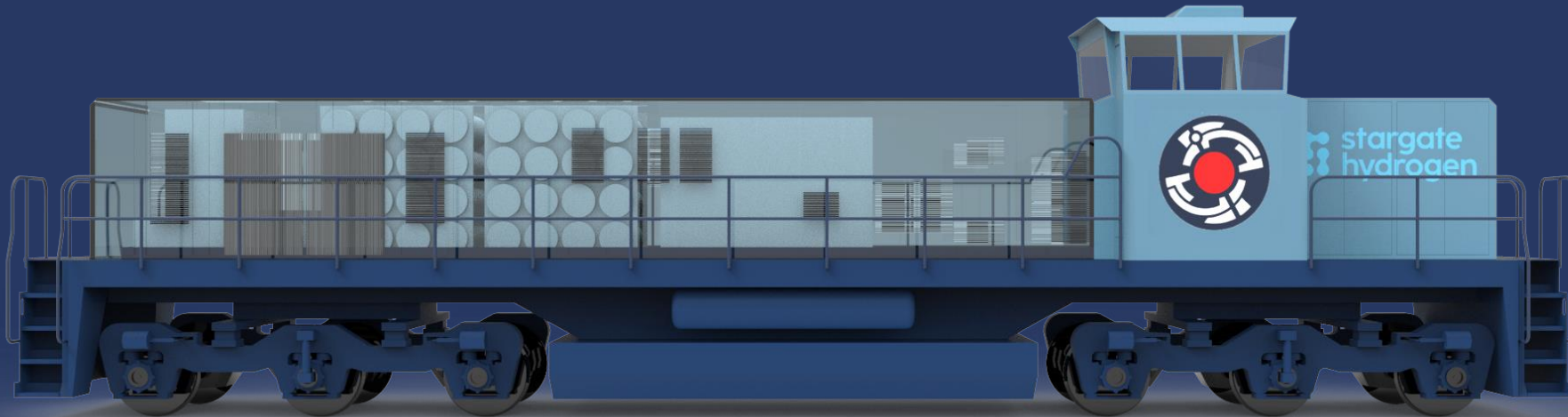


Source: Statista.com



” Stargate to deliver hydrogen locomotives to international rail company Operail

15/01/2021

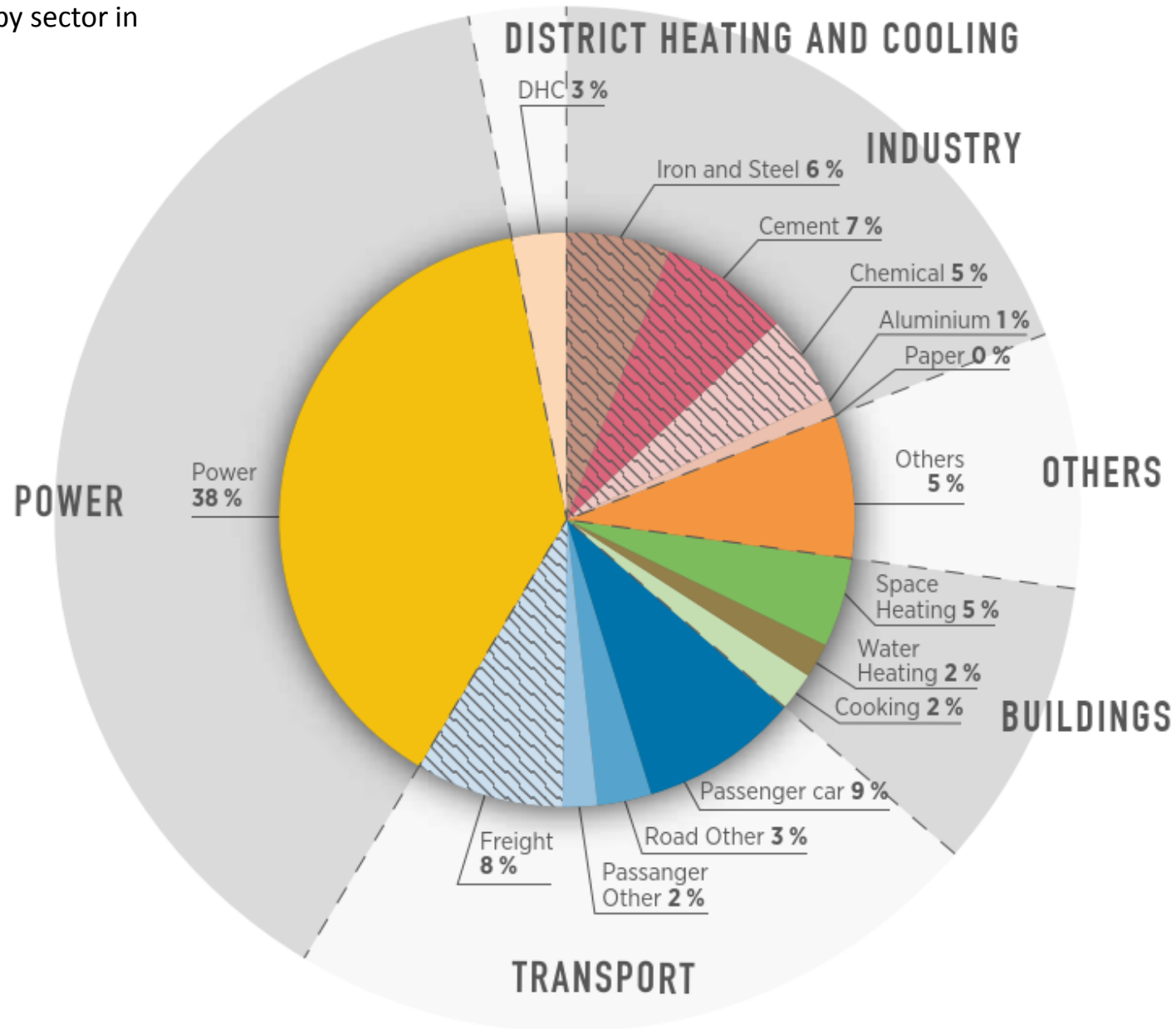


- The conversion from diesel to fuel cells saves 370 tonnes of CO₂ emissions per freight locomotive a year.
- We want to convert 40 diesel freight locomotives into fuel cell electric locomotives.
- The delivery of the first hydrogen locomotive prototype is planned for the end of 2022.



Breakdown of global energy-related CO₂ emissions by sector in 2015.

Source: IRENA 2018



Stargate electrolyzers

- Electrolyzers based on alkaline technology with large-scale industrial users (steelmakers, cement plants, chemical plants, utilities) as the main target market.
- Turn-key solutions focused on customer needs.



Hydrogen Valley DK



Stargate electrolyzers

15/10/2021

gateway S E R I E S

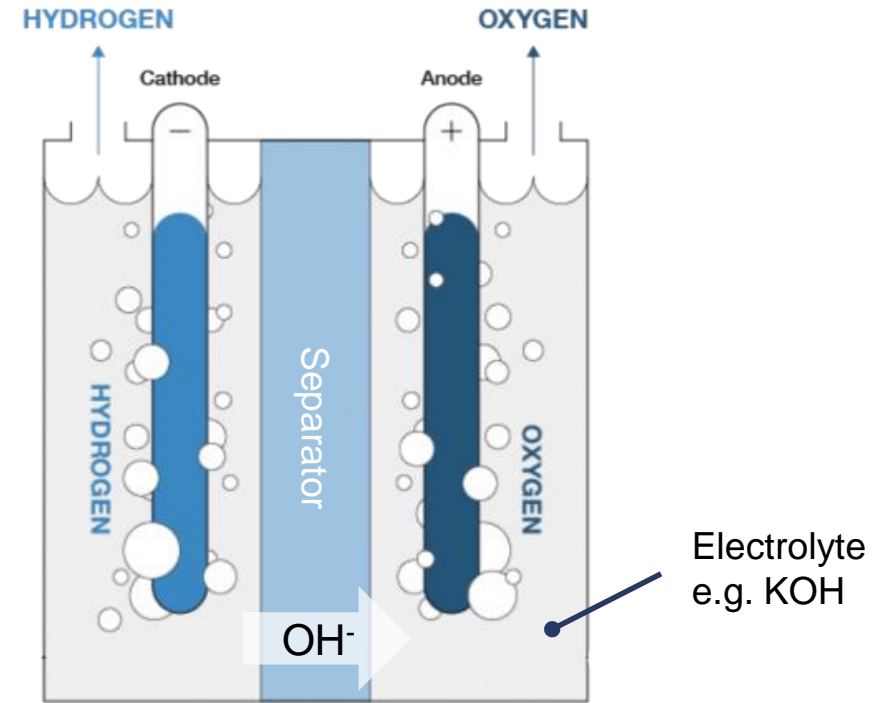
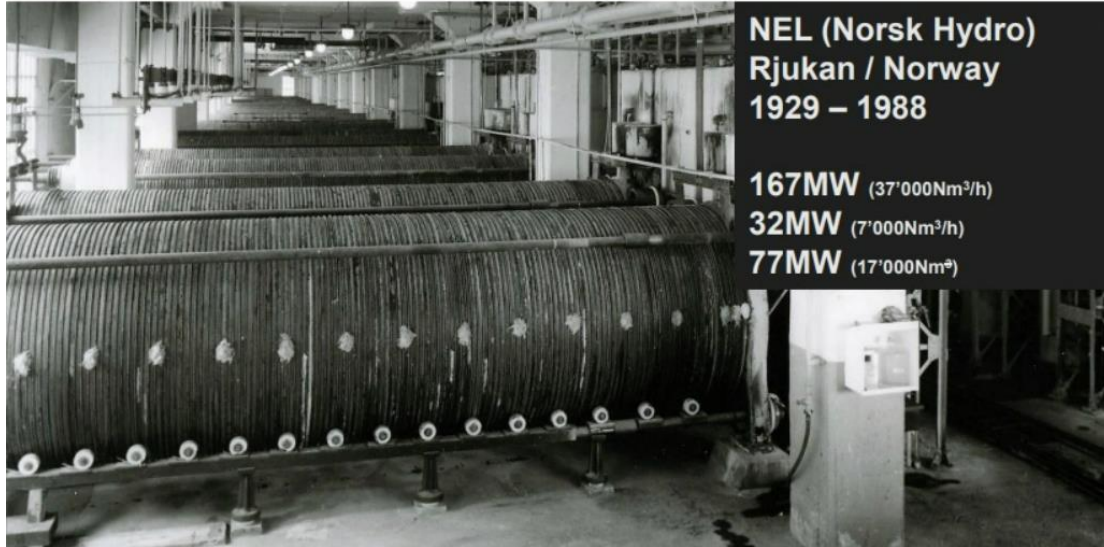
- Containerized units for small-to-medium scale systems
- Tailored for hydrogen refueling station applications
- High-purity product ($\leq 99.999\% \text{ H}_2$)

starbase S E R I E S

- Skid-mounted units for large-scale systems
- Tailored for industrial applications: steel, refineries, green chemicals, etc.
- High-purity product ($\leq 99.999\% \text{ H}_2$)



Alkaline electrolyzers



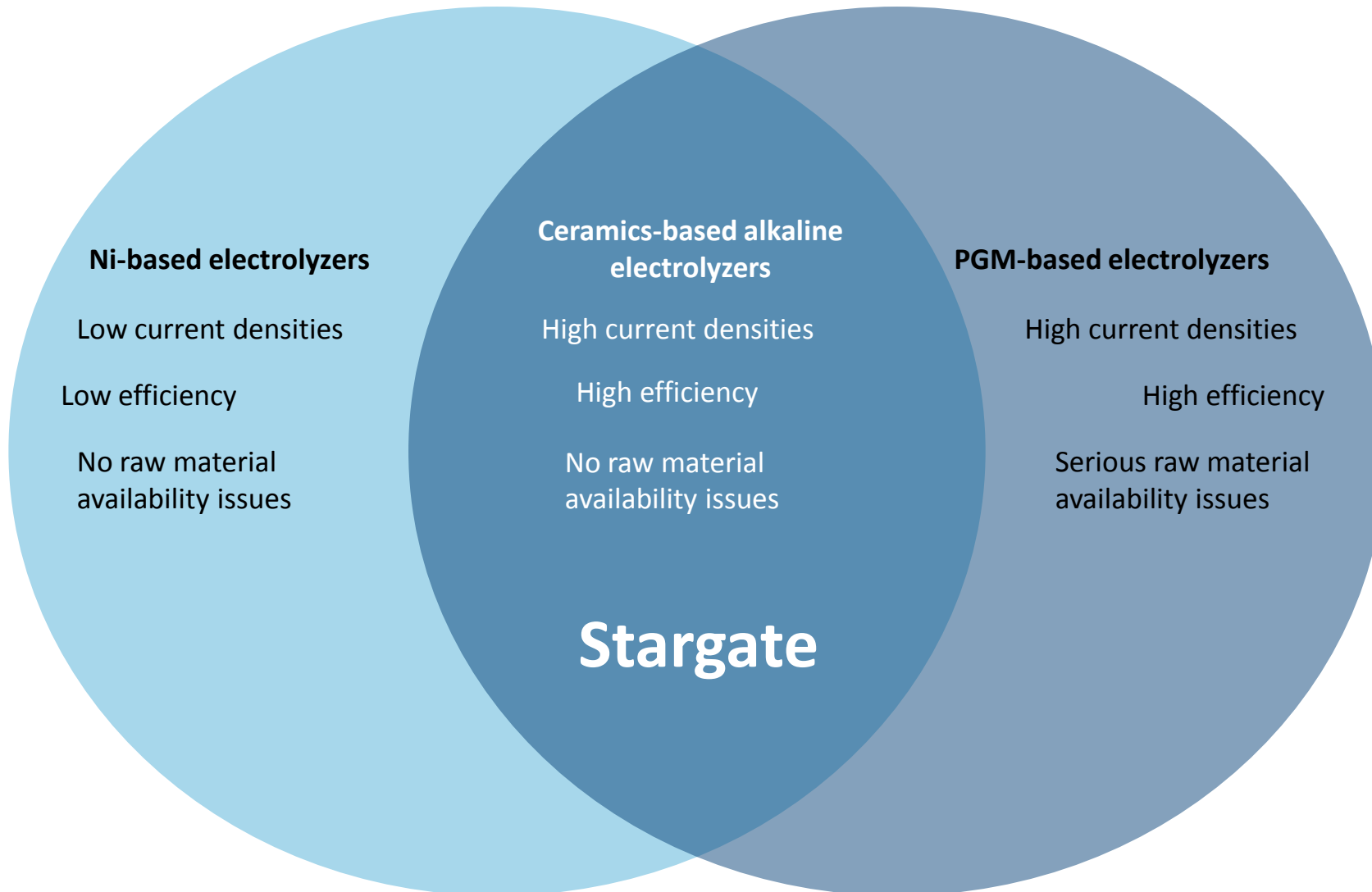
Industrially proven, reliable technology...

... but rate of innovation has been slow.



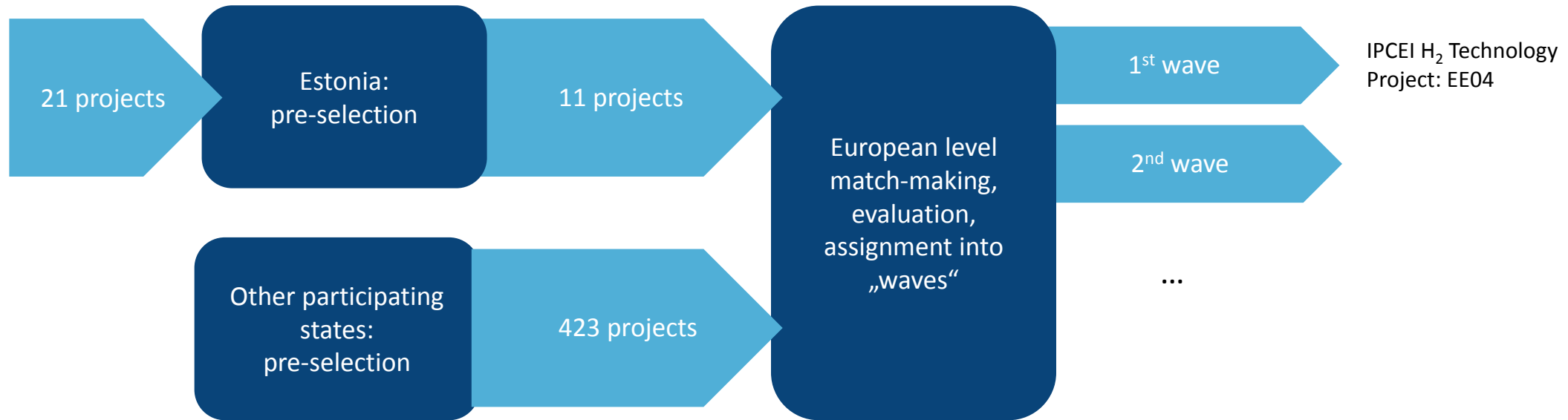
Stargate approach

15/10/2021



Important Projects of Common European Interest (IPCEI)

15/10/2021



Important Projects of Common European Interest (IPCEI)

5+9

YEARS

50.8

EUR

(RDI+FID)

0%

PRECIOUS METALS

45

KWH/KG H₂

1

GW/YEAR

PRODUCTION
CAPACITY

550

EUR/KW_{CAPEX}

96

DIRECT JOBS
DURING RDI+FID

156

MILLION TONS
CO₂ SAVED

Direct partners:



(Finland)



(Italy)



(Spain)



(Estonia)



Green Power
(Italy)



(Estonia)

Indirect partners:



(Italy)



(Belgium)



(Germany)



(Germany)



(Denmark)



(Estonia)



(Estonia)



(Estonia)



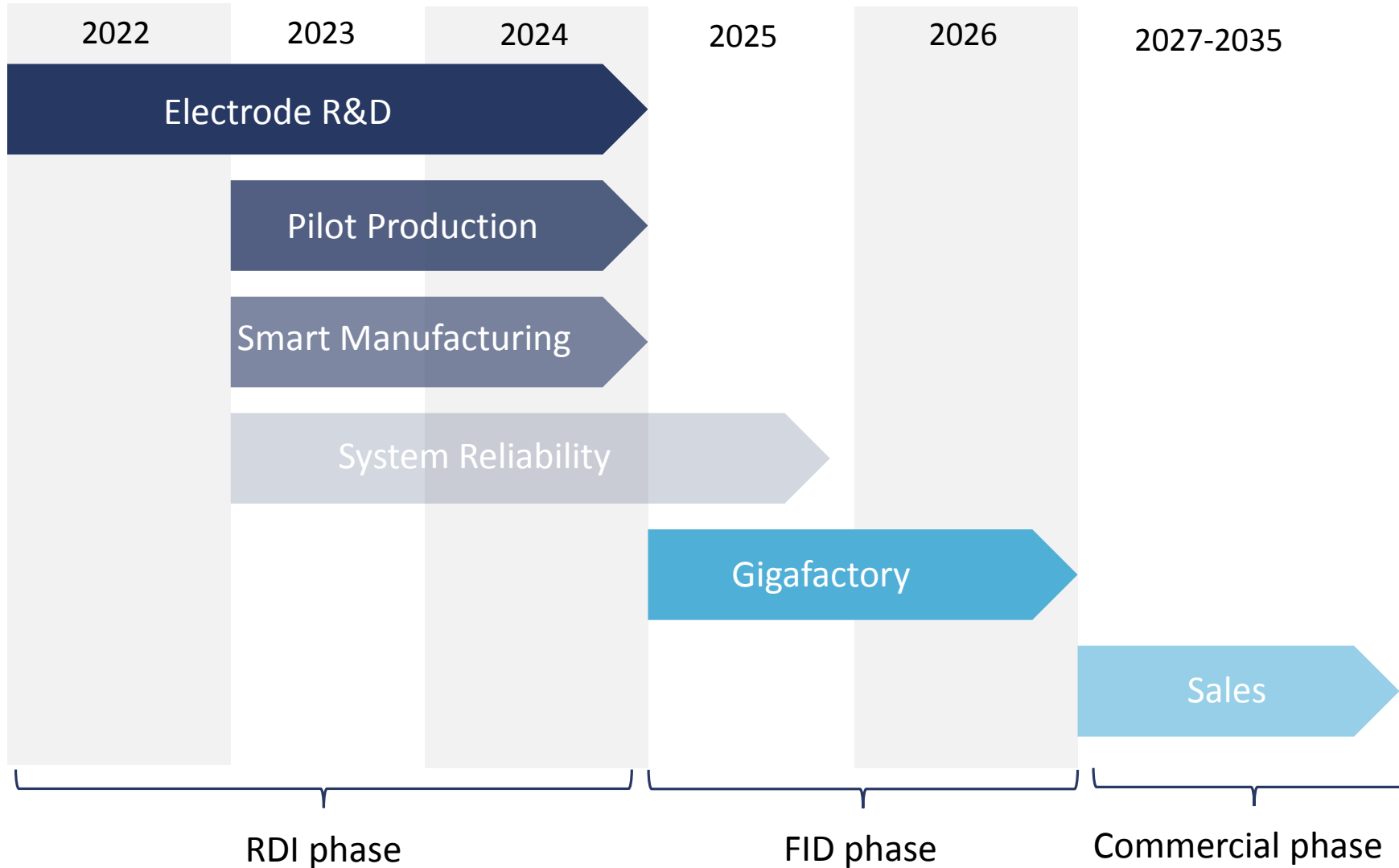
(Estonia)



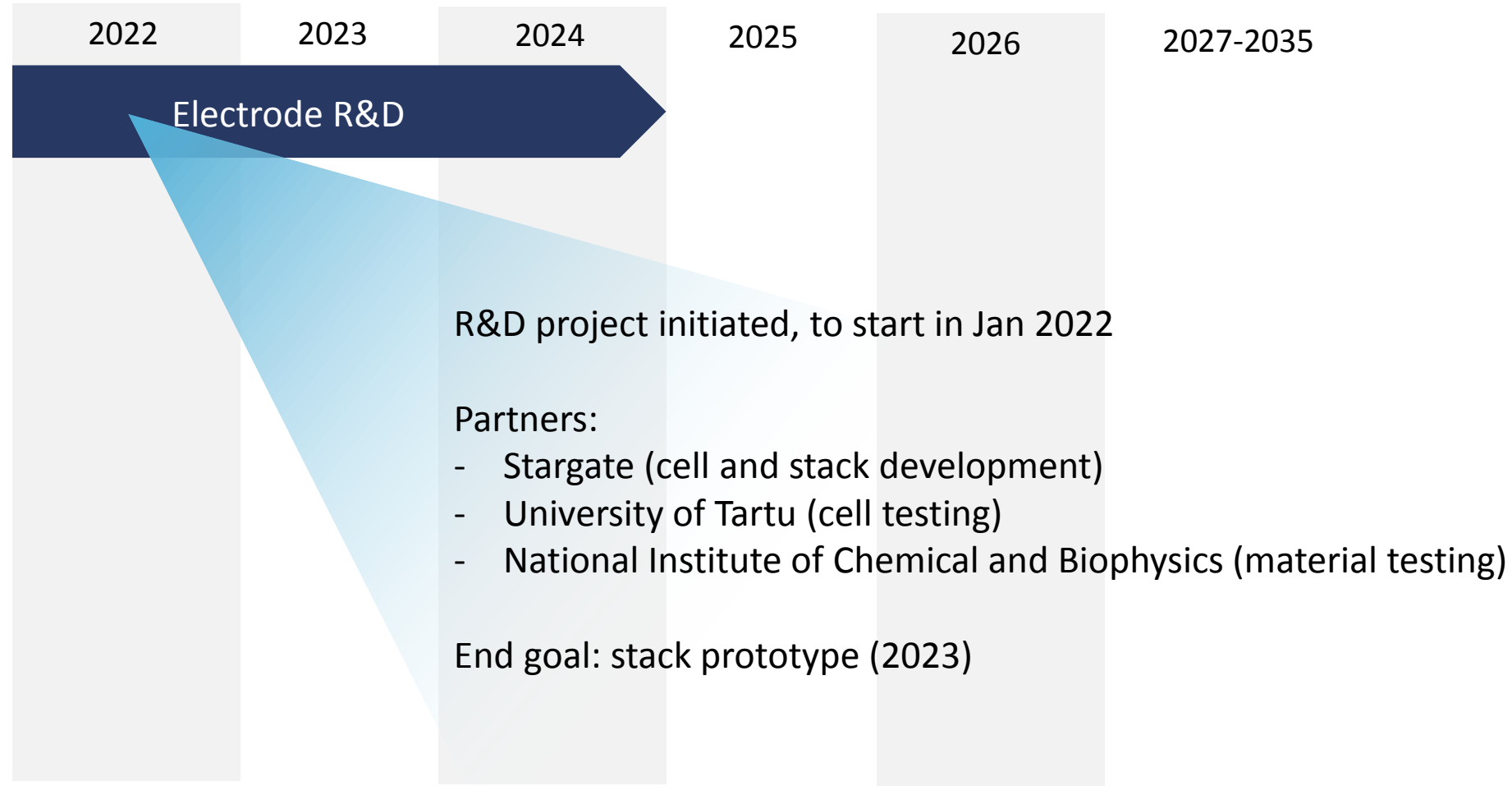
(Estonia)



Stargate IPCEI



Stargate IPCEI – first steps



Project start in Jan 2022 is pending funding approval by Enterprise Estonia.



Thank you!



stargatehydrogen.com