

Coradia iLint – Hydrogen Fuel Cell Train



ALSTOM



RAIL CONFERENCE

Agenda

- Motivation to strike a new path
- Coradia iLINT and its technology
- Safety and certification
- Production and supply of hydrogen
- Efficient Utilization of grid capacity
- Next steps ...



Motivation to strike a new path...



Significant part of the **rail network is not electrified** and high cost of traditional electrification



Achieve greater resiliency and address increasing prices of diesel fuel



Need to improve **air quality** and **reduce noise**



Overload of roads and need to **reduce pressure on grid** at peak times

Hydrogen :
the ideal
alternative
energy
source



HFC Rolling Stock – comparison with electric alternatives

+ Performance, operating range and refueling duration comparable to that of diesel trains

(900 to 1.100 km range, refueling from empty tank takes 15 minutes)

- higher investment in infrastructure



*Based on a regional railcar with 150 seats/150 standees and 140 km/h maximum operating speed

HMU

+ lower investment in infrastructure

- suboptimal relationship between operating range and cost / weight / re-charging duration (200 km range: ~33 t of batteries/ 45 minutes recharging)



+ optimal only if electrification infrastructure is already in place

- Operating range of sections without overhead line very low (approx. 40 to 70 km)

BEMU



BEMU+



+



Motivation to strike a new path...

Coal



34 MJ/kg



1801

Diesel



43



1925

Hydrogen



120 MJ/kg



2018



CORADIA Lint: the Diesel platform from which HFC train developed....

LINT 27: 47 trains



LINT 41: 688 trains



LINT 54: 203 trains



LINT 81: 72 trains



More than 1000 LINT Diesel Trains sold worldwide, including in Ottawa, Canada

... a reliable and service proven base for the first hydrogen HMU



Fuel Cell Trains: The Technology – transformation from Diesel to HMU



Removal of diesel propulsion system



Integration of electrical propulsion system



Diesel powerpack



Diesel tank



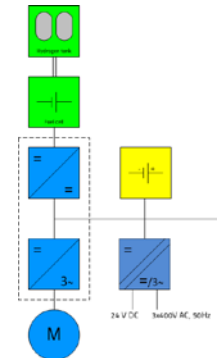
Hydrogen tank

Fuel cell pack

Battery pack

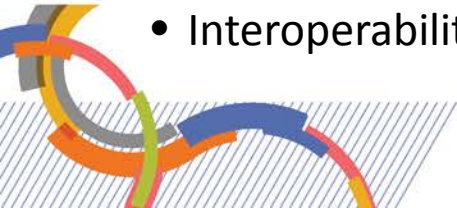
Converter system

Electrical traction motor

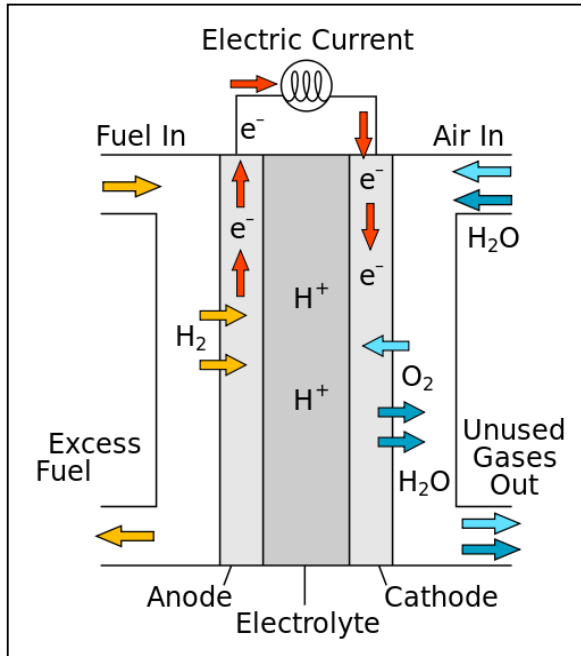


Fuel Cell Trains: Design criteria

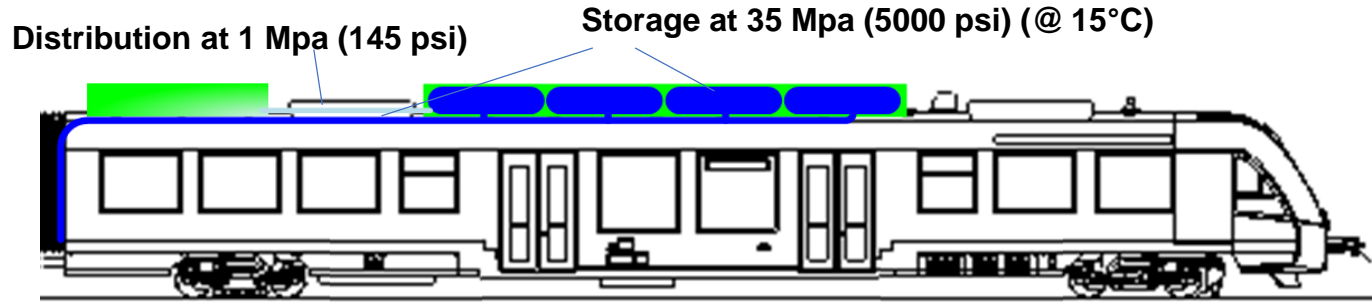
- Retain the same train dimensions
- No significant changes in weight/point of gravity
- Re-use of main components (eg. bogie)
- Maintain excellent performance (availability, reliability, acceleration, range, etc)
- Avoid adding equipment in passenger areas
- No adverse impact on passenger experience and comfort
- High energy efficiency
- Scalability – technology can be scaled and used to retrofit existing fleets, can be used on passenger locomotives, bi-level multiple units (of varying lengths) etc.
- Interoperability (mixed fleet)



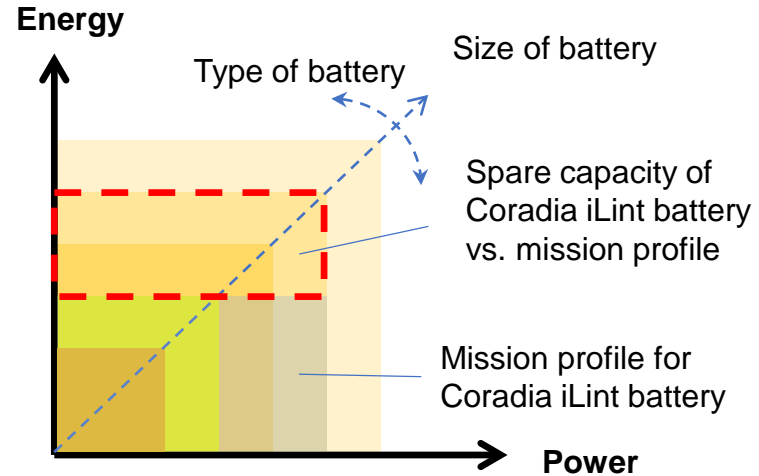
CORADIA iLint: The fuel cell composition



CORADIA iLint: Hydrogen storage

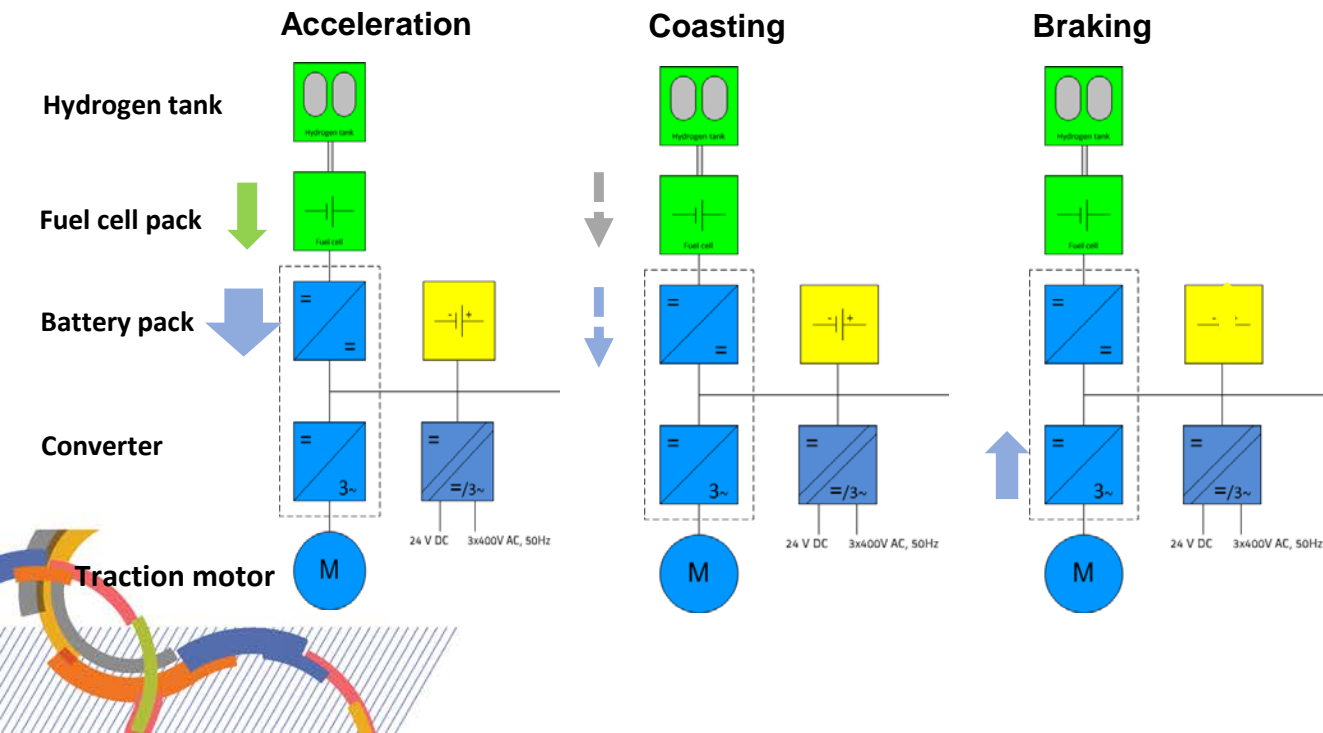


CORADIA iLint: The lithium-Ion battery composition



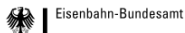
Fuel Cell Trains: CORADIA iLint - energy management

Energy management is the key to achieve highest efficiency



- Operates fuel cells at **optimal efficiency**
- **Optimizes energy management** during acceleration, coasting and braking
- **Recuperates kinetic energy during braking** (>30% recuperation of traction energy used)

CORADIA iLint: Validation and certification process (example for Germany)



Core subjects

- Running dynamics
- Crash
- Brake
- Wheelsets
- Train radio / Train protection



Safety assessment on Common Safety Methods (CSM)



Eisenbahn-Bundesamt



Technical Specification for Interoperability

- Infrastructure
- Energy
- Rolling Stock
- Train Control / Communications

Notified National Technical Rules

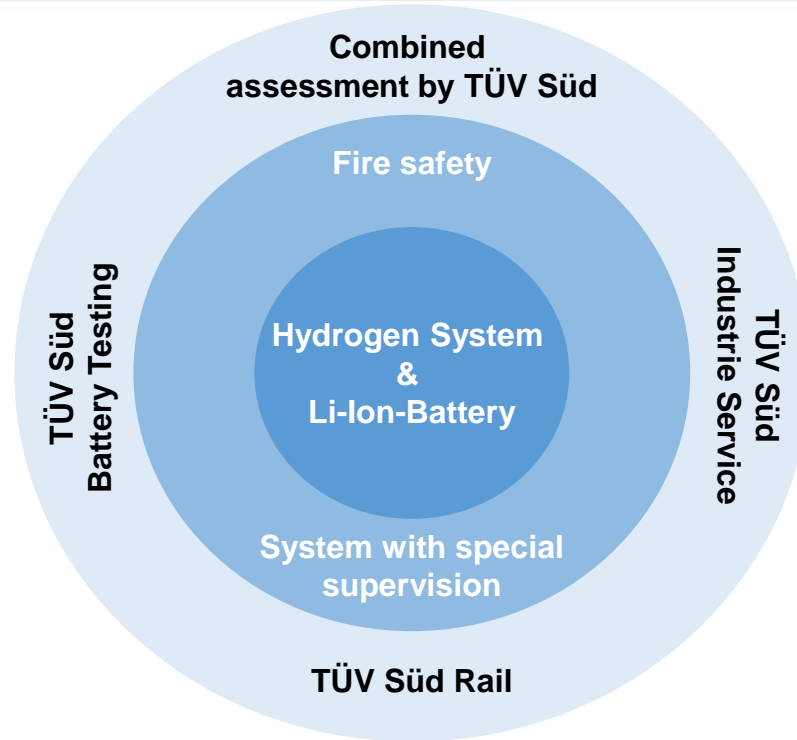
- Running dynamics
- Fire Safety
- EMC
- Functional Safety
- Labeling
- *and some others*

CORADIA iLint: Validation and certification process – the strategy

Risk analysis

with consideration of
environmental and
operational conditions

Definition of
requirements



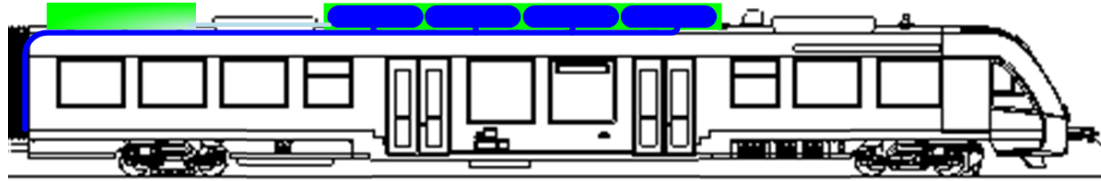
Independent inspection
and assessment

Validation of fulfillment
of requirements

Follow-up on realization

CORADIA iLint: Certification ...

Hydrogen safety



- Certification of pressure vessels in accordance with **EC 79/2009**
- Certification of overall system in accordance with 2014/68/EU (**PED**)
- Validation of structural safety (frame / vessels / piping) by S&V-test in accordance with **EN 61373**
- Certification of railway conditions (Environment, EMC, Fire Safety)
 - Fire safety - **EN 45545-2**
 - Environment - **EN 50125/IEC 60077**
 - EMC - **EN 50121-3-2**



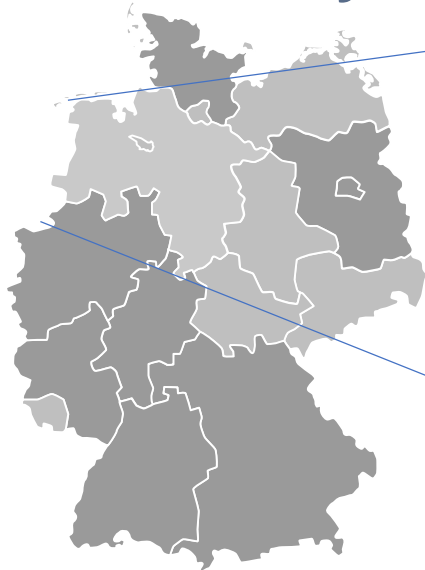
CORADIA iLint: From certification to regular passenger service

- **Certification** for passenger service in Germany received on **11.07.2018**
- **Inauguration** of passenger service at Bremervörde on **16.09.2018**
- **Daily passenger service** according to regular time table since **17.09.2018**

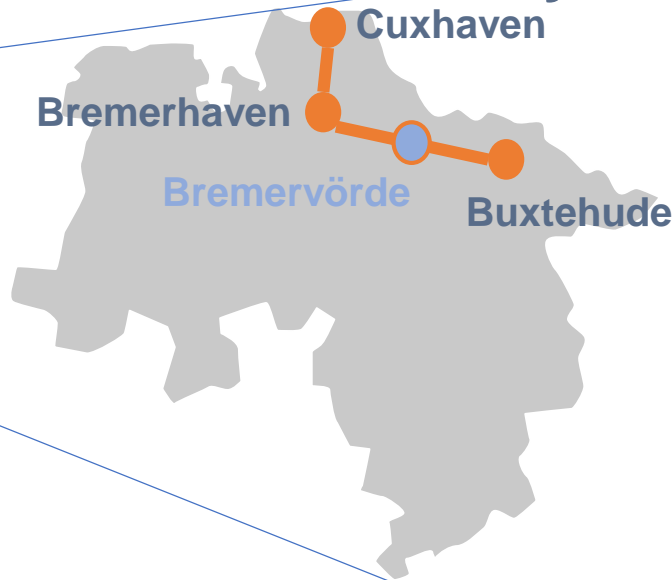


CORADIA iLint: ... in daily passenger service!

Germany



Lower Saxony



- Daily passenger operation
- Operation in mixed fleet
- 75 miles of tracks
- One mobile refueling station in Bremervörde



CORADIA iLint - entrance into daily passenger revenue service on Sept. 16, 2018



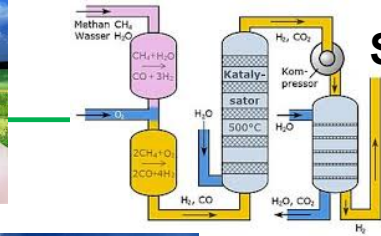
Hydrogen-powered trains begin service in Germany.

In a breakthrough for a green fuel, two hydrogen-powered trains are expected to go into commercial service Monday on a rail line in northern Germany near Hamburg. The trains, which will serve cities including Bremerhaven and Cuxhaven, will be powered by hydrogen fuel cells that generate electricity through a chemical reaction. The trains are being promoted as a cheaper alternative to stringing wires on rail lines that are not electrified. Hydrogen-powered vehicles produce no emissions of carbon dioxide, which is blamed for climate change, or other pollutants.....

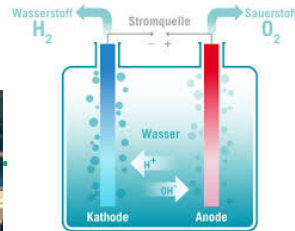
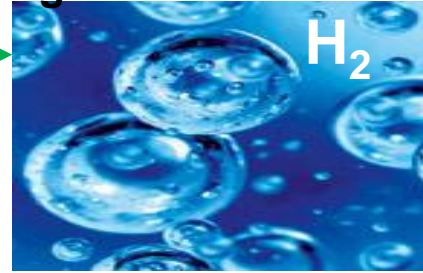
Hydrogen supply: From by-product to regenerative energy



By-product of other processes



Steam reforming



Electrolysis



Hydrogen supply: Mobile refueling station



Hydrogen supply: An ecological comparison



minus
700t CO₂
per year...



...equals annual
emissions of
400 cars



Reduction per iLint vehicle



minus
11.000t CO₂
per year...

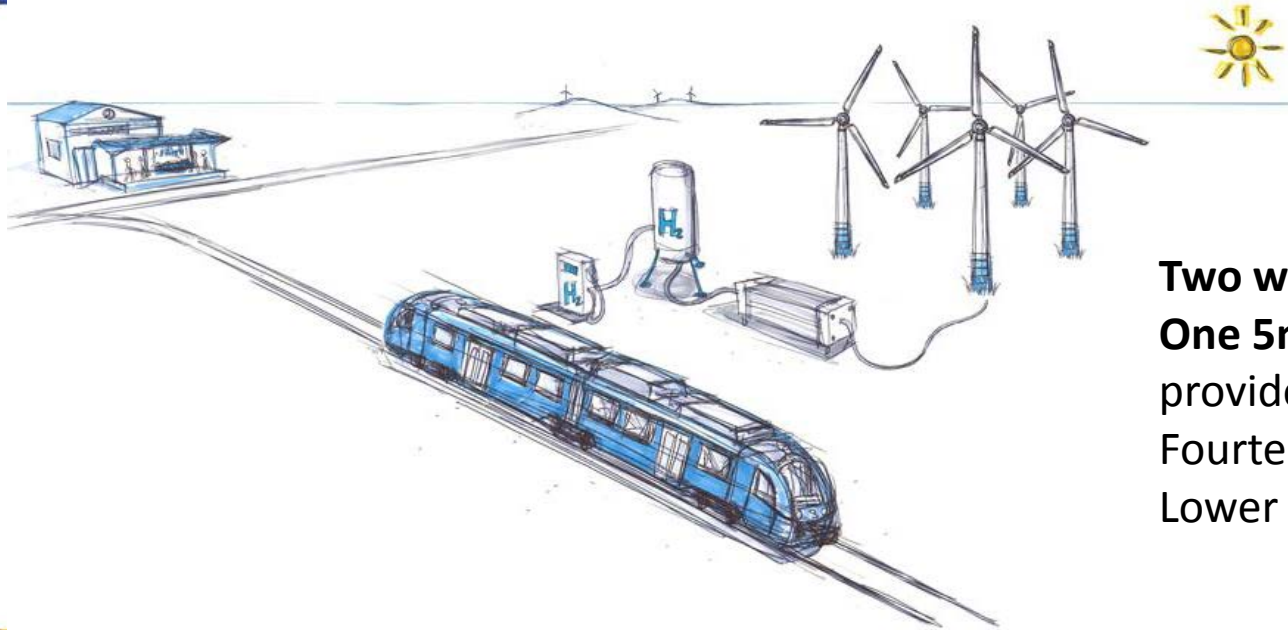


...equals annual
emissions of
6.000 cars



Reduction per iLint fleet

Hydrogen supply: Resiliency – Grid use/balancing



Two windmills and
One 5mw electrolyzer can
provide the H₂ for the
Fourteen 2-car iLint trains for
Lower Saxony



Electrical mobility and effects on other sectors: Load on transmission grids

As the **share** of renewable energy is **increasing**...



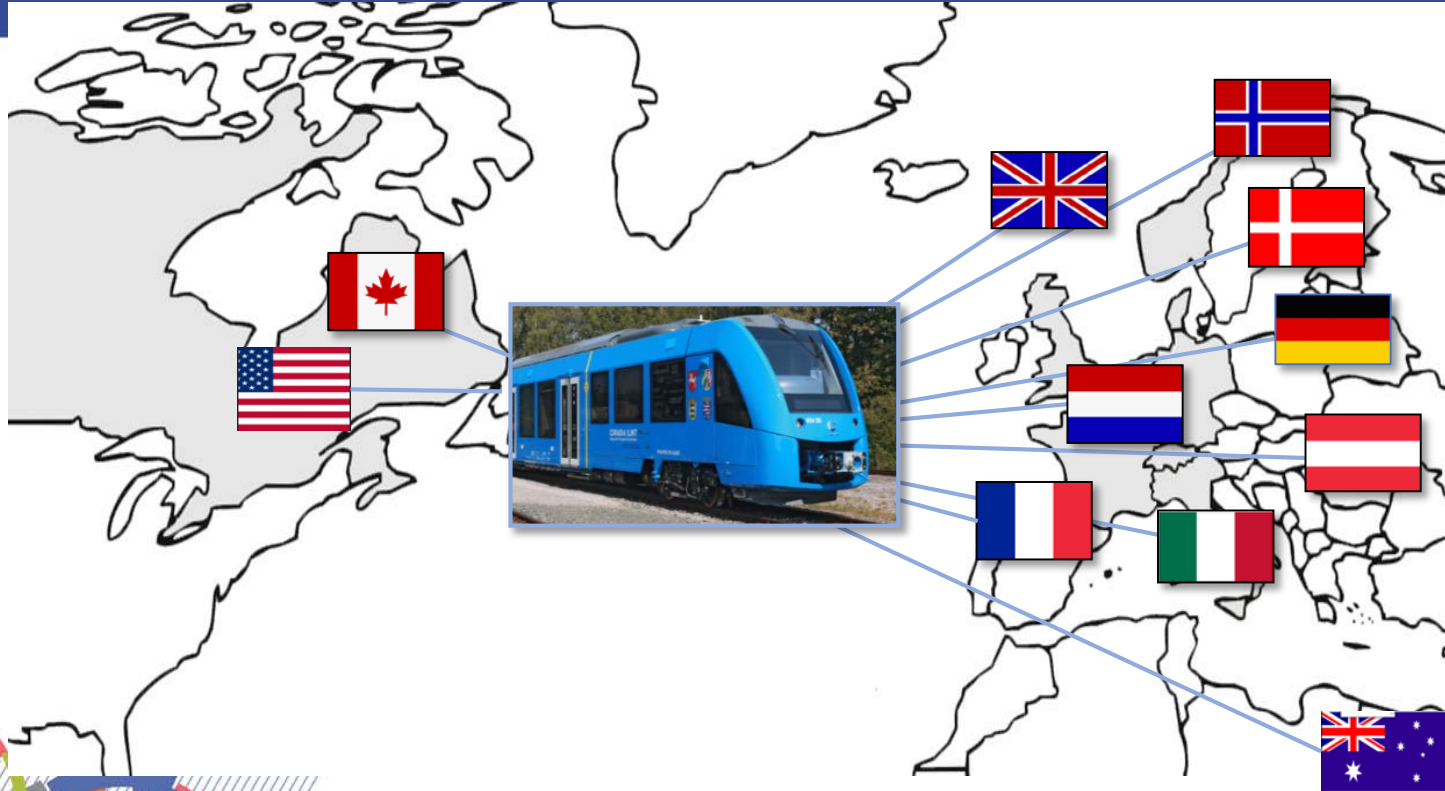
... the **transmission networks** are more and more **overloaded** – hydrogen can be produced in **off-peak** .



One solution: **Local use** of green electricity for **electrolysis**



Next steps: Introduction of HFC Rolling Stock in....



Thank you!!!

CORADIA iLint on YouTube ...

