Hydrogen key element for emission free rail traffic

November 30, 2017

ALSTOM
Designing fluidity

Alstom is offering a full range of products and services for the growing rail market

Trains

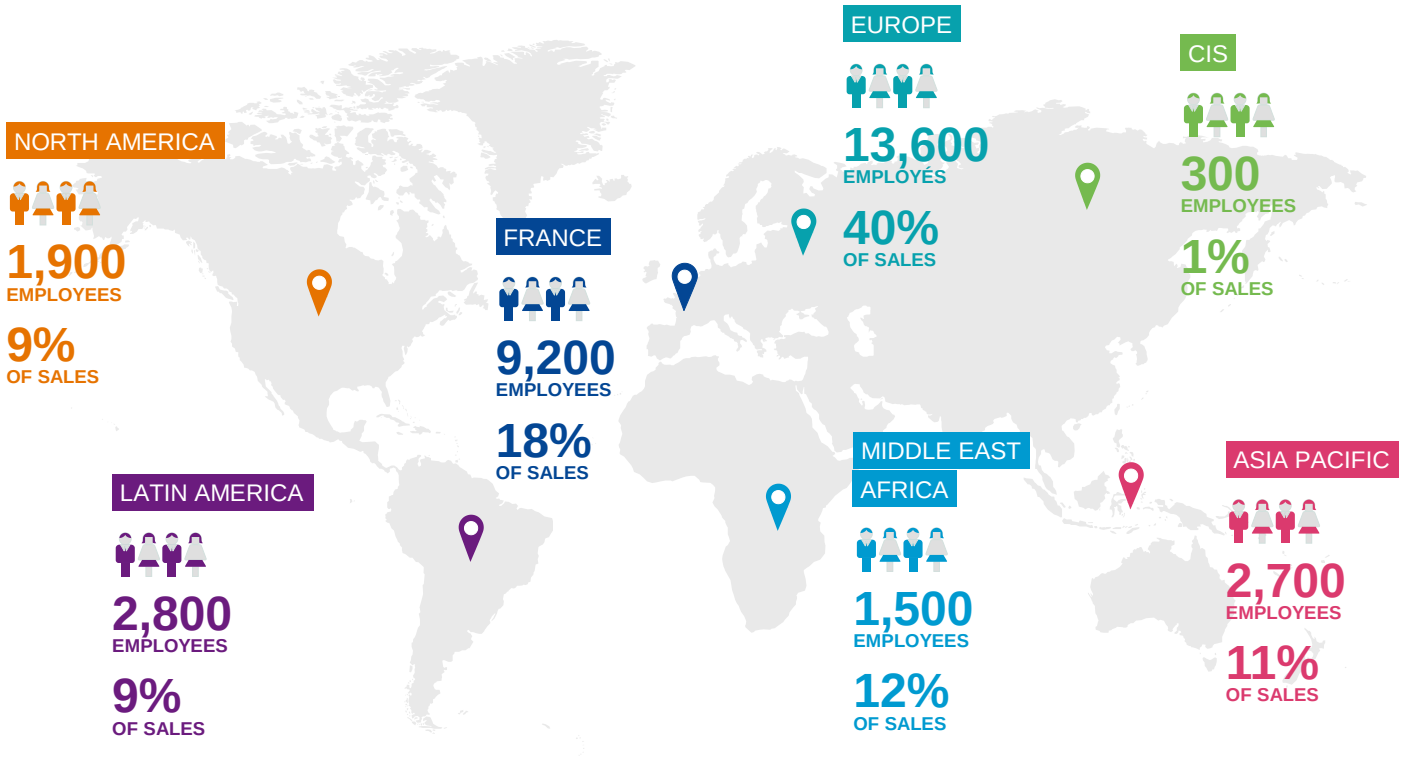
Systems

Services

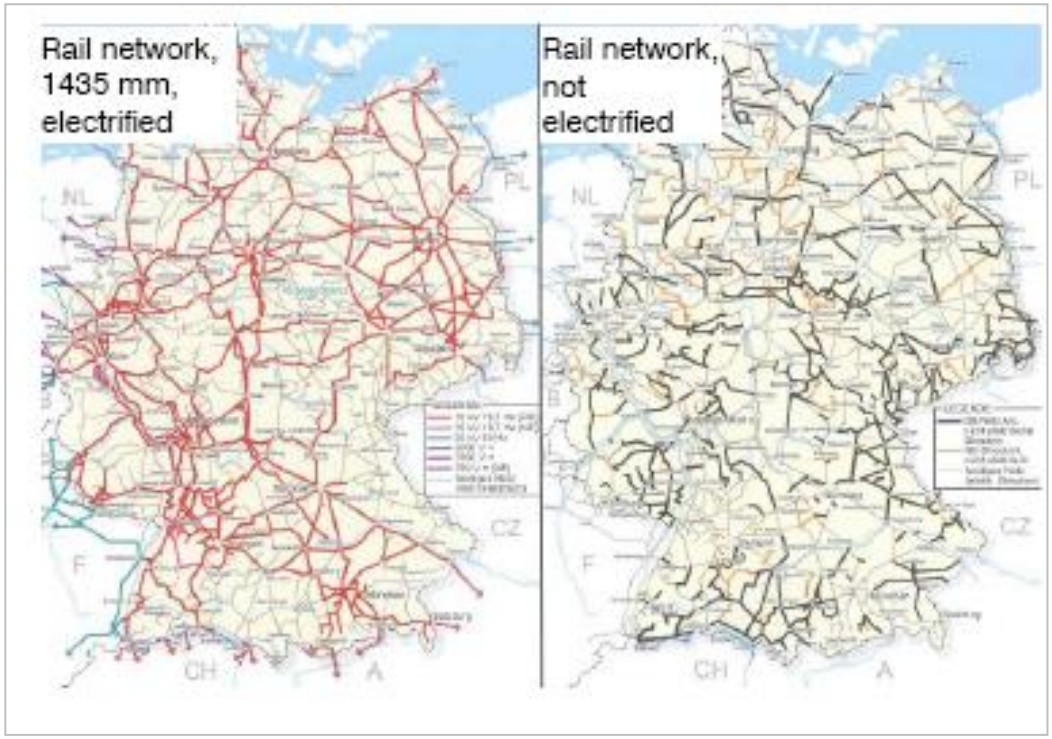
Signaling

With a worldwide presence, Alstom is able to serve its clients on a global level

32,000 employees working on **105 sites** in **60 countries** serving **200 customers**



Important part of German rail network will stay non-electrified



- Degree of electrification: 49%
- Extension of electrification by 230 million Euro per year
- Complete electrification would take 95 years
- Most projects on extension of main lines

Source: SCI - study

The vision: Our customers receive emission-free train availability

Construction and operation of the **H2 infrastructure** (with partners)

Maintenance and **service**

Delivery of the **trains**

Operator receives a maintained and tanked vehicle!

What are the drivers for technological leaps in railway transportation

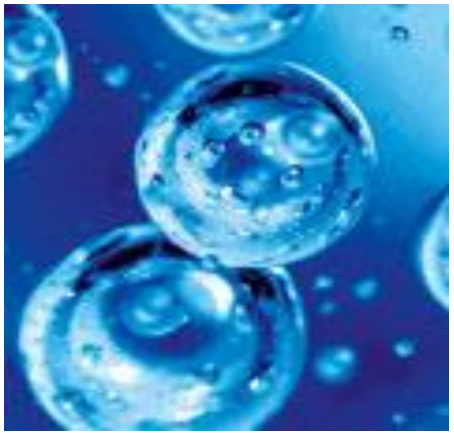
Coal

- 34 MJ/kg

Diesel

- 43 MJ/kg

Hydrogen



- 120 MJ/kg

Hydrogen is the ideal energy source for the railway transport to match the challenges of the future

- Trend is shifting towards emission free transportation
- Price level for diesel and traction current is likely to rise in the medium and long term
- Lower acceptance and stricter regulations regarding rail noise
- Progressing urbanisation
- Significant part of the rail network is not electrified (eg. 50% in Germany)

No other energy source meets the demanding requirements of rail operations in a long term perspective

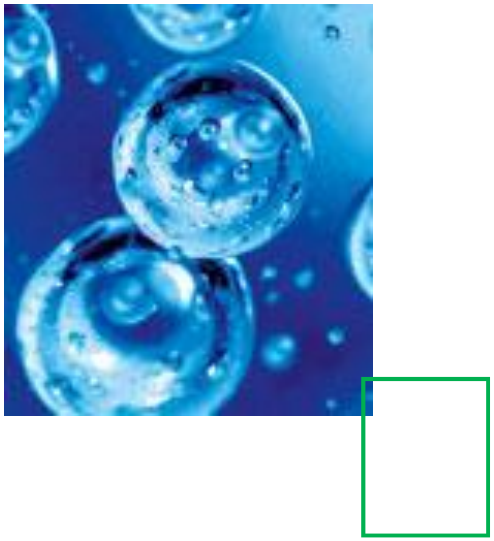
Diesel

- Fossil fuel = CO2-Output

Pure battery traction

- Necessary batteries would be too heavy less passengers could be transported

Hydrogen



- Allows 100% CO_2-free traffic
- H_2-Technology far advanced

Hydrogen as an energy source is especially suitable for regional transport

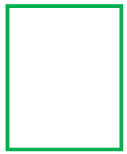
Long-distance transport?

- Existing electrification
- Very high energy consumption
- Power demand too high

Light rail vehicle?

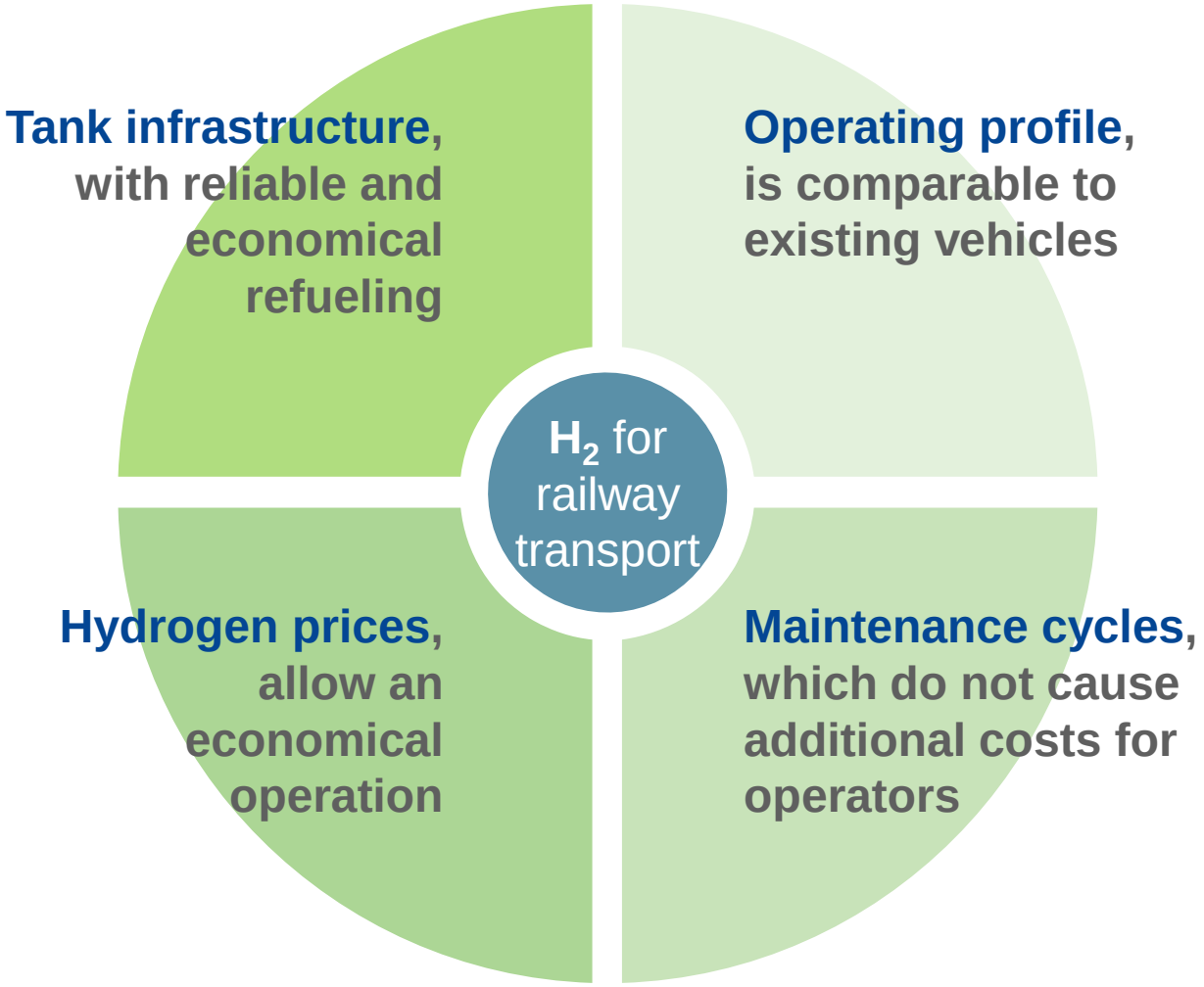
- Existing electrification
- H2-Tramways generally possible

Regional transport ?



- Operating concept suitable for energy and power requirements
- Circulation in regional networks
- No continuous electrification (50% in Germany)

Hydrogen fulfils the special demands of regional railway transportation



We match thsese special demands with our new hydrogen powered Coradia iLint

Alstom Diesel train Coradia Lint

- Proven construction
- Lightweight construction
- Catenary free

NEW: Alstom H2-powered train Coradia iLint with fuel cell technology

Alstom Electric train Coradia Continental

- Low maintenance costs
- Low noise emission
- Recovery of braking energy

First prototype of Coradia iLint was presented to the public at InnoTrans in Berlin in September 2016

First steps towards zero emission with „grey“ hydrogen – future solutions have to rely in „green“ hydrogen“

CO_2 emission per vehicle km (in kg)

With green hydrogen, one iLint saves about ~700t of CO2 per year, a typical fleet of 15 trains more than 11.000t

minus
700t CO2
per year…

…corresponds to the annual output of
400 cars

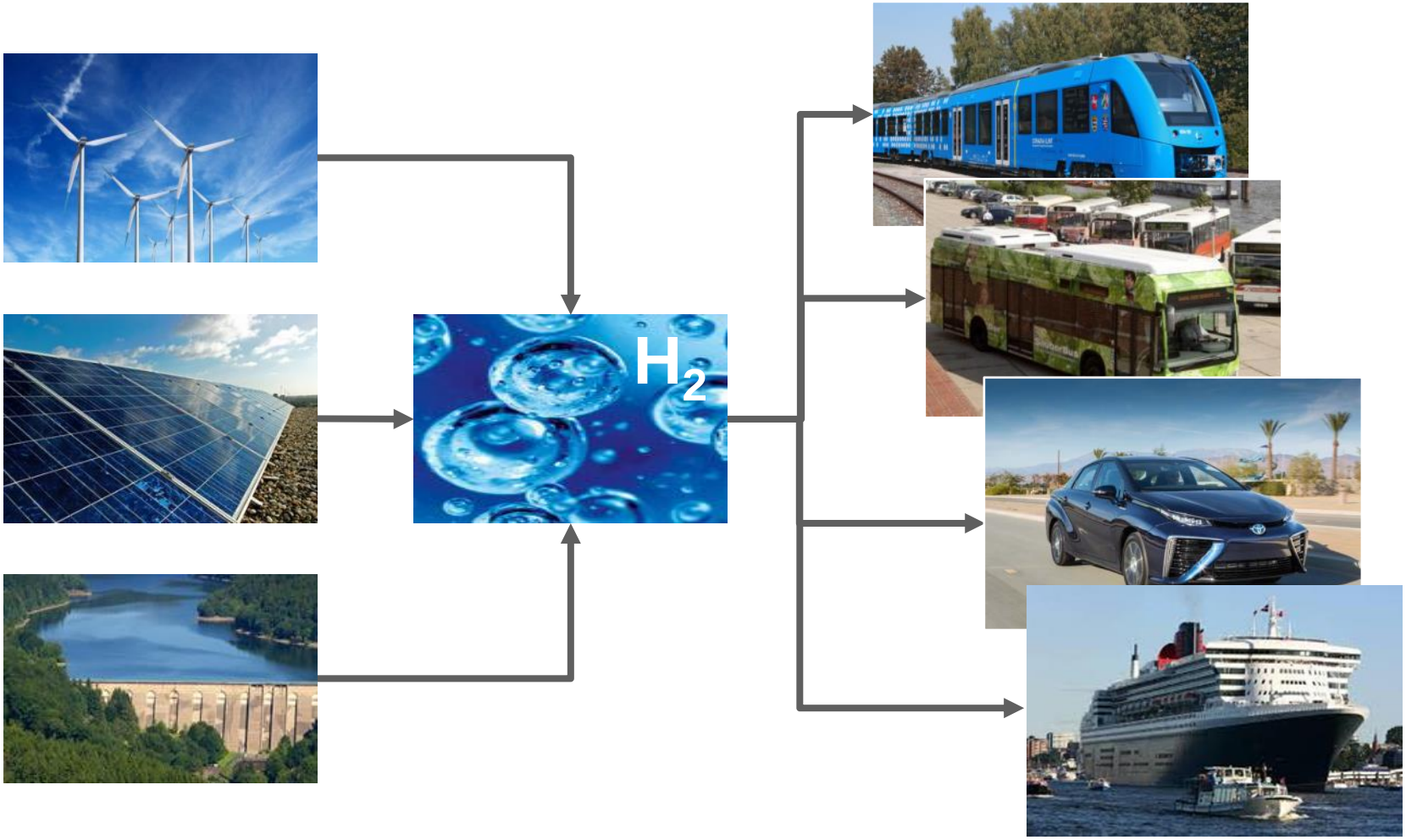
Saving per iLint

minus
11,000t CO2
per year…

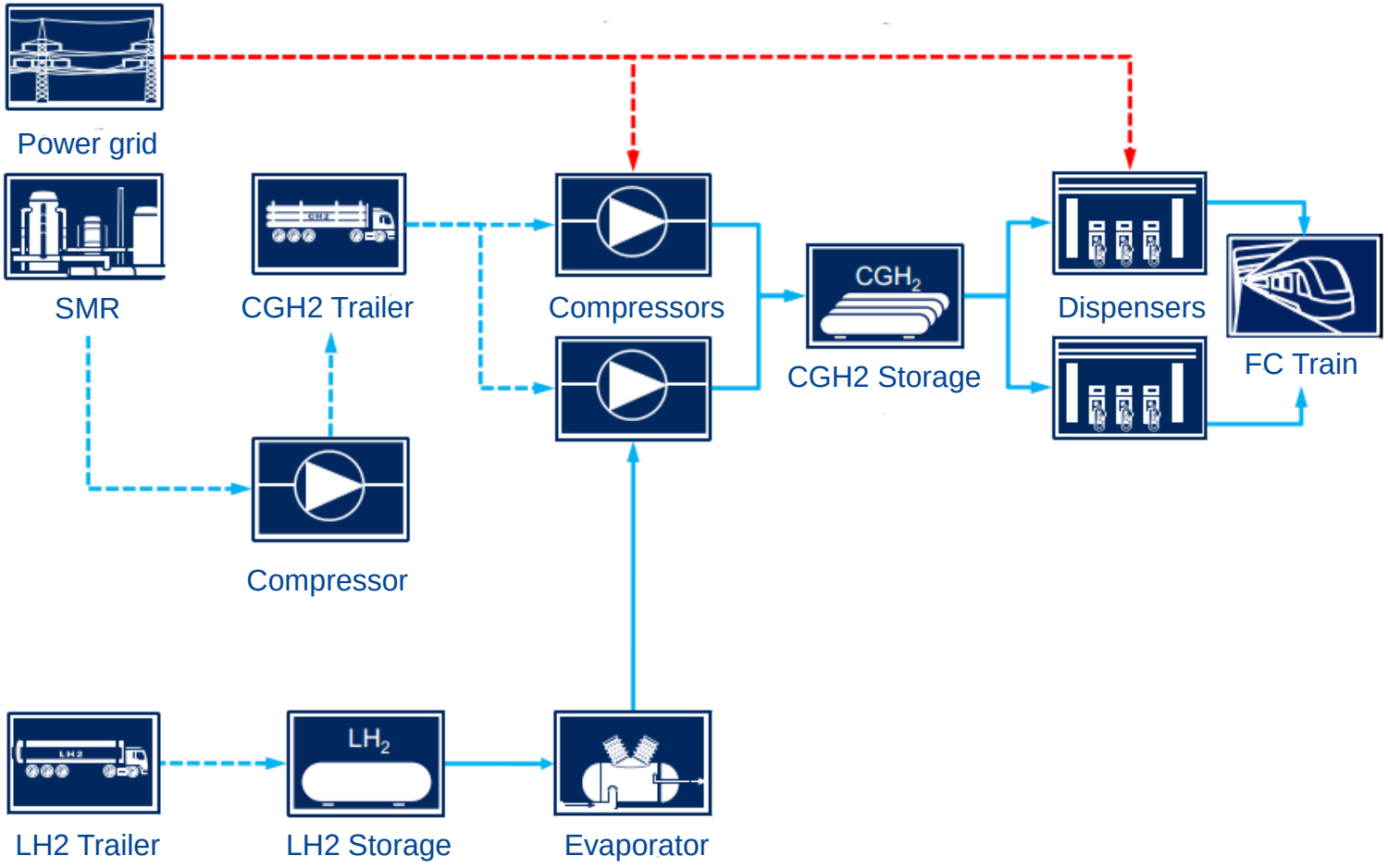
…corresponds to the annual output of
6,000 cars

Saving per iLint fleet

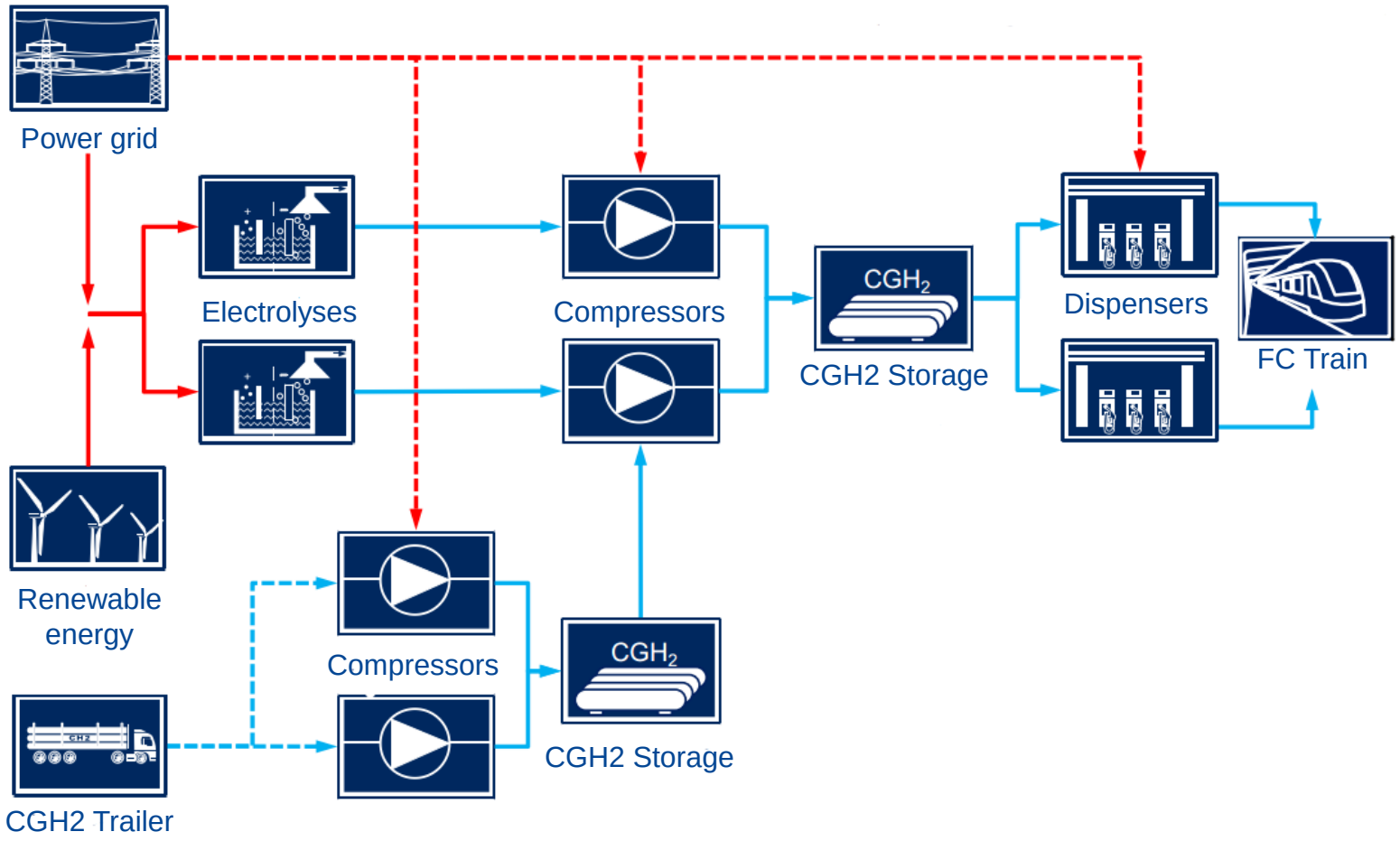
Green hydrogen as a basis for further environmentally friendly transport solutions



Most common way of hydrogen production today is via steam reforming



Target is green hydrogen production using renewable energy sources



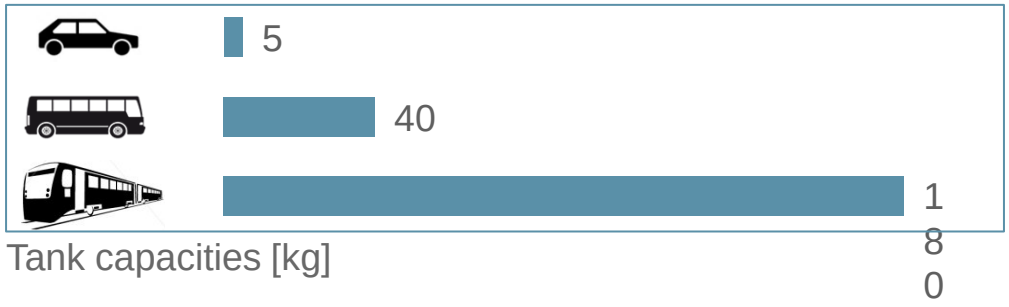
10 MW of wind power to produce hydrogen for 15 iLints

About **10 MW** of wind power necessary…

…to power a **4 MW** electrolysis plant…

…to run a fleet of **15 iLints!**

Key facts of train refueling



- Trains need higher quantities of hydrogen then cars and buses
- Hydrogen is stored at 35 MPa in the train
- Refueling nozzle: SAE J 2601-2 HD
- Hydrogen refueling stations to become part of the railway infrastructure
  - Redundant facilities to achive high availability
  - No impact on train operation vs. DMU