Welcome to the best practice workshop

ALTERNATIVE FUELS

Proposed by
the UIC Energy efficiency and CO_2 Emissions Sector

Organised by UIC & the Sector's core members:

Gerald Olde Monnikhof, ProRail
Christophe Gueudar Delahaye, SNCF
Matthias Rücker, SBB
Denzel Collins, NR

Philippe Stefanos, UIC

11 June 2024

Workshop timeline

09:30	Introduction	UIC
09:50	Renewable energy Directive, HVO & biofuels	RVO - Netherlands' Enterprise (Gov.) Agency
10:15	Study on alternatives to fossil diesel in rail – next step	AERRL
10:40	Decarbonising rail: relevance of biofuels for rail in Norway	Norwegian Railway Directorate
11:05	Study on greenhouse gas and Nitrogen oxides from biofuels	Ricardo (study commissioned by ProRail)
11:30	Break	
11:55	Ammonia: An Infrastructure Manager's perspective	Network Rail
12:20	Biofuels for track maintenance	Plasser & Theurer
12:45	Panel discussion	
13:00	Lunch	
14:00	Hydrotreated Vegetable Oil (HVO) use	DB Cargo
14:25	Hydrotreated Vegetable Oil (HVO) use	SBB
14:50	Use of biofuels & Biodiesel (B100)	SNCF
15:15	HVO & Fatty Acids/Methyl Esters (FAME) tests outcomes	LINEAS
15:40	Panel discussion	
16:00	Closing words Networking mini cocktail	

Introduction

Decarbonising rail

- **Electrification**

- **Partial electrification**
  - Hybridisation pantograph / combustion engine
  - Hybridisation pantograph / energy storage system (battery)

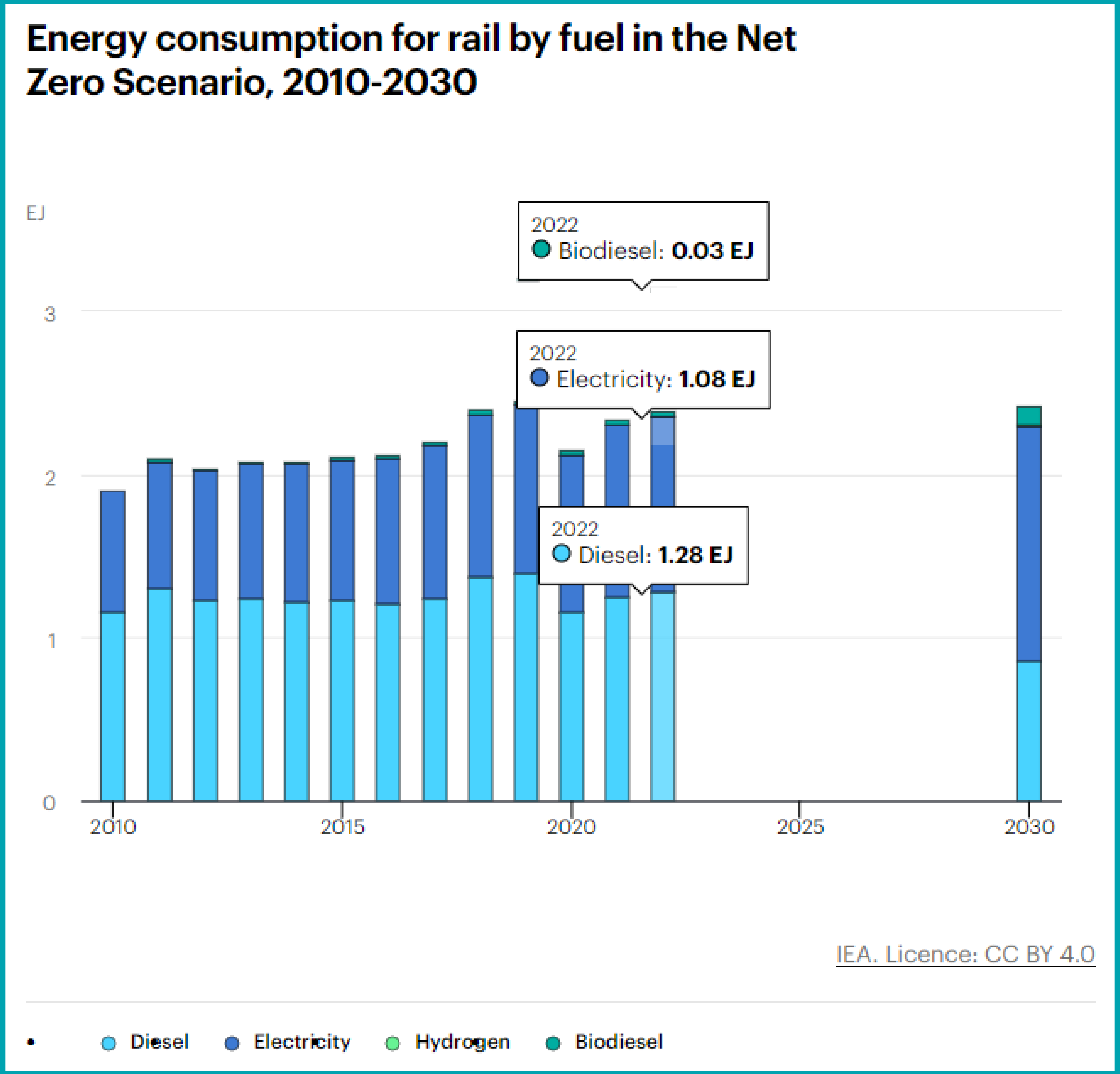
- **Alternatives to fossil fuels (for combustion engines)**
  - Renewable fuels

Introduction

Why is this important since in the EU, most of operations are ran on electrified tracks?

In 2007, the EU only accounted for 15 % of the industrialised countries' use of diesel on the railways, whereas the consumption was dominated by the US (70 %) and growing. In the EU and in Canada liquid fuel consumption was decreasing (UIC 2007).

The IEA reports that in 2022, diesel still represent more than 50% of the energy consumption of rail worldwide (and biodiesel only a very small share).



Introduction

Alternative fuels, what do we mean?

Alternatives to fossil diesel (and other fossil fuels).

These are **renewable fuels**:

- **Biofuels** (from biomass)
  - Pure biomass oil
  - Fatty acid methyl/ethyl ester (FAME / FAEE)
  - Processed biomass oil
    - Hydrotreated vegetable oil (HVO)
  - Biogas
- **Renewable fuels from non-biological origin** (RFNBO)
  - E-fuels
    - Hydrogen from electrolysis powered by renewable energy
      - Hydrogen for combustion
      - Hydrogen for fuel cells
    - E-ethanol, e-methane, e-ammonia, etc. from hydrotreatment
- **Recycled carbon fuels (RCF)**

They are considered renewable either:

- because they are produced from renewable energy and do not produce greenhouse gas when used (hydrogen, e-fuels),
- because their production implies carbon capture, making their use virtually “carbon neutral” (biomass/e-fuels/recycled)

Fuel	Energy content by weight (lower calorific value, MJ/kg)	Energy content by volume (lower calorific value, MJ/l)
FUELS FROM BIOMASS AND/OR BIOMASS PROCESSING OPERATIONS		
Bio-Propane	46	24
Pure vegetable oil (oil produced from oil plants through pressing, extraction or comparable procedures, crude or refined but chemically unmodified)	37	34
Biodiesel – fatty acid methyl ester (methyl-ester produced from oil of biomass origin)	37	33
Biodiesel – fatty acid ethyl ester (ethyl-ester produced from oil of biomass origin)	38	34
Biogas that can be purified to natural gas quality	50	—
Hydrotreated (thermochemically treated with hydrogen) oil of biomass origin, to be used for replacement of diesel	44	34
Hydrotreated (thermochemically treated with hydrogen) oil of biomass origin, to be used for replacement of petrol	45	30
Hydrotreated (thermochemically treated with hydrogen) oil of biomass origin, to be used for replacement of jet fuel	44	34
RENEWABLE FUELS THAT CAN BE PRODUCED FROM VARIOUS RENEWABLE SOURCES, INCLUDING BIOMASS		
Methanol from renewable sources	20	16
Ethanol from renewable sources	27	21
Hydrogen from renewable sources	120	—
Butanol from renewable sources	33	27
Fischer-Tropsch diesel (a synthetic hydrocarbon or mixture of synthetic hydrocarbons to be used for replacement of diesel)	44	34

Introduction

Renewable Energy Directive RED, 2023)

Energy content of fuels

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Introduction

Renewable Energy Directive RED, 2023)

Energy content of fuels

Existing use cases as replacement to fossil diesel

Introduction

Power and biomass-to-liquids (PBtL)

Fuels obtained from the combination of renewable hydrogen (from electrolysis) and biogenic feedstocks, derived from biomass and containing both carbon and hydrogen.

They come with the advantage to significantly improve the fuel yield from biogenic carbon.

To avoid the use of freshwater and minimise the impacts, biomass can be sourced **from waste and by-products** (*see Research for TRAN committee*).

These can then be used straight in **existing combustion engine rolling stock (without heavy modification)**

Beneficial aspects	Adverse aspects
• Reduce gaseous (except nitrogen oxides) and particulate emissions • Minimal sulphur content • Higher cetane number and flash point • Higher denisty/viscosity • Improved lubricity • Biodegradable and low toxicity	• Reduced energy content (by approx. 8-10%) • Increased fuel consumption • Increased nitrogen oxide • Poor low temperature starting & operation • Poor oxidation stability and water absoprtion characteristics • Incompatability with certain elastomers and natural runners • More rapid lubricating oil degradation • Degradation during long-term storage

Introduction

It was already identified benefits and disadvantages of using FAME in comparison to diesel:

Today comes in more knowledge and best practices from trials, pilot projects and adoption of FAME or HVO in rail,

Let’s dig into it!

Introduction

Sources

Renewable Energy Directive, 2023
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023L2413&qid=1699364355105

Research for TRAN Committee: Assessment of the potential of sustainable fuels in transport, European Parliament, 2023, https://www.europarl.europa.eu/thinktank/en/document/IPOL_STU(2023)733103

Study on alternatives to fossil diesel in railways, AERRL x Eolos, Dec. 2022,
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Biofuels for rail transport Overview, ETIP
https://www.etipbioenergy.eu/value-chains/products-end-use/end-use/rail

Railways and biofuels report, UIC x ATOC, 2007,
https://uic.org/IMG/pdf/railways_and_biofuels_final_report.pdf

General organisation of Rolling Stock & Energy Sectors

Railway System Forum

Chair: Robert Ampomah, Network Rail,
Christian Chavanel, UIC

Rolling Stock and Energy Sectors & Labelling

Laurent Fréchède, UIC

Rolling Stock

Chair: Marco Caposciutti, Trenitalia
Laurent Fréchède, UIC

Energy

Chair : Jo Lewington, Network Rail
Co Chair: Claudio Spalvieri, RFI
Sunjoong Kim, UIC

Labelling

Henri Tsukahara, UIC

General organisation of Rolling Stock Sector

Rolling Stock
Chair: Marco Caposciutti, Trenitalia
Laurent Fréchède, UIC

Energy
Chair : Jo Lewington, Network Rail
Co Chair: Claudio Spalvieri, RFI
Sunjoong Kim, UIC

Labelling
Henri Tsukahara, UIC

SET Passengers
Chair: Ms Chen Ping
Hajar Toumi UIC

SET Running Gear
Chair: Frédéric Desgaches
Stefano Guidi & Hajar Toumi
Hajar UIC

SET TCMS & OMTS
Chair: Ms Hongwei Zhao
Shinta Tsukii , UIC

SET Diesel
Chair: Jaromir Bittner
Stefano Guidi & Sunjoong Kim, UIC

Traindy
Chair: Thierry Durand
Hajar Toumi UIC

SET Freight
Chair: Eric Lambert
Hajar Toumi UIC

ZEFES
Eric Lambert
Laurent Fréchède, UIC

CTWG
Kristof Van Londersele
Stefano Guidi, UIC

SET Braking
Chair: Frank Minde
Henri Tsukahara, UIC

B 126-3
Leonardo Cabbruci
(dynamometers bench)
Henri Tsukahara, UIC

B 126-13
Stefan Dörsch (composite brake blocks & pads)
Henri Tsukahara, UIC

SET Traction
Chair: Bo Chen
Shinta Tsukii, UIC

SET Maintenance
Chair: to be defined
SET to be relaunched

SET: Sector Expert Team
TCMS: Train Control and Monitoring System
OMTS: On Board Multimedia and Telematic Services

We have:
8 active SETs
1 special group and 4 subgroups

Laurent Fréchède: SET Maintenance
Henri Tsukahara: SET Running Gear, SET Braking
Shinta Tsukii: SET TCMS& OMTS, SET Traction
Stefano Guidi & Sun Joong Kim: SET Diesel
Stefano Guidi & Toumi Hajar: SET Running Gear
Hajar Toumi: SET Passengers, SET Freight, Traindy

General organisation of Energy Sector

Rolling Stock

Chair: Marco Caposciutti, Trenitalia
Laurent Fréchède, UIC



Energy

Chair : Jo Lewington, Network Rail
Co Chair: Claudio Spalvieri, RFI
Sunjoong Kim, UIC

Labelling

Henri Tsukahara, UIC

This sector is more and more dynamic as Energy is very sensitive

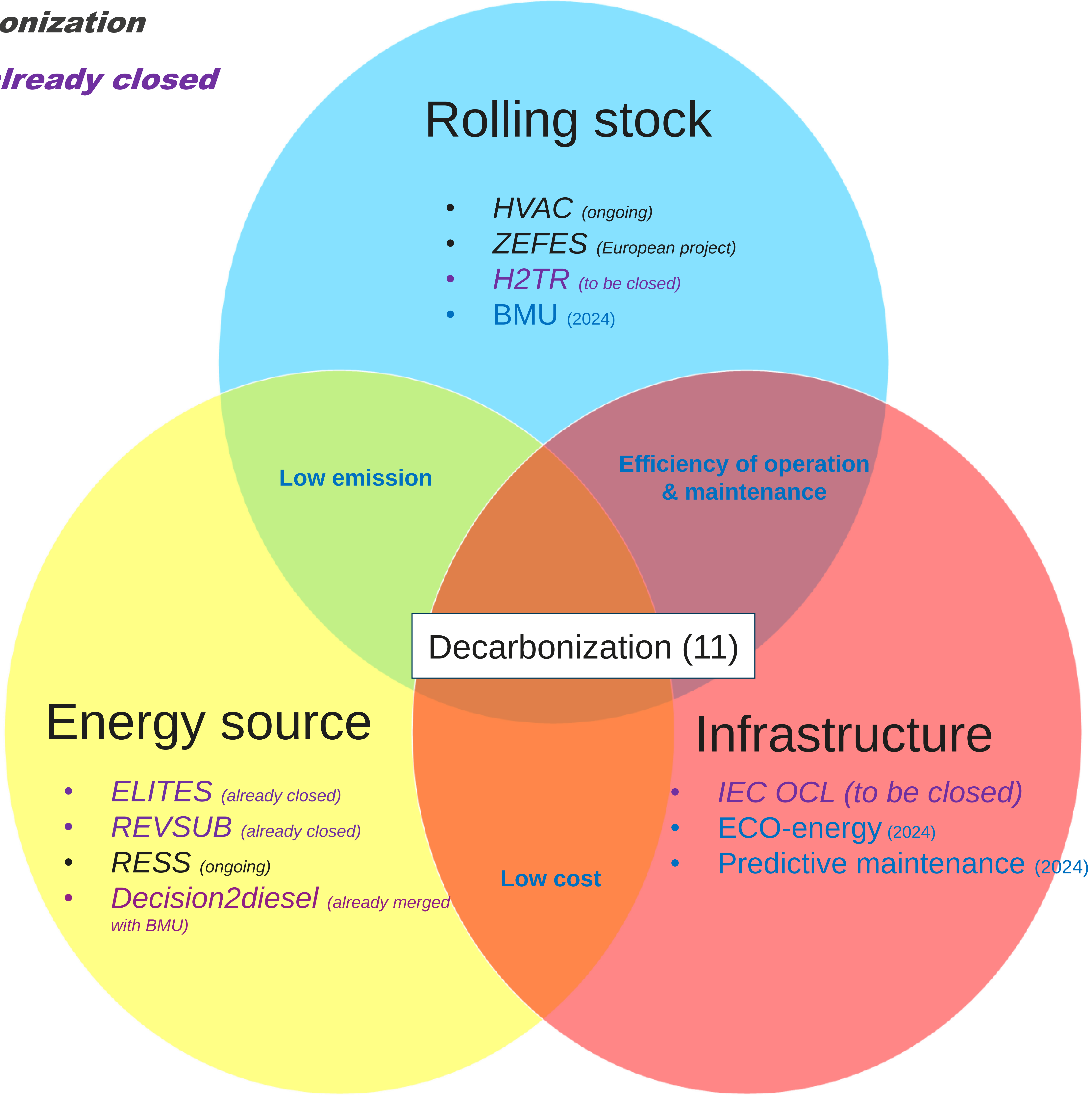
- Its cost increases and is randomized
- There is an urgent need for decarbonization
- New alternatives to diesel trains, from pure electric, to battery trains
- H_2 trains need their own supply stations

There are plenty of rail electrification projects all over the world, “transport greening”

- Battery
- Hydrogen
- Energy Storage
- Decision to Diesel

Sector Expert Team (SET)
Sun Joong Kim: Energy & SET Diesel

11 OPTINs for decarbonization
=> 3 ongoing OPTINs
=> 5 to be closed or already closed
=> 3 to be launched



- In blue, the ones we plan to launch.
- In black, the existing ones
- In purple, those in the completion phase or already closed

1. REFOCUSING TECHNICAL PROJECTS (to be launched in 2025?)

Rolling Stock

1 — IRS Rolling Stock
3 years
2700 k€

2 — Crack Free Axle
2 years
200 k€

3 — OMTS
2 years
200 k€

4 — ECO Engines
Remplacement of Diesel Combustion Fluid in RS Engines
2 years
200 k€

5 — MODU-FREIGHT
Modular Freight System
2 years
200 k€

6 — CODAG
Codification Application Guide
2 years
200 k€

Developed in collaboration with other UIC Platforms

Collaboration with:

- **RSF** (Infrastructure) : projects 1, 2, 4, 5, 6
- **Safety** Platform: projects 1, 2, 3, 4, 5
- **Security** Platform: project 1
- **Sustainability** Platform: projects 1, 4, 5, 6
- **Passenger:** projects 1, 2, 3, 4
- **Freight:** projects 1, 4, 5, 6

For further information, please contact
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UIC
WORK PROGRAMME
2025

ECO ENGINES
Rolling Stock Sector
RSF/ 2025/ 897

Shinta Tsukii, Senior Advisor

Project Summary

Railway System/ Rolling Stock Sector

Scope

- Many DMUs that are less than half their estimated lifetime in operation.
  Converting them for operation with natural gas or biogas will allow them to remain in operation during the second phase of their life.
- UIC could provide a methodology that can be used to reduce the emissions of diesel engines while other solutions involving the replacement of the thermal engine become mature.

Duration & Cost

- From 01/2025 to 12/2026 - **2** years
- Per year : 100k € - Total 200k €

Objectives, Drivers & Benefits

Objectives

- Identifying best practices, good KPIs and a decision-making tool on solutions of replacement fluid for diesel combustion fuels

Drivers

- Greenhouse gas emission reduction targets

Benefits

- A methodology that can be used to reduce the emissions of diesel engines while other solutions involving the replacement of the thermal engine become mature (see specific situation of the diesel locomotives)
- This can be used in EUROPE and other Regions

Key Points

Key Point 1

- Solutions to be applied to existing rolling stock while awaiting alternative solutions for all use cases (see locomotives for freight or heavy passenger trains)

Key Point 2

- 20% of the kilometres worked by multiple units are done by DMUs
- 44% of the lines in Europe are not electrified

Key Point 3

- Hydrogen cells and traction batteries produce a limited power not sufficient for freight locomotives for instance

Deliverables, Dependencies & Support

Deliverables

- State of the art [deadline on 30/06/2025]
- Methodology for choice making [deadline on 31/03/2026]
- IRS + software [deadline on 31/12/2026]

Dependencies

Support

- Sector Expert Team on Diesel(SET12), Traction(SET11) and Data Communication & Driver's Cab(SET08)
- UIC Sustainability Unit
- Manufacturers, Risk Assessment Bodies or Research centers

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INTERNATIONAL UNION
OF RAILWAYS

Alternative fuels workshop

Alternatives to fossil fuels in rail

RVO

Netherlands' Enterprise (Gov.) Agency

Renewable Energy Directive, HVO & biofuels

Paul Sinnige

Strategic advisor sustainable fuels and feedstock

UIC Alternative fuels workshop, 11 June 2024

INTERNATIONAL UNION OF RAILWAYS

Rijksdienst voor Ondernemend Nederland

EU Renewable fuel for transport policy (RED)
HVO & other biofuels

UIC Alternative Fuels workshop

Paris, June 11 2024

Paul Sinnige

RVO, Netherlands Energy Agency

>> Duurzaam, Agrarisch, Innovatief
en Internationaal ondernemen

Main changes RED II to III for transport

Transport tragets

REDII

At least 14% renewables in transport (road and rail)

+

At least 3.5% advanced biofuels

+

Incentives for advanced biofuels (double counting) + use of fuels in maritime and aviation (1.2x multiplier)

Revised RED

At least 29% renewables in transport (all transport modes)

or

14.5% reduction of emission intensity of fuels

+

At least 5.5% advanced biofuels and RFNBOs (combined target of which at least 1%-point RFNBOs)

+

Incentives for advanced biofuels and RFNBOs (double counting)

+

Incentives for their use in aviation and maritime (1.2x or 1.5x multipliers for advanced biofuels and RFNBO respectively)

New indicative target of 1.2% in the maritime sector

RFNBO = Renewable Fuels of Non Biological Origin

European Commission

Implementation in the Netherlands

RED-III transportdoelen

RED-II

Minstens 14% hernieuwbare energie in transport (weg en spoor)

+

Minstens 3.5% geavanceerde biobrandstoffen

+

Stimulans voor geavanceerde biobrandstoffen (dubbeltelling) + gebruik van brandstoffen in maritiem en luchtvaart (1.2x multiplier)

RED-III

~~Minstens 29% hernieuwbare energie in transport (alle transport sectoren)~~

~~of~~

14.5% emissiereductie van brandstoffen

+

Minstens 5.5% geavanceerde biobrandstoffen en RFNBOs (gecombineerd doel waarvan minstens 1%-punt RFNBOs)

~~+~~

~~Stimulans voor geavanceeerde biobrandstoffen en RFNBOs (dubbeltelling)~~

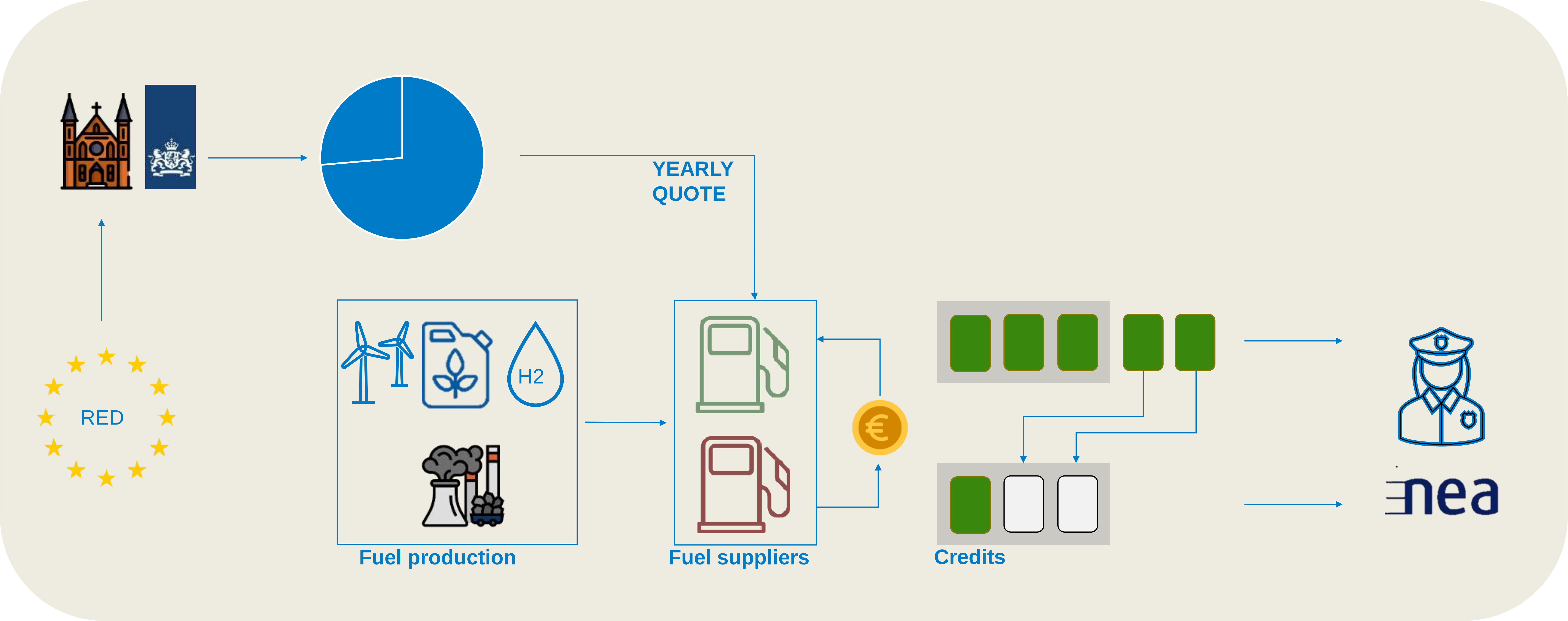
+

Stimulans (1.2x voor het gebruik van brandstoffen in zeevaart en luchtvaart or 1.5x multipliers voor respectief geavanceerde biobrandstoffen en RFNBOs)

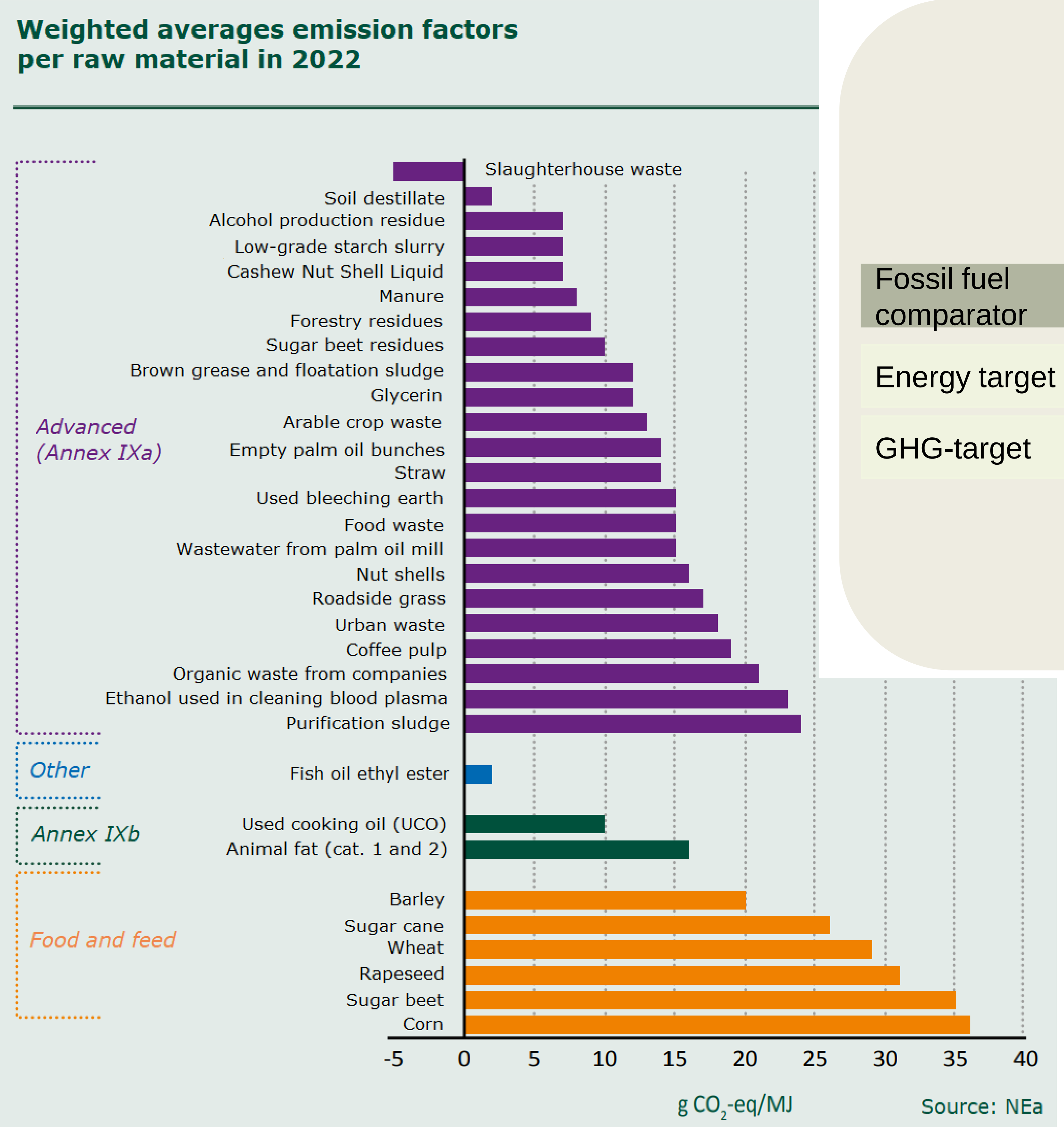
Nieuw doel van 1.2% in de maritieme sector

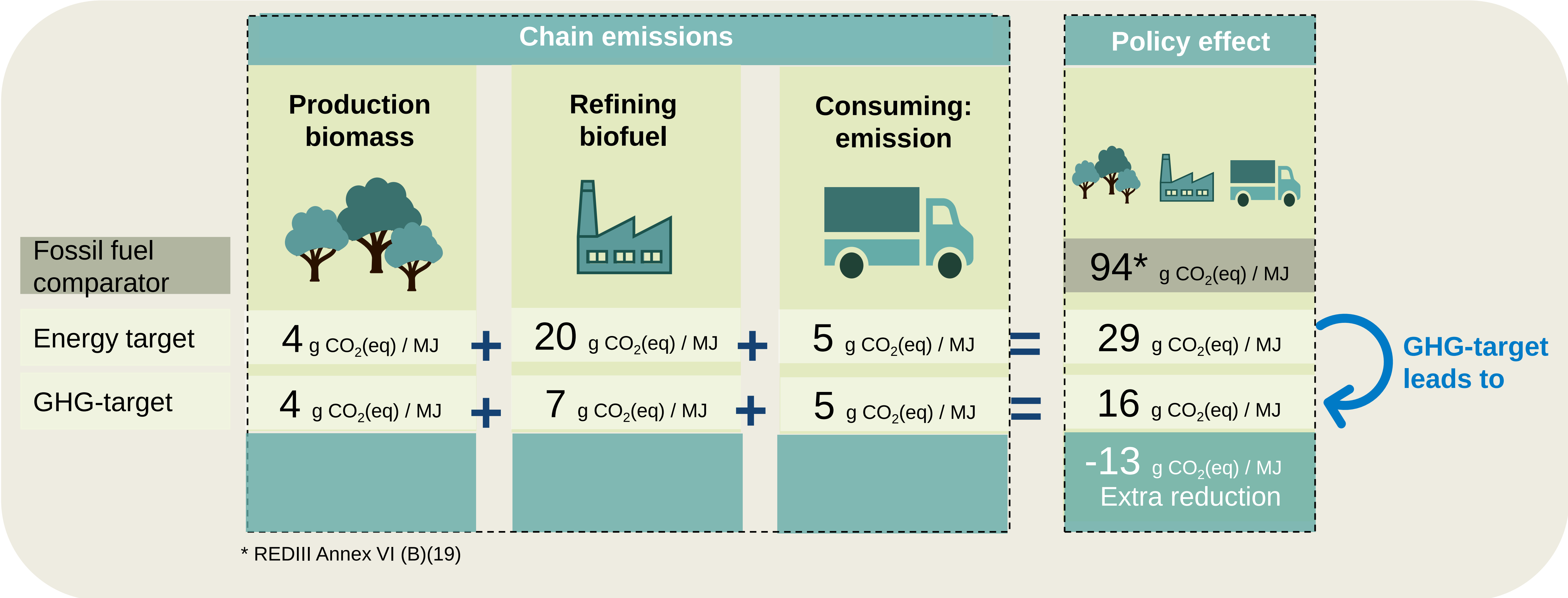
RFNBO = Renewable Fuels of Non-Biological Origin

Dutch System Renewable Energy in transport



Netherlands will pivot to GHG-target





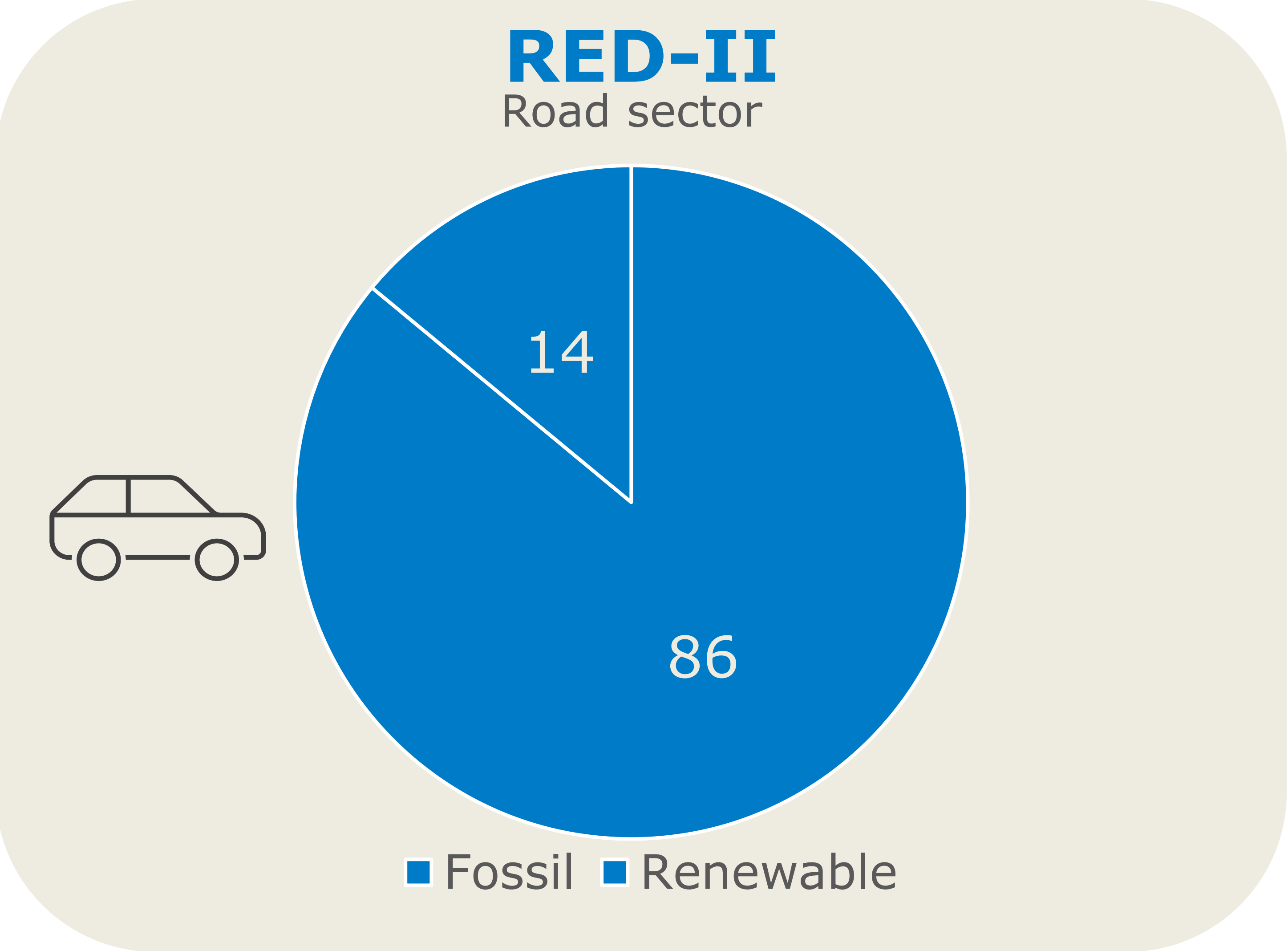
WHY?

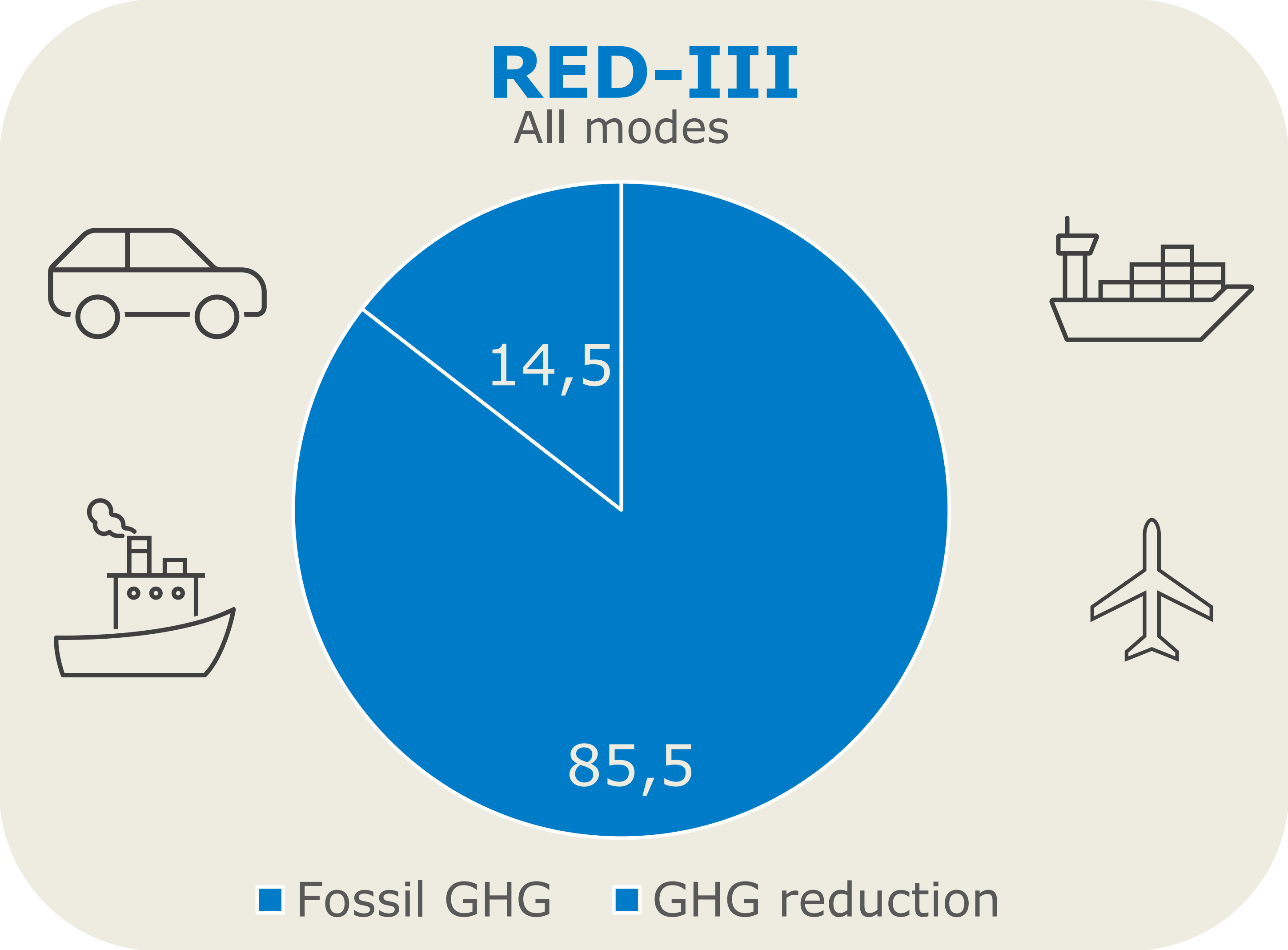
- Straight to our goal
- Incentivise best performance
- No double counting

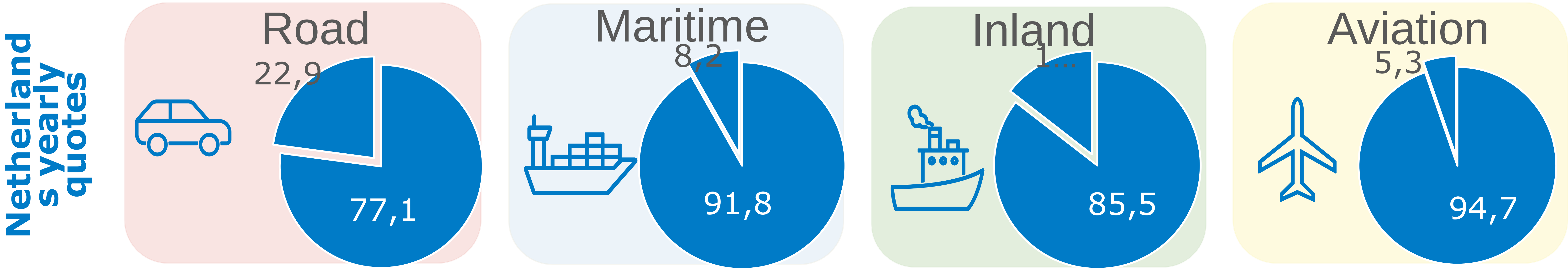
Challenge

- Increasing reliance on PoS and UDB

Netherlands to set mode specific targets







Advanced Biofuels

- Based on feedstock listed in Annex IX REDII (EU) 2018/2001
- Double counted towards the obligation and/or subject to subtarget
- Amended March 2024

Part A. Feedstocks for the production of biogas for transport and advanced biofuels, the contribution of which towards the minimum shares referred to in the first and fourth subparagraphs of Article 25(1) may be considered to be twice their energy content:

(a) Algae if cultivated on land in ponds or photobioreactors;

(b) Biomass fraction of mixed municipal waste, but not separated household waste subject to recycling targets under point (a) of Article 11(2) of Directive 2008/98/EC;

(c) Biowaste as defined in point (4) of Article 3 of Directive 2008/98/EC from private households subject to separate collection as defined in point (11) of Article 3 of that Directive;

(d) Biomass fraction of industrial waste not fit for use in the food or feed chain, including material from retail and wholesale and the agro-food and fish and aquaculture industry, and excluding feedstocks listed in part B of this Annex;

(e) Straw;

(f) Animal manure and sewage sludge;

(g) Palm oil mill effluent and empty palm fruit bunches;

(h) Tall oil pitch;

(i) Crude glycerine;

(j) Bagasse;

(k) Grape marcs and wine lees;

(l) Nut shells;

(m) Husks;

(n) Cobs cleaned of kernels of corn;

(o) Biomass fraction of wastes and residues from forestry and forest-based industries, namely, bark, branches, pre-commercial thinnings, leaves, needles, tree tops, saw dust, cutter shavings, black liquor, brown liquor, fibre sludge, lignin and tall oil;

(p) Other non-food cellulosic material;

(q) Other ligno-cellulosic material except saw logs and veneer logs.

Part B. Feedstocks for the production of biofuels and biogas for transport, the contribution of which towards the minimum share established in the first subparagraph of Article 25(1) shall be limited and may be considered to be twice their energy content:

(a) Used cooking oil;

(b) Animal fats classified as categories 1 and 2 in accordance with Regulation (EC) No 1069/2009.

Annex IX RED II amended (1)

Feedstocks added in Part A:

(r) Fusel oils from alcoholic distillation;

(s) Raw methanol from kraft pulping stemming from the production of wood pulp;

(t) Intermediate crops, such as catch crops and cover crops that are grown in areas where due to a short vegetation period the production of food and feed crops is limited to one harvest and provided their use does not trigger demand for additional land, and provided the soil organic matter content is maintained, where used for the production of biofuel for the aviation sector;

(u) Crops grown on severely degraded land, except food and feed crops, where used for the production of biofuel for the aviation sector;

(v) Cyanobacteria.”;. (c) Damaged crops that are not fit for use in the food or feed chain, excluding substances that have been intentionally modified or contaminated in order to meet this definition;

(d) Municipal wastewater and derivatives other than sewage sludge;

(e) Crops grown on severely degraded land excluding food and feed crops and feedstocks listed in Part A of this Annex, where not used for the production of biofuel for the aviation sector;

(f) Intermediate crops, such as catch crops and cover crops, and excluding feedstocks listed in Part A of this Annex, that are grown in areas where due to a short vegetation period the production of food and feed crops is limited to one harvest and provided their use does not trigger demand for additional land and provided the soil organic matter content is maintained, where not used for the production of biofuel for the aviation sector.

Annex IX RED II amended (2)

Feedstocks added in Part B:

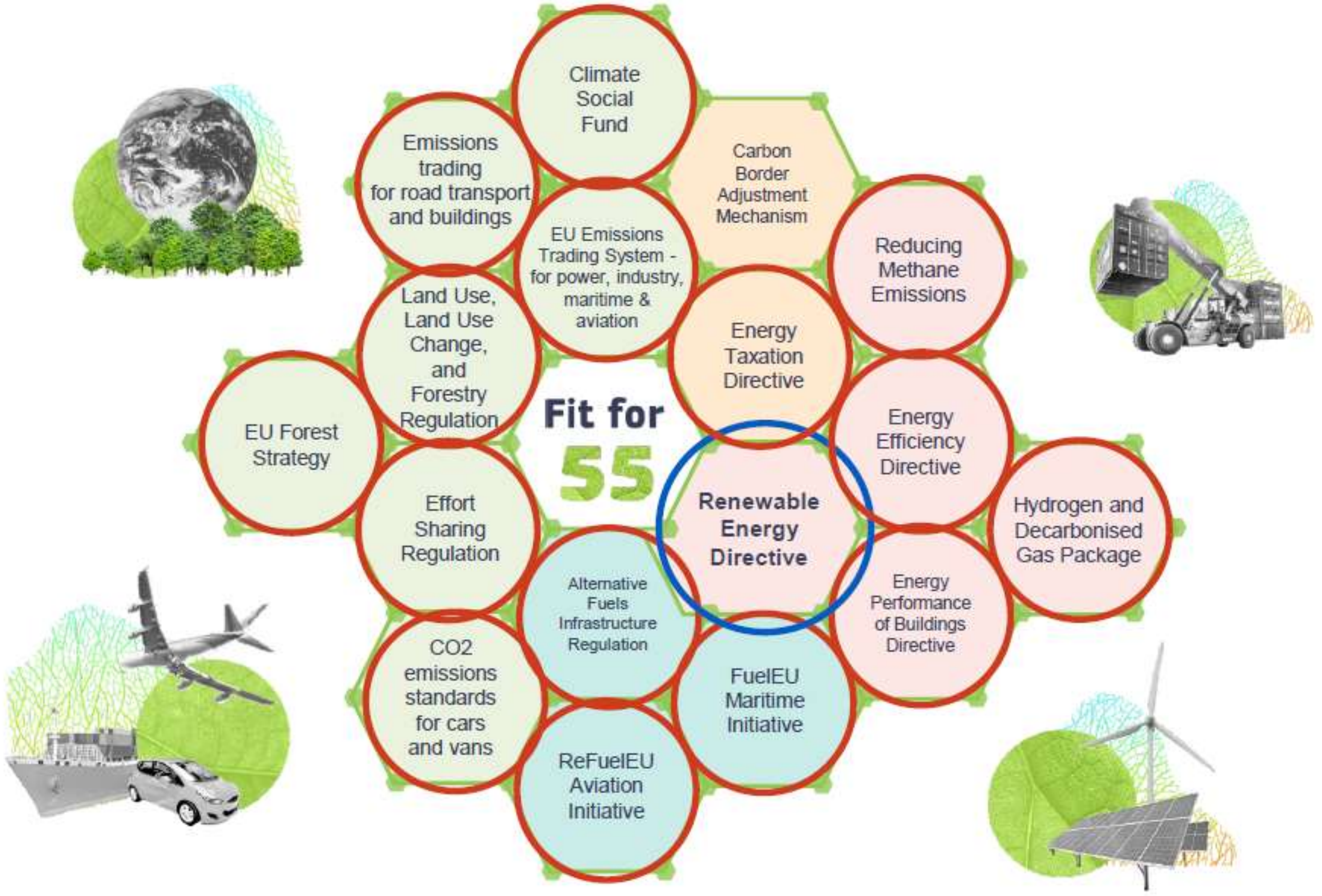
(c) Damaged crops that are not fit for use in the food or feed chain, excluding substances that have been intentionally modified or contaminated in order to meet this definition;

(d) Municipal wastewater and derivatives other than sewage sludge;

(e) Crops grown on severely degraded land excluding food and feed crops and feedstocks listed in Part A of this Annex, where not used for the production of biofuel for the aviation sector;

(f) Intermediate crops, such as catch crops and cover crops, and excluding feedstocks listed in Part A of this Annex, that are grown in areas where due to a short vegetation period the production of food and feed crops is limited to one harvest and provided their use does not trigger demand for additional land and provided the soil organic matter content is maintained, where not used for the production of biofuel for the aviation sector.”.

Transport provisions as part of Fit for 55



Types of steering mechanisms in FF55

Mandated share of renewables

RED II
- e.g. minimum 14% renewable energy in fuel mix by 2030

ReFuelEU Aviation
- e.g. minimum 5% of SAF in fuel mix by 2030

GHG intensity reduction

RED III
- e.g. -14.5% GHG emission intensity by 2030

FuelEU Maritime
- e.g. -6% GHG emission intensity by 2030

Energy Taxation Directive (ETD)
- e.g. minimum tax tariff categories dependent on GHG emission intensity

Effective GHG emission reduction

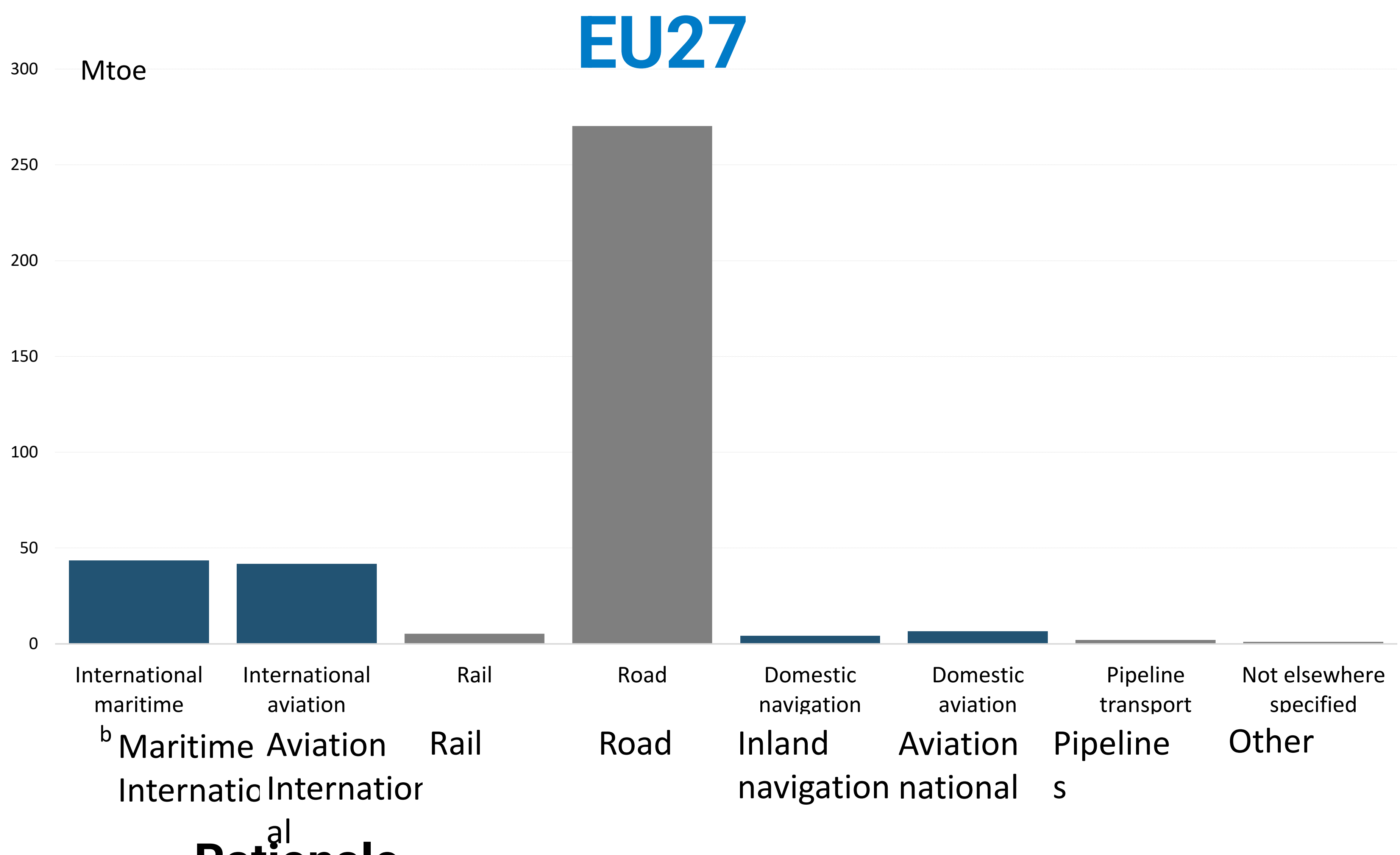
ETS
- e.g. -61% overall GHG emissions in these sectors compared to 2005

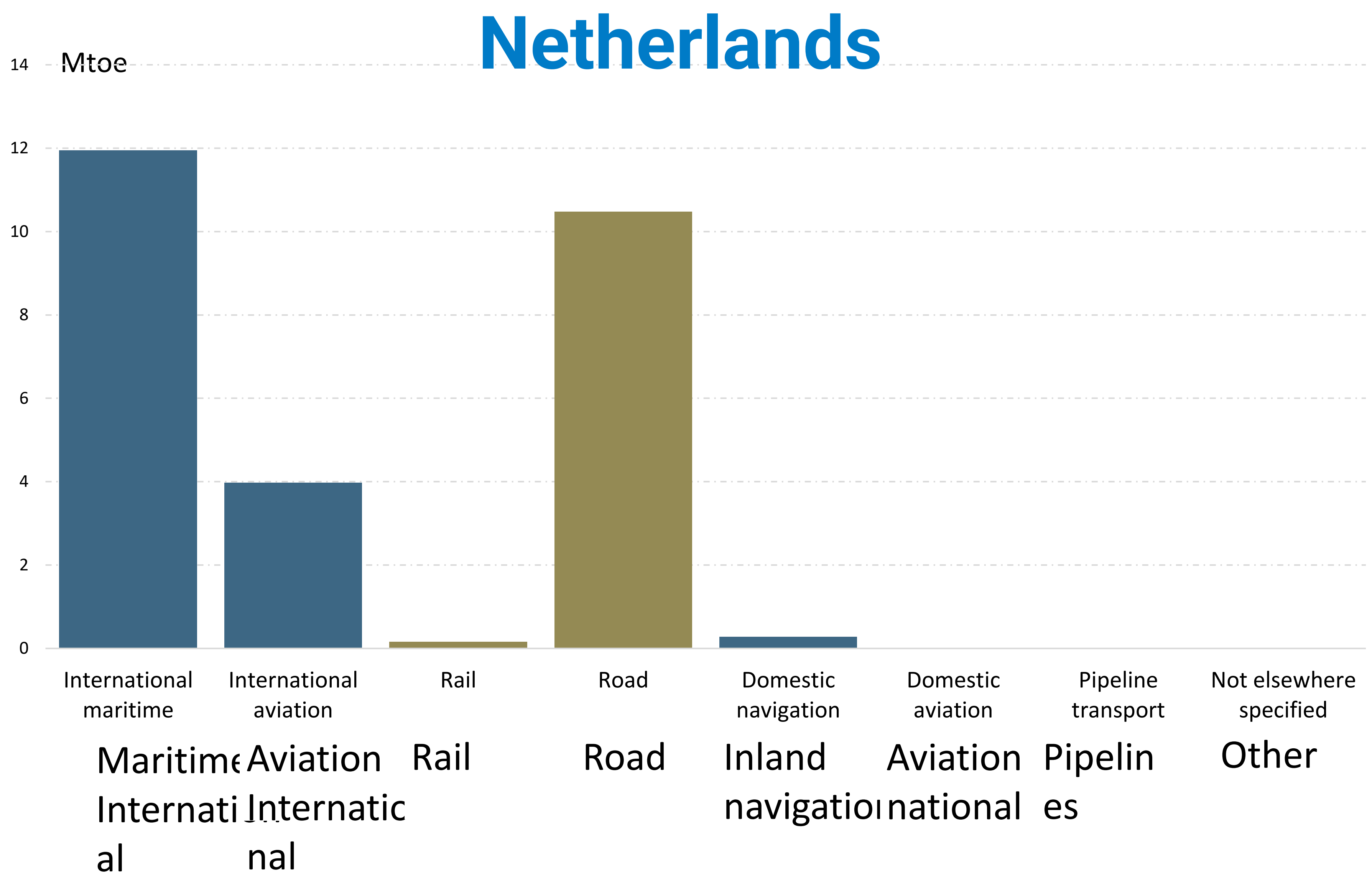
ETS II
- e.g. -43% overall GHG emissions in these sectors compared to 2005

Effort Sharing Regulation (ESR)
- e.g. -48% GHG emissions in these sectors in the Netherlands compared to 2005

Platform Hernieuwbare Brandstoffen.

Energy consumption in the transport sector in 2019
EU 27 and Netherlands compared



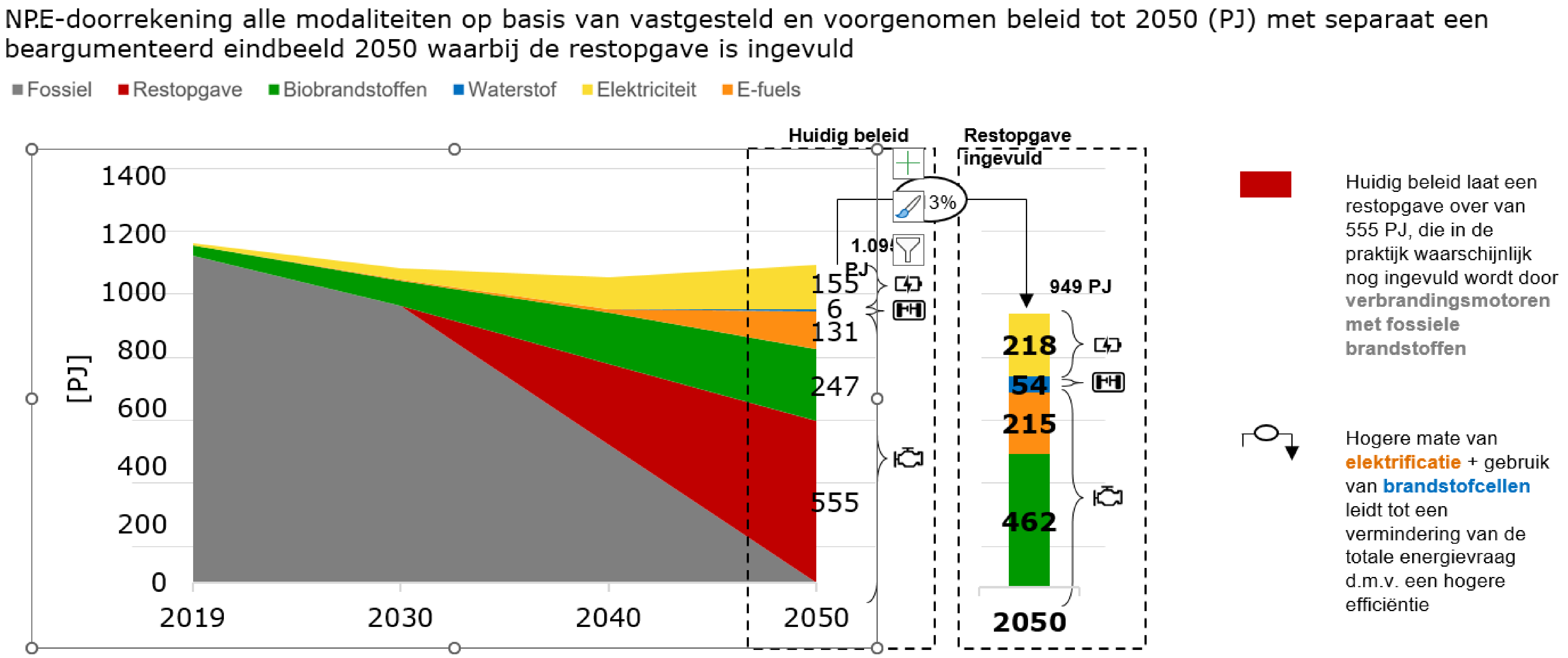


Rationale

- Maritime has large role in fuel consumption in the Netherlands
- International Maritime Organisation (IMO) emission reduction targets will soon also require renewable fuels (currently, emission reductions via renewable fuels/energy carriers are not yet included in IMO-regulation)
- Proposed FuelEU Maritime aims at decreasing the carbon intensity of fuels used; this supports the use of renewable fuels in this sector

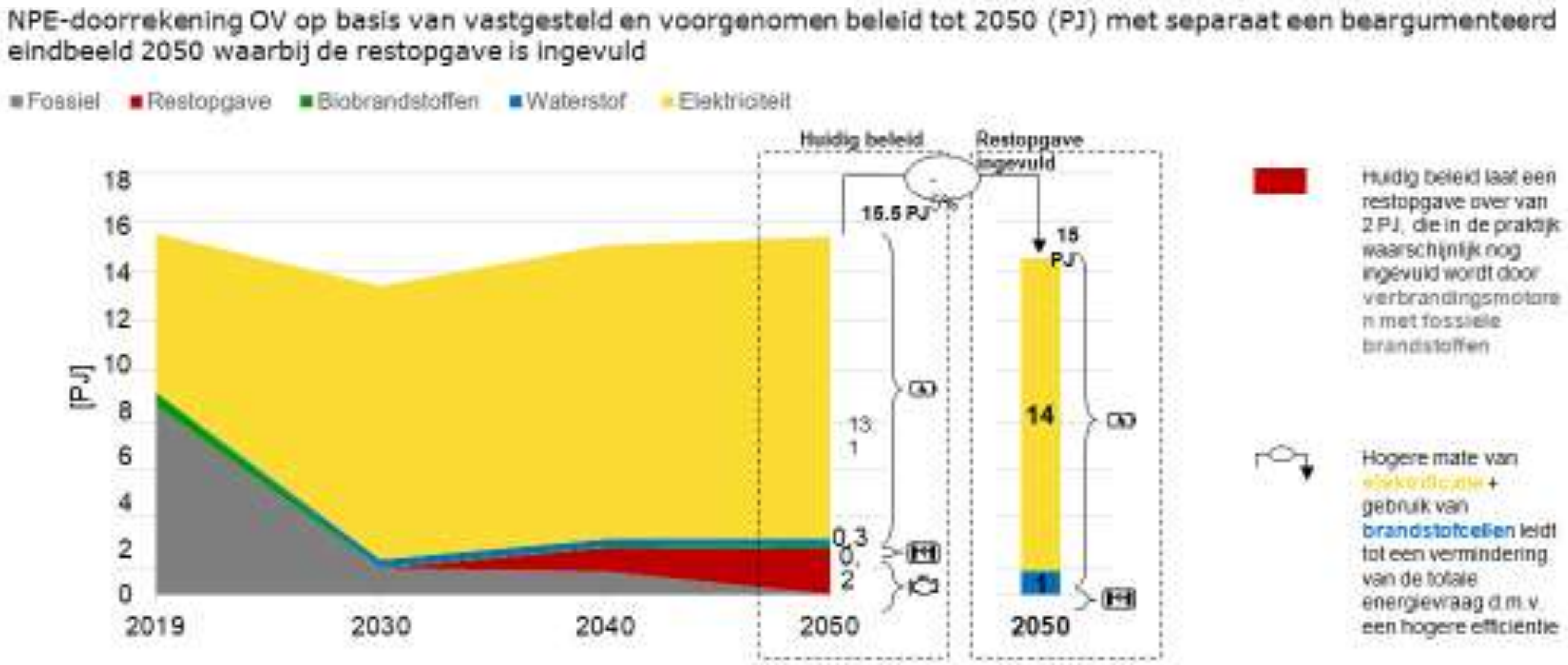
Based on Eurostat data, complete energy balances [NRG_BAL_C]

NL National Plan Energy systems 2050

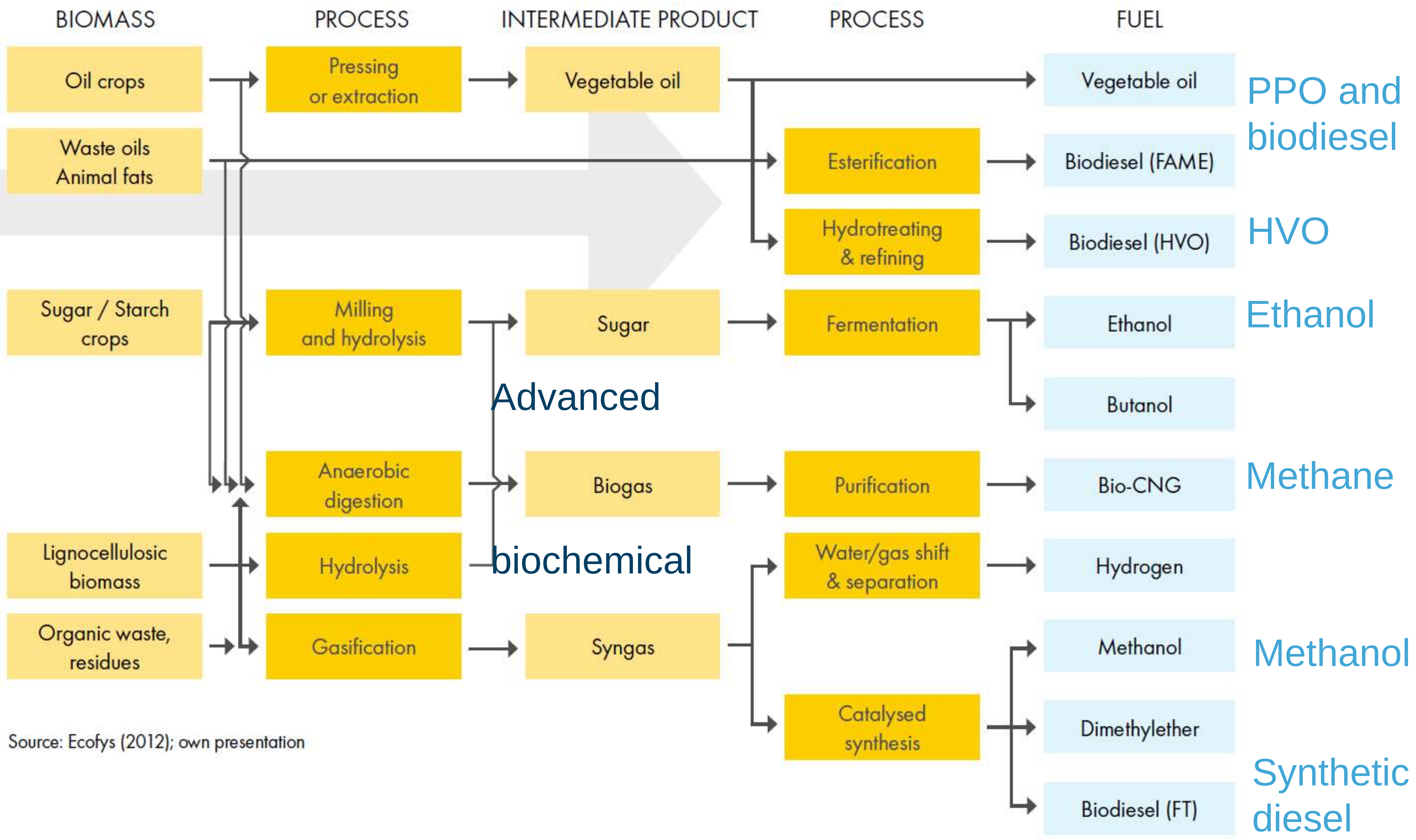


All transport modes

Public transport



Biofuel production routes

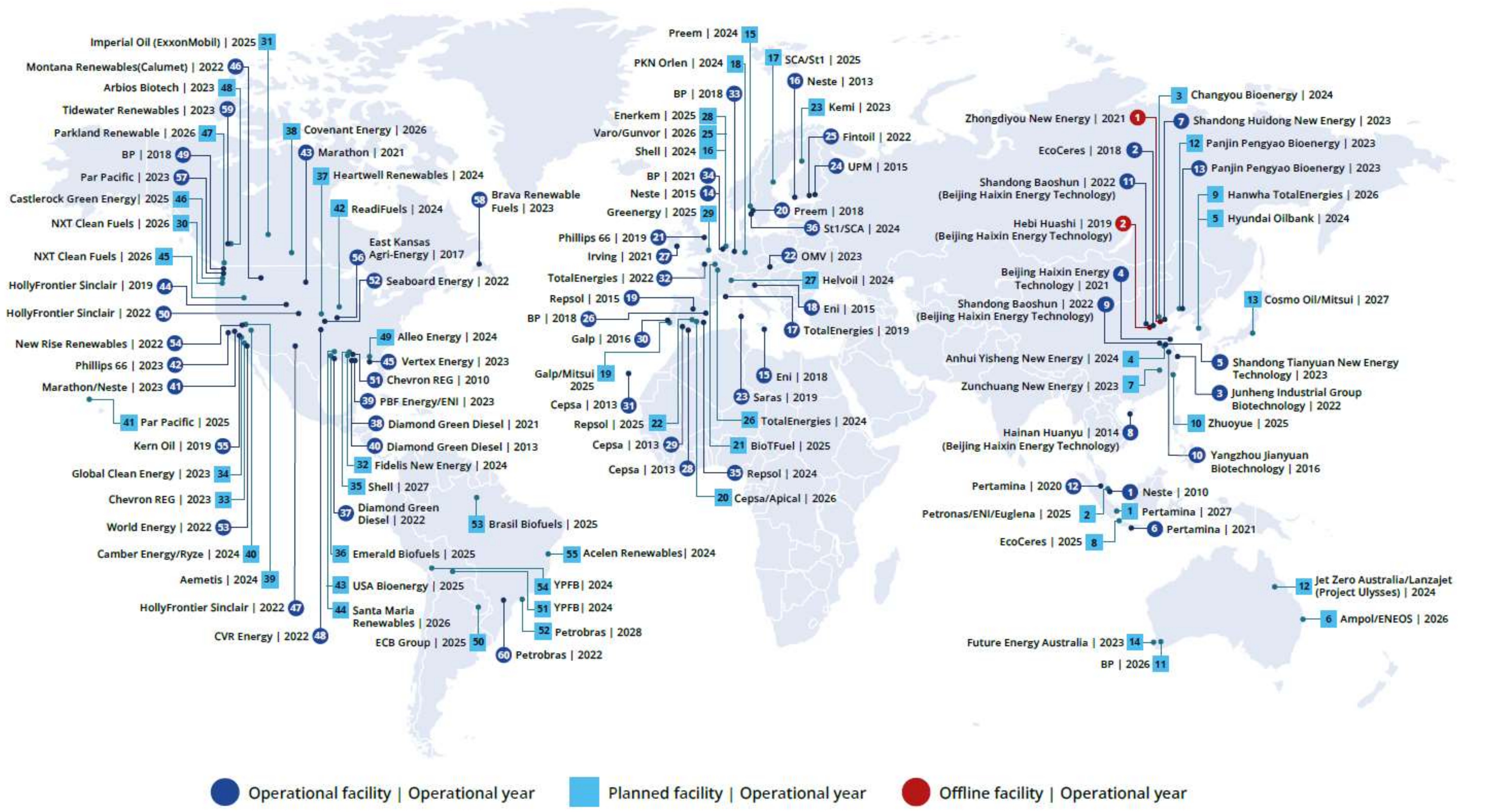


Source: Ecofys (2012); own presentation

HVO/Renewable Diesel Capacity Map

HVO and Renewable Diesel are one of the fastest-growing fuel markets in Europe and the US. Capacity is forecast to double by 2028 with demand likely to outstrip supply. In line with this rapid growth, a proper physical spot market is emerging. Argus captures the value of HVO/RD using bids, offers and trades made by market participants on the trade initiation platform, Argus Open Markets®, to underpin independent HVO price assessments.

Learn about our truly representative daily pricing that captures market-relevant content on supply, demand, feedstocks and more. Visit argusmedia.com/HVO



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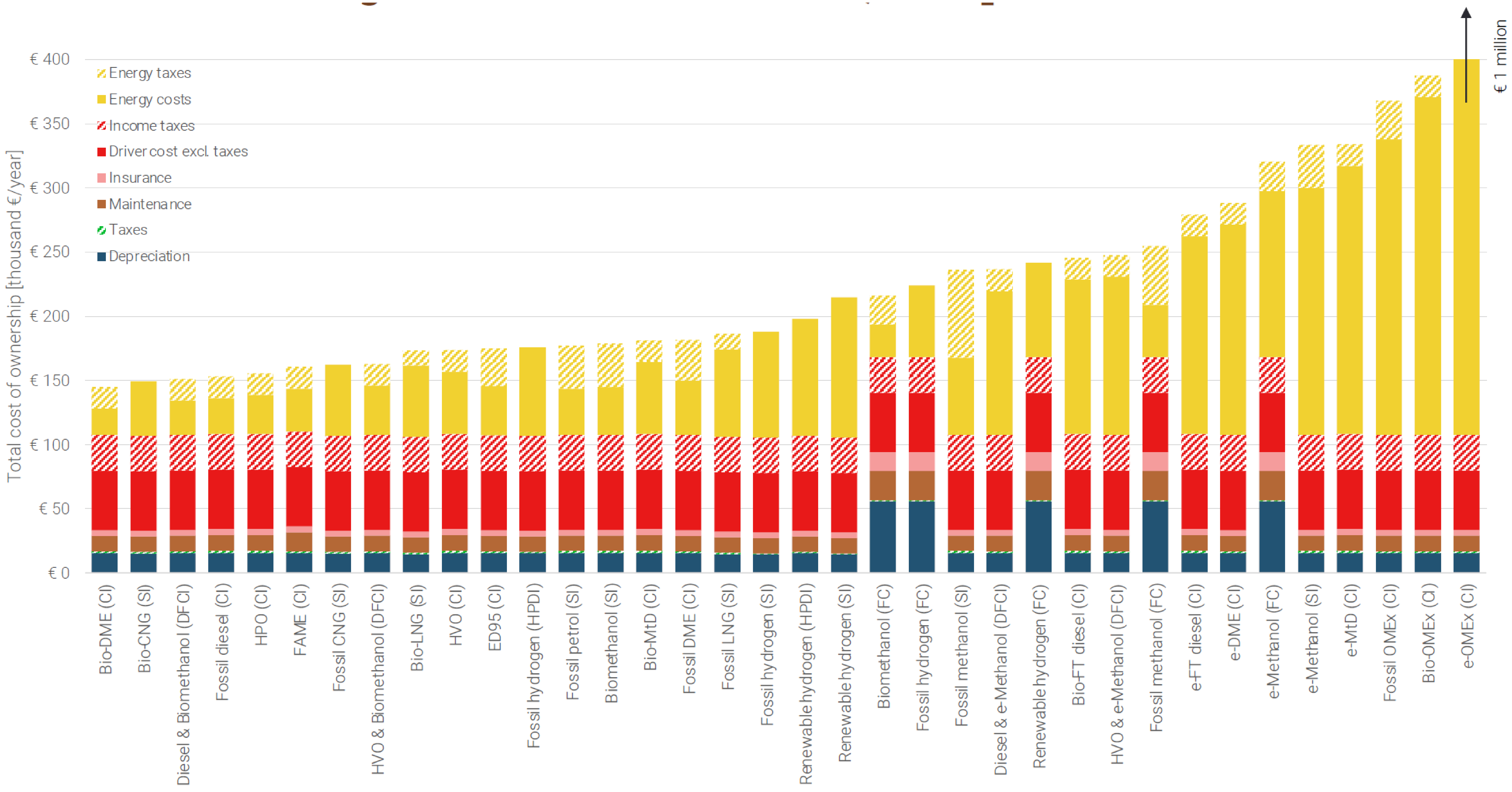
V1.0 May 2024

Source: www.argusmedia.com

Comparing total cost of ownership (HD)

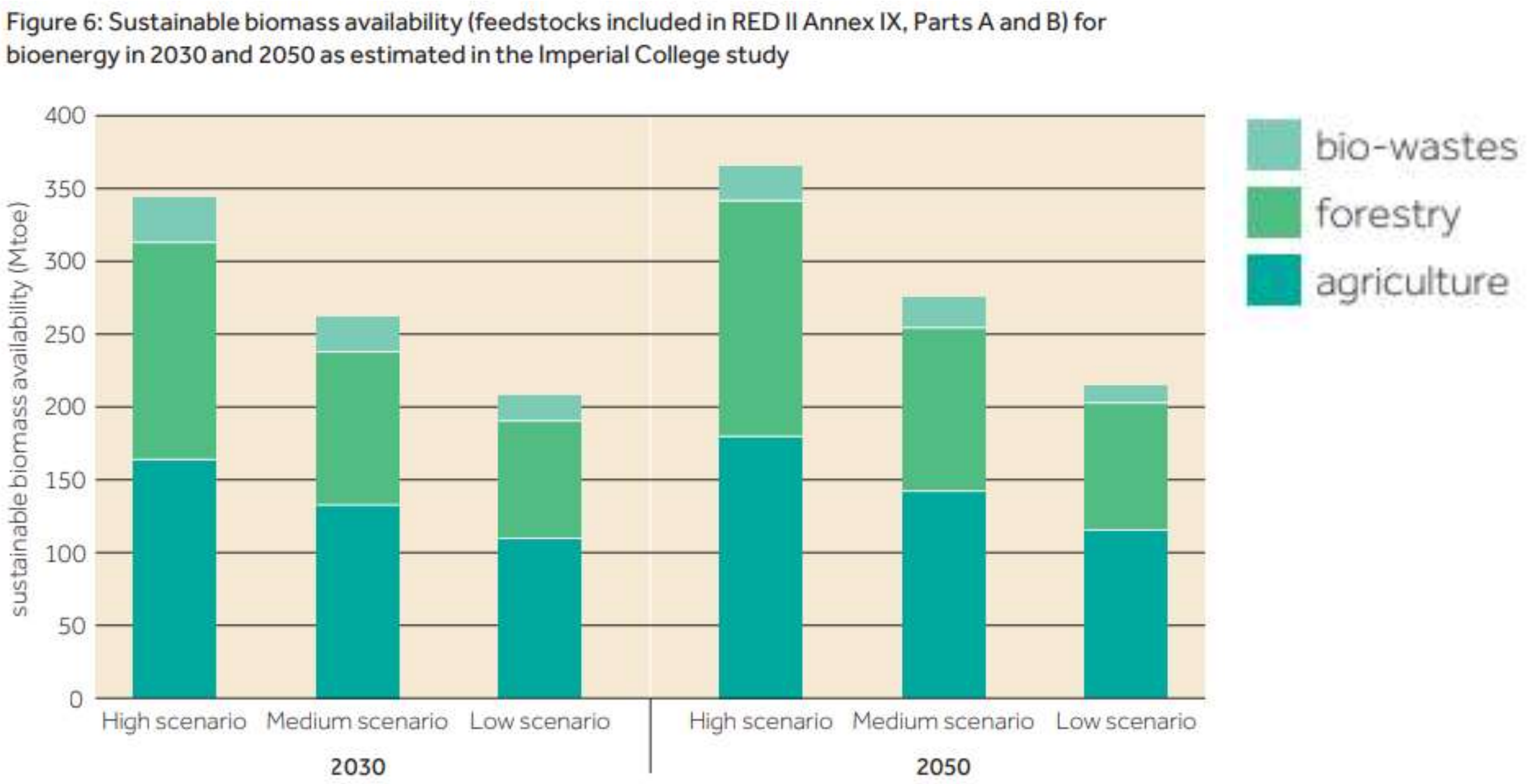


* e-OMEx has been calculated with an assumed fuel price

CI = Compression ignition, DFCI = Dual fuel compression ignition, SI = Spark ignition, HPDI **= High pressure direct injection**, FC = Fuel cell.
*** Note that all renewable fuels in the study are subject to energy content compensation for excise duties (Handboek Accijns 4.7.2)**

Source: To drop-in or to adapt, Studio Gear-Up, March 2022

Sustainable biomass availability in EU



Source: Concawe review Imperial College Londen study Sustainable biomass in the EU, to 2050

Feedstock types agricultural production

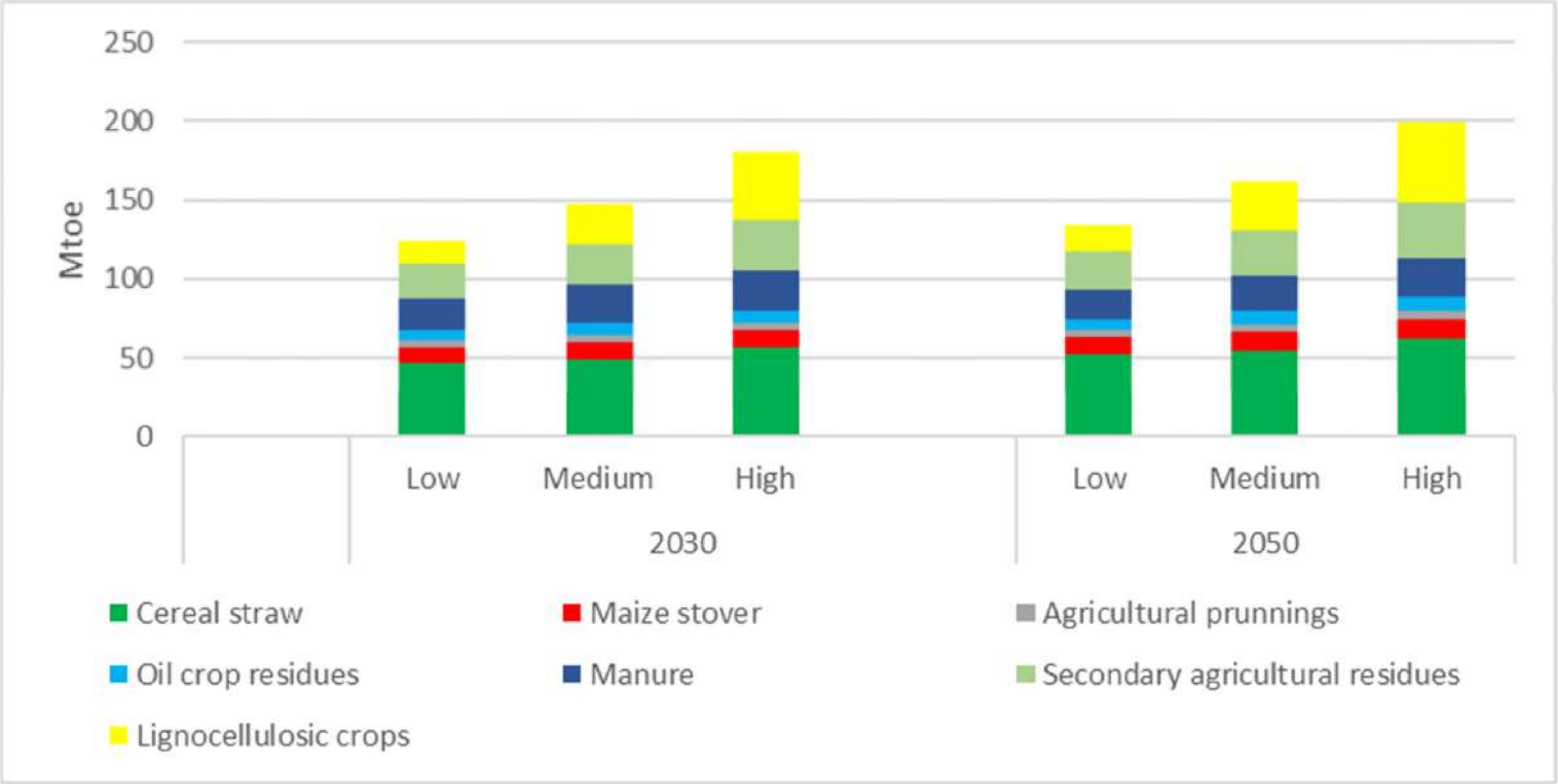


Figure 4 Estimated sustainable biomass potentials for all markets per feedstock type for 2030 and 2050 in Mtoe

Source: Sustainable biomass availability in the EU, to 2050, Imperial Collage London

EU distribution agricultural biomass

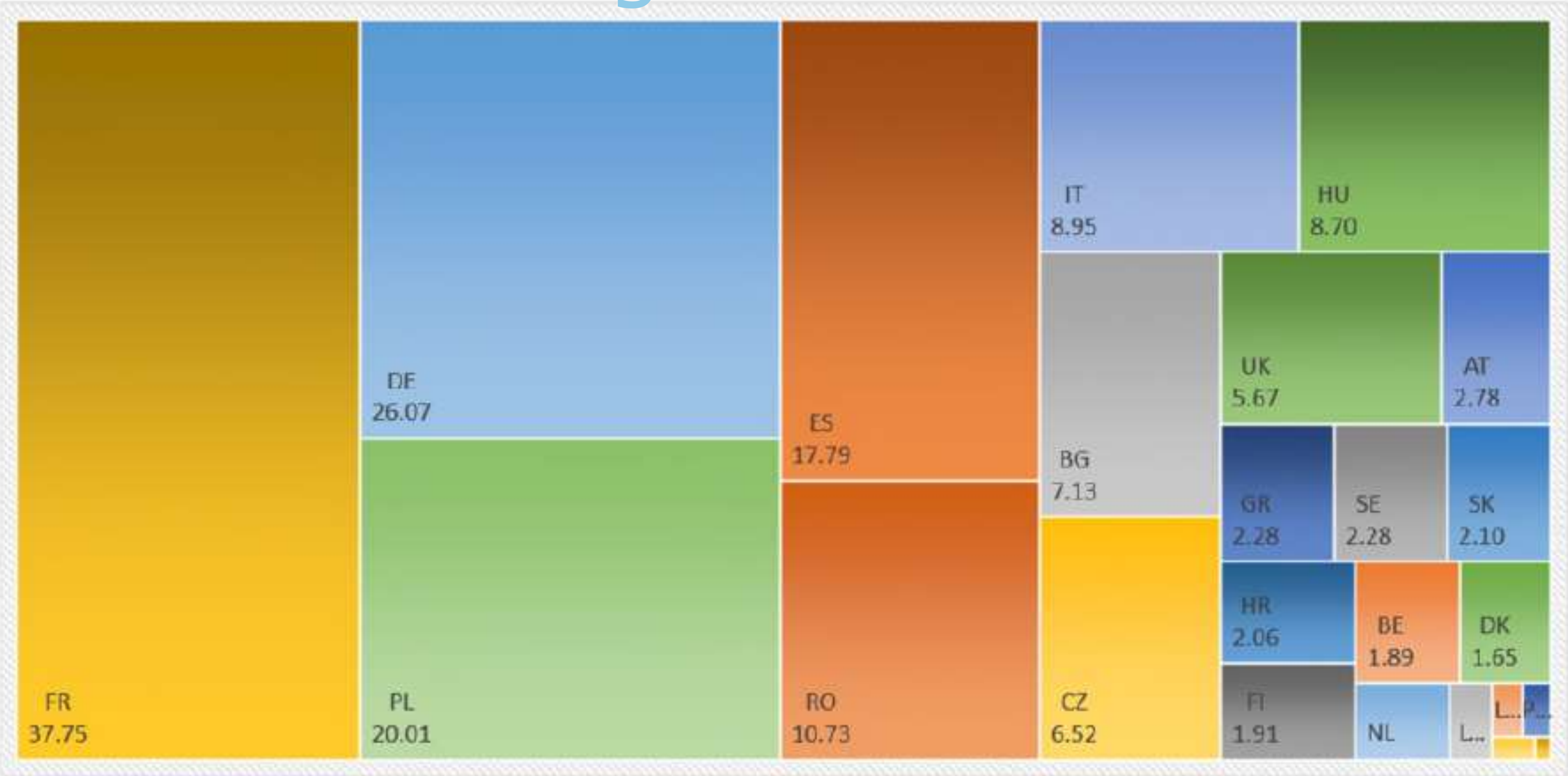


Figure 5 Geographic distribution of agricultural biomass from cereal straw, maize stover, oilseed crop field residues and agricultural prunnings in EU27 & UK (in million dry tonnes for 2030- Low mobilisation scenario). (See Annex X for country names)

Netherlands Enterprise Agency

Thank You!

Questions?

>> *Sustainable. Agricultural.*
Innovative. International.

Workshop timeline

10:15	**Study on alternatives to fossil diesel in rail – next step**	AERRL
10:40	**Decarbonising rail: relevance of biofuels for rail in Norway**	Norwegian Railway Directorate
11:05	**Study on greenhouse gas and Nitrogen oxides from biofuels**	Ricardo (study commissioned by ProRail)
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16:00	**Closing words** **Networking mini cocktail**	

INTERNATIONAL UNION
OF RAILWAYS

AERRL

Association of European Rail Rolling Stock Lessors

Study on alternatives to fossil diesel in rail – next step

Carole Coune

Secretary General

UIC Alternative fuels workshop, 11 June 2024

AERRL STUDY ON ALTERNATIVES TO FOSSIL DIESEL USE IN RAILWAYS – next step

A common roadmap towards a zero net fleet by 2050 ?

Carole Coune, Secretary General

Our main purpose

Promote interoperable and safe European rail rolling stock, by adressing operational, legal, economic, technical and scientific matters and issues relating directly or indirectly, to locomotives, passenger trains (multiple units and coaches) operated in the EU and Switzerland.

Who we are ?

The Association of European Rail Rolling Stock Lessors

INPA

Immatriculated on 25th of May 2021

Brussels, Square de Meeûs 37

Effective members

Companies with main leasing activities in railway sector

With main activities and office in EU

Our governance

Fabien Rochefort, Chair

Torsten Lehnert & Bart Lam, Vice-Chair

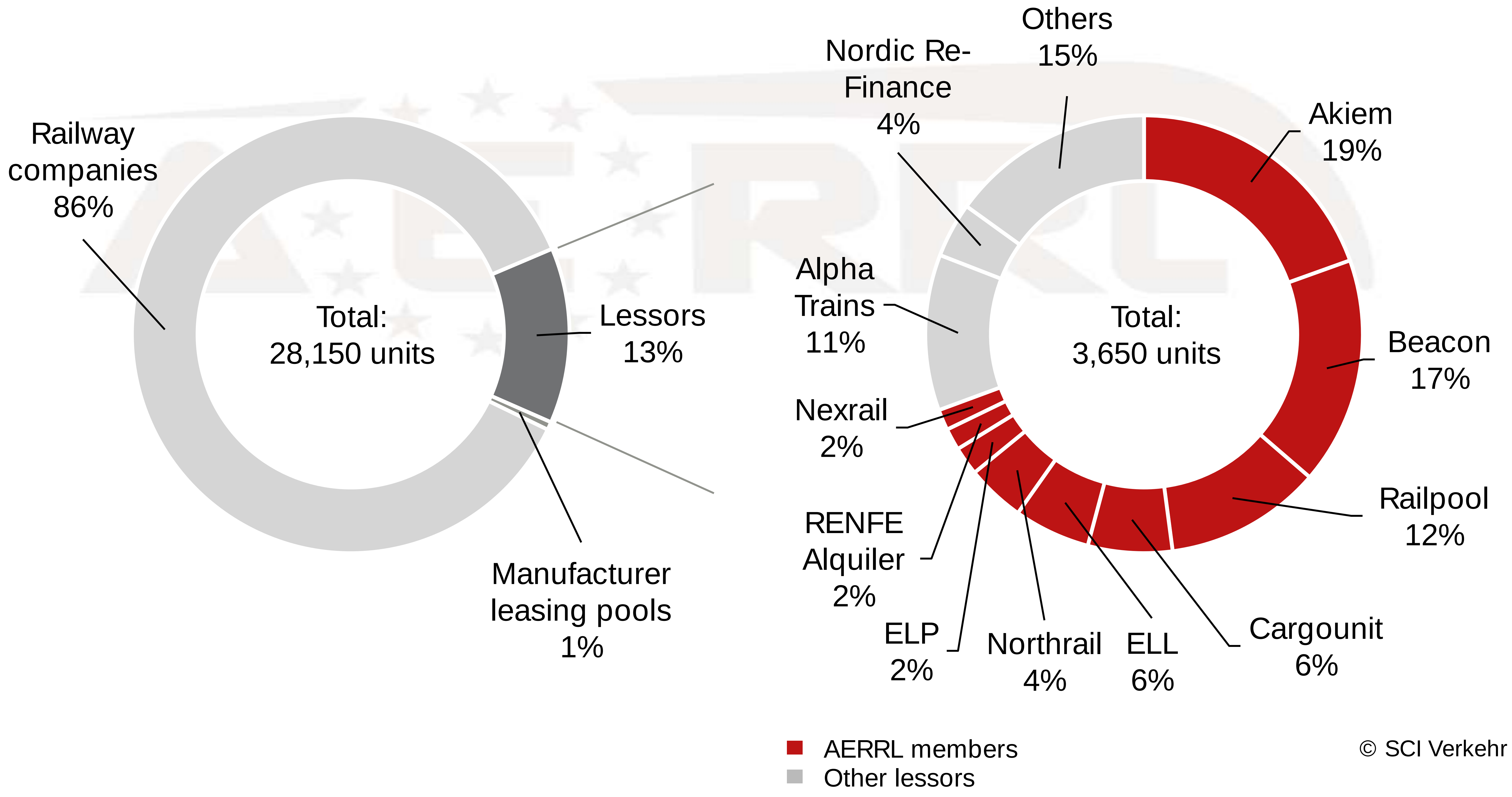
Volker Simmering & Carmen Garcia Cristobal, Directors

Carole Coune, Secretary General

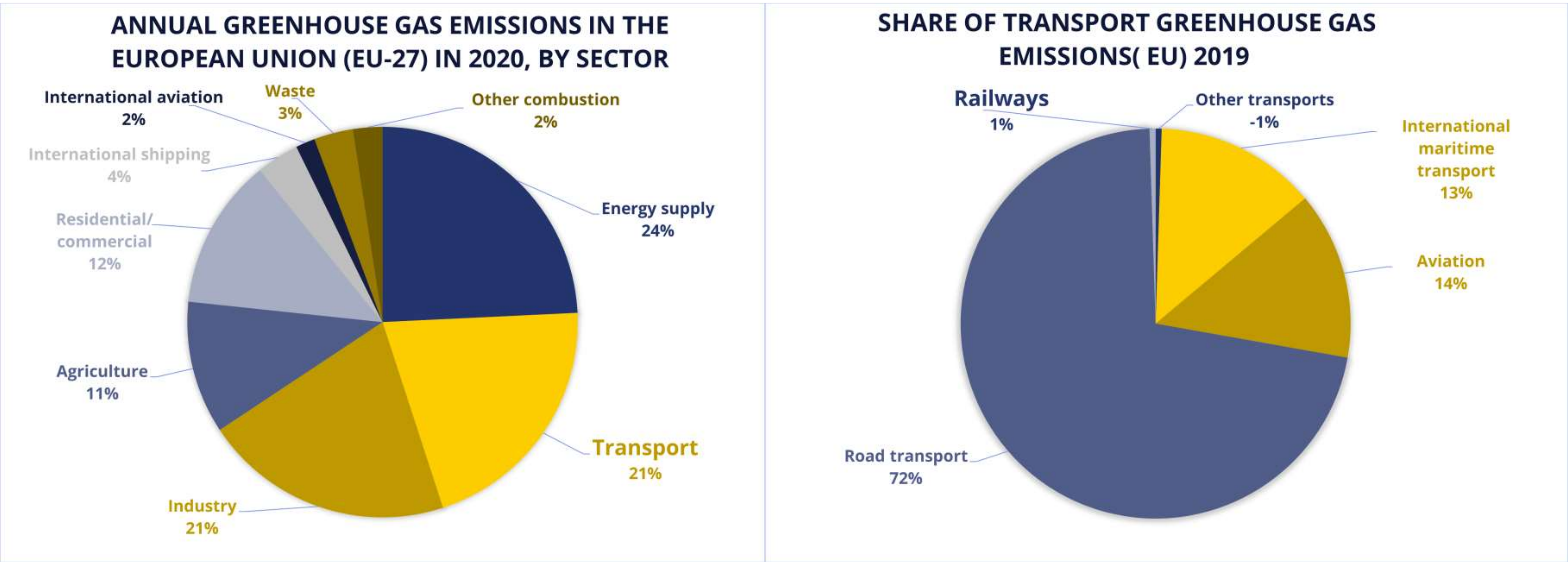
Our members

Lessors own 3650 units as of 2023 and AERRL members own 70 % of the lessors fleet as of 2023.
AERRL (as of 2023), 61 % of the lessors' fleet is electric traction.

Locomotive fleet by owner type (28,150 units) **and fleet of leasing locomotives by lessor** (3,650 units) **in the EU + CH/NO as of 2023**



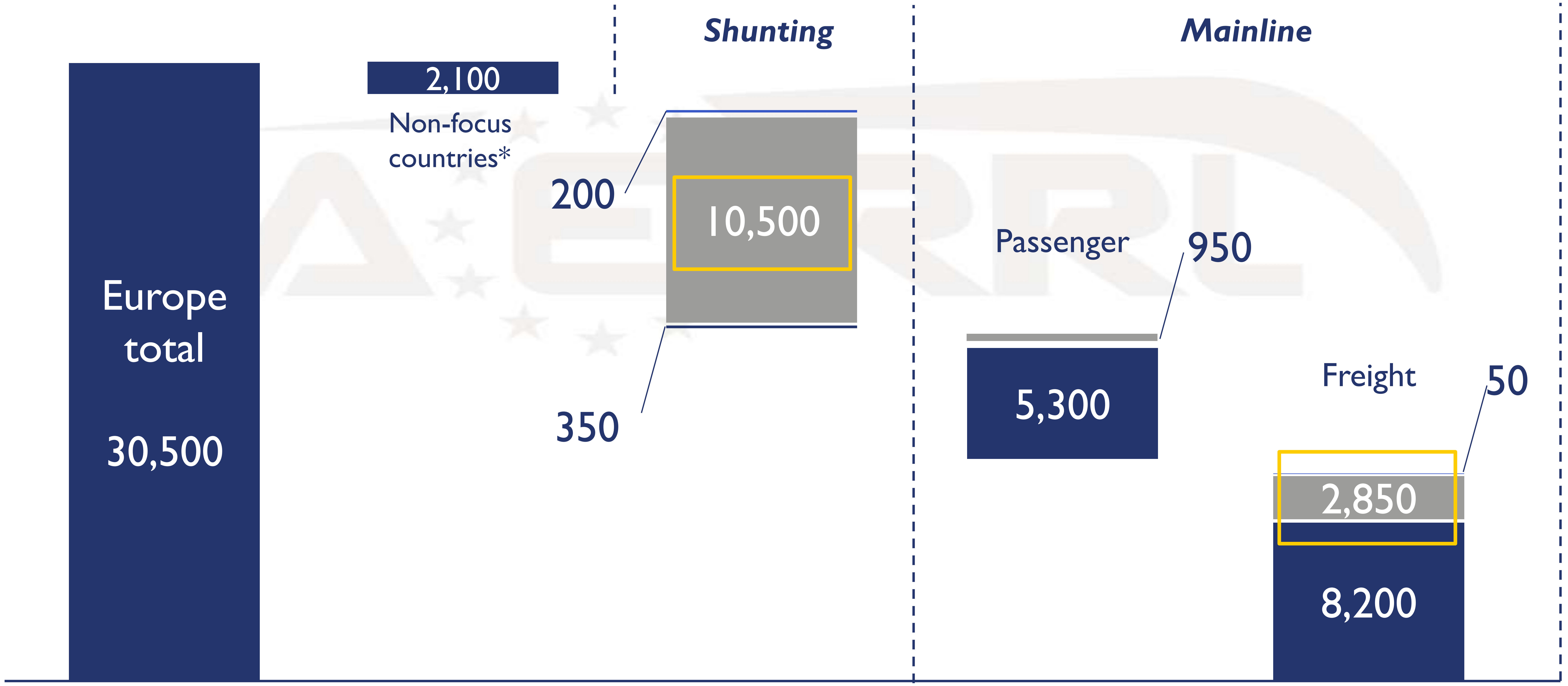
CO2 EMISSIONS FROM RAIL = LESS THAN 1%, A DROP IN THE OCEAN



Sources: AERRL study on alternatives to fossil diesel use in railways, eolos (December 2022), Statista, European Environmental Agency (2019)

14.300 DIESEL LOCOMOTIVES IN EU = MORE THAN 50 % OF LOCO RUNNING IN EU AND OPERATED BY EU RAILWAY COMPANIES

Locomotives in Europe in 2020 (30,500 units)
of which operating in EU member states + CH/NO (28,400 units)



*non-EU member states, excluding CH/NO

Source: SCI Verkehr European rolling stock leasing fleet -Market overview for freight and passenger assets, based on the European fleet on 31st December 2020

TOWARDS A FREIGHT TRANSPORT SYSTEM FOR EFFICIENCY

AERRL akiem BEACON CARGOUNIT

SUPPORTED BY:

CRÉDIT AGRICOLE CORPORATE & INVESTMENT BANK ING KFW IPEX-Bank SOCIETE GENERALE

eolos
engineering the future®

December 2022

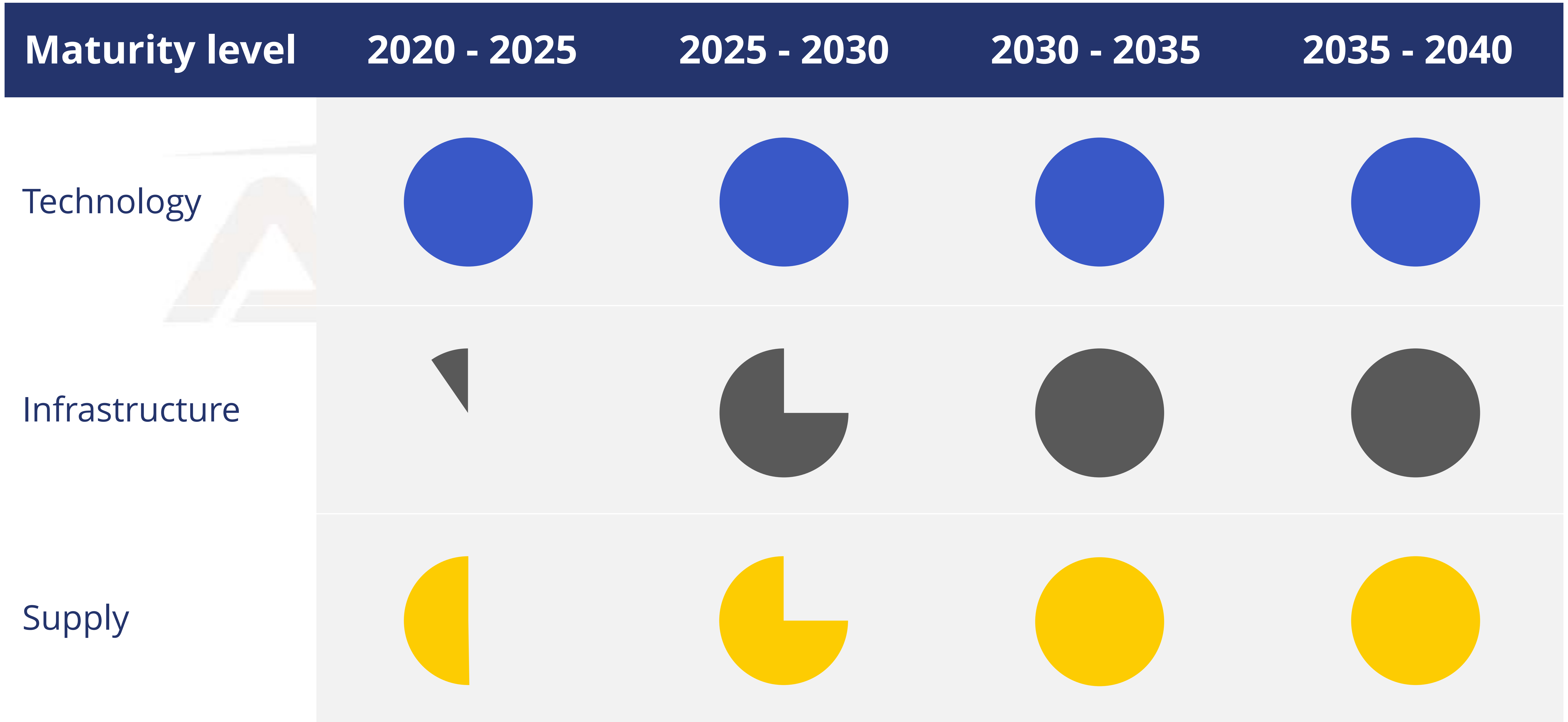
CANDIDATE NR. 1 IS A BRIDGE SOLUTION

HVO

Hydrotreated Vegetable Oil

85/90 % less CO_2 emissions

TECHNOLOGY, INFRASTRUCTURE AND SUPPLY AVAILIBILITY READINESS FOR HVO



SECOND-GENERATION BIOFUEL

USES WASTE FROM FOOD INDUSTRY

- Unlike first generations using crops
- 85/90 % less CO_2 emissions
- Ca. 30 % more expensive

AERRL PROPOSAL TO PROMOTE HVO USE AT EU LEVEL

PRICE

- Lower taxes (ETD Directive)
- Review EU Taxonomy

SUPPLY

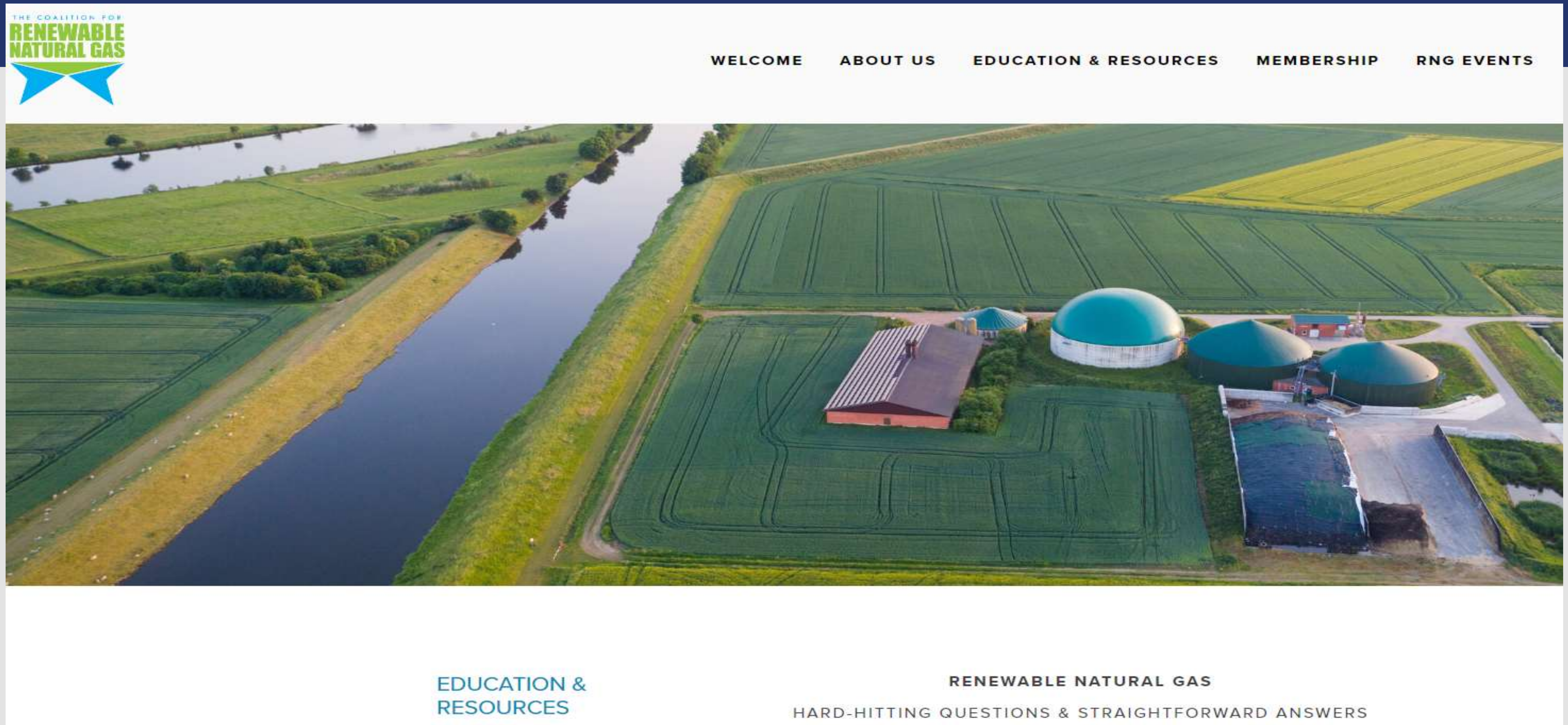
- Increased by Horizon programme subsidies

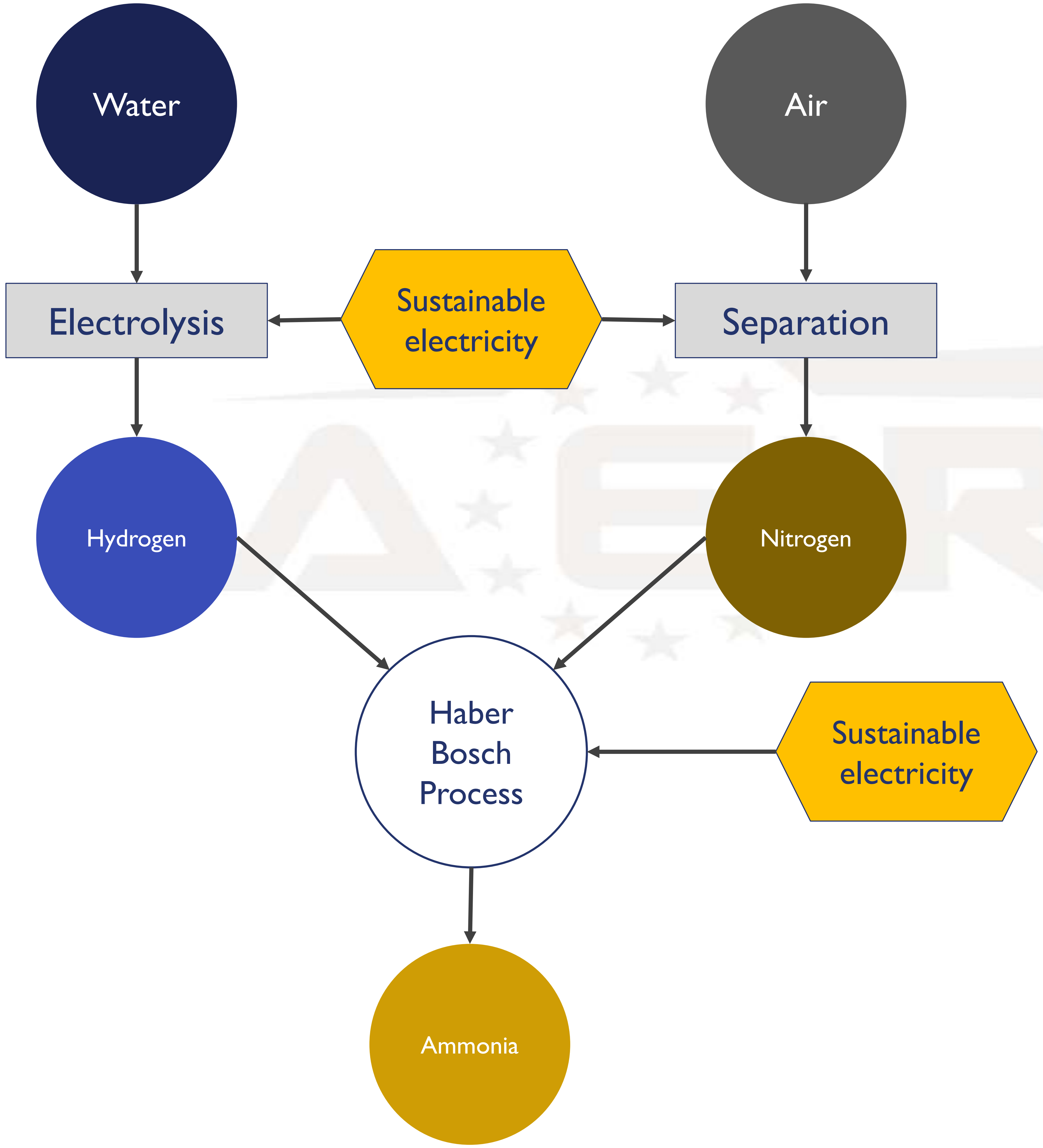
DISTRIBUTION

- facilitation

RENEWABLE NATURAL GAS (RNG) : BIOMETHANE PRODUCED BY GASIFICATION AND METHANATION PROCESSES OF BIOMASS

70 % less CO2 emissions





Green ammonia production and use, the Royal society, February 2020

↓

Hydrogen-derived product – zero emission fuel

But **HEAVY CONSTRAINTS**

Ammonia

EXISTING USES

- Fertilizers
- Refrigeration
- Explosives
- Textiles and pharmaceuticals

EXPANDED USES

Energy store to electricity generation

- (after cracking) in PEM fuel Cell
- Using alkaline fuel cell
- Direct combustion engine/turbine

Transport fuel

- Direct combustion engine/turbine
- Directly in solid oxide fuel cell
- (after cracking) in PEM fuel cell

Heat transfer

- Phase change/absorption
  Bulk thermal storage

Green ammonia production and use, the Royal society, February 2020

↓

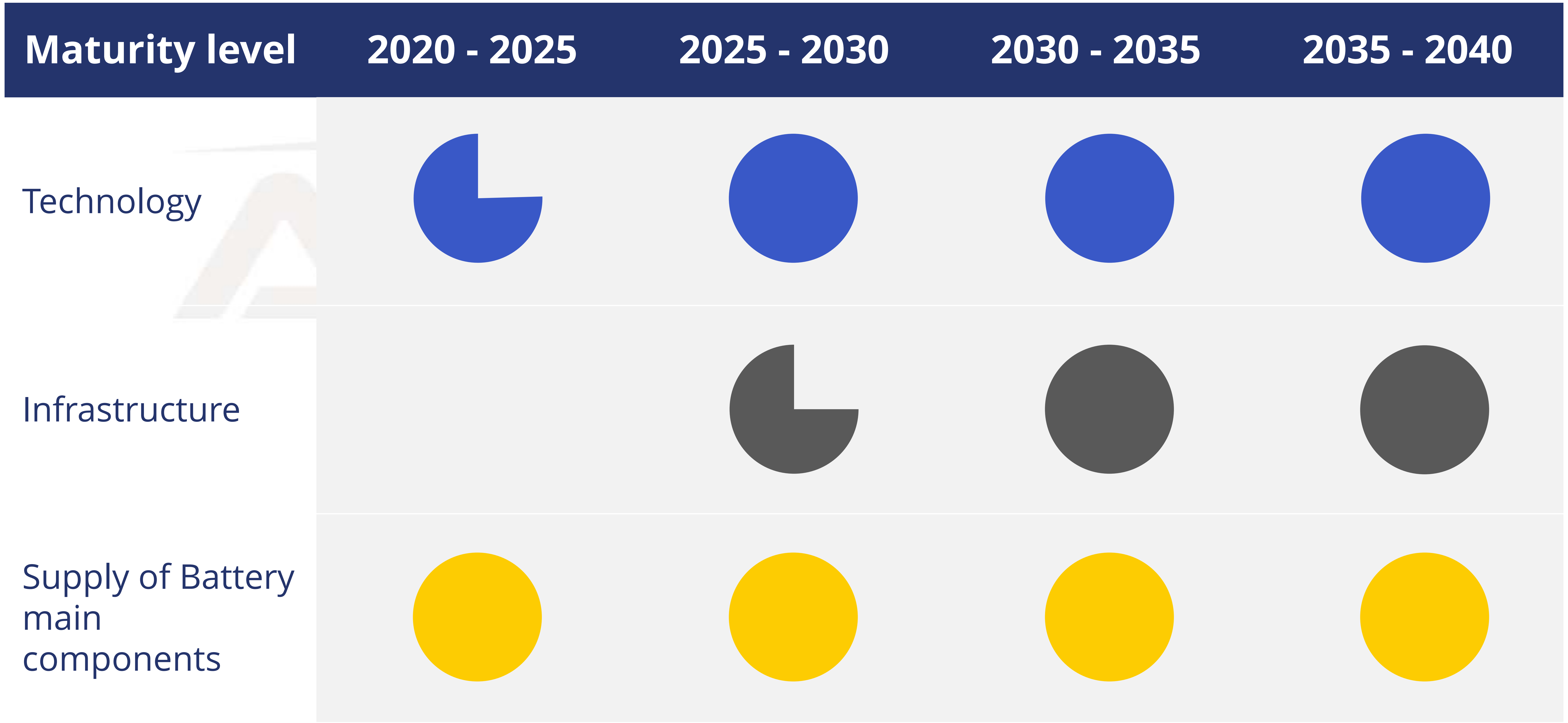
Hydrogen-derived product – zero emission fuel

But **HEAVY CONSTRAINTS**

CONSTRAINTS LINKED TO AMMONIA AND RNG USE

RNG	AMMONIA
Upgrading locomotives required	Extensive retrofit needed
New refueling stations - SAFETY	Proper handling and storage procedures
Availability unpredictable, as main destination is for heating of households	Used to fuel an Internal Combustion Engine requires carrying 3 times the volume of diesel to cover the same distance

TECHNOLOGY, INFRASTRUCTURE AND SUPPLY AVAILABILITY READINESS FOR BATTERY



SIEMENS, MIREO PLUS B

https://www.mobility.siemens.com/global/en/portfolio/rail/stories/totally-fit-for-the-future-mireo-plus-b.html

HYBRID BATTERY/ELECTRIC

Solution for 85 % of diesel locomotives

BATTERY/ELECTRIC TECHNOLOGY, THE GAME-CHANGER IF 3 CONSTRAINTS ARE OVERCOME

CONSTRAINTS	SOLUTIONS
Cannot be applied to heavy freight (15%)	Another alternative such as hydrogen fuel cells for this type of traffic
Range of applications and limitations not yet known	Further studies linked to specific infrastructures
Scarcity of materials (ex: lithium)	new battery technologies will emerge driven by the industrial and automotive sectors to move away from lithium, cobalt… dependence

Opportunity: EU subsidises the development of the battery recycling infrastructure

"This study recommends supporting primarily the use of **Dual-Mode Battery/Electric trains** combined with **partial electrification for the long-term future**.

Removing diesel-only traction from modern operations and accelerating the rate of rail electrification is crucial to enabling a greener and cleaner transport network fit for our carbon-neutral ambitions."

ÖBB: electrification needs limited to 26 % of the railway track considered, in their study

AERRL PROPOSALS TO PROMOTE BATTERY/ELECTRIC SOLUTION

PRIORITY SUBSIDISATION FOR PROJECTS

To promote partial electrification **combined** with the use of battery-powered rolling stock

UPGRADE CURRENT LOCOMOTIVES

To promote and subsidize the upgrade of current locomotives into dual-mode battery-electric (decom > 2050)

SUBSIDISE ELECTRIFICATION

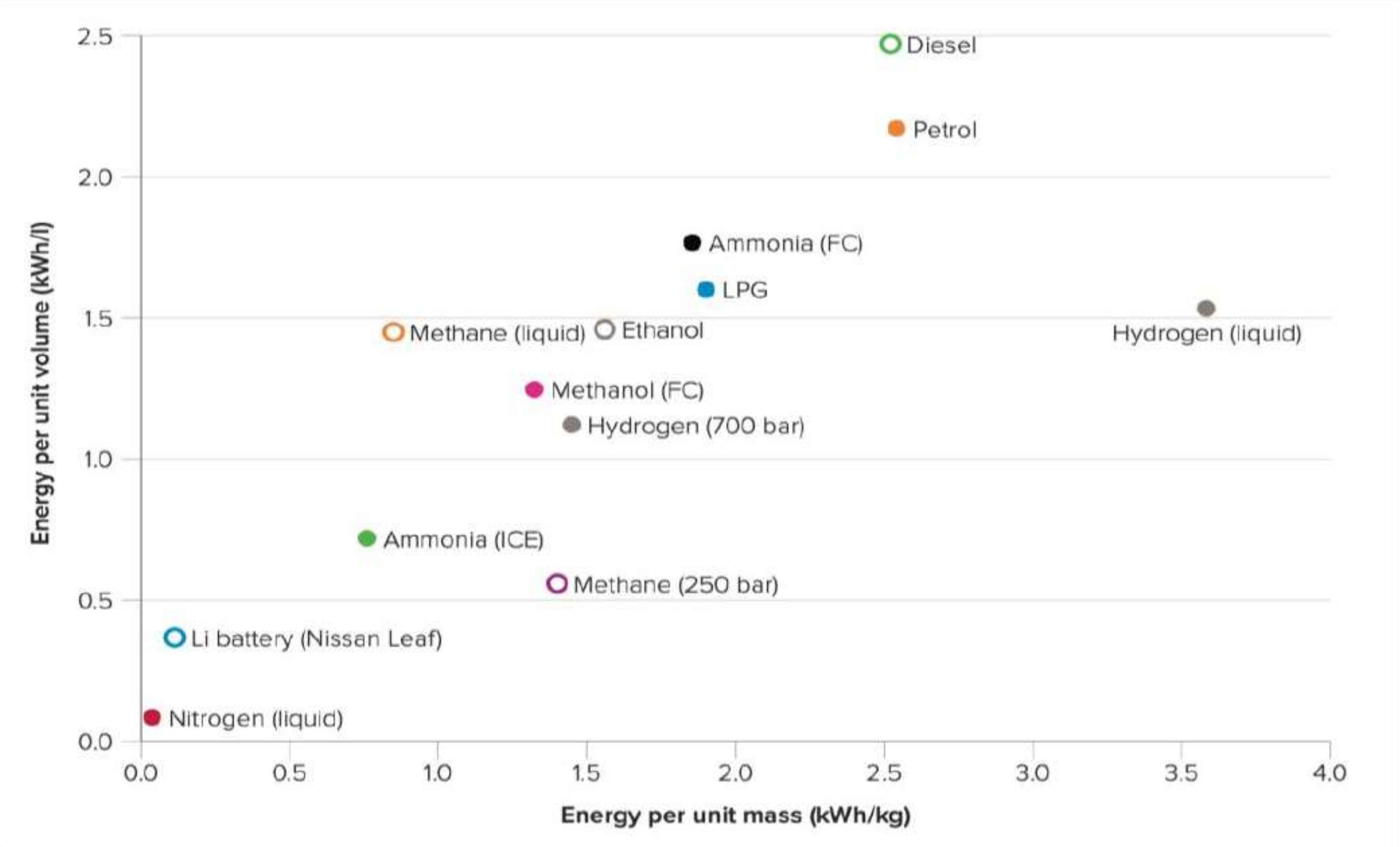
To continue to subsidize the electrification

LET'S GO FOR BATTERY/ELECTRIC ASSOCIATED WITH PARTIAL ELECTRIFICATION BECAUSE …

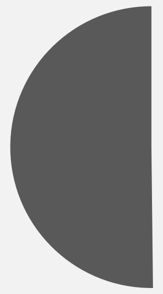
- Winning duo
- Fully aligned with the EU Taxonomy
- High level of technological readiness
- Several challenges addressed, from a holistic point of view

Leading to lower electrification cost

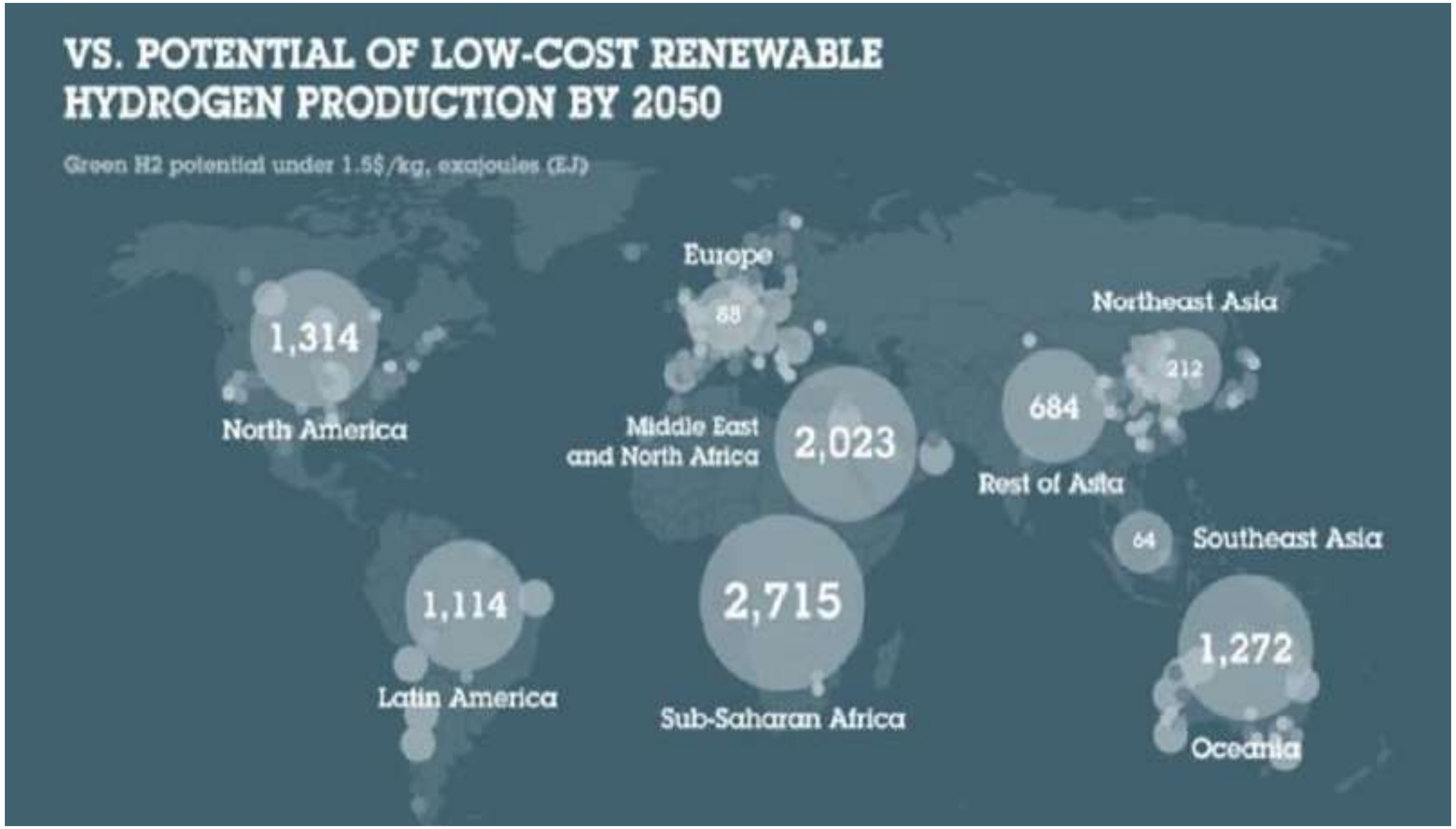
FOR HEAVY FREIGHT AND LONG NON-ELECTRIFIED ROUTES HYDROGEN, HAVING HIGH ENERGY DENSITY



TECHNOLOGY, INFRASTRUCTURE AND SUPPLY AVAILBILITY READINESS FOR GREEN H2

Maturity level	2020 - 2025	2025 - 2030	2030 - 2035	2035 - 2040
Technology				
Infrastructure				
Supply of Green H2 for the railway				

OVERVIEW OF LOW-COST GREEN H2 PRODUCTION CAPABILITIES IN THE WORLD



MAIN CONSTRAINTS TO OVERCOME TO USE HYDROGEN FOR RAIL TRANSPORT AT LARGE SCALE

CONSTRAINTS	SOLUTIONS
Safety in tunnels	Studies – tests - regulations
Price and availability of green H2	Probably solved after 2050
Distribution Infrastructure	Heavy investments - probably solved after 2050
Low global efficiency WTW	

OUR INITIAL ROADMAP

2020-2025 | 2025-2030 | 2030-2035 | 2035-2040 | 2040-2045 | 2045-2050

Maintaining Diesel operations with HVO

This options could be applied to Rolling Stock that should be decommissioned by 2035-2040 or for heavy duty freight

! RED: Renewable Energy Directive
ETD: Energy Taxation Directive

Design the freight transport system for efficiency

Balance investments btw infrastructure and rolling stock

! Re-homologation, financing or subsidies necessary

Upgrading part of the existing fleet to RNG, Hybrid Diesel/Battery or ICE Ammonia

This options could be applied to Rolling Stock (< III B) that will be decommissioned btw 2040-2050

Procurement of new rolling stock incorporating new technologies

Dual Mode Diesel / Electric

New vehicles are available with new technologies (Hybrid Battery/Electric or H2 where Green H2 supply is available)

! EU Taxonomy
Infrastructure and supply readiness

Next step towards a sectorial roadmap to a zero net fleet by 2050

1. Anticipating battery/electric technology as the prevailing technology

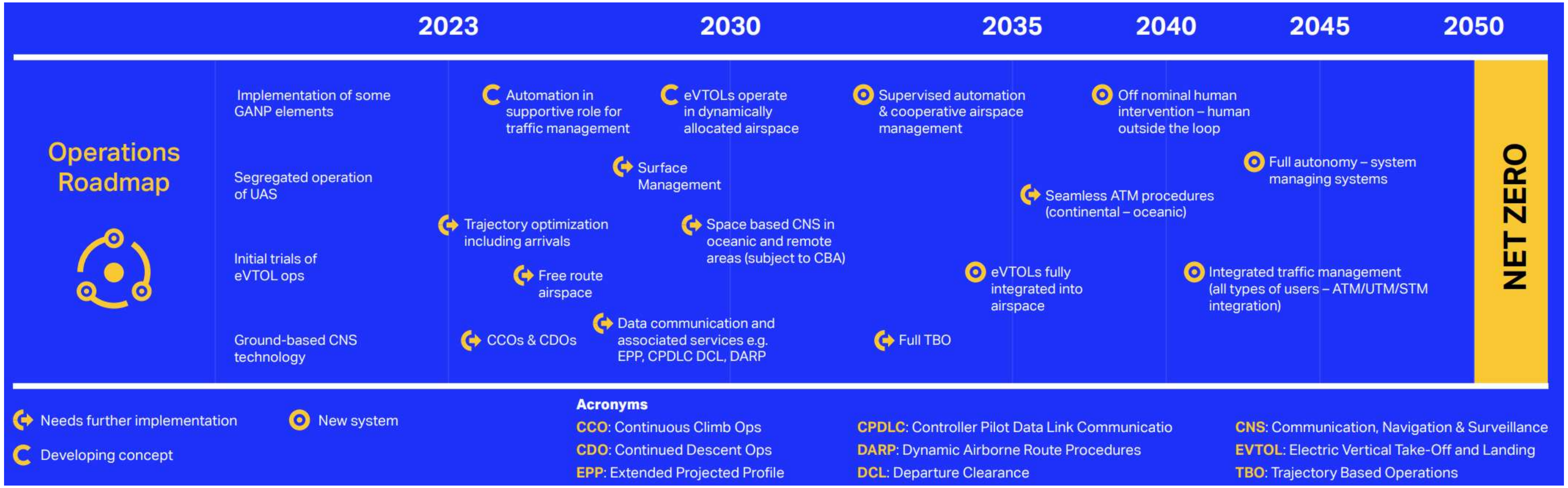
- ❖ A relevant use case (to be generalized, with mainline/port/industrial line- a CORR ?)
- ❖ To clarify needs on infra and rolling stock side

- On technological side =>technology – performances)
- On financial side =>CBA, including environmental aspects (new or retrofitted RS)
- On public support side : how to accelerate with public support (subsidies, decrease of infra fee, regulatory context…)

=> New report : confirming or amending the initial roadmap, with recommendation to the public authorities

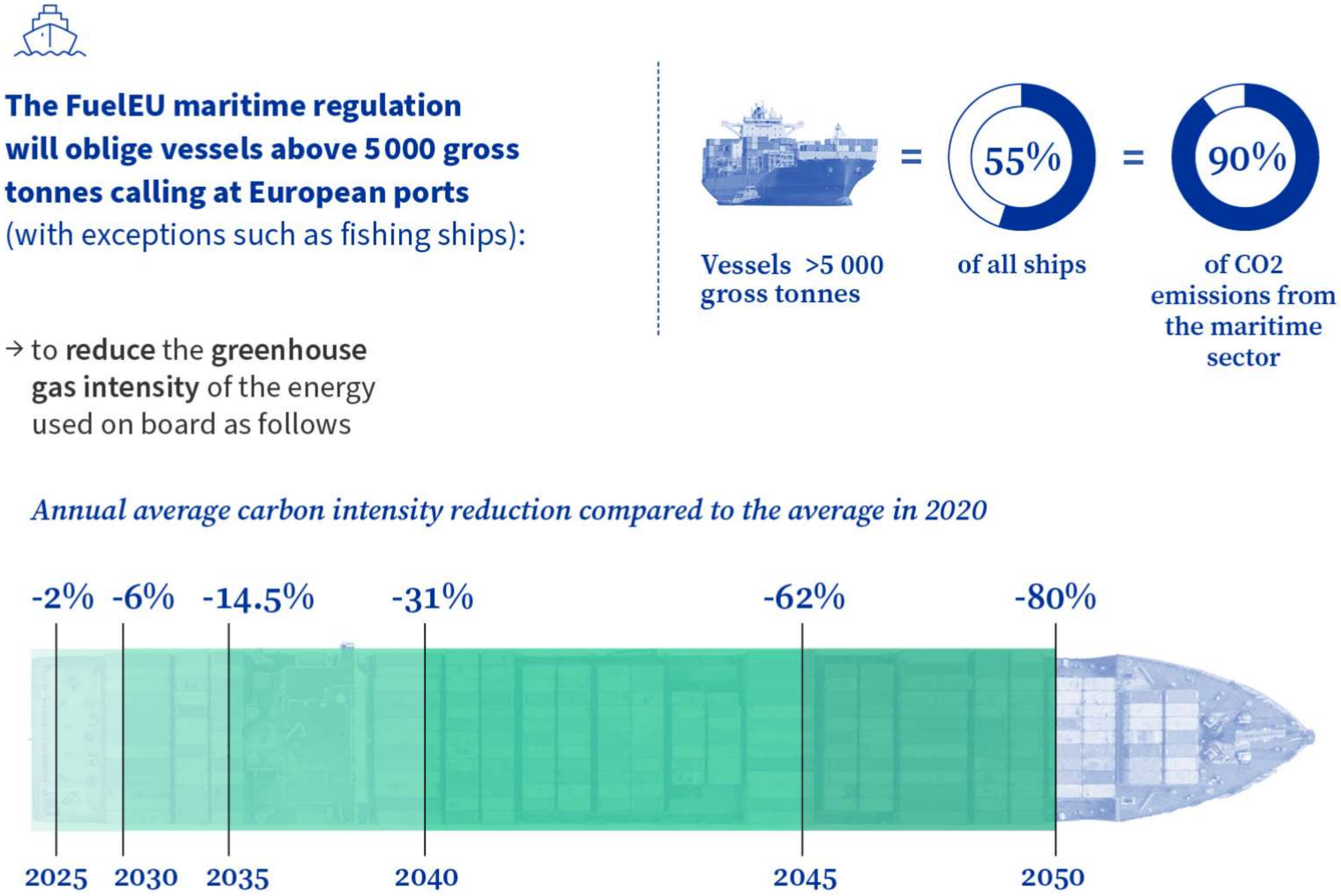
2. Include H2, even if will be deployed in a later stage ?

Aviation Decarbonization Roadmap



Source: IATA - https://www.iata.org/contentassets/8d19e716636a47c184e7221c77563c93/operations-net-zero-roadmap.pdf

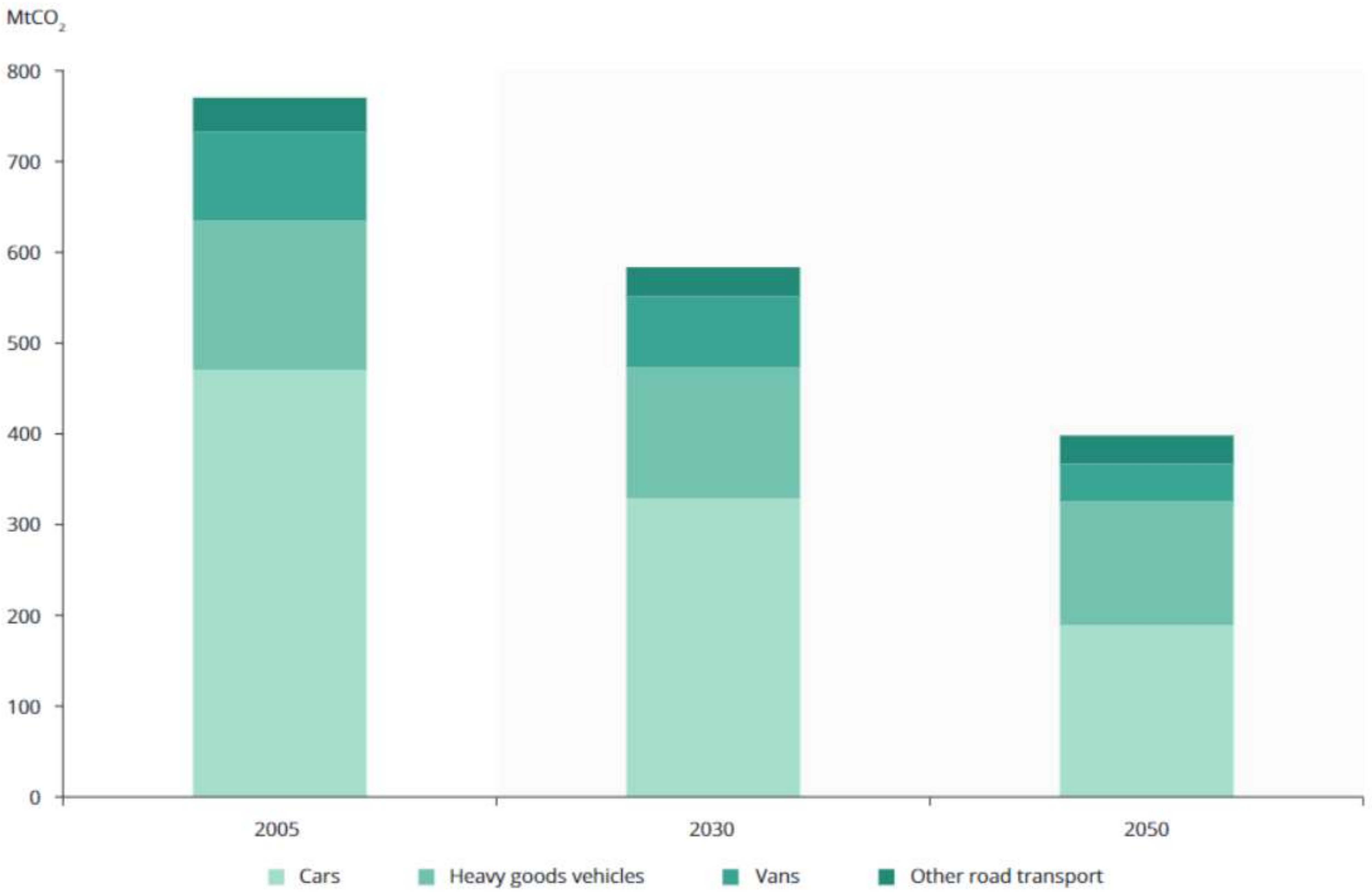
Maritime Road Decarbonization Roadmap



Source European Council - https://www.consilium.europa.eu/en/infographics/fit-for-55-refueleu-and-fueleu/

Road Decarbonization Roadmap

Figure 2.4 **CO_2 emissions from road transport in the *EU Reference Scenario 2020* in the EU-27 ($MtCO_2$)**



Note: The *EU Reference Scenario 2020* includes Member State and EU policies adopted up to the end of 2019.

Source: EC (2021e).

Thank you for your attention.

Please, contact me in case of interest
carole.coune@aerrl.eu

Workshop timeline

10:40	**Decarbonising rail: relevance of biofuels for rail in Norway**	Norwegian Railway Directorate
11:05	**Study on greenhouse gas and Nitrogen oxides from biofuels**	Ricardo (study commissioned by ProRail)
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INTERNATIONAL UNION
OF RAILWAYS

JernBaneDirektoratet

Norwegian Railway Directorate

Decarbonising rail: relevance of biofuels for rail in Norway

Stephen Oommen

Head of Project

UIC Alternative fuels workshop, 11 June 2024

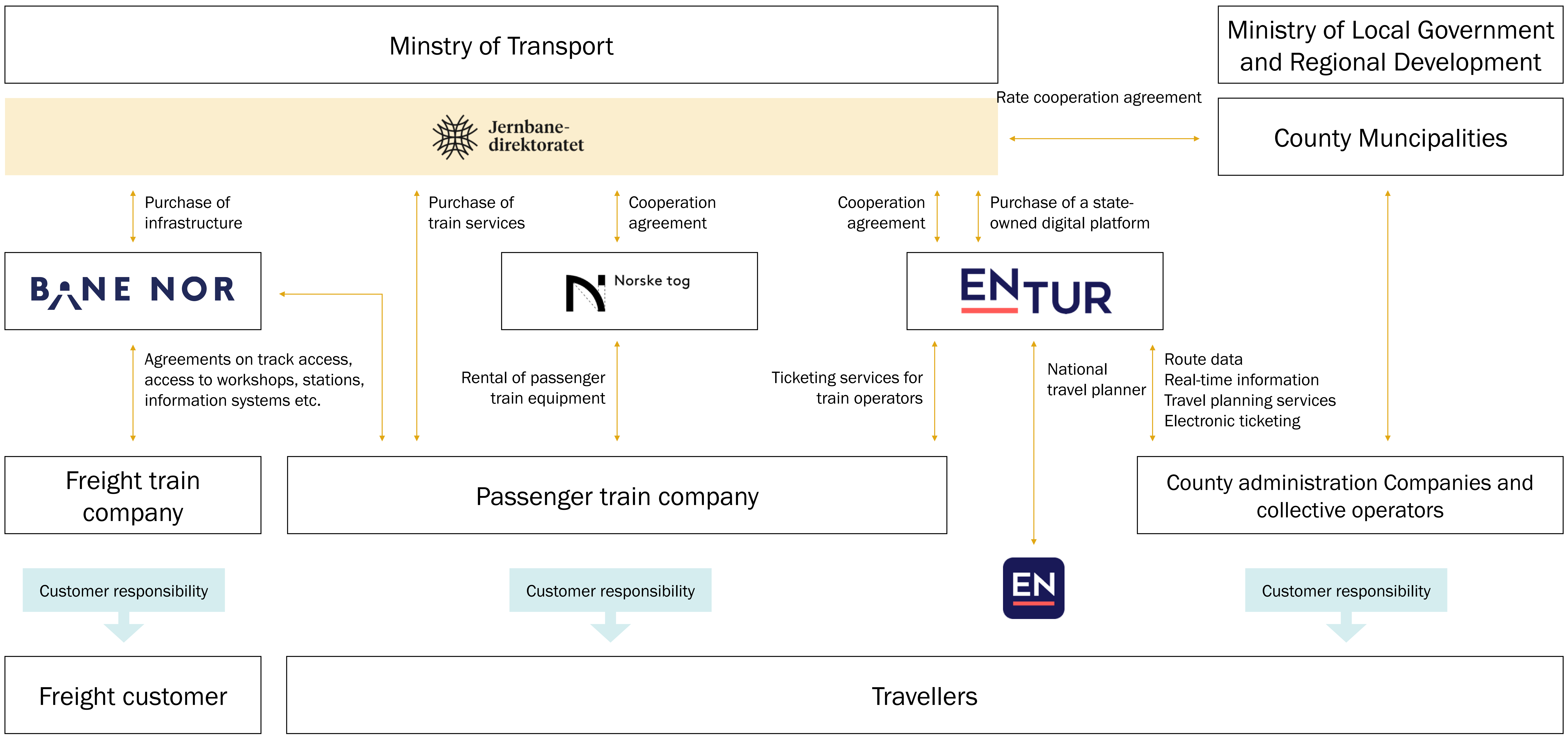
Decarbonizing rail: Relevance of biofuels for rail in Norway

Stephen Oommen,
Head of Project,
The Norwegian Railway Directorate

UIC Alternative fuels workshop, 11th June 2024

Jernbane-
direktoratet

«The Norwegian Railway Directorate shall ensure that the railway sector is operated as efficiently, safely and as environment friendly as possible for the good of passengers, freight transport and society in general»


Minstry of Transport
Ministry of Local Government and Regional Development
Rate cooperation agreement
Jernbane-direktoratet
County Muncipalities
Purchase of infrastructure
Purchase of train services
Cooperation agreement
Cooperation agreement
Purchase of a state-owned digital platform
BANE NOR
Norske tog
ENTUR
Agreements on track access, access to workshops, stations, information systems etc.
Rental of passenger train equipment
Ticketing services for train operators
National travel planner
Route data
Real-time information
Travel planning services
Electronic ticketing
Freight train company
Passenger train company
County administration Companies and collective operators
Customer responsibility
Customer responsibility
EN
Customer responsibility
Freight customer
Travellers

The Norwegian Rail Network

- 4200 km
- 2500 km is electrified
- 740 tunnels
- Mostly single track

Lines	Length	Bridges	Tunnels	Height	Max incline
Nordland line	729 km	361	156	680 masl	19 ‰
Røros line	384 km	223	6	670 masl	15 ‰
Solør line	94 km	31	1	183 masl	8 ‰
Rauma line	115 km	103	5	660 masl	20 ‰

ROYAL NORWEGIAN
MINISTRY OF TRANSPORT

Supplementary award letter nr 3, 2022

Conceptual Appraisal

- Consider alternatives that reduce emissions from railway
- Investigate the need for:
  - Assessment of infrastructure requirements
  - Replacement or retrofitting of rolling stock, maintenance machinery and shunting locomotives.
- Comprehensive analysis of the pros and cons of various alternatives:
  - Socio- economic analysis
  - Energy efficiency
  - Emissions contributing to the Norwegian GHG inventory
  - Assess the sequence of measures based on cost per ton of CO_2

Why a Conceptual appraisal?

ROYAL NORWEGIAN MINISTRY OF TRANSPORT

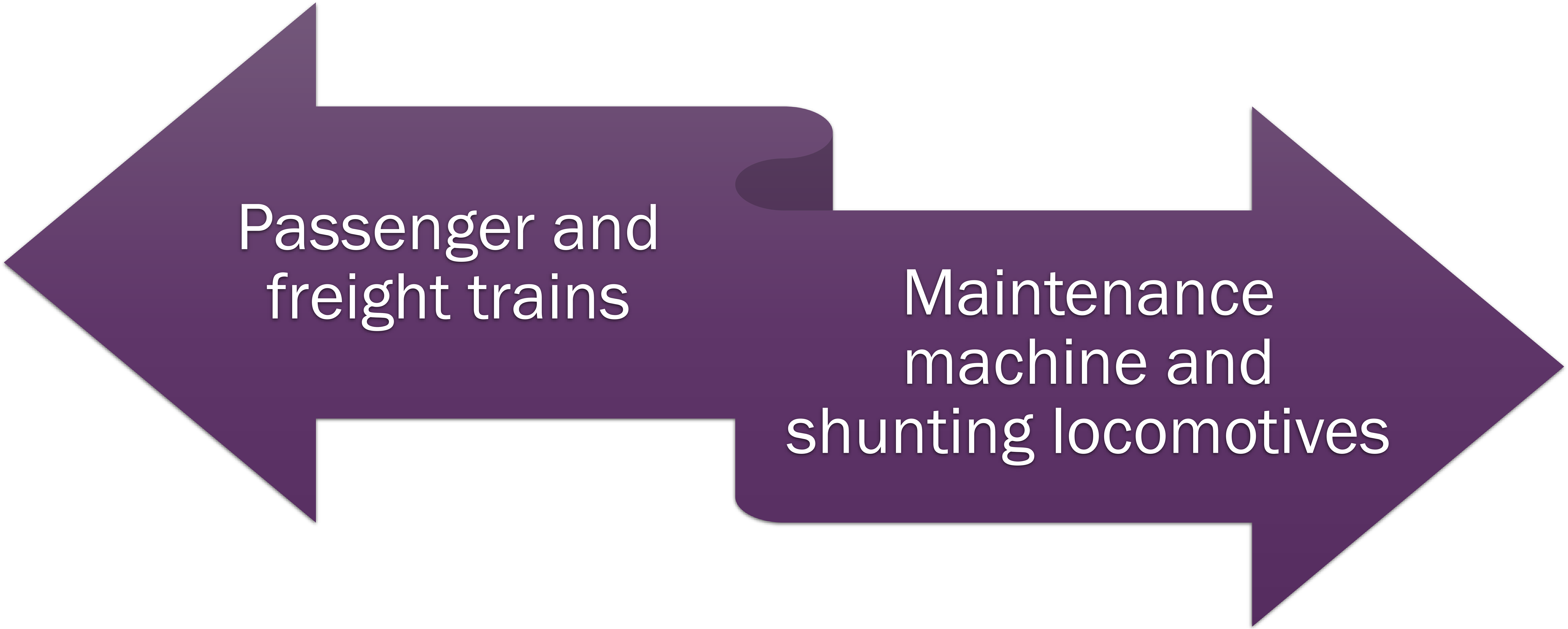
ROYAL NORWEGIAN MINISTRY OF FINANCE

- Mandatory requirement for all public investment projects budgets anticipated to exceed NOK 1 billion. (=100 M€)
- Alignment with National and international commitments.

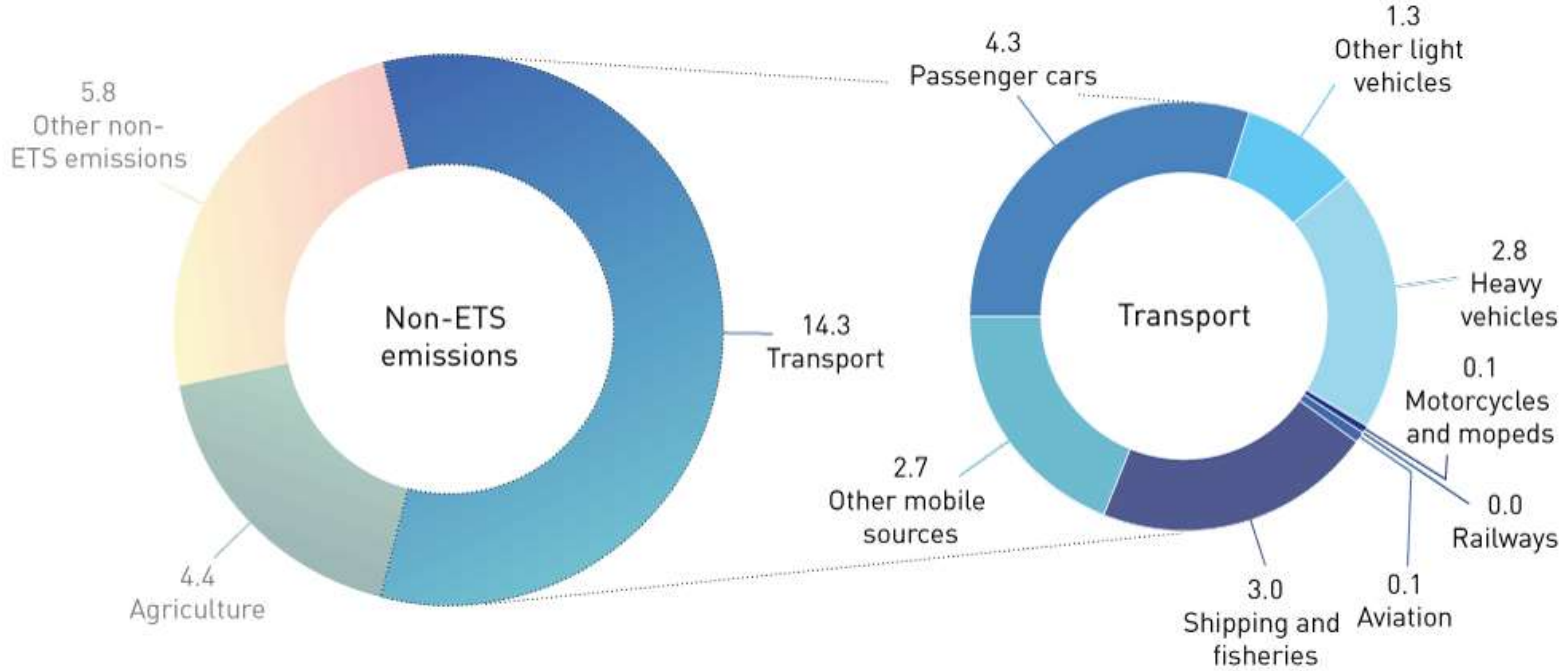
Process


WORKSHOP 1
WORKSHOP 2
WORKSHOP 3
Request for Information
Problem
Needs analysis
Strategy chapter
Requirements
Possibilities study
Alternatives analysis
Guidelines for pre-project phase

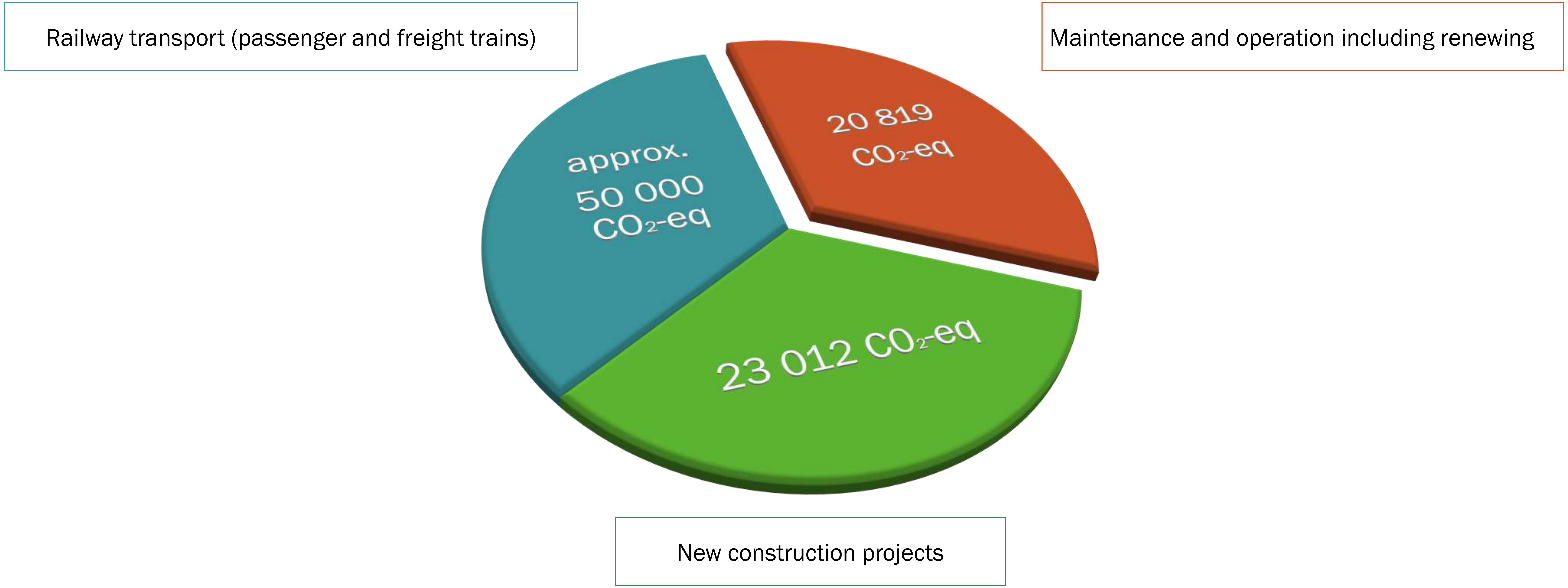
Process


Passenger and freight trains
Maintenance machine and shunting locomotives

Problem – Norway's GHG emissions

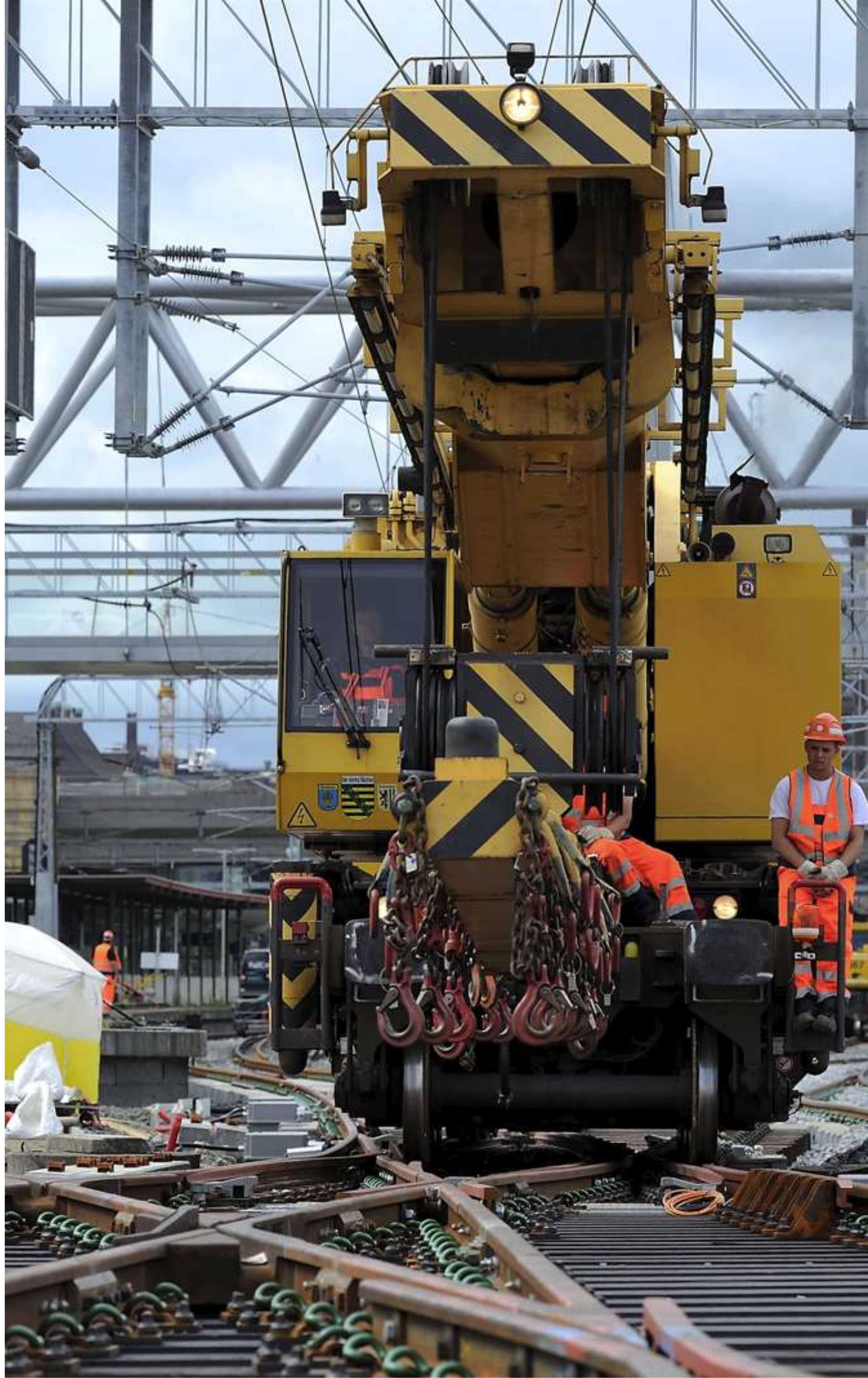


GHG on the railway



Current fleet

- 200 registered maintenance machines, in addition special machines from other parts of Europe are contracted when needed.
- Maintenance machines - mainly from 1970-1990, but there are also a few newer types in use.
- Norwegian rail will adapt ERTMS from 2034.
  - Increased cost for vehicle owners - on-board equipment
  - Fleet approaching end of life will demand in replacement of existing fleet
- 80% of CO_2 emissions occur on electrified tracks.



Assessed energy carriers on the railway and possible combinations

- Diesel
- HVO
- Hybrid: Catenary with biofuel
- Hybrid: Catenary with battery
- Tribrid: Catenary, battery and biofuel
- Biogas
- Hydrogen
- e-fuels
- Battery (only)

Request For Information (RFI)

- Product range in near future
- Development of On-track maintenance machines in Europe concerning various energy storage solutions.
- Other feasible methods/solutions to reduce CO_2 emissions
- Comparison of differences in investment costs
- Maintenance costs
- Energy consumption
- Total cost of ownership
- Noise levels
- Machine operating capacity
- Maximum operating range/driving distance

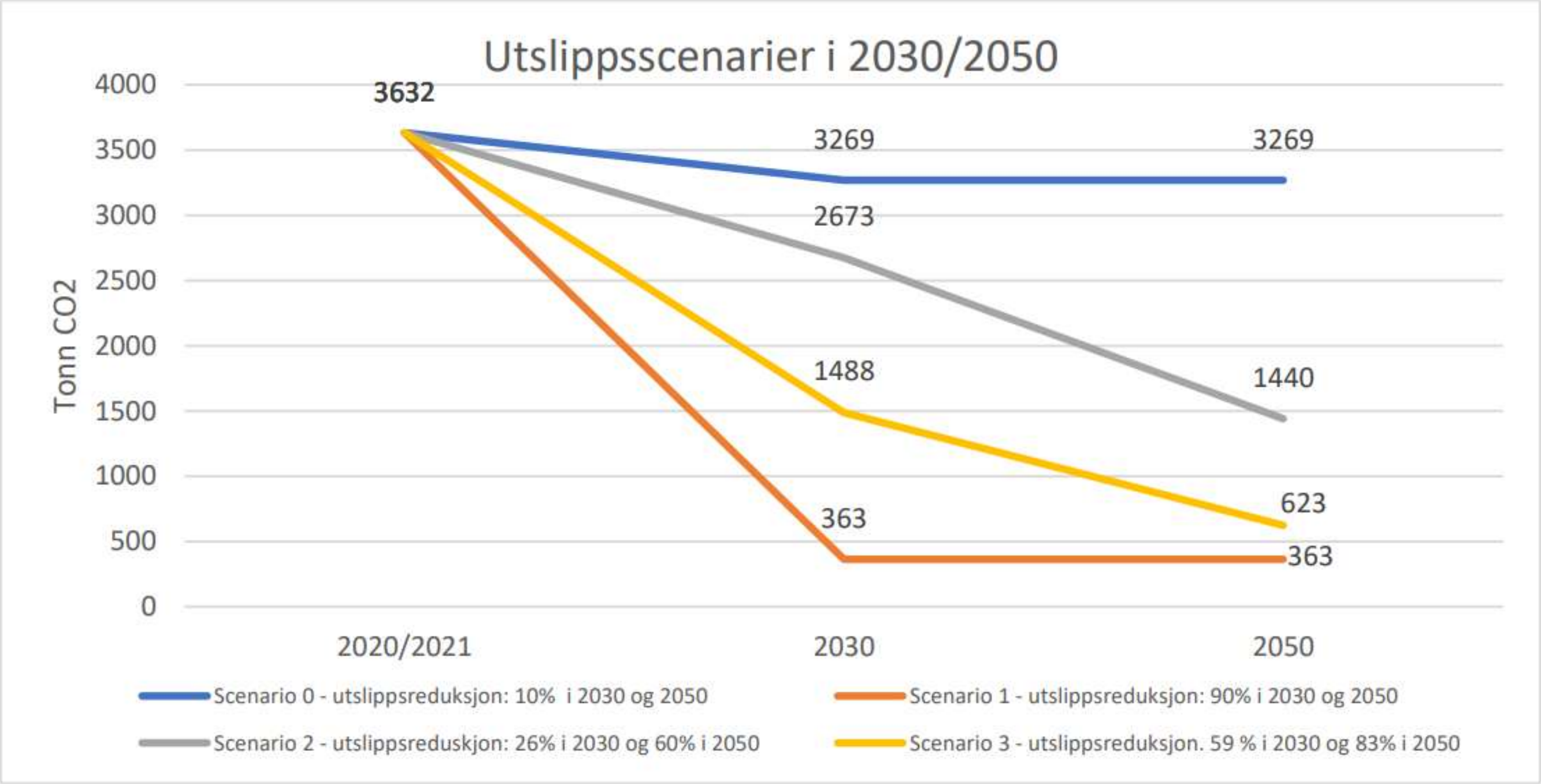
Request For Information (RFI)

- Expected for the various energy carriers (2023, 2027, 2030, 2045 & 2050)
  - **Minimum engine power below 300 kW**
    - variants hybrid (catenary/battery) and hydrogen are ranked equally
  - **Medium engine power from 300-600 kW**
    - Best rating is for hydrogen, but also believe in hybrid (catenary/battery) and battery
  - **Large engine power greater than 600kW**
    - Hydrogen gets the best rating, followed by hybrid (catenary/battery). No one recommends battery as a solution.

Investment costs for maintenance machines

Comparison of differences in investment costs	2023	2027	2030	2045	2050
Diesel	100 %	100 %	100 %	100 %	100 %
HVO	100 %	100 %	100 %	100 %	100 %
Hybrid: Catenary/ diesel	152 %	152 %	146 %	140 %	136 %
Hybrid: Catenary/ battery	140 %	135 %	135 %	129 %	122 %
Hybrid: Diesel/ battery	127 %	125 %	123 %	117 %	112 %
Tribrid: Catenary/battery/diesel	143 %	140 %	136 %	132 %	127 %
Biogas	-	-	-	-	-
Hydrogen gas	145 %	140 %	130 %	125 %	115 %
Battery (only)	165 %	160 %	154 %	135 %	130 %
Electrofuels (e-fuels)	100 %	100 %	100 %	100 %	100 %

Biodiesel as a transitional solution?



Bane NOR (2022) : Feasibility study to achieve emission reduction from work machines in the periods until 2030 and 2050.

Norwegian requirements for biofuels

Norwegian Environment Agency

- The main requirement means that those who sell fuel (resellers) must ensure that 19 % by volume of the fuel they sell for road traffic in 2024 is biofuel. In addition, there is a partial requirement that 12.5 % must be advanced biofuel.
- Advanced biofuel beyond the partial requirement of 12.5 % counts twice in the turnover requirement for road traffic. Double counting means that one liter of advanced biofuel counts as two liters of conventional biofuel.
- This double counting means that the physical proportion of biofuel required to meet the turnover requirement is between 15.75% & 19 %.

Recommendations from NEA

Norwegian Environment Agency

- Biodiesel for railways basically provides no reduction in national emissions
  - Because it is legally required to sell biodiesel through turnover requirements. Biodiesel to railways will be included in this requirement.
  - If biodiesel for railways is to exceed the statutory turnover requirements, it must be so In this case, there is a requirement that it be kept "outside" of the turnover requirement. It may require considerable resources to make this type of demand and to follow up on these be observed.
- Biodiesel has sustainability challenges and can provide increased emissions globally. Some types of biofuel are much worse than that others
- Biodiesel is expensive!
  - Advanced biodiesel is approx. 6 500 NOK/tonn (= 567€/tonn)
  - Biodiesel from frying oil/animal fat is approx. 4 500 NOK/tonn (= 393€/tonn)
  - Conventional biodiesel is approx. 2000 NOK/tonn (= 175€/tonn)

Recommendations NRD

- There is a variation in type of machinery, flexibility requirements, owner/user structure.
- For shunting locomotives: assume hybrid battery vehicles, or hydrogen vehicles by 2030.
- On-track maintenance machines: TRL in early stages. For Track motor cars for electrified lines and catenary maintenance vehicles could be replaced with low emission machines. It is assumed that hybrid battery-catenary or battery only will be preferred as solution for these machines
- Bane NOR will be responsible for establishing a central system for data collection related to the diesel consumption from infrastructure vehicles and shunting locomotives.
- Bane NOR will be responsible for follow up optimization solutions.
- Bane NOR sets requirements for suppliers of operations and maintenance services regarding GHG.

Scoping and Identified Alternatives

42

Framework conditions

9

Performance goals

7

Identified possibilties

Concepts

0 Fossil diesel

1a Biodiesel

2a Hydrogen

3 Battery with partial electrification

4 Electification

H_2

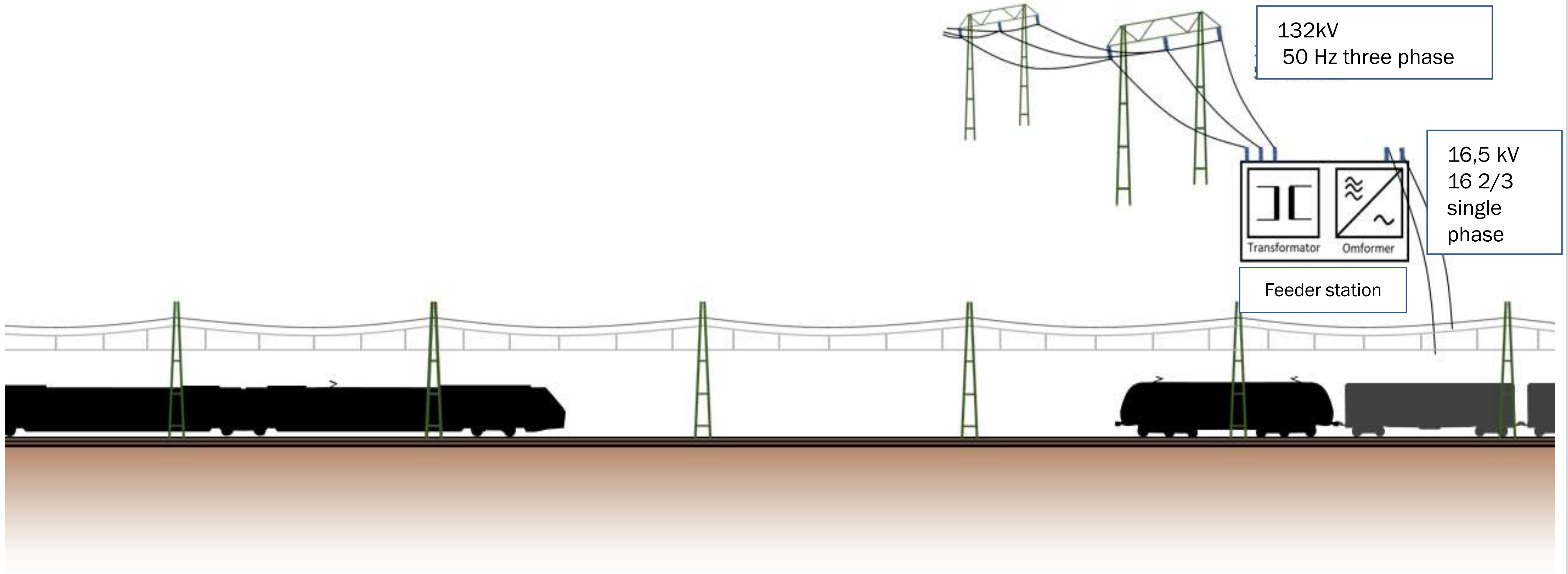
H_2

1b Biodiesel with partial electrification

2b Hydrogen with partial electrification

Concept

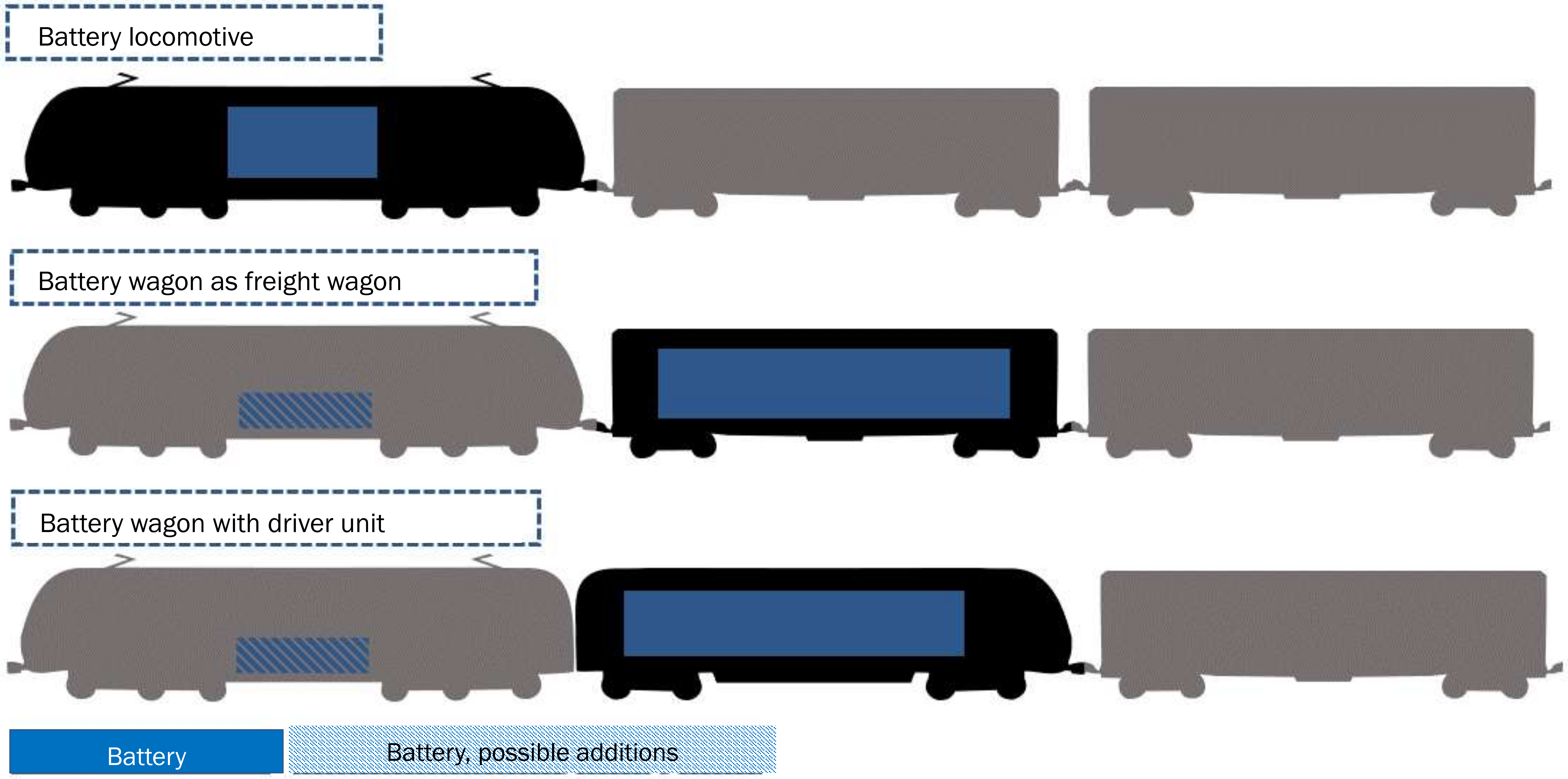
4 Elektrifisering



Jernbane-
direktoratet

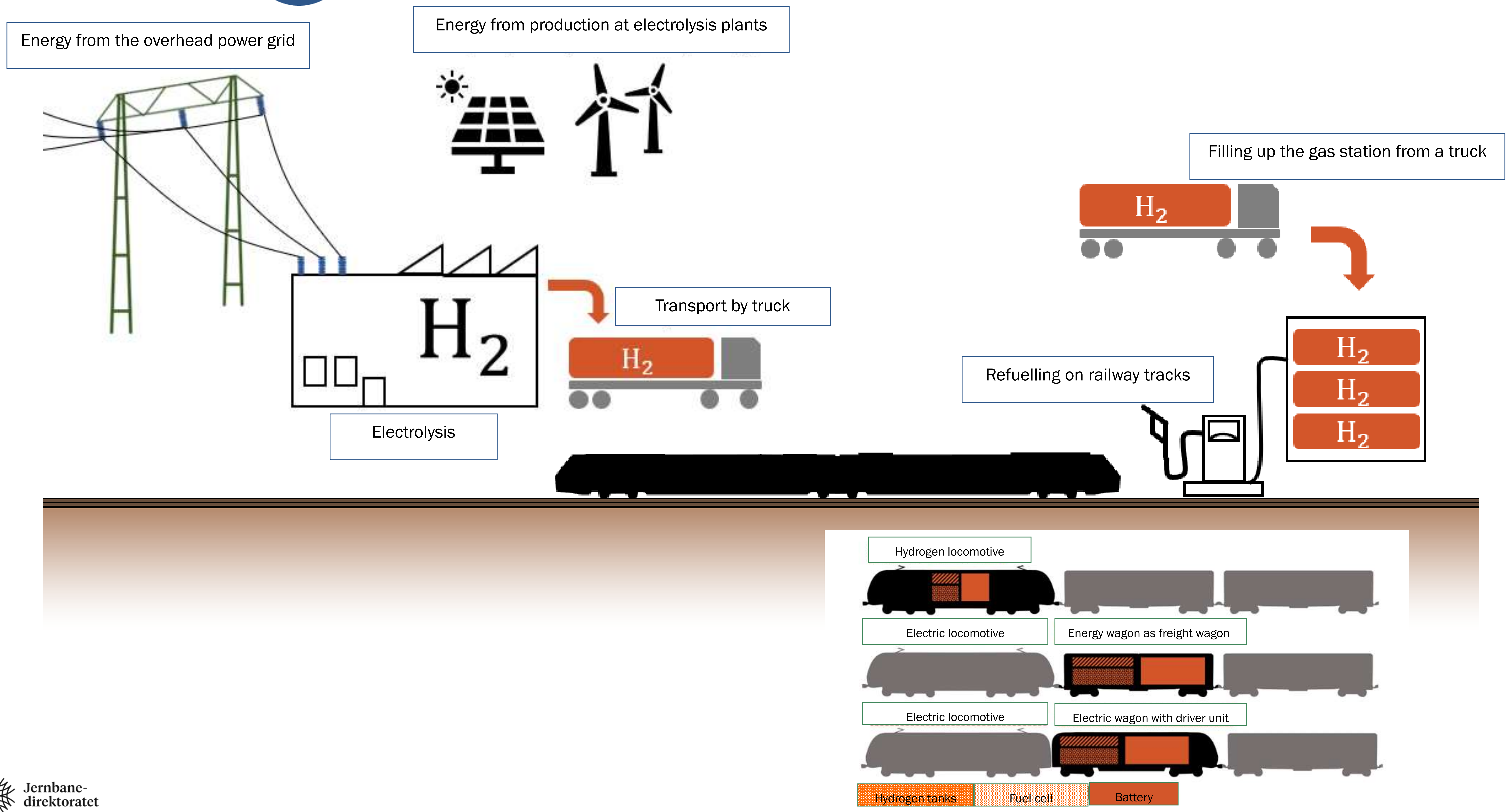
Concept

3 Battery with partial electrification



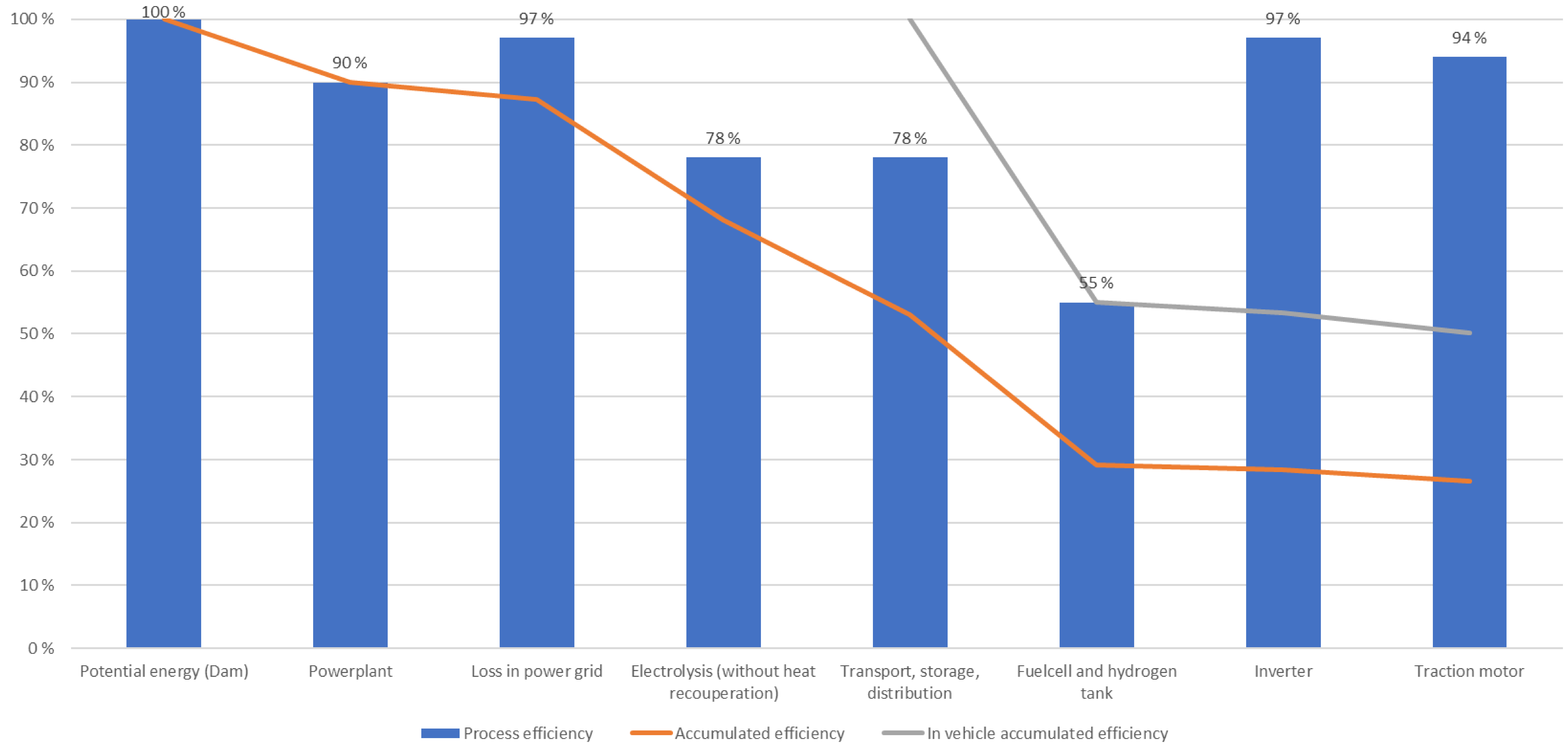
Concept

H_2 **2a** Hydrogen



Well to wheel- energy efficiency

H2 2a Hydrogen



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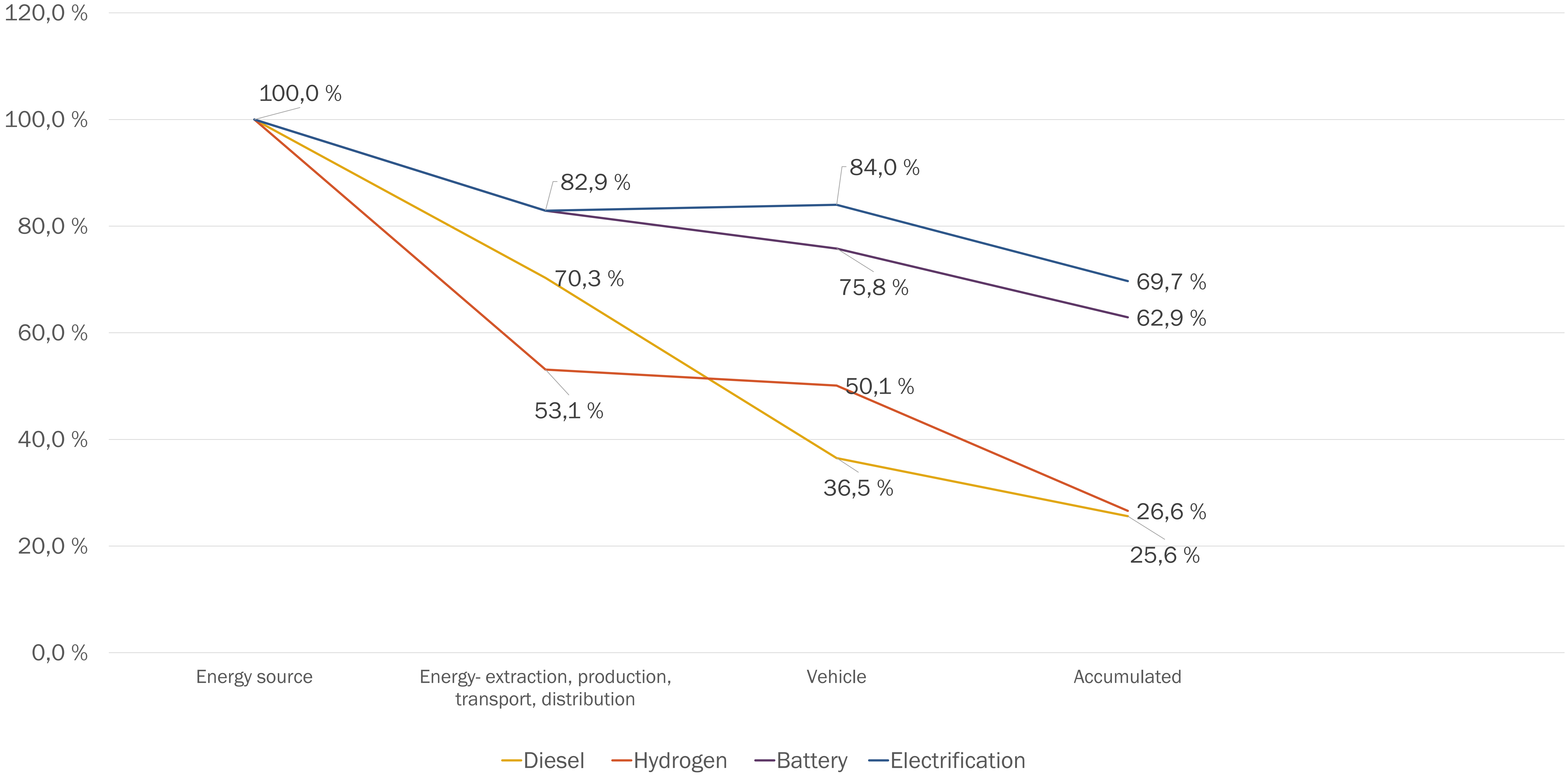
Well to wheel- Energy efficiency



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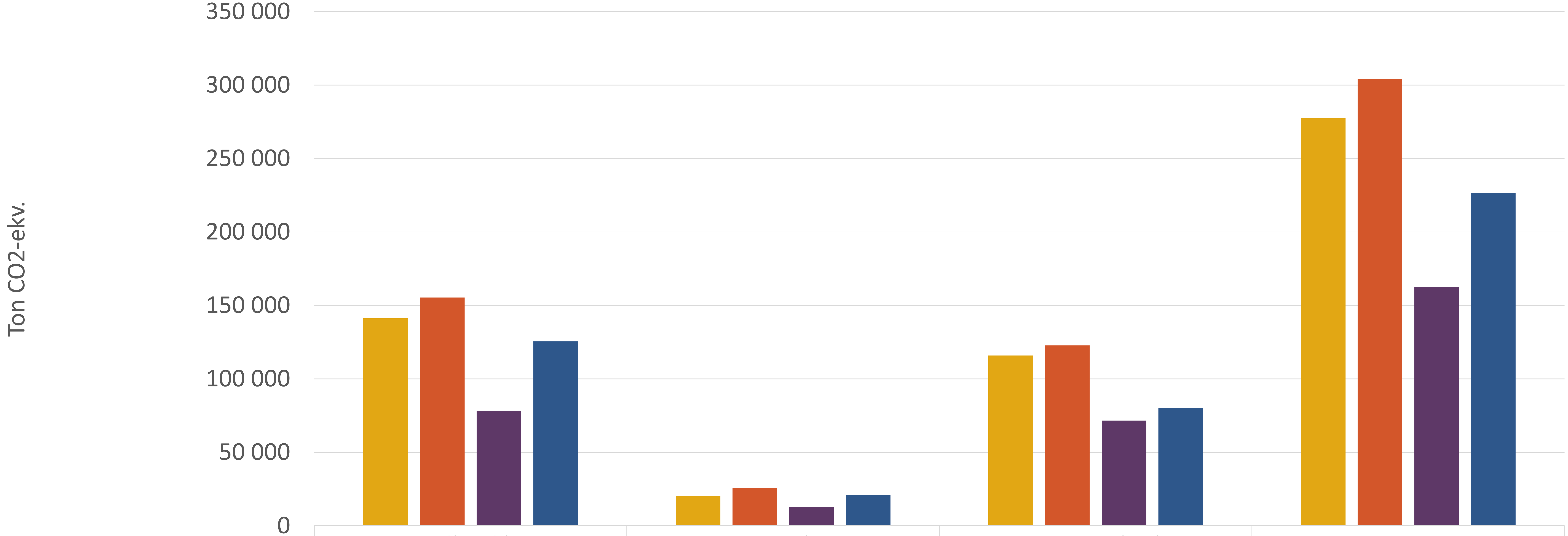
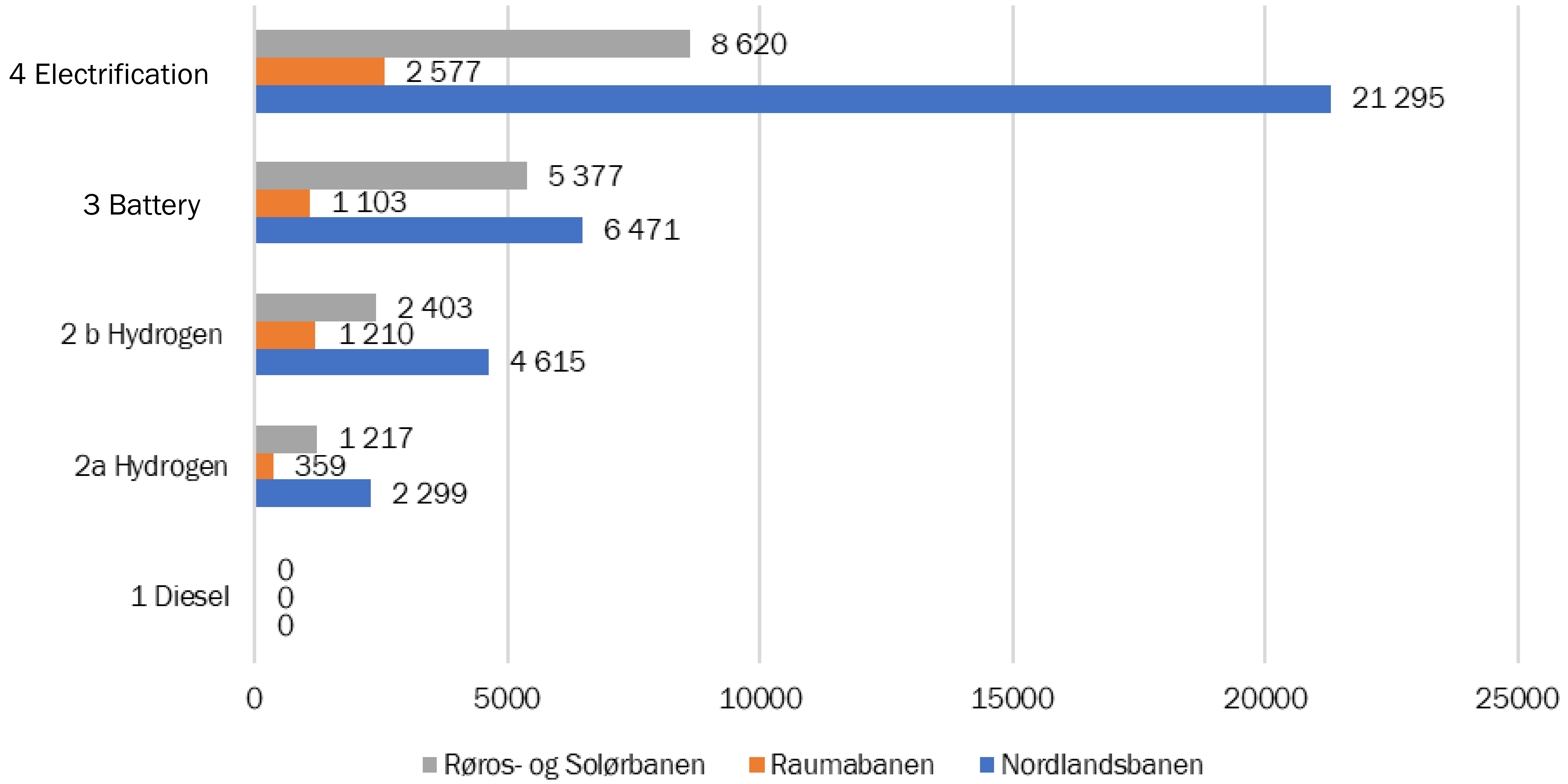
GHG over 75-year analysis period

The total greenhouse gas emissions (tons of CO2 equivalent) from the alternatives over the 75-year analysis period



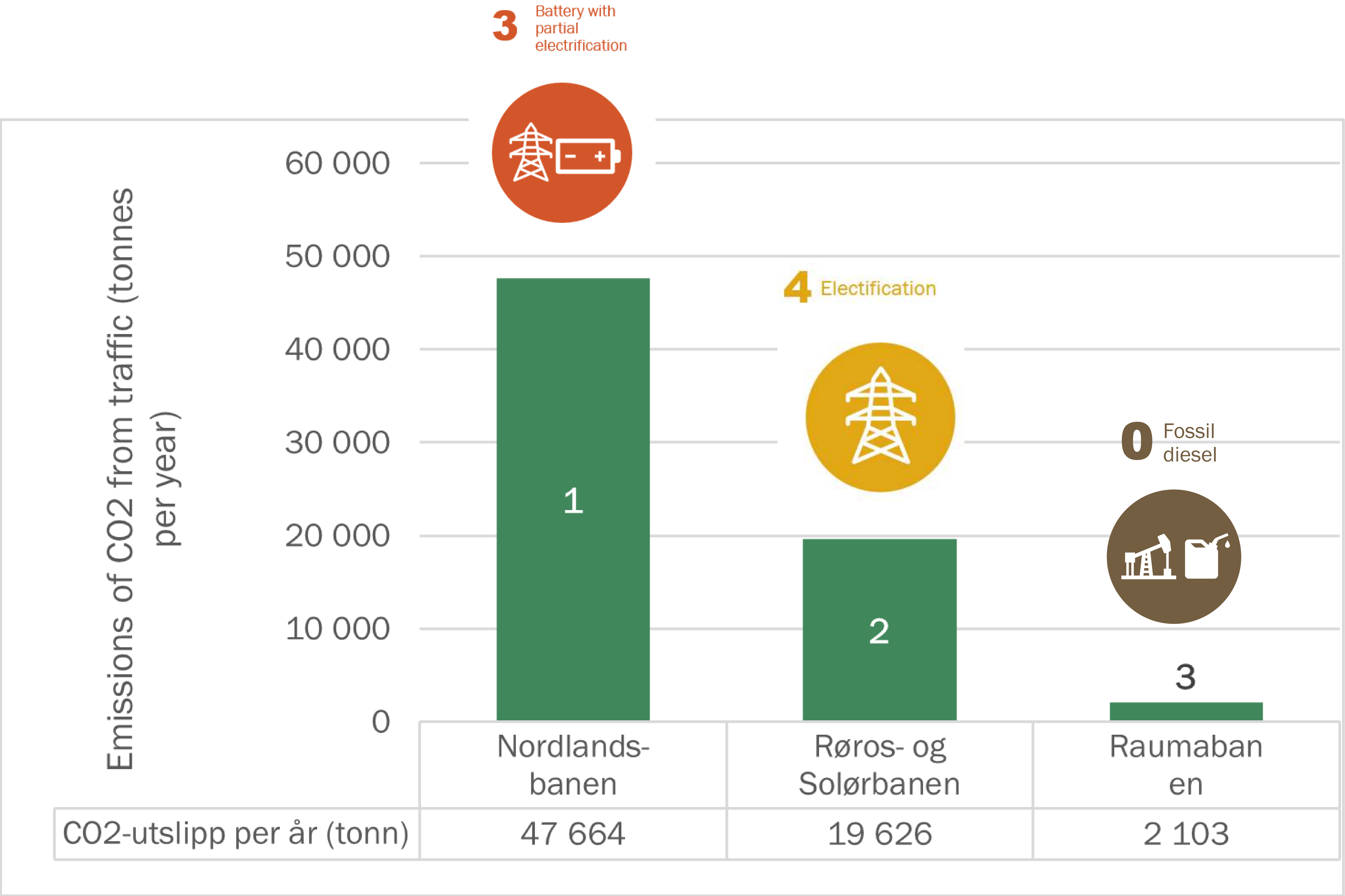
	Nordland line	Rauma line	Røros- og Solør lines	Sum
2a Hydrogen	141 244	20 160	115 951	277 355
2b Hydogen med partial el	155 425	25 897	122 775	304 097
3 Battery	78 363	12 809	71 566	162 738
4 Electrification	125 555	20 801	80 282	226 638

Costs of introducing a new form of energy



Total investment costs for the infrastructure (MNOK)

Recommendations



National Transport Plan

DET KONGELIGE
SAMFERDSELSDEPARTEMENT

Meld. St. 14

(2023–2024)

Melding til Stortinget

Nasjonal transportplan 2025–2036

All the recommendations from the project are taken into consideration the next Transport Plan 2025-2036.

Contributors

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Wabtec CORPORATION
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RANA GRUBER
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tunnel HP
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CIRCLE K
ASKO – vi forsyner Norge med mat
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WINDHOFF
Meraker Hydrogen
Leclanché Energy Storage Solutions
Hitachi Energy
Norsk Industri
Gen2 Energy
SJT statens jernbanetilsyn
Jernbane-direktoratet
Biogass Norge
OnRail Scandinavia
Glomfjord Hydrogen
GREENSTAT
ZERO
NEXRAIL LEASE

Thank you for your attention!

For further information do contact:
stephen.oommen@jerbanedirektoratet.no

Workshop timeline

11:05	**Study on greenhouse gas and Nitrogen oxides from biofuels**	Ricardo (study commissioned by ProRail)
11:30	Break	
11:55	**Ammonia: An Infrastructure Manager's perspective**	Network Rail
12:20	**Biofuels for track maintenance**	Plasser & Theurer
12:45	**Panel discussion**	
13:00	Lunch	
14:00	**Hydrotreated Vegetable Oil (HVO) use**	DB Cargo
14:25	**Hydrotreated Vegetable Oil (HVO) use**	SBB
14:50	**Use of biofuels & Biodiesel (B100)**	SNCF
15:15	**HVO & Fatty Acids/Methyl Esters (FAME) tests outcomes**	LINEAS
15:40	**Panel discussion**	
16:00	**Closing words** **Networking mini cocktail**	

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OF RAILWAYS

Ricardo

Study on greenhouse gas and Nitrogen oxides from biofuels

Koen Van Der Horst

Technical consultant

UIC Alternative fuels workshop, 11 June 2024

Ricardo & ProRail

Koen van der Horst and Martijn Wolf

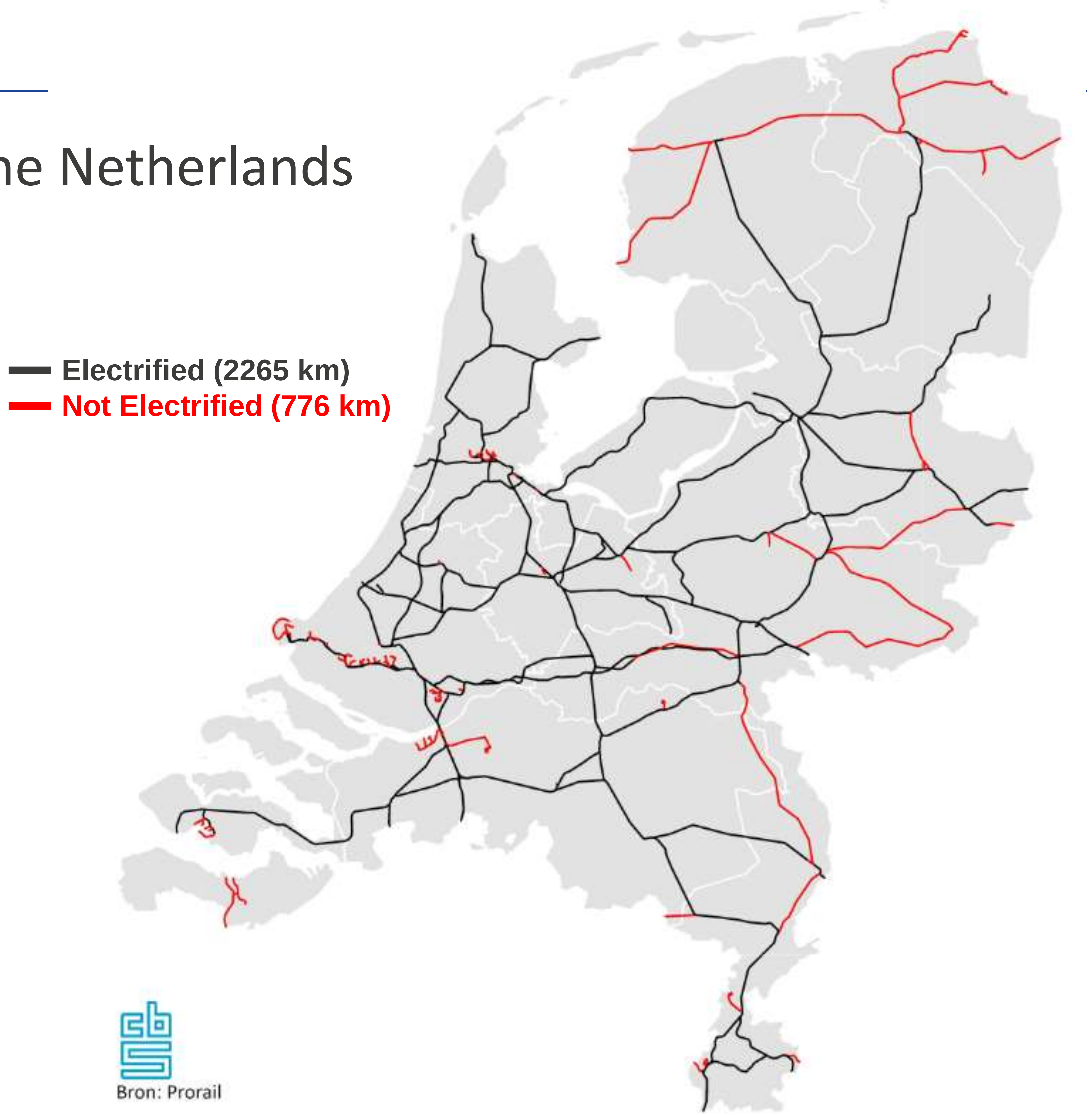
CO_2- and NO_x-emissions of Dutch Diesel Trains Including the Impact of Biofuels

UIC Alternative fuels workshop, 11 June 2024

INTRODUCTION PRORAIL

Responsible for the railway infrastructure in The Netherlands

776 km (~25%) is not electrified



ProRail

INTERNATIONAL UNION
OF RAILWAYS

CO_2- AND NO_X-EMISSIONS OF DUTCH DIESEL TRAINS INCLUDING THE IMPACT OF BIOFUELS

and Zero-Emission Solutions

Martijn Wolf

Koen van der Horst

ProRail RICARDO

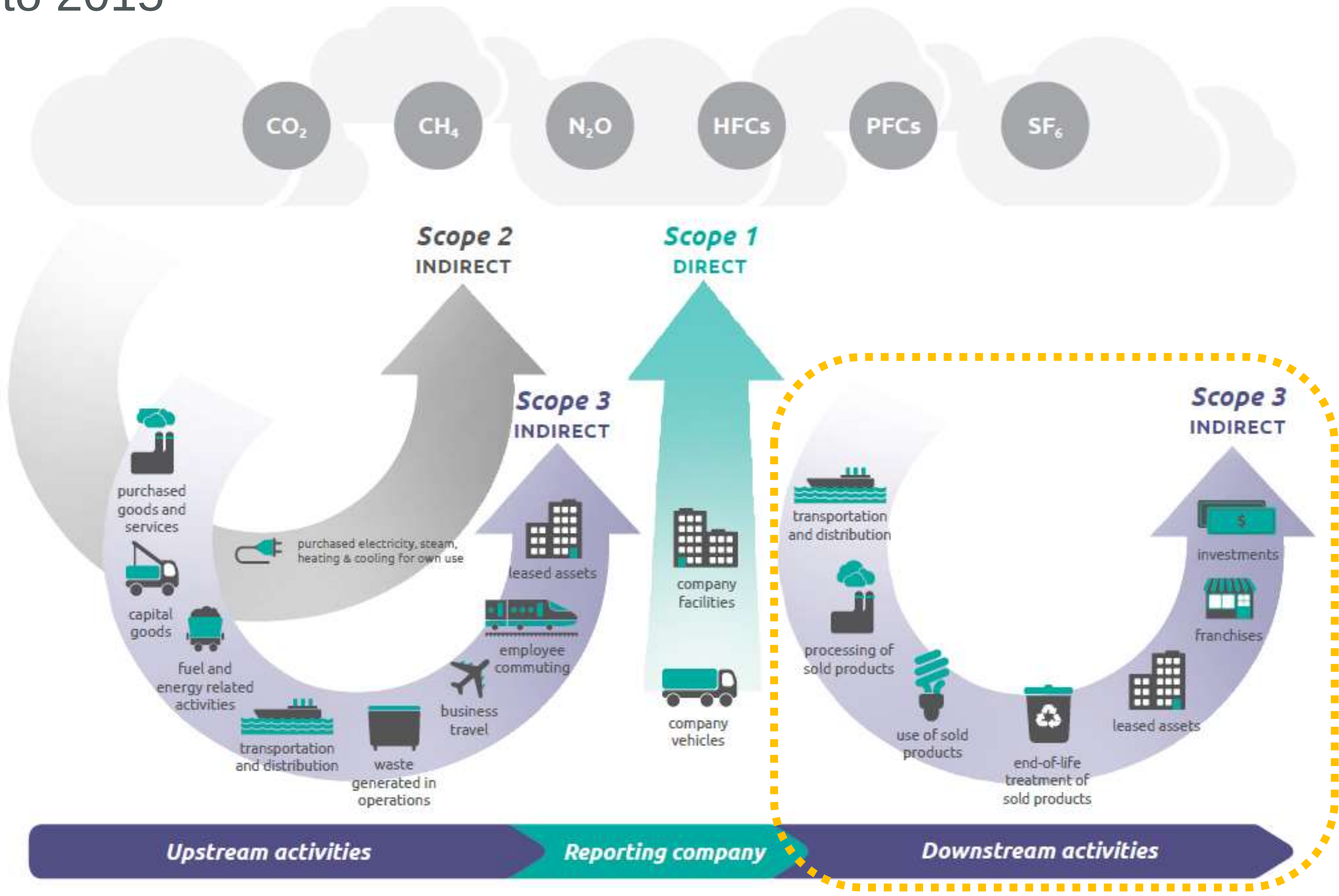
Koen van der Horst and Martijn Wolf

CO_2- and NO_x-emissions of Dutch Diesel Trains Including the Impact of Biofuels

CO_2 objectives ProRail

ProRails' objectives for their scope 1, 2 and 3 emissions:

- 2030: reduction of minimal 55% with reference to 2015
- 2050: completely CO_2-neutral

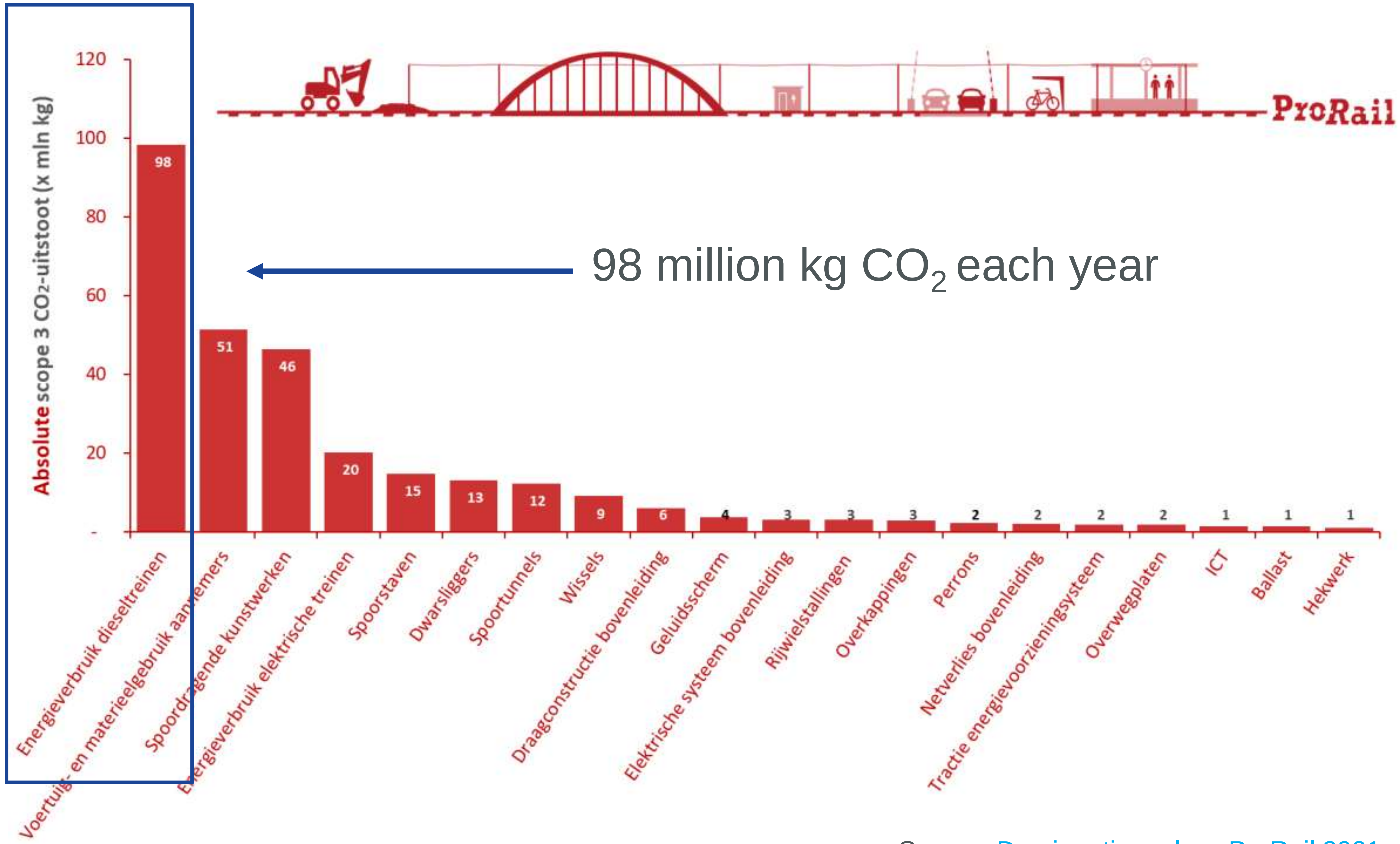


Description and goal of the project

Scope 3: emissions over which a company has indirect influence

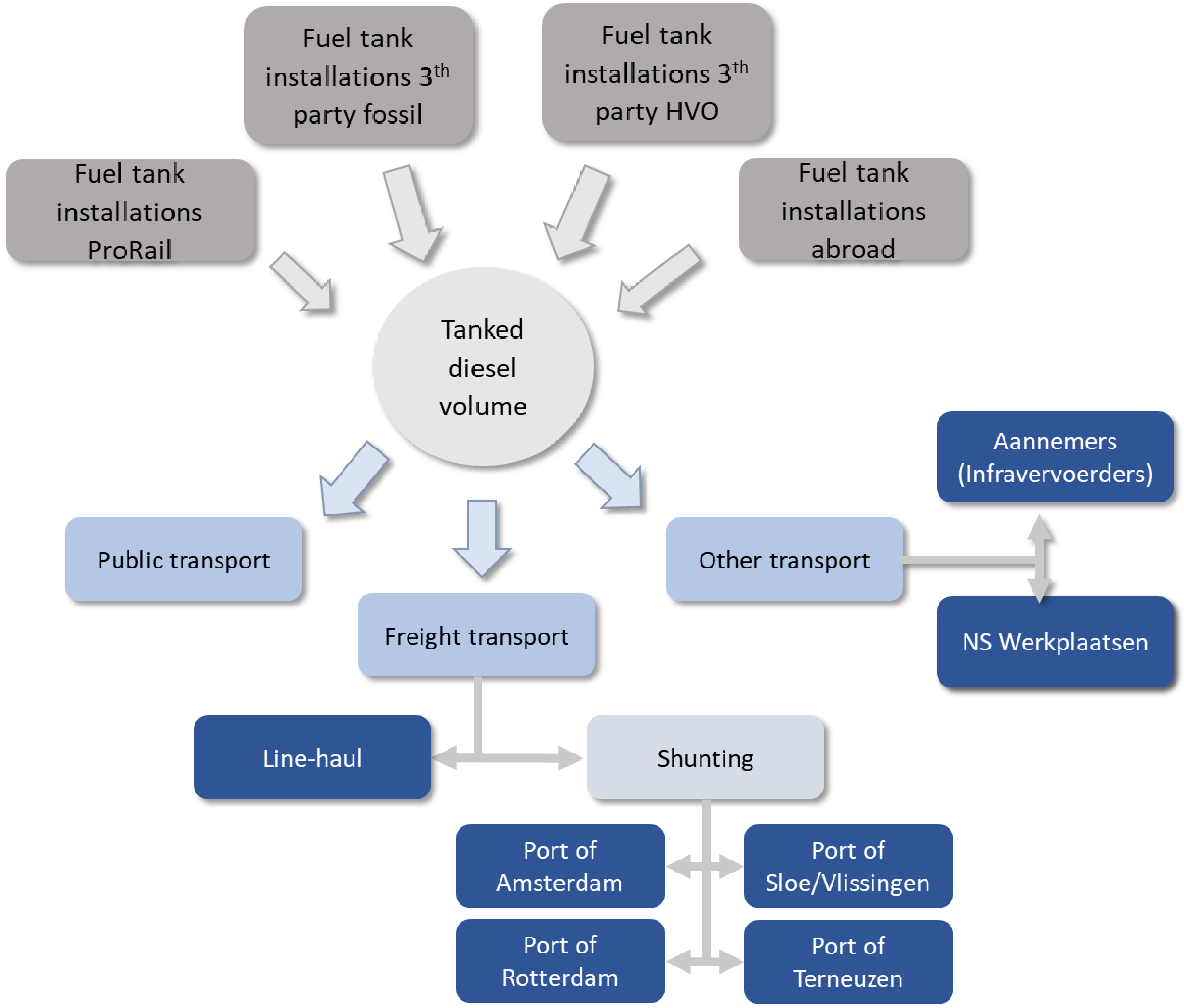
Step 1: Obtain insight into the magnitude and distribution of diesel consumption of rail users and the associated CO_2 and NO_x emissions.

Step 2: Potential zero-emission solutions to achieve decarbonization objectives.



Source: Dominantieanalyse ProRail 2021

Diesel Usage for Rail Customers



Public transport

Freight transport

Other transport

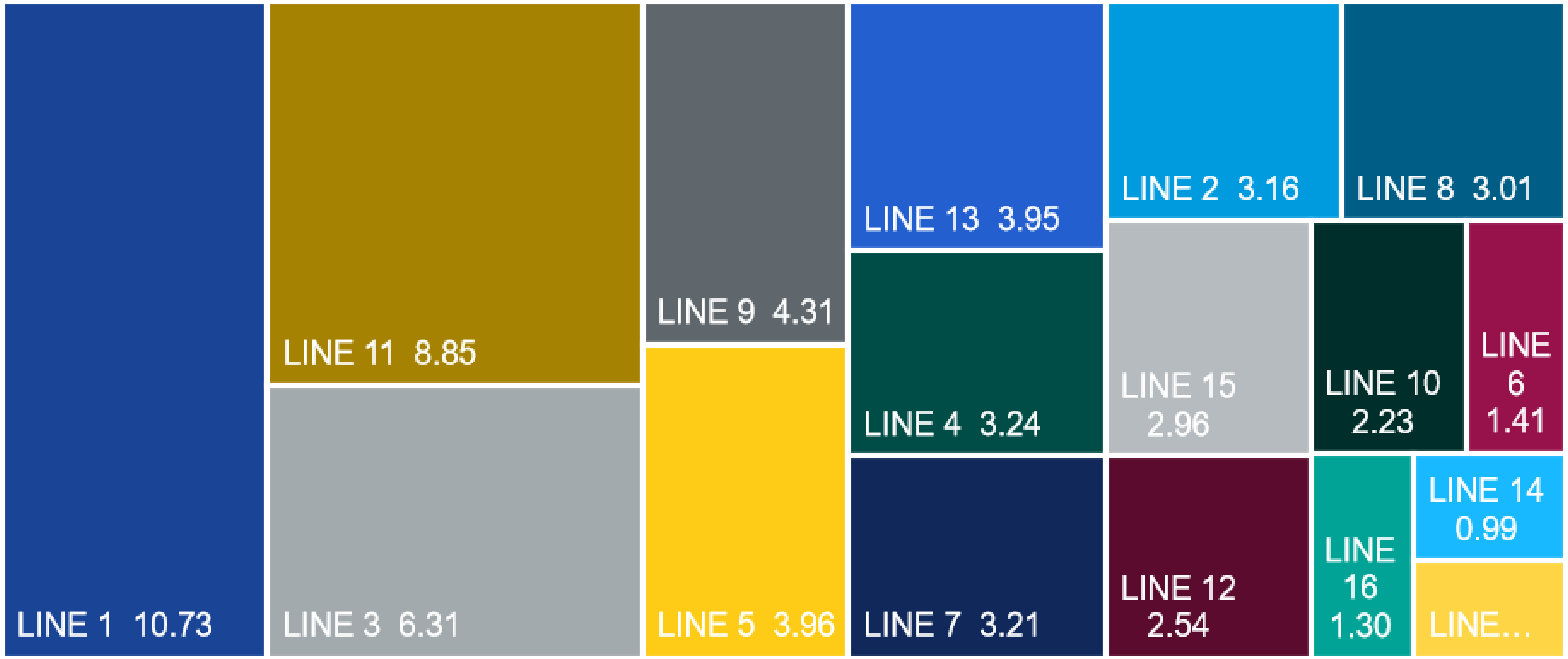
CO_2 and NO_x emission factors: diesel trains

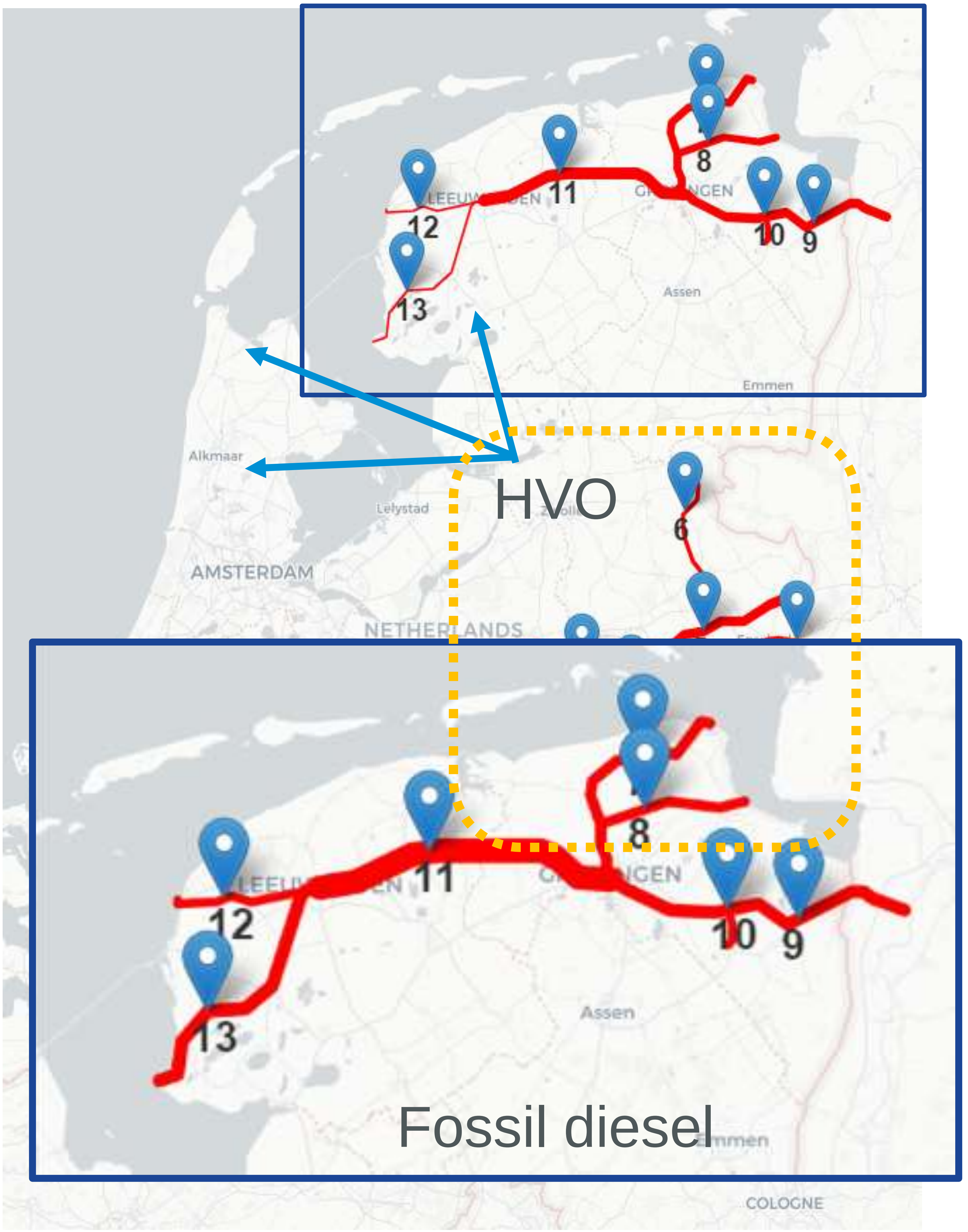
	CO_2 emission factor (well-to-wheel) [kg CO_2/L]
	Public transport trains and Freight trains
Fossil diesel	3.529
HVO	0.357

Public transport

- 4 different public transport companies → 17 unique lines
- Thickness of the line is the relative CO_2-emission
- Total: 53.6 million kg CO_2/year

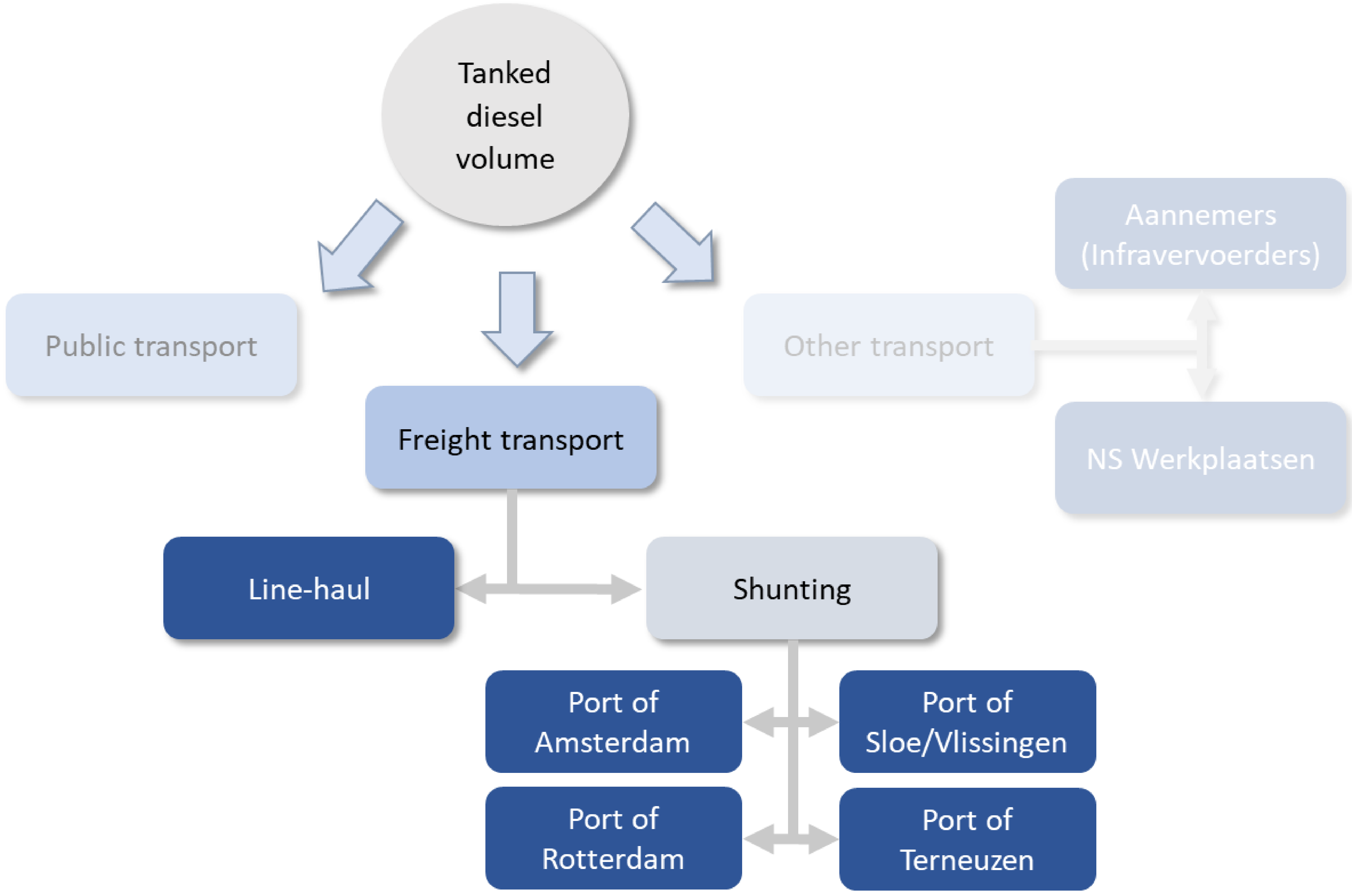
CO_2-emission public transport per line [million kg CO_2/year]



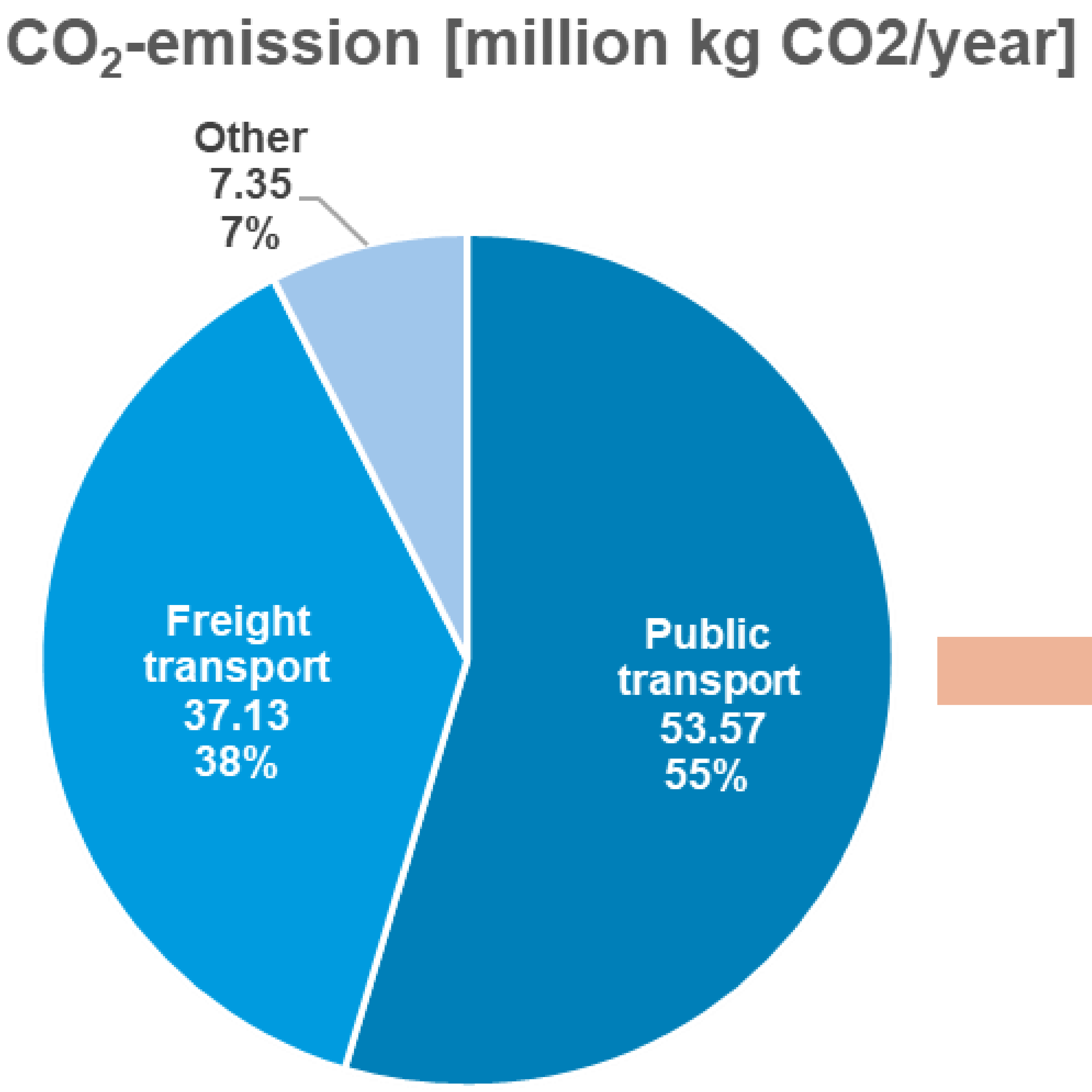


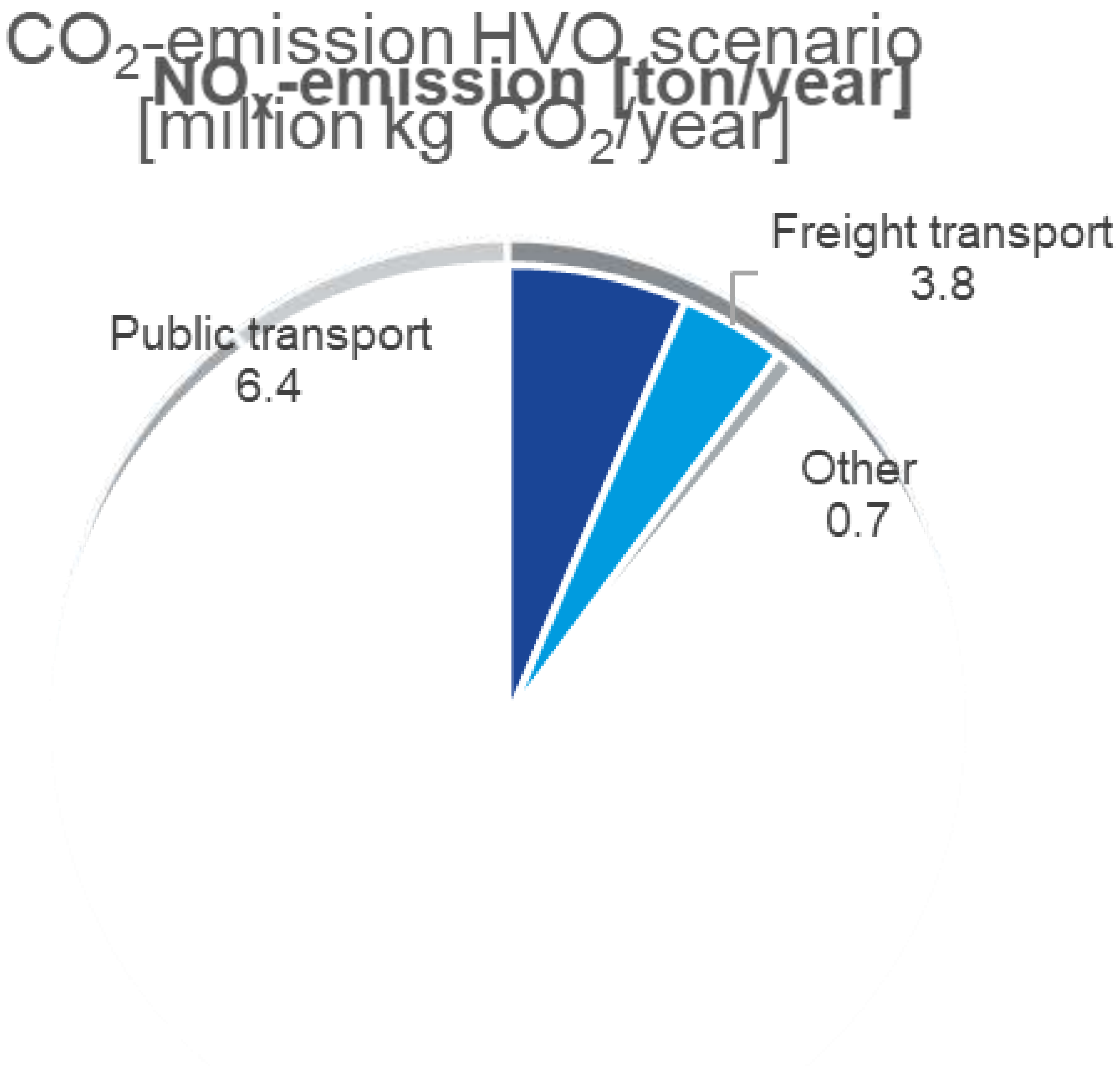
Freight transport

- Subdivision between line-haul and shunting (port areas)
- Thickness of the line indicates the relative CO2 emissions



Summary

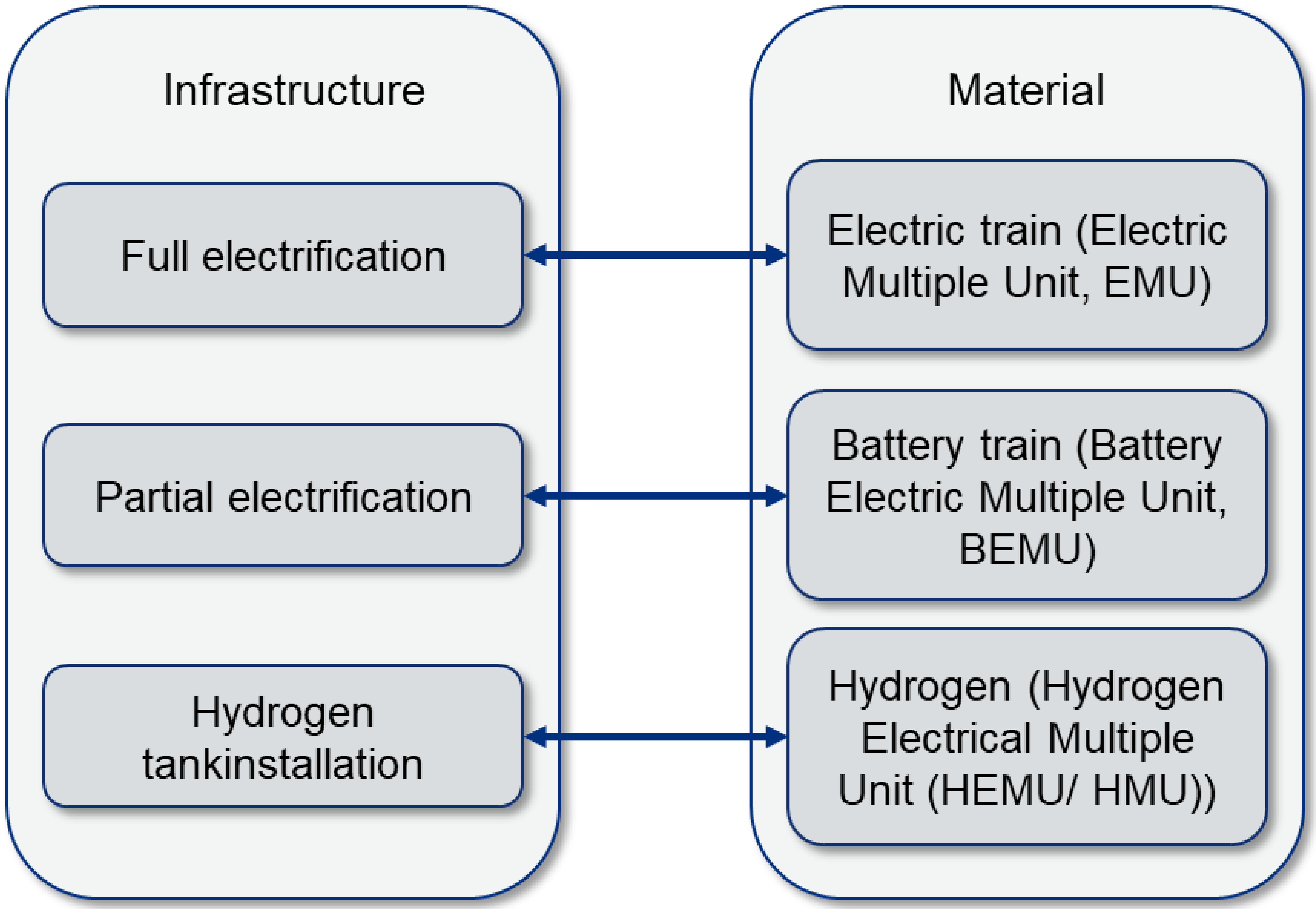




Public transport has the biggest share

Freight transport has the biggest share

Zero-emission solutions



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Thank you for your attention

RICARDO

Koen van der Horst
Technical consultant

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Ricardo.com

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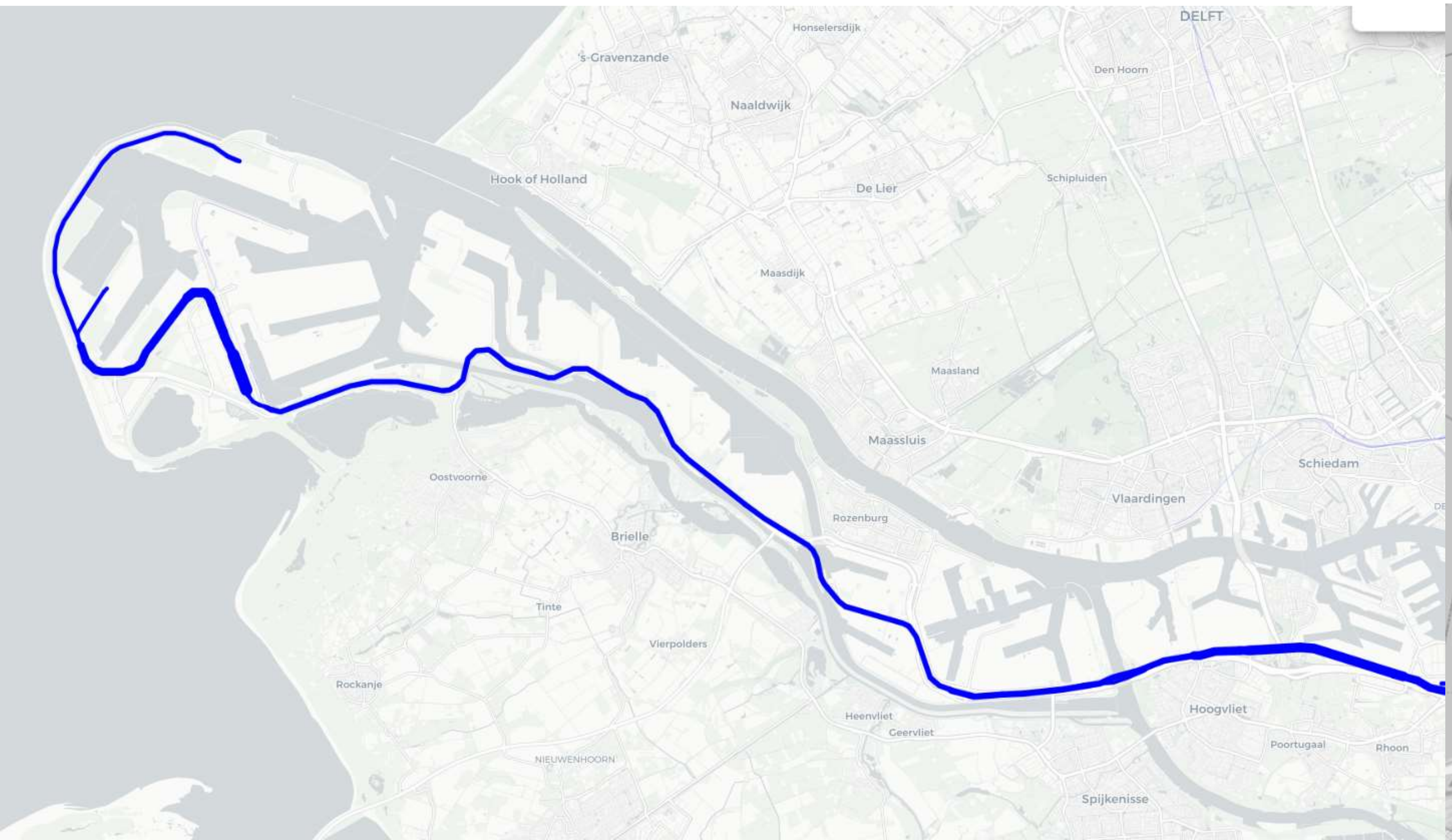
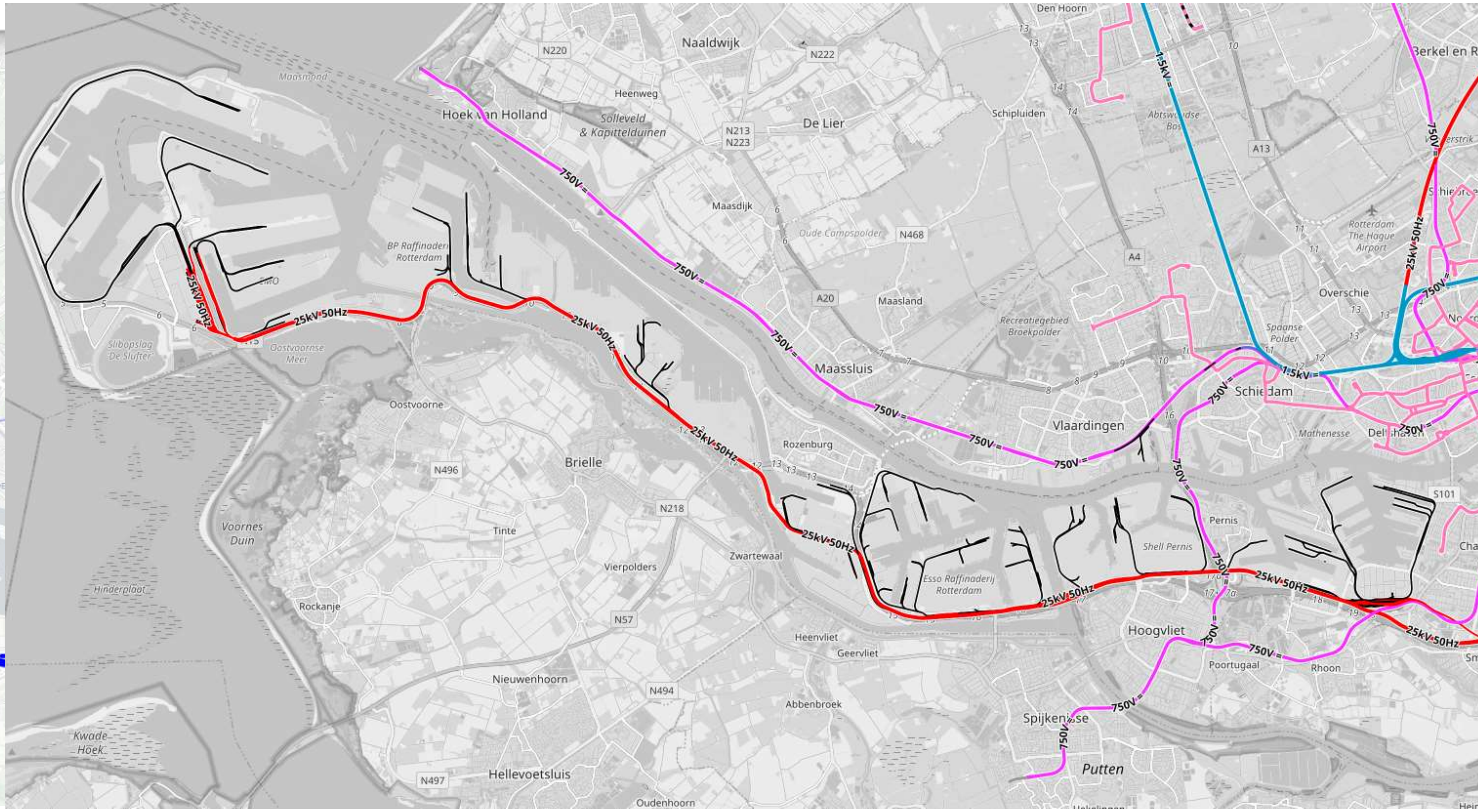
Example: freight transport in The Port of Rotterdam

Driven fossil diesel kilometers



Electrification in The Port of Rotterdam (red = 25 kV AC)



Break time

Until 11h55

Workshop timeline

11:55	**Ammonia: An Infrastructure Manager’s perspective**	Network Rail
12:20	**Biofuels for track maintenance**	Plasser & Theurer
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16:00	**Closing words** **Networking mini cocktail**	

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Network Rail

Ammonia: An Infrastructure Manager’s perspective

Rory Dickerson

Senior Engineer

UIC Alternative fuels workshop, 11 June 2024

Alternative Traction: Ammonia: An Infrastructure Manager's Perspective

Rory Dickerson

Senior Traction & Rolling Stock Engineer

Brief

A discussion on some of the hazards and benefits of Ammonia in comparison to Hydrogen as a fuel

(assuming eDiesel and HVO are not desired)

https://bahnbilder.ch/picture/19820

NetworkRail

Director's Request

"The shipping industry is looking at ammonia as an alternative to oil, why isn't rail?"

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Climate change: Fertiliser could be used to power ocean-going ships

19 February 2020 · Comments

BBC Sign in Home News Sport Weather iPlayer Sounds

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The foul-smelling fuel that could power big ships

6 November 2020

University of Birmingham research project

Considered ammonia as a fuel

Cracked onboard into hydrogen

- PEM Fuel Cell
- Solid Oxide Fuel Cell

- Ammonia direct
  - Solid Oxide Fuel Cell
  - Internal Combustion Engine
- Single freight journey simulated

https://bahnbilder.ch/picture/19820

NetworkRail

University of Birmingham research project

Conclusions

- Positive within scope researched
- SOFC
  - Most efficient
  - Lowest TRL → most expensive
- Internal Combustion Engine
  - Slightly reduced efficiency vs diesel
  - Highest TRL
  - Affordable with Blue Ammonia

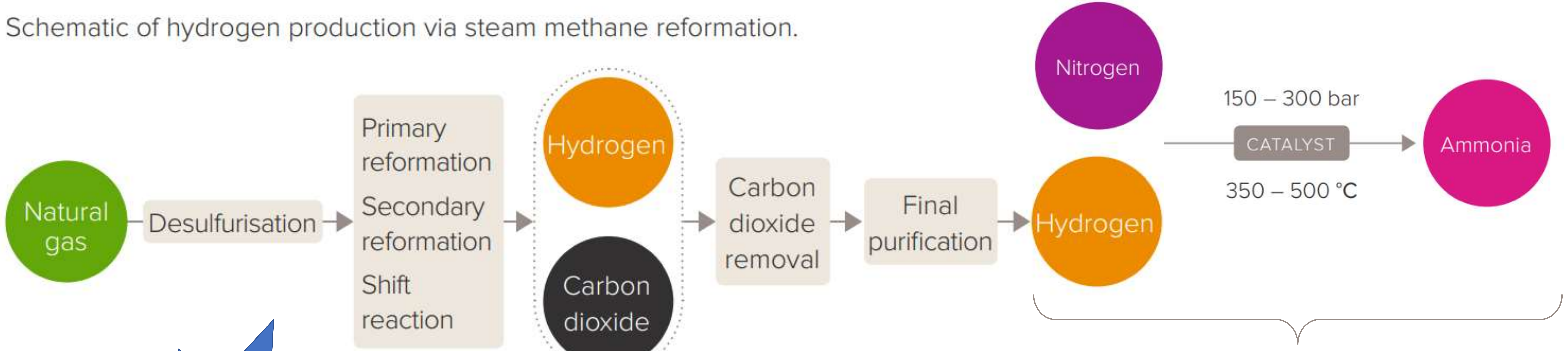
What next?

Network Rail is an Infrastructure Manager

- Locomotives services are hired
- Freight is privatised
- Is NR best placed to be funding engine development?
- HyTunnel highlighted hazards associated with hydrogen releases in confined spaces
- Trains operate under RU SMS, IMs should understand the risks of alternative fuels

DRS Class 66, 66423, Wigan North Western... © El Pollock cc-by-sa/2.0 :: Geograph Britain and Ireland

Ammonia production



Haber-Bosch Process

Low Cost

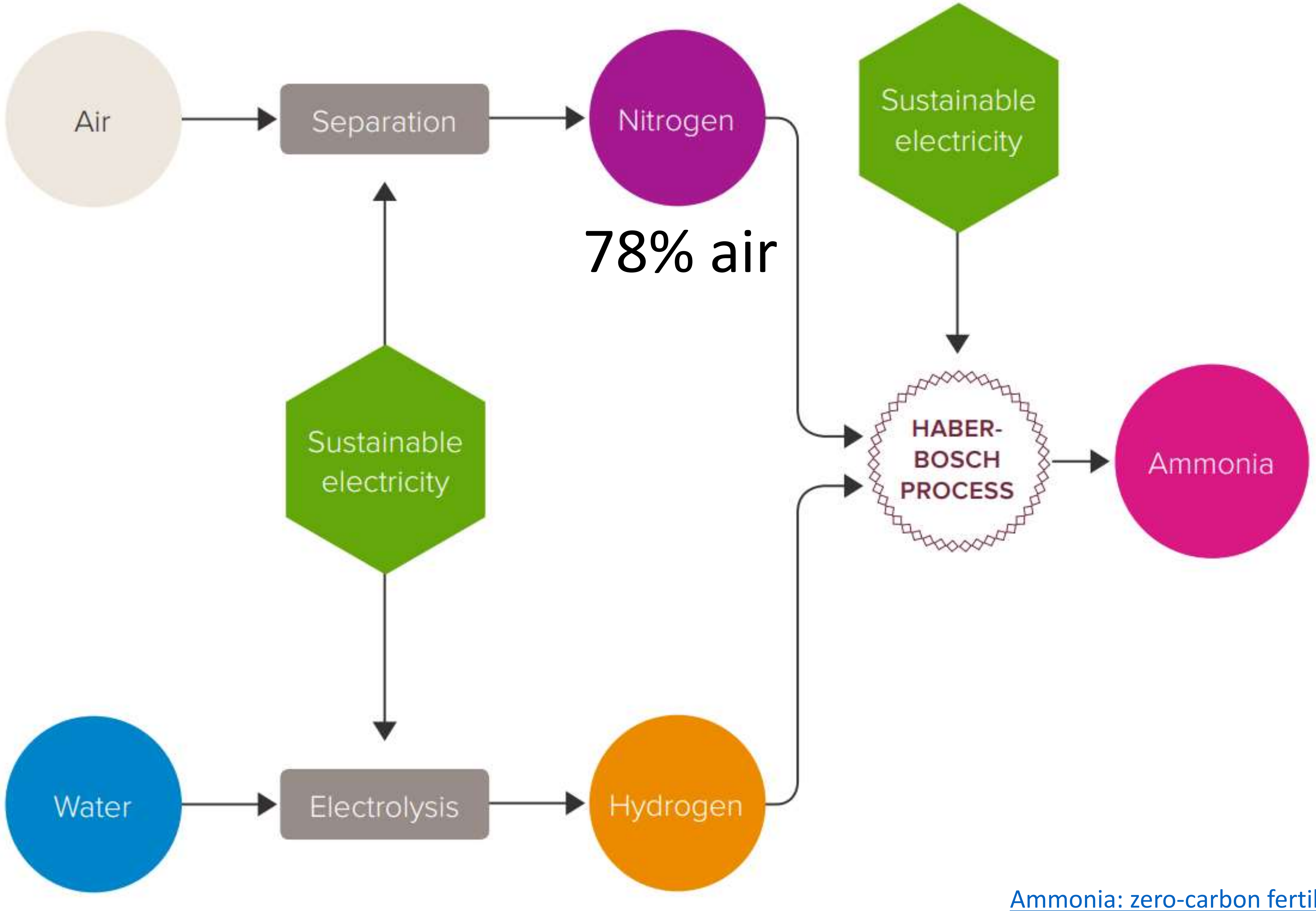
CCS

Production: ~176 million tonnes per year

[Ammonia: zero-carbon fertiliser, fuel and energy store (royalsociety.org)]

Ammonia production

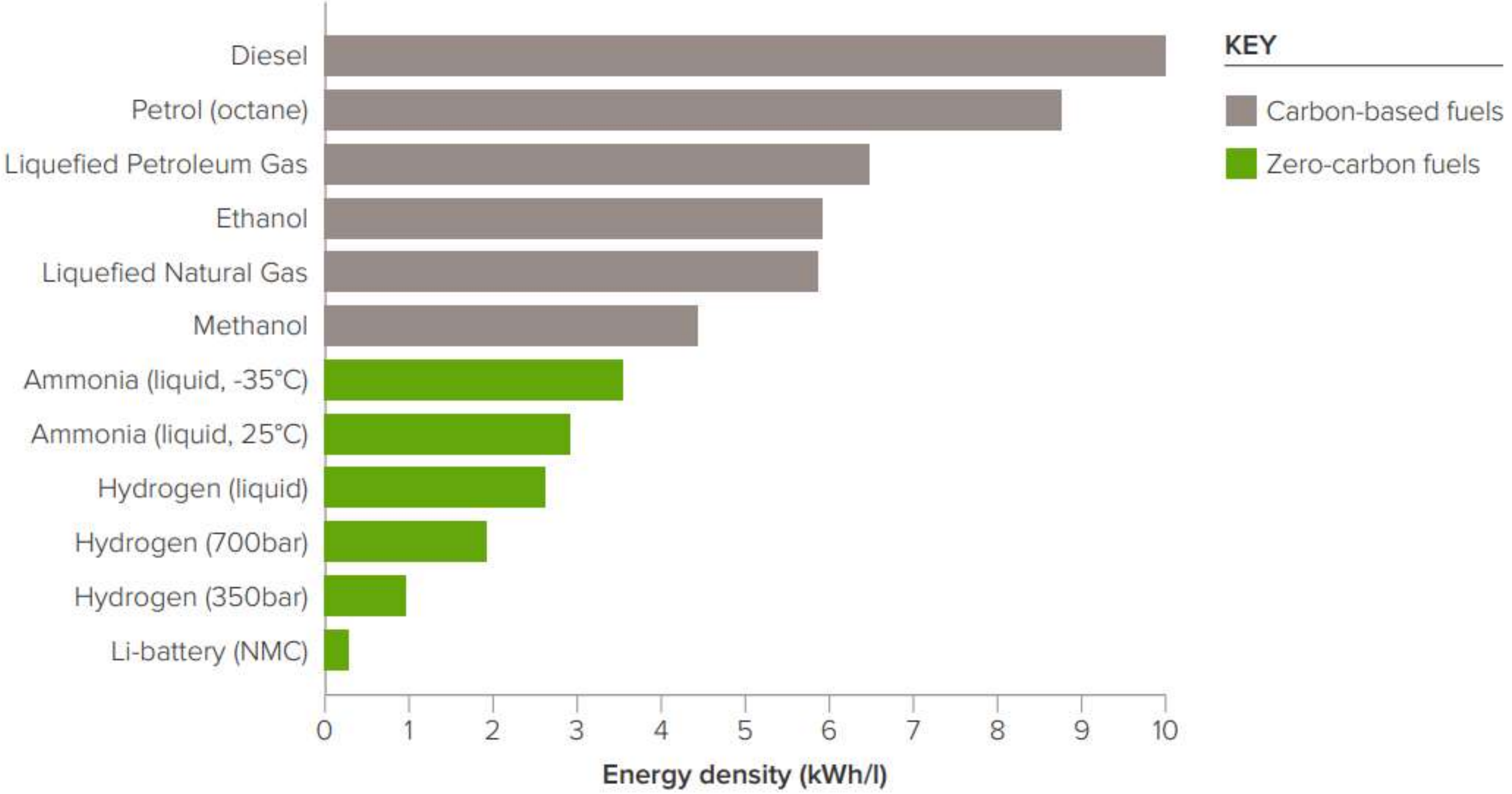
Schematic of green ammonia production based upon hydrogen production from water electrolysis and the full decarbonisation of the Haber-Bosch process.



Ammonia: zero-carbon fertiliser, fuel and energy store (royalsociety.org)

Ammonia

The volumetric energy density of a range of fuel options.



Ammonia: zero-carbon fertiliser, fuel and energy store (royalsociety.org)

Ammonia

Property	Diesel	Hydrogen	Ammonia
Storage	Steel tank	350 bar compressed (gas) or Liquid at -253°C	15-16 bar compressed (liquid, room temp.) or -33°C
Specific Energy (MJ/kg)	45.6	120	18.6
Specific Energy (contained approx.)	**40** (guess)	**9**	**10**
Energy Density (MJ/l)	38.6	2.9	11.5
Energy Density (contained approx.)	**38** (guess)	**2.2**	**9**
Flammability in air (% vol)	-	4-74	16-27 (Methane 4-15)
H-phrase		H220 (Extremely Flammable)	H221 (Flammable)

- Storage volume: 4 times better than hydrogen, 4 times worse than diesel
- Storage mass: comparable to hydrogen, 4 times worse than diesel
- Flammability: safer than hydrogen and methane

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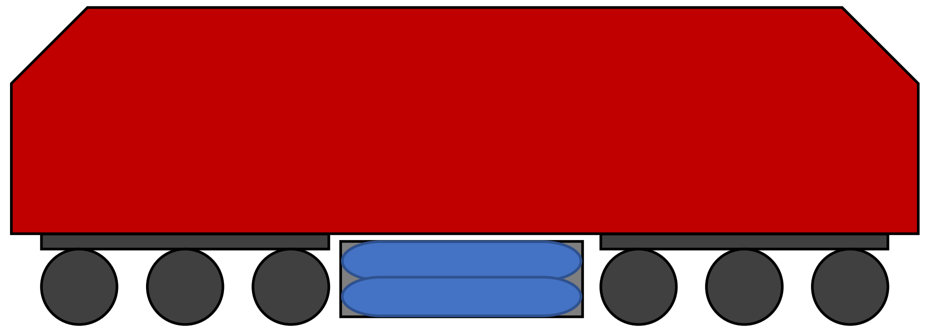
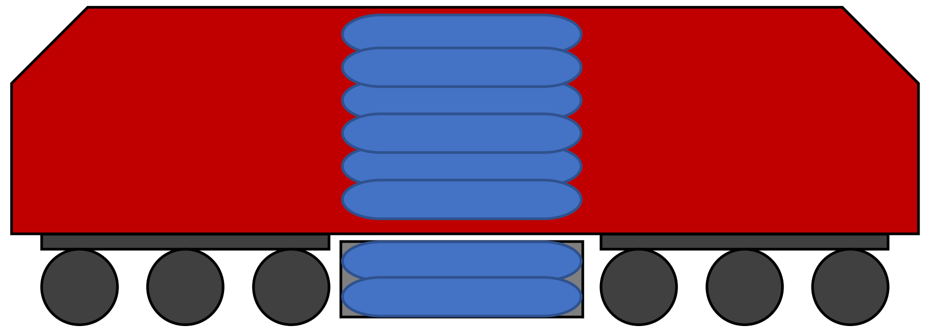
Volumetric Compromise (Locomotive)



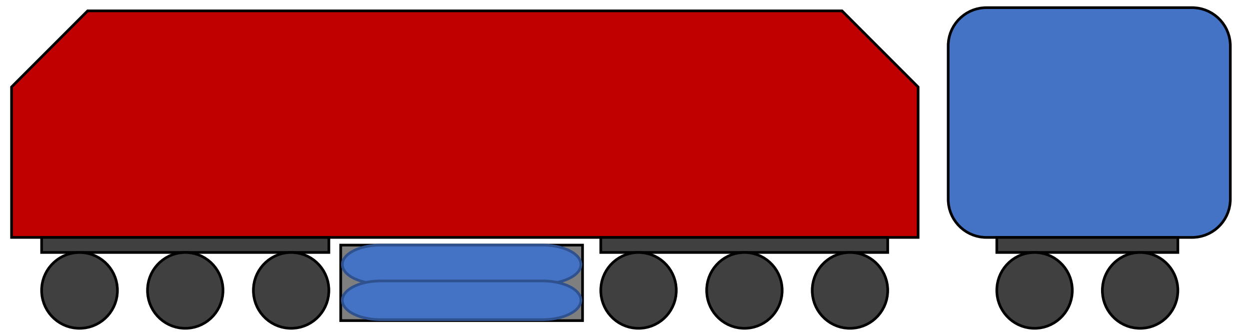
Reduced range

- More frequent refuelling (& infrastructure)
- Assumes ICE changed are accommodated



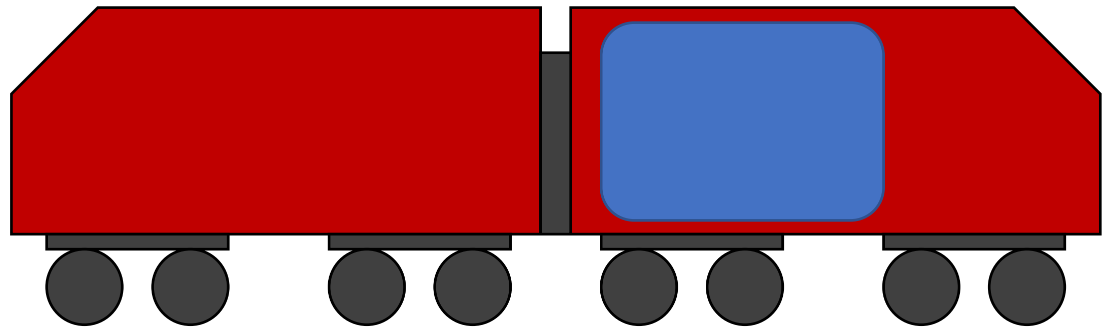
Re-engineer or New design

- Range may still be compromised due to space
- Big job



Fuel tender

- ICE, exhaust treatment still need adapting
- Single direction, reduces payload capacity
- 2nd loco or loop required to reverse

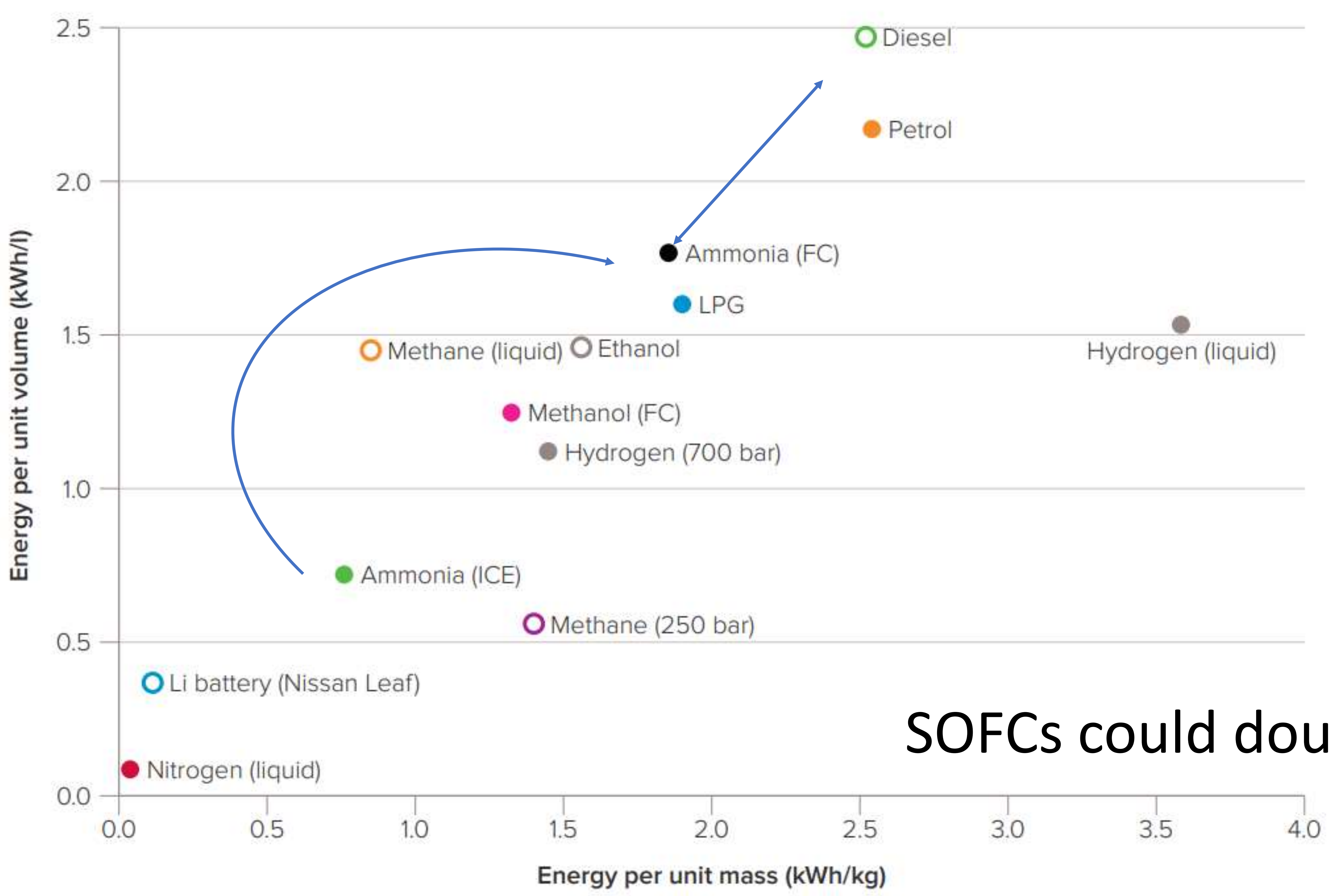


New two-part design

- Big loco – 1 wagon less payload?
- Increased cost vs. single body loco

Ammonia

Specific energy and energy density of a range of energy stores for mobile applications accounting for typical container properties and energy conversion technology efficiencies.



SOFCs could double the efficiency

[Ammonia: zero-carbon fertiliser, fuel and energy store (royalsociety.org)](royalsociety.org)

Ammonia exposure from use

- Industrial Refrigeration
- Fertiliser Production
- Freight (transportation): safer than road, lineside exposure limited, train driver is separated. Wagons are simple
- Rail Fuel:
  - More complicated pipework
  - Vibration
  - Ammonia carried on vehicle at the front of the train
  - Train driver within a few metres of Ammonia whist working

These increase the risk of exposure

NetworkRail

Ammonia – toxicity

Petrol

*Table 2: Summary of the human inhalation toxicity of petrol vapour. *Refers to estimated concentrations based on post-incident measurements: See also Annex II.*

Study type	Concentration (ppm)	Duration	Temperature	Effect(s)	Ref
Human volunteer studies	140 – 270	8 h	23 °C	Mild irritation (coughing, sore throat), conjunctival hyperaemia.	[30]
	200	0.5 h		Threshold level for eye irritation.	[35]
	900	8 h	22 °C	Mild CNS effects (dizziness). Tolerable.	[30]
	2,600	1 h	n/s	Onset of neuromuscular effects (incoordination)	[30]
	> 10,700	< 5 min	n/s	Rapid onset of dizziness and 'drunkenness' (ataxia, confusion). Threshold level for onset of anaesthetic effects.	[30]
Case studies	8,000 – 35,000*	Minutes	'hot'	Death occurred sometime within 45 minutes of initial exposure.	[12]
	5,000 – 16,000*	Minutes	n/s	Death occurred sometime within five minutes of exposure.	[31]

Ammonia

Table 1: Summary of toxic effects following acute exposure to ammonia by inhalation

Exposure		Signs and symptoms
mg/m^3	ppm	
35	50	Irritation to eyes, nose and throat (2 hours' exposure)
70	100	Rapid eye and respiratory tract irritation
174	250	Tolerable by most people (30–60 minutes' exposure)
488	700	Immediately irritating to eyes and throat
>1,045	>1,500	Pulmonary oedema, coughing, laryngospasm
1,740–3,134	2,500–4,500	Fatal (30 minutes' exposure)
3,480–6,965	5,000–10,000	Rapidly fatal due to airway obstruction, may also cause skin damage

Values in mg/m^3 are approximate calculations from ppm, where mg/m^3 = ppm x gram molecular weight/24.45 (molar volume of air at standard temperature and pressure)

References

[2, 14]

- Fertilizers Europe assessed 38 rail-related ammonia accidents from 4 databases.
  - No fatalities from release of ammonia

NetworkRail

Ammonia vs Hydrogen leak scenarios

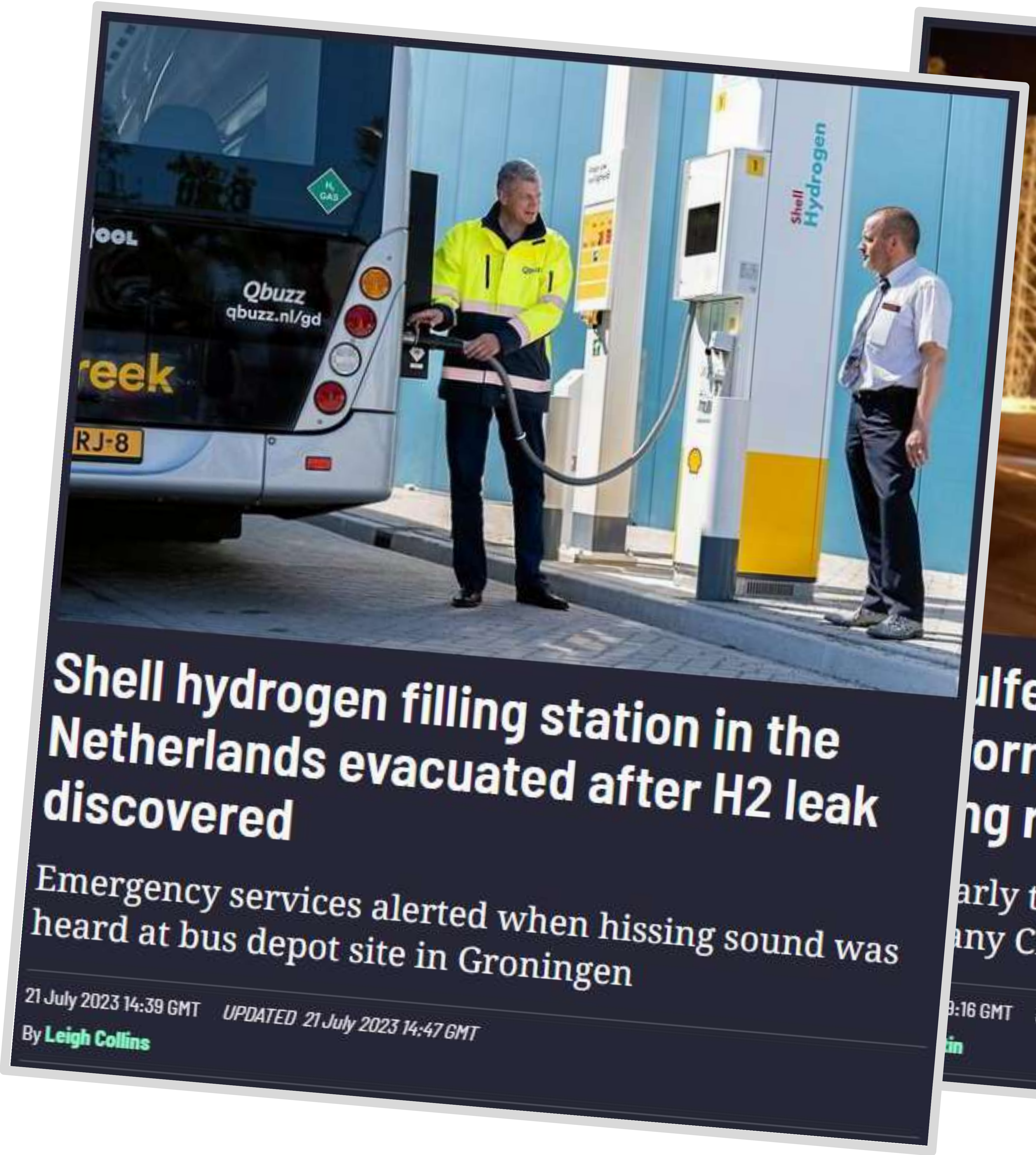
Hydrogen (350 bar):

- Detection: sound, detectors
- Hazard: cold gas, fire, deflagration, explosion if confined
- Action: evacuate, automatic/remote shutdown, ventilate, wait

Ammonia (16 bar):

- Detection: sound, detectors, smell
- Hazard: cold gas, toxic gas, fire/explosion in specific circumstances
- Action: evacuate, automatic/remote shutdown, ventilate, **approach with PPE, local shutdown, cover, re-capture, repair (more options – faster resolution)**

Hydrogen events

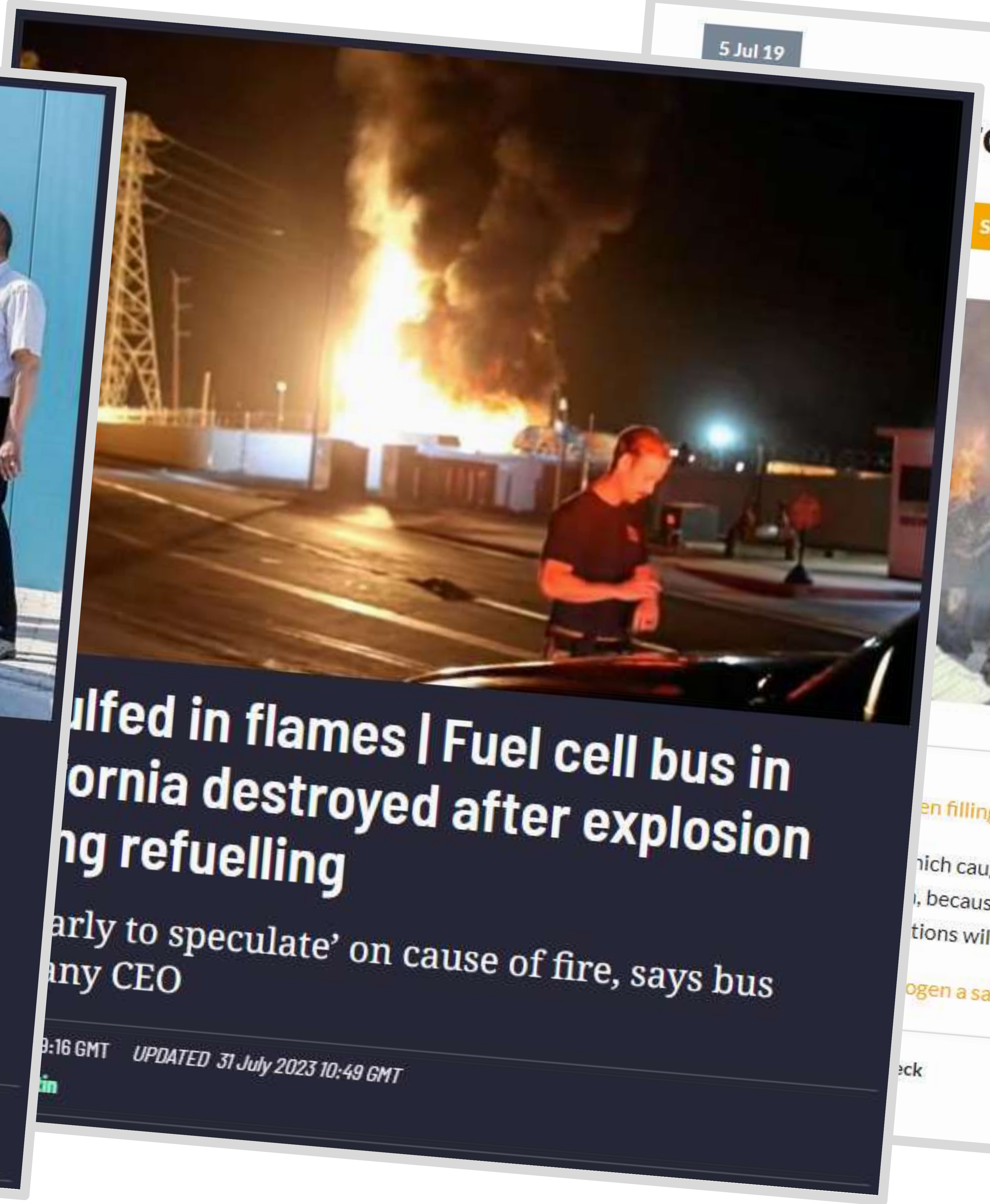


Shell hydrogen filling station in the Netherlands evacuated after H2 leak discovered

Emergency services alerted when hissing sound was heard at bus depot site in Groningen

21 July 2023 14:39 GMT UPDATED 21 July 2023 14:47 GMT

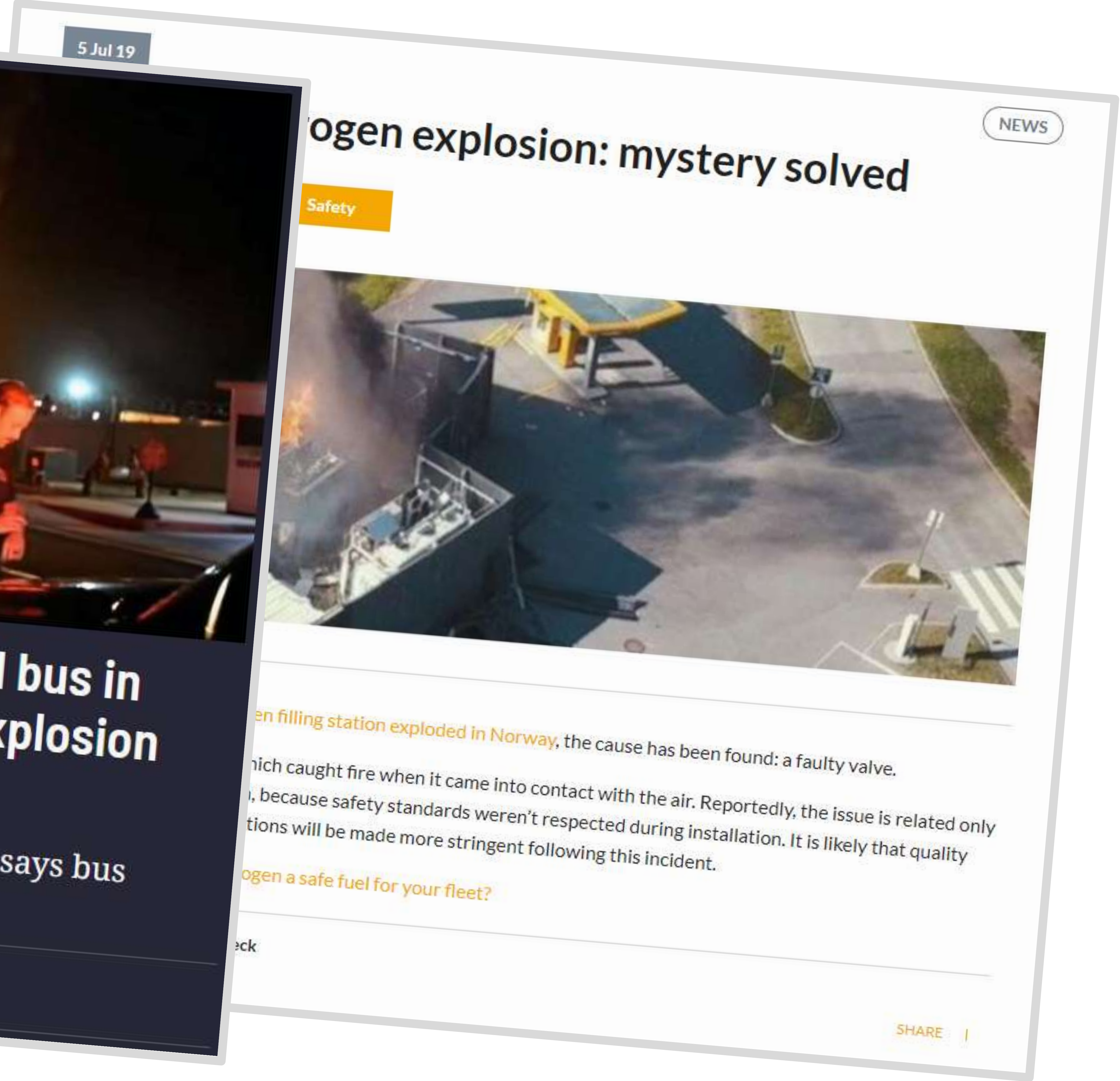
By Leigh Collins



...lfed in flames | Fuel cell bus in ...ornia destroyed after explosion ...ng refuelling

...arly to speculate' on cause of fire, says bus ...any CEO

...:16 GMT UPDATED 31 July 2023 10:49 GMT



5 Jul 19

NEWS

...ogen explosion: mystery solved

Safety

...en filling station exploded in Norway, the cause has been found: a faulty valve.

...hich caught fire when it came into contact with the air. Reportedly, the issue is related only ..., because safety standards weren't respected during installation. It is likely that quality ...tions will be made more stringent following this incident.

...ogen a safe fuel for your fleet?

SHARE |

Most significant hazard from a leak?

Hydrogen

Fire and explosion

- Applies to buildings and people
- PPE to protect from explosion?

- After evacuation, fire/explosion risk to assets remains until leak stops or burns out

Ammonia

Toxicity

- Applies to people only
- PPE available
- Easy to detect

- After evacuation, toxicity risk is nullified
- Fire / explosion risks not zero (but far less than hydrogen)

NetworkRail

Some regulations

Regulations also suggest Ammonia may be less hazardous in the round:

Regulation	Hydrogen	Ammonia
The Planning (Hazardous Substances) Regulations 2015	2 tonnes	50 tonnes (8.5 tonnes of Hydrogen)
COMAH Regulations 2015 Lower Tier (Seveso III Directive (2012/18/EU))	5 tonnes	50 tonnes
COMAH Regulations 2015 Upper Tier (Seveso III Directive (2012/18/EU))	50 tonnes	200 tonnes
	H220 (Extremely Flammable)	H221 (Flammable) H280 (Contains gas under pressure; may explode if heated) H314 (Causes severe skin burns and eye damage) H331 (Toxic if inhaled) H400 (Very toxic to aquatic life) H411 (Toxic to aquatic life with long lasting effects)

Other uses

- Ammonia could be suitable for maintenance machines
- Less dense fuel more tolerable
- Less flammable fuel particularly advantageous with rail grinding etc.
- Equipping workers with additional or different PPE not too complicated (dust and fume hazards may already exists)

NetworkRail

Ammonia – reducing the risk

- Segregation – Protect storage vessels from impact
- Double barriers – reduce hazards from leaks (such as direct exposure)
- Detection
- Automatic Shut-off
- PPE – Respirators for staff
- Pressure relief valves (or methods) – safest possible vent location
- Ammonia (Rail Vehicle Fuel) handling manual
- Engines must have sufficiently minimised ammonia emissions (slip) and NO_x (Exhaust treatment should be easier with reduced PM)

Ammonia – good and bad

- Good practices are established
- Energy density around ¼ diesel (better than hydrogen)
- Storable as a liquid at room temperature at 15-16 bar (vs 350 bar for hydrogen)
- Can be renewably generated (€?)
- If generated from methane, Carbon can be captured at source -> low cost
- Not especially flammable (much better than hydrogen)
- Quick to refuel (faster & simpler than hydrogen)
- Strong odour
- Not good with some metals, quite corrosive etc.
- Toxic above some concentrations…

References

- Guidance_for_transporting_ammonia_in_rail_4.pdf (fertilizerseurope.com)
- International-PtX-Hub_202401_Ammonia-transport-and-storage.pdf
- Ammonia: zero-carbon fertiliser, fuel and energy store (royalsociety.org)
- Ammonia as a Marine Fuel Safety Handbook (grontskipsfartsprogram.no)
- Safety assessment of ammonia as a transport fuel (dtu.dk)

Workshop timeline

12:20	**Biofuels for track maintenance**	Plasser & Theurer
12:45	**Panel discussion**	
13:00	Lunch	
14:00	**Hydrotreated Vegetable Oil (HVO) use**	DB Cargo
14:25	**Hydrotreated Vegetable Oil (HVO) use**	SBB
14:50	**Use of biofuels & Biodiesel (B100)**	SNCF
15:15	**HVO & Fatty Acids/Methyl Esters (FAME) tests outcomes**	LINEAS
15:40	**Panel discussion**	
16:00	**Closing words** **Networking mini cocktail**	

INTERNATIONAL UNION
OF RAILWAYS

Plasser & Theurer

Biofuels for track maintenance

Markus Buchner

Product Manager

UIC Alternative fuels workshop, 11 June 2024

HIGH CAPACITY I PRECISION I RELIABILITY

Plasser & Theurer

Biofuels for Track Maintenance

Markus Buchner | Paris | 11 June 2024

menti.com | Code **4411 3878**

Alternative Drive Concepts

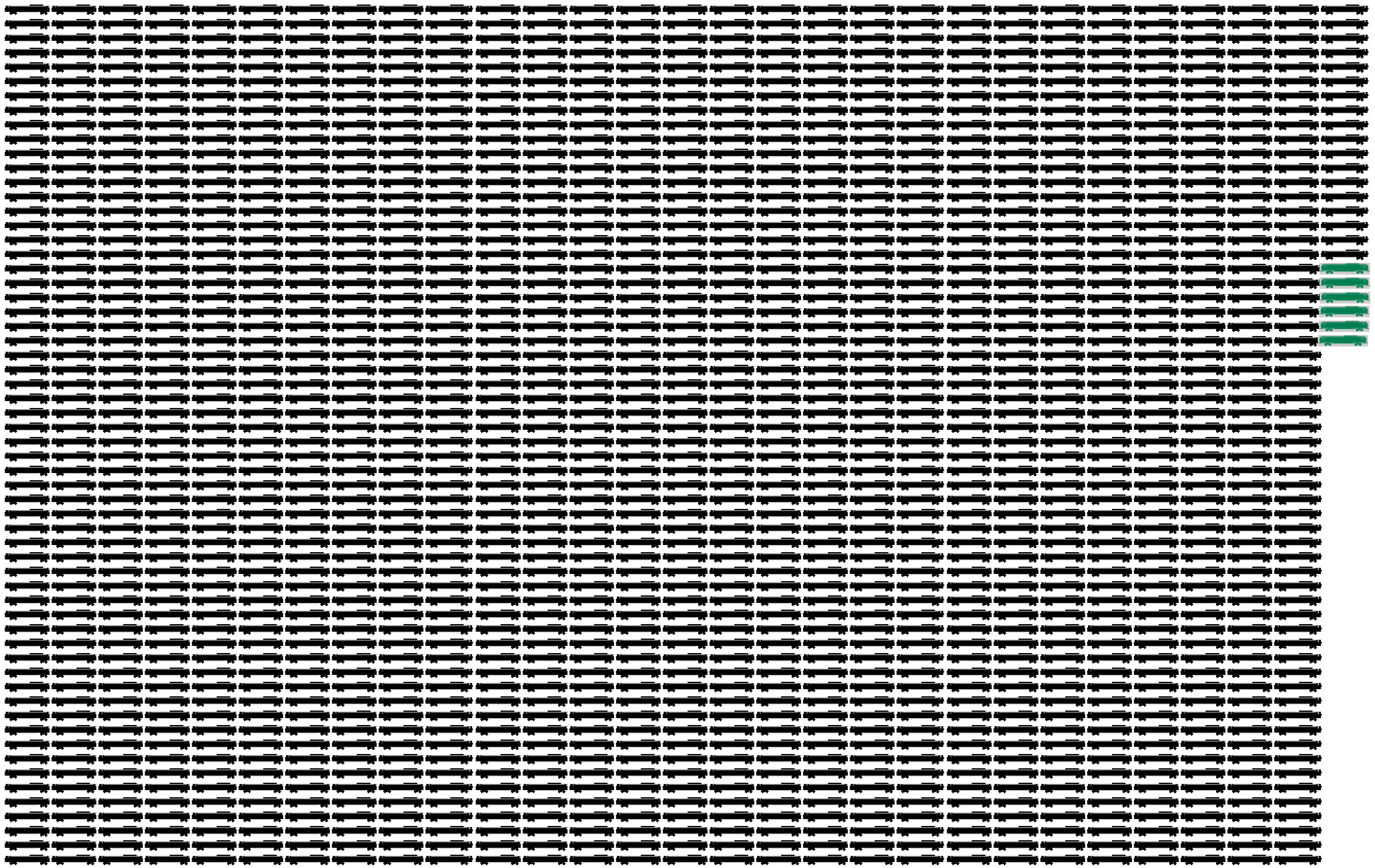
Biofuels for Track Maintenance

Portfolio overview

Machine divisions

Plasser & Theurer Fleet

17000 Machines since 1953



Plasser & Theurer

Biofuels for Track Maintenance

Outlook

Plasser & Theurer

All newly manufactured Plasser & Theurer machines can be delivered so they are **compatible** for synthetic fuels.

- **Fuel switching** can also be considered for older vehicle series.
- However, a **case-by-case assessment** is always assumed to be necessary here.

Synfuels include all fuels that are synthetically produced from non-fossil origin:

- hydrogenated vegetable oils,
- HVO (hydrotreated vegetable oil),
- e-fuels, and x-to-liquid fuels

HVO is a second-generation biofuel and is already used in freight transport. DB Cargo will save around 30,000 t of CO2 in Germany this year by replacing 10 million litres of diesel fuel with HVO.

Alternative Drive Concepts

Plasser & Theurer

Evolution at Plasser & Theurer

Alternative Drive Concepts

Plasser & Theurer

Evolution at Plasser & Theurer

Economic, Ecologic, Ergonomic

Since 2015

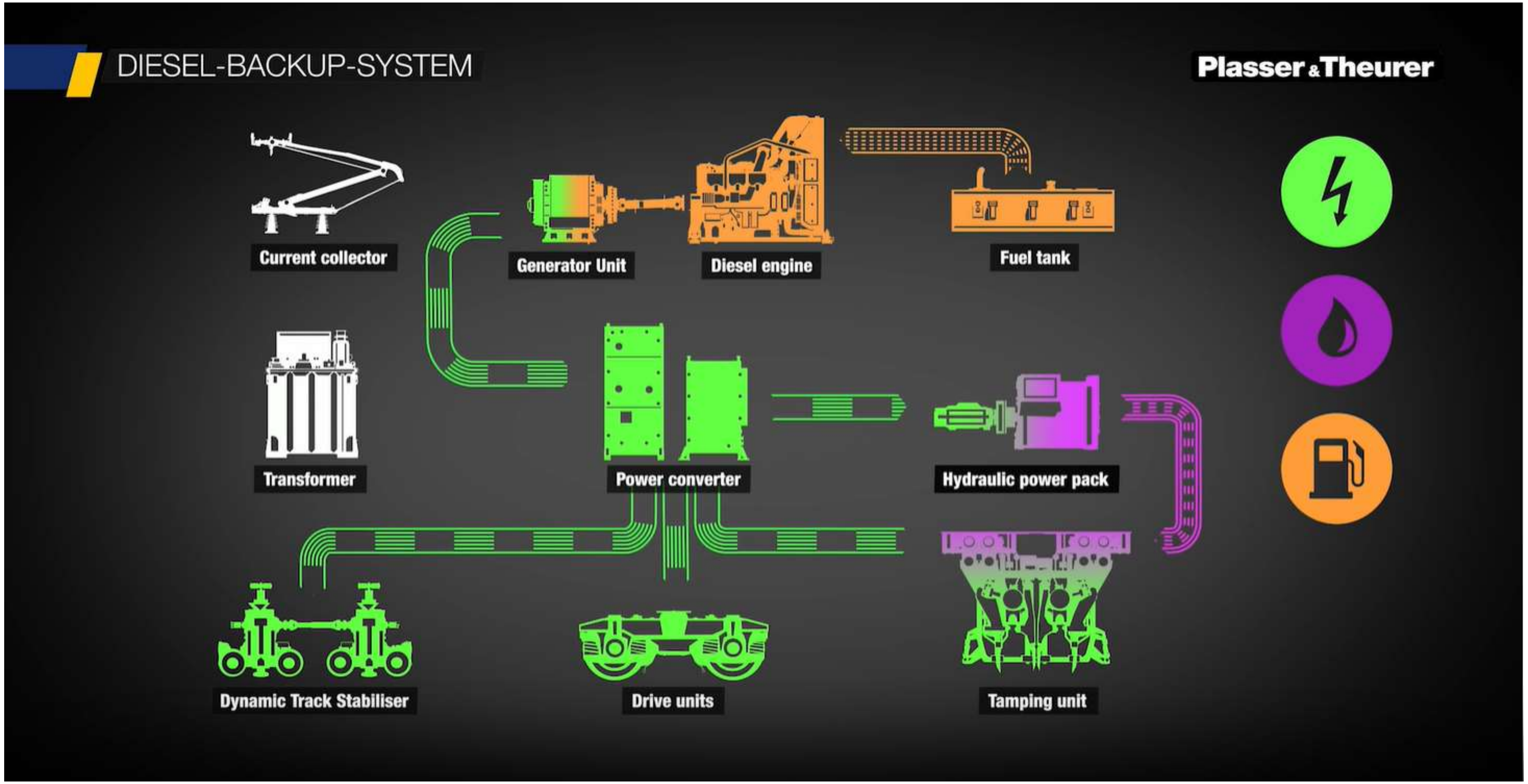
- **75** Orders for E^3 Machines
- **14** delivered
- **61** in production / engineering

We are currently working on **various opportunities** for machines with alternative drive concepts.

Auslieferung	Kunde	Maschinentyp	Bautyp / Technologie	Ko.Nr.	Stromsystem	Notes	
06/2015	Franz Plasser Vermietung	Dynamic Stopfexpress 09-4X E^3	EH	6277	15kV/16.7Hz		
06/2015	Franz Plasser Vermietung	BDS 2000 E^3	EH	6278	15kV/16.7Hz		
09/2016	Krebs Gleisbau AG	Unimat 09-32/4S Dynamic E^3	EH	6475/6235	15kV/16.7Hz	DB Zulassung in 2020	
12/2017	Franz Plasser Vermietung	09-4x4/4S E^3 (Vollelektrisch)	VE	6557/6558	15kV/16.7Hz		
2017		HTW 100 E^3	Batterie	6609	-		
08/2018	Ventura Francesco	Unimat 09-32/4S Dynamic E^3	EH	6775/6777	25kV/50Hz & 3kV		
09/2018	RFI Rom	Unimat Combi 08-275 E^3	EH	6764/6765	25kV/50Hz & 3kV		
10/2019	Rhomberg Sersa Vermietung GmbH	Unimat 09-8x4/4S Dynamic E^3	VE	6924			
10/2019	Rhomberg Sersa Vermietung GmbH	BDS 2000 E^3	VE	6925			
Auftragsdatum: 18.10.2018	RFI Rom	UNIMAT COMBI 08-275 $E3^{'3}$					
Auftragsdatum: 27.08.2019	Franz Plasser Vermietung	Unimat 09-8x4/4S BR Dynamic E^3					
Auftragsdatum: 11.06.2020	DB Bahnbau	Unimat 09-4x4/4S Dynamic E^3				in Produktion	

E³ Alternative Drive Concept

High Level Architecture

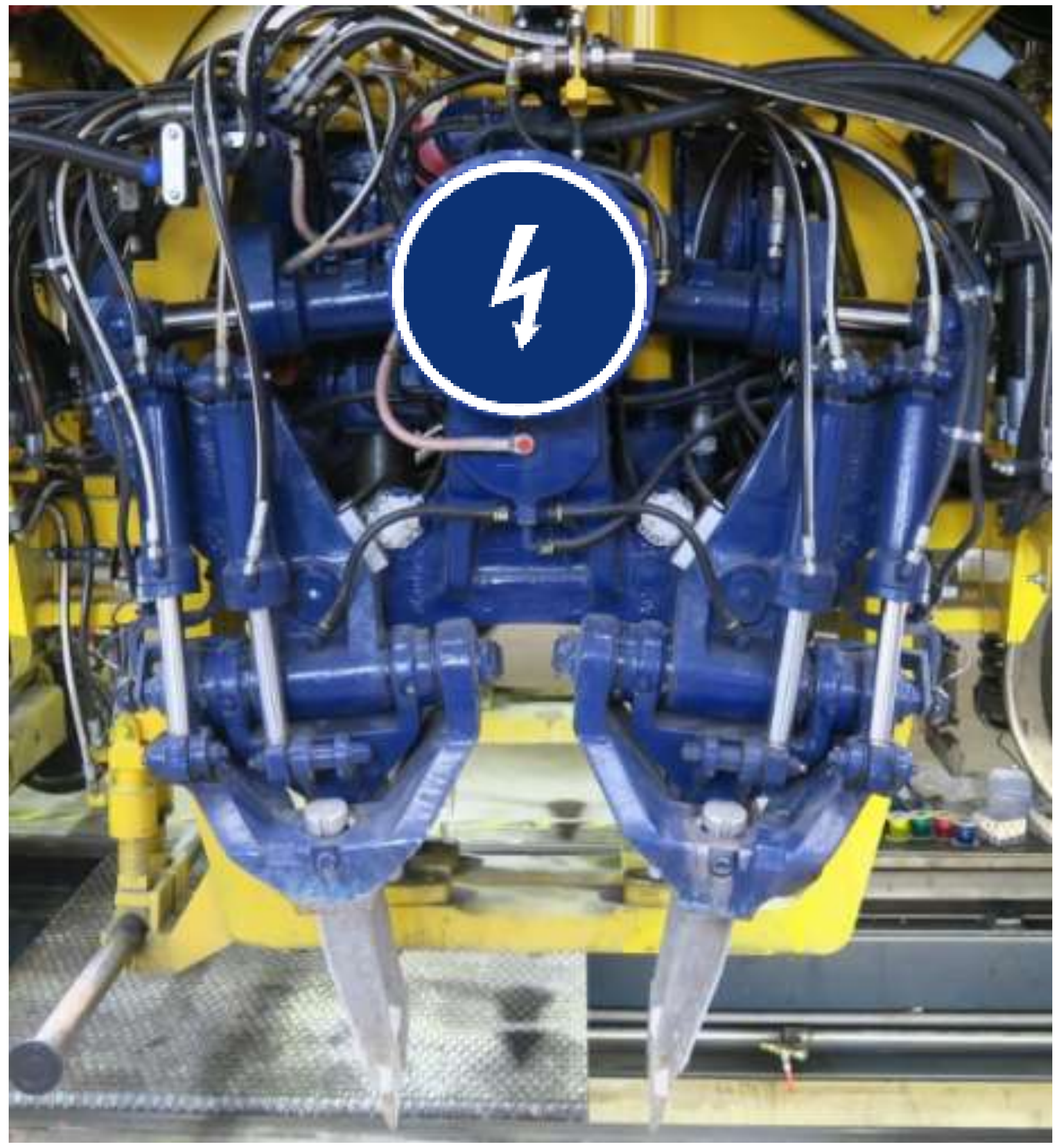


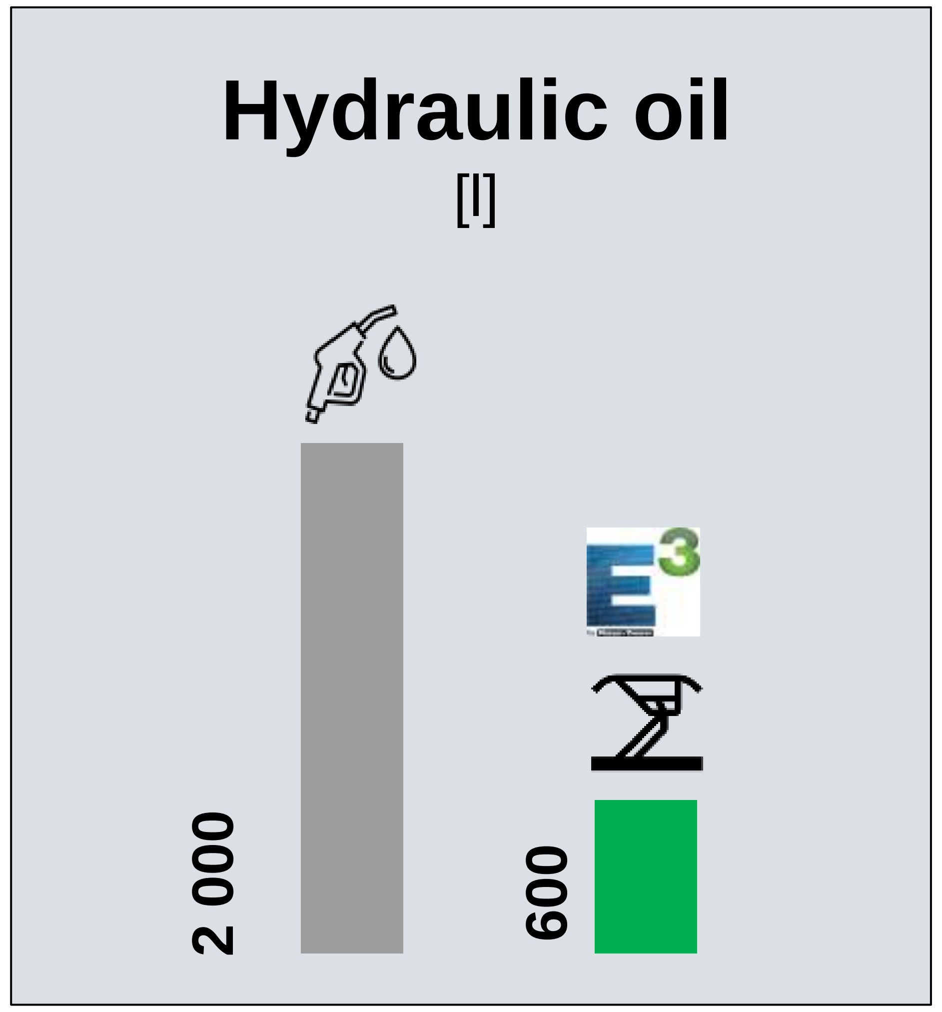
Electric tamping unit

Advantages

Advantages of the electric tamping unit

- Reduces **CO_2** emissions
- Significantly reduces **operating noise**
- Faster **response characteristic** of the tamping unit
- Potentially **minimises life cycle costs** of the tamping unit
- **Hydraulic oil tank** can be **reduced in size**
- High stability of frequency and amplitude of the work units
  - **Better results**
  - **Improved working speed**
  - **Reduced costs**





Alternative Drive Concepts

Plasser & Theurer Portfolio

E³ Potential		
Product Line	**E³ Fleet**	**3-5 Year Potential**
Track Tamping Machine	✓	✓
Universal Tamping Machine	✓	✓
Stabiliser / Consolidating Machine	✗ ✓	✓
Ballast Distributing and Profiling Machine	✓	✓
Track Motor Vehicle	✓	✓
Rail Rectification Machine	✗	✓
Catenary Renewal and Installation Machine	✓	✓
Track Inspection Vehicle	✗	✓
Track Renewal / Laying Machine	✗	Dependent on development of Battery / Synfuel / H_2 Technology Development
Ballast Cleaning Machine	✗	
Formation Rehabilitation Machine	✗	
Material Conveyor and Hopper Unit - Logistics	✗	

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Workshop timeline

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Panel discussion
Questions and answers

RVO

AERRL

JBD/NRD

Ricardo

NR

P&T

Lunch time

Until 14h00

Workshop timeline

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INTERNATIONAL UNION OF RAILWAYS

DB Cargo

Hydrotreated Vegetable Oil (HVO) use

Patrick Bertman

Head of Product & Pricing Strategies

UIC Alternative fuels workshop, 11 June 2024

Cargo

Use of renewable fuels at DB Cargo

Experiences and perspectives

12. June 2024 | fuels of the future | Paris

Management Summary

DB Cargo

CO_2 emissions lead to global temperature rise and climate change – Therefore Sustainability is part of Deutsche Bahn strategy "Strong Rail"

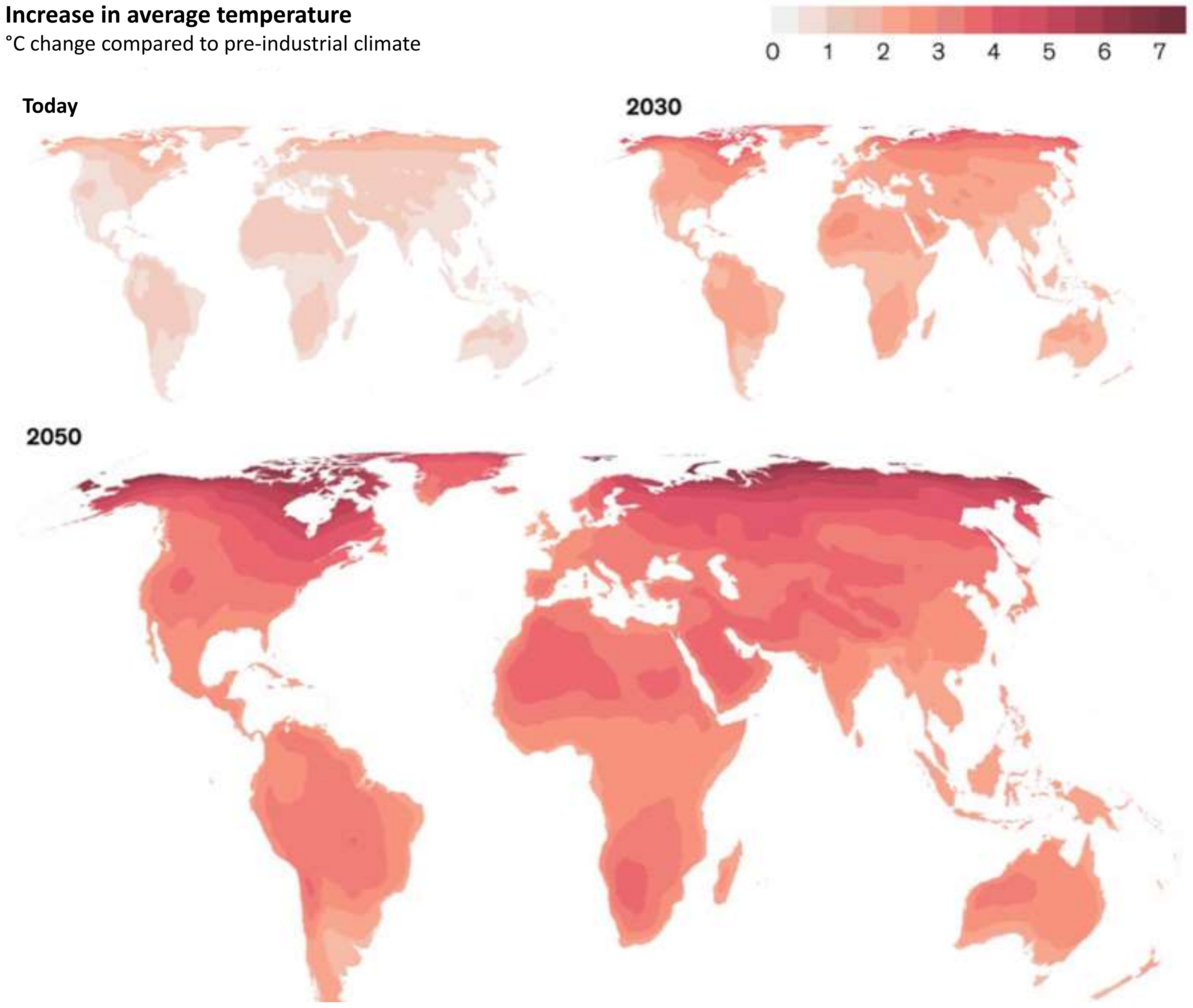
To contribute towards climate neutrality at DB in 2040 we have three main fields of activities – One of them is the Transition from fossil diesel to climate-neutral operation

HVO saves up to 90% CO_2 compared to fossil diesel - All results on Engine bench tests and operational testing with HVO were consistently positive

CO_2 emissions lead to global temperature rise and climate change. If we do not change anything, we will destroy our livelihood

DB Cargo

Climate change through CO_2 emissions



...and the consequences for our lives

Heat

In 50 years: 1/3 of people could live in **regions** with **extreme** travel **risk rating**

Drought

Existential threat for up to **143 million people** by 2050

Glacier melt

Coastal areas and cities become **uninhabitable,** e.g. Antwerp, Hamburg, Shanghai

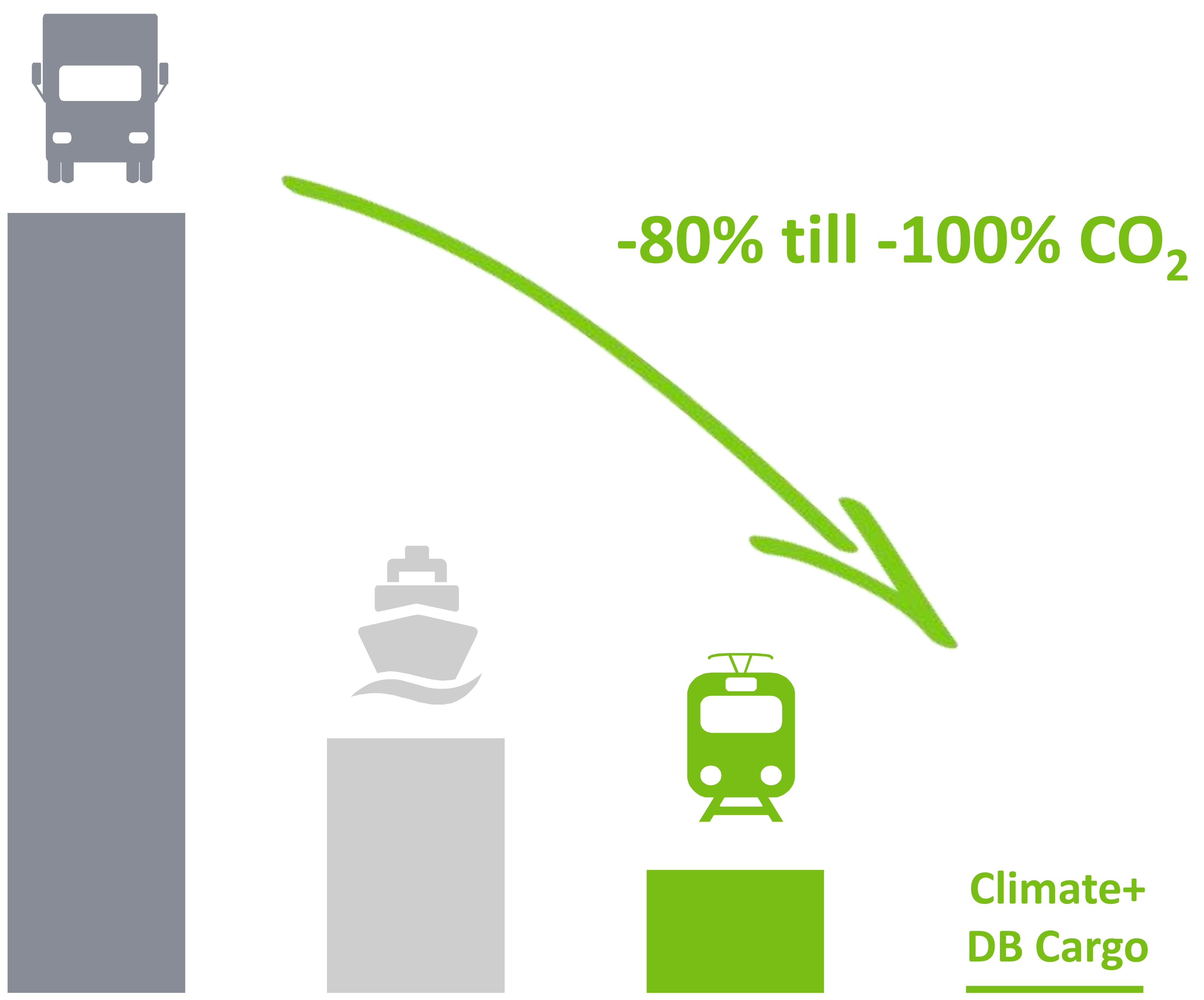
Health

Health costs of **2-4 billion USD** annually until 2030

Rail is the only way to achieve the climate protection targets

Rail is the most environment-friendly transport mode

emissions in g CO_2/tkm



- The **transport sector must halve its emissions** by 2030 (-78 million tons compared to 2019)
- **Rail** produces **80 to 100 percent less CO_2** than trucks
- **Shifting traffic to rail** is a key lever **for** achieving **climate targets**

Sustainability is part of Deutsche Bahn strategy “Strong Rail”

DB
Cargo

Green transformation

We take responsibility for our planet, greening not only our products and services, but also the way we work.

- Climate protection
- Resource protection
- Nature conservation
- Noise protection
- Social responsibility

Three main fields of activities and two packages of measures contribute towards climate neutrality at DB in 2040

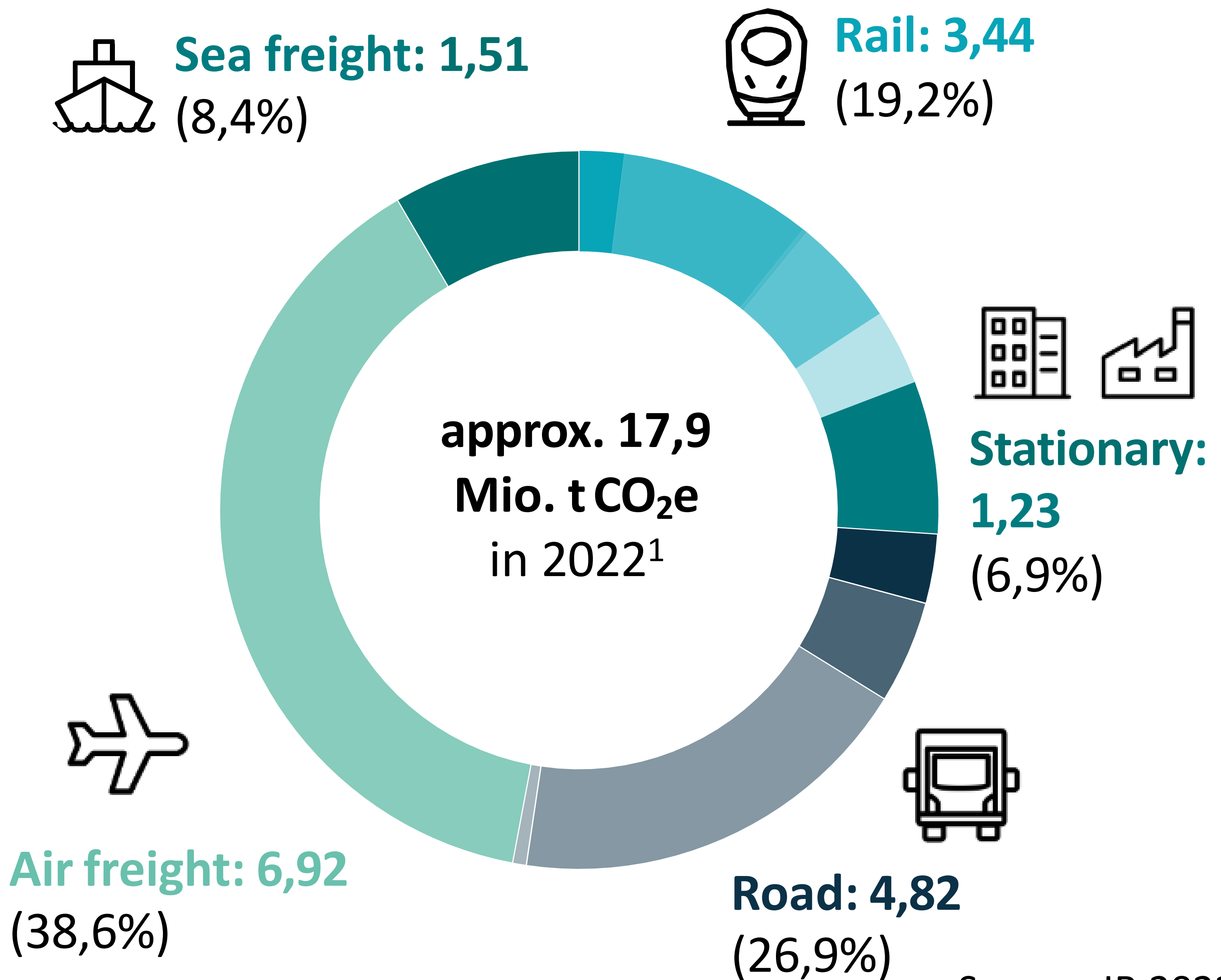
DB Cargo

Our mission:

Climate Neutrality until 2040

Today:

CO_2e-emissions Deutsche Bahn AG (2022)[1]



Source: IB 2022

Three main fields of activities to reach climate neutrality:

- Green Power Transformation
- Diesel Exit
- Renewable Heat

New: Two DB group programs

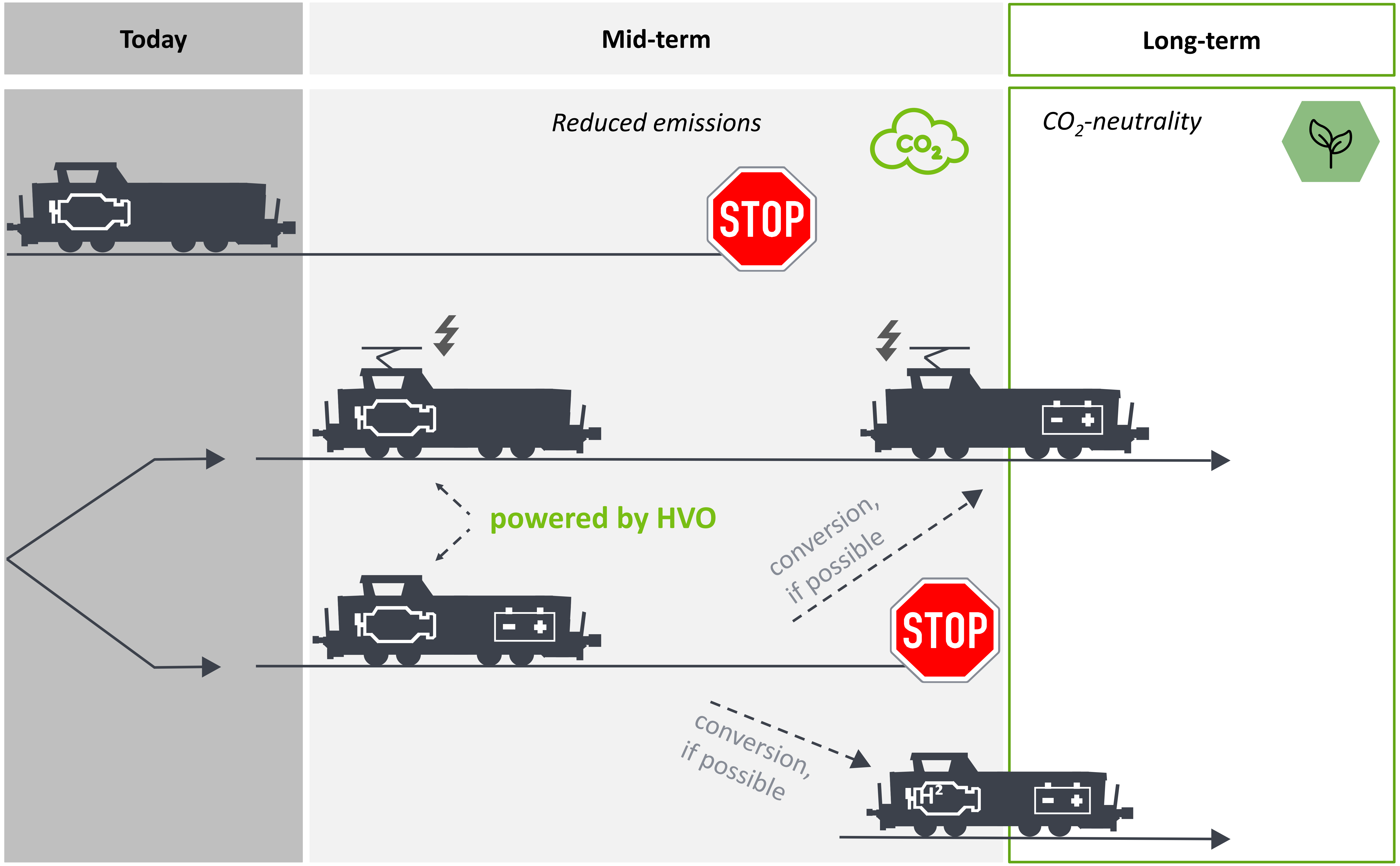
- **Diesel Exit**
- **Renewable Heat**

- **Climate neutrality by 2040** requires **100% green power** and innovative, sustainable solutions for **Diesel Exit** as well as **green heating supply**
- **Measures** on Greening Power, Diesel Exit and Renewable Heat are planned for **medium term**

(1) 2021: 18,5 Mio. t CO_2, 2020: 16 Mio. t CO_2 due to the CoVid-Pandemic, 2019: 20 Mio. t CO_2

Against the backdrop of the climate targets, the decarbonisation of the diesel fleet is coming into focus

Transition from fossil diesel to climate-neutral operation



Technical Requirements:

- **Enough traction capacity** (power) for short-range services
- Energy storage with **recharging via catenary** (Battery, Supercaps, etc.)
  > 500 kWh
- Energy storage with **stationary refueling** (Diesel, HVO, H², etc.)
  > 1.200 kWh

Operational requirements:

- **No long standstill** for recharging/ refueling energy storage
- **No losses** in (operational) **efficiency**
- Reduction of emissions down to an absolute minimum
  Target: CO_2-neutrality

The use of Hydrotreated vegetable oils (HVO) saves up to 90% CO_2 compared to fossil diesel

DB Cargo

Main advantages and properties of HVO

Production

- Only **biological residues and waste materials** are used as raw materials
- HVO is furthermore **palm oil-free**

Compatibility

- **"Drop-In" fuel** - Engine compatibility proven through several tests
- Several engine **manufacturers approved** the use of HVO

Costs

- Approx.**+30 ct/l additional costs** compared to fossil diesel
- Migration of refueling **infrastructure** comparatively **simple and inexpensive**

Availability

- **Short-/middle-term switch** from fossil diesel to HVO possible
- **Short-term Availability** of several million liters/year

All results on Engine bench tests and operational testing with HVO were consistently positive

DB Cargo

Engine Bench tests

- Extensive engine test bench trials carried out in 2021-23 on over **15 DB Cargo engines**
- **Certified** comparative **measurements** (including performance behavior, fuel consumption and greenhouse gas emissions) between HVO fuel and fossil diesel
- **All engines** analyzed work **smoothly** with the **HVO fuel**

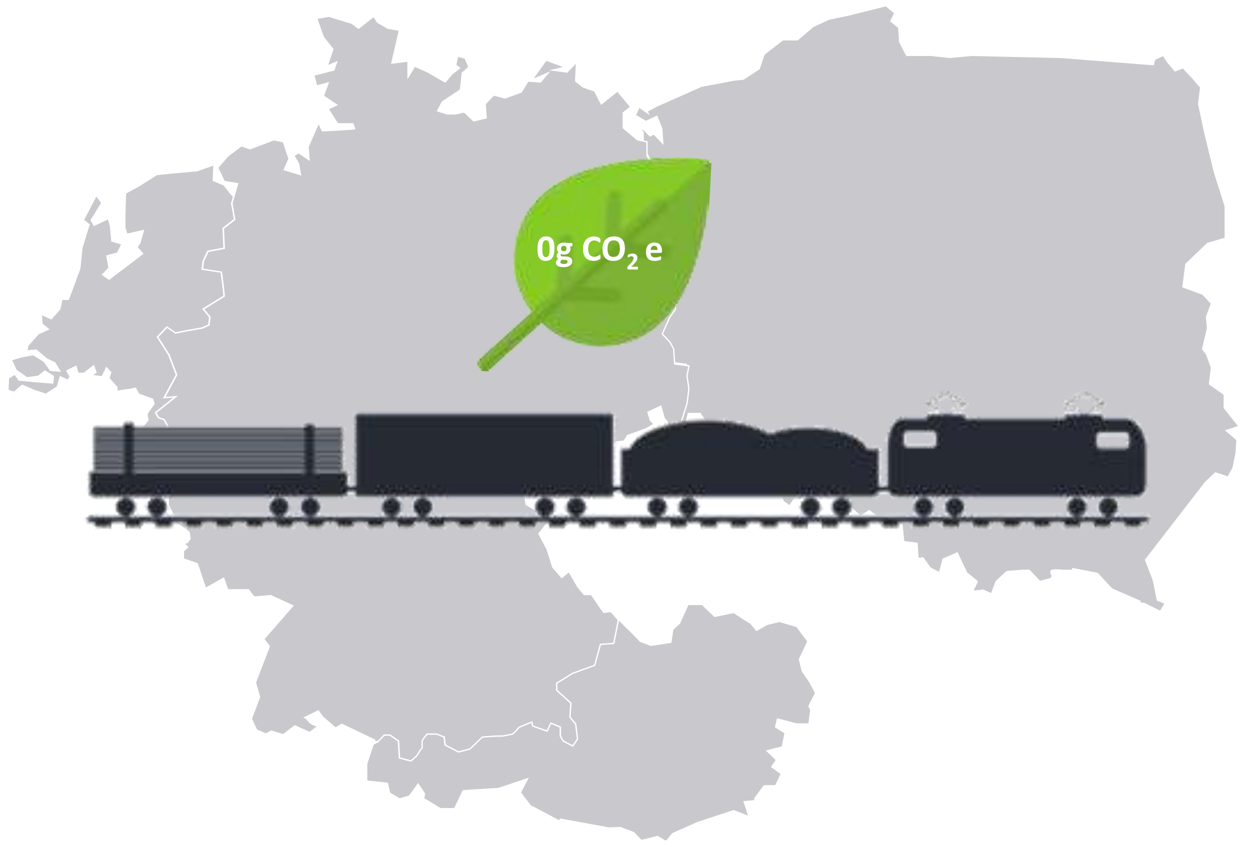
Operational Testing

- **Extensive** operational **testing** carried out on various diesel-powered DB Cargo series
- **Diesel locomotives** are HVO-compatible **without restriction**. Release of DB Cargo's entire diesel locomotive fleet (>1,300 locomotives)
- Rededication of **nine filling stations** with a volume **of over 10 million liters** per year

Climate+ | For even more sustainability on the railway we extended our portfolio with HVO for our customers

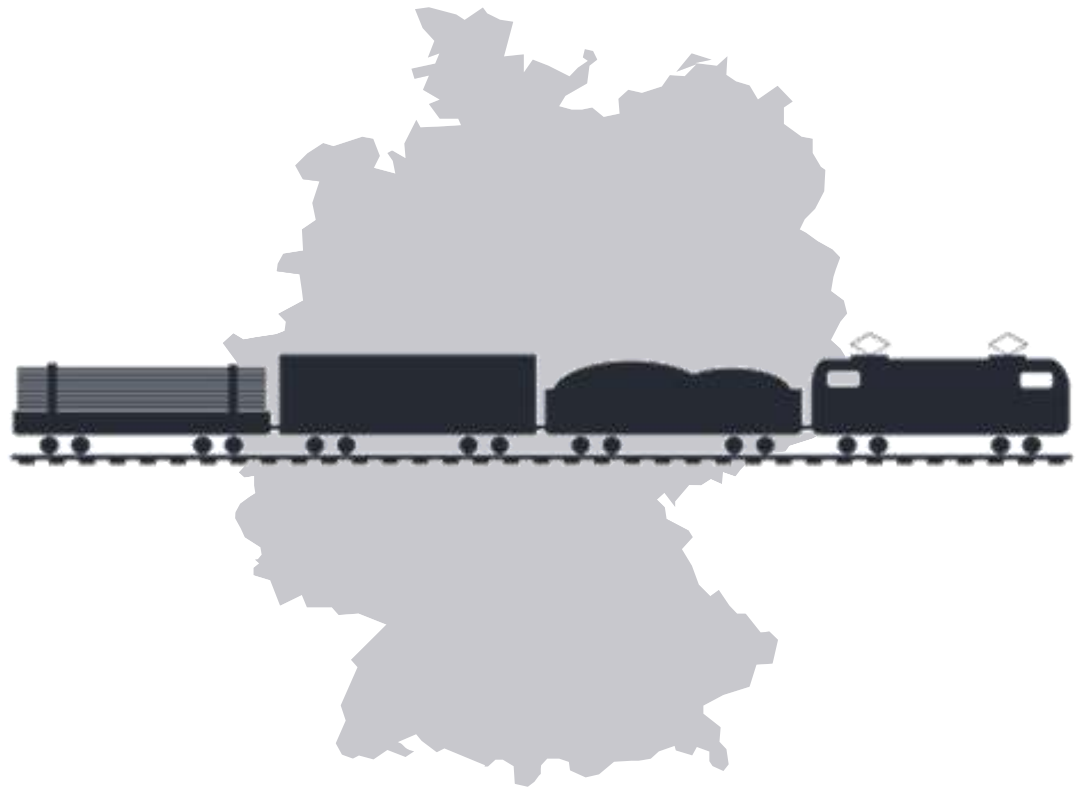
Travel by rail with 100% renewable power

- Use of **100% renewable power**
- For rail freight in GE, AT, NL and PL
- TÜV-certified



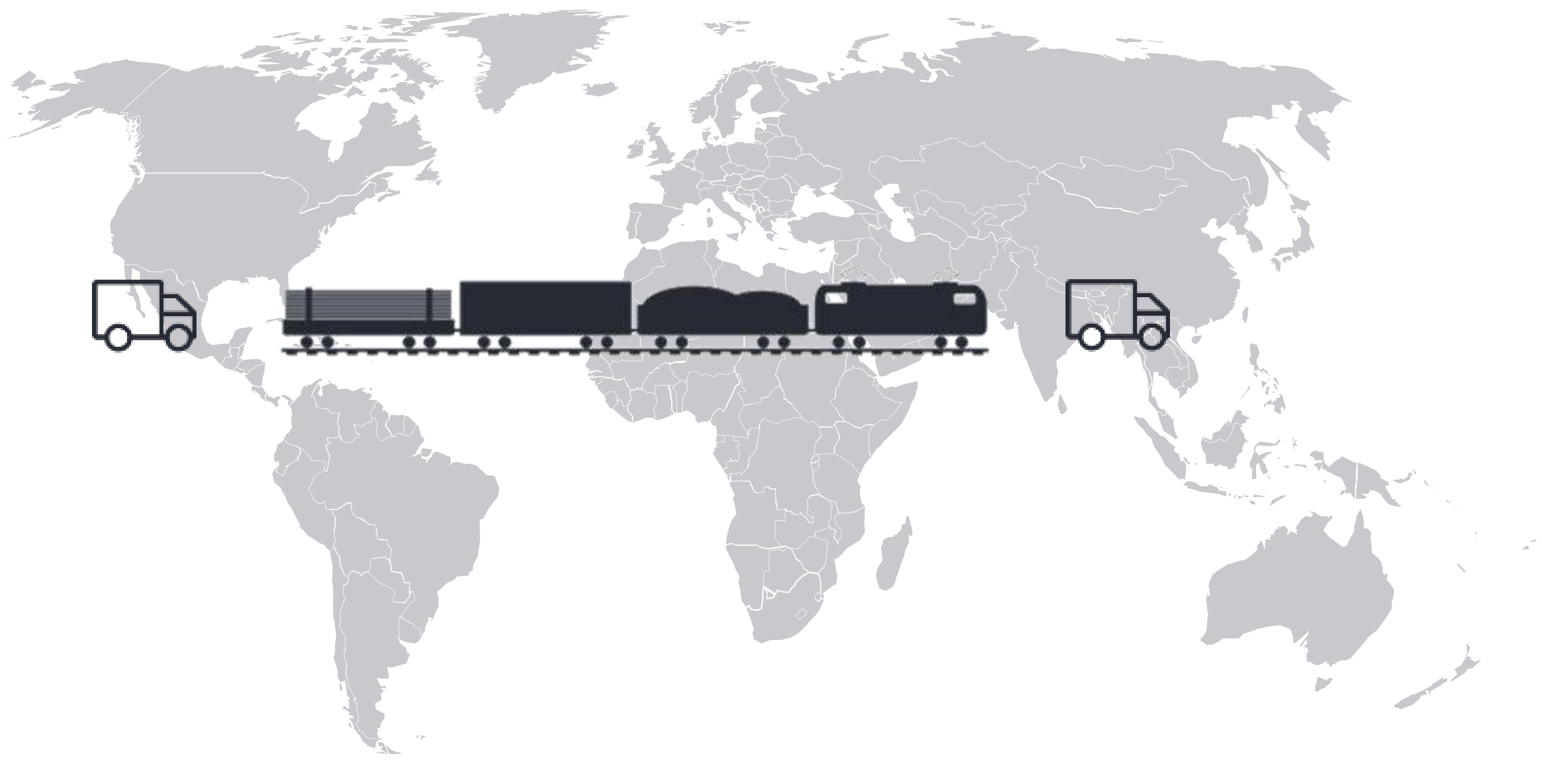
Save emissions on non-electrified routes

- **Avoidance** of approx. **90% CO_2** by use of HVO
- For rail tansport in GE



Compensate for non-avoidable emissions

- **Compensation** of **CO_2 emissions**
- Available worldwide and also on non-electrified routes
- Pre- & post-carriage on the road



HVO is a success story for DB Cargo!

DB Cargo

Highlights HVO 2023

Testing

Emission measurements

Stationary tests

Operations

Netherlands

Italia

Press events

München

Bremen

Newspapers

Media campaign

White Paper

Webinar

Ad campaign

Neste Testimonial

Speaker

Patrick Bertman
DB Cargo
Head of Product & Pricing Strategies
Patrick.Bertman@deutschebahn.com


DB
Cargo

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14:25	Hydrotreated Vegetable Oil (HVO) use	SBB
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INTERNATIONAL UNION
OF RAILWAYS

SBB

Hydrotreated Vegetable Oil (HVO) use

Roland Aeschbacher

Project Manager Energy efficiency

UIC Alternative fuels workshop, 11 June 2024

Introduction of HVO at SBB.

Roland Aeschbacher / SBB energy efficiency team

11.06.2024 UIC Paris – Alternative Fuels

Launch.
What does SBB need diesel for?
SBB's climate targets

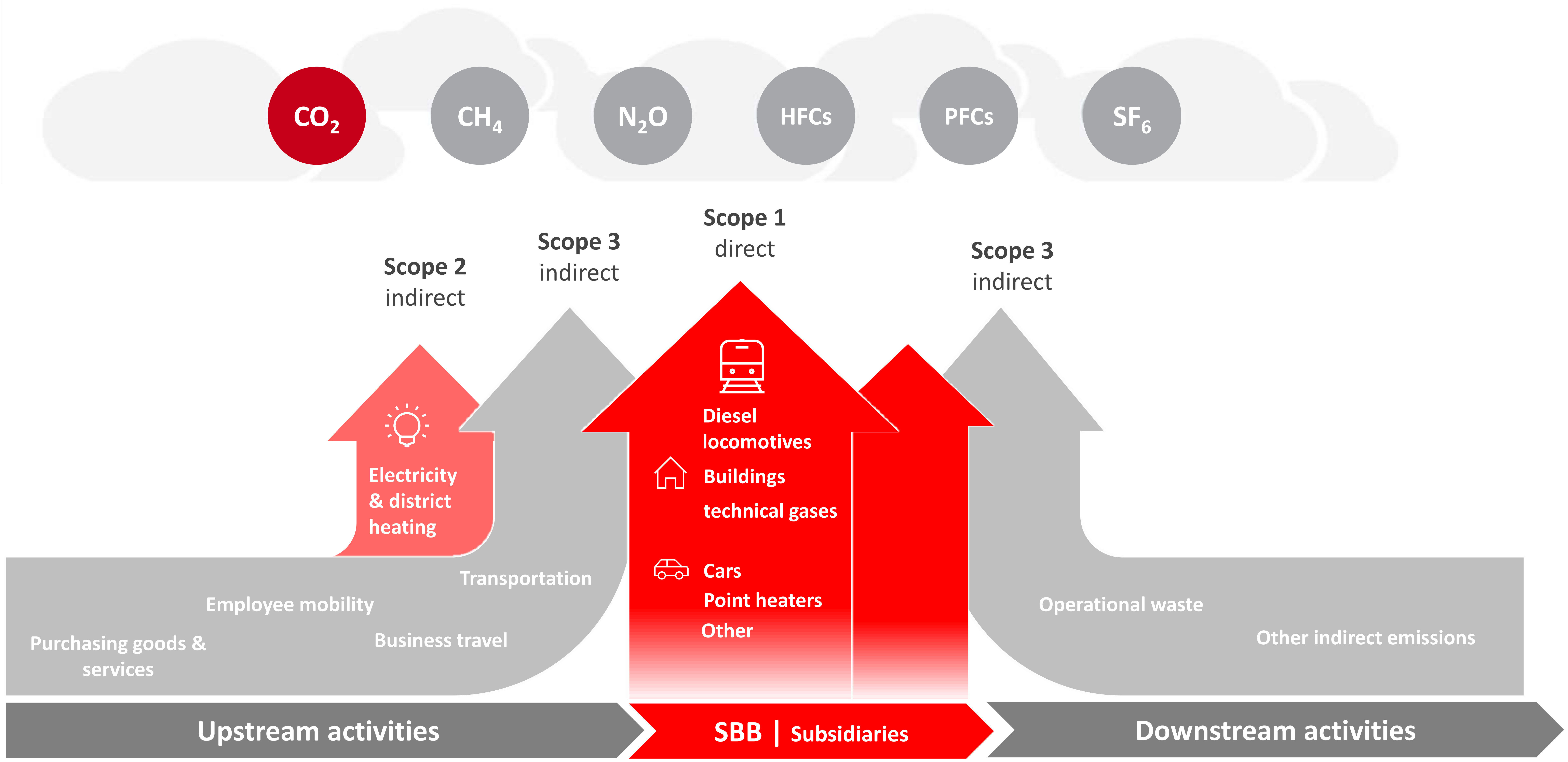
HVO in our strategy.
Transitional solution
Advantages of HVO

Challenges in technology.
Mix-up
Background
Compatibility

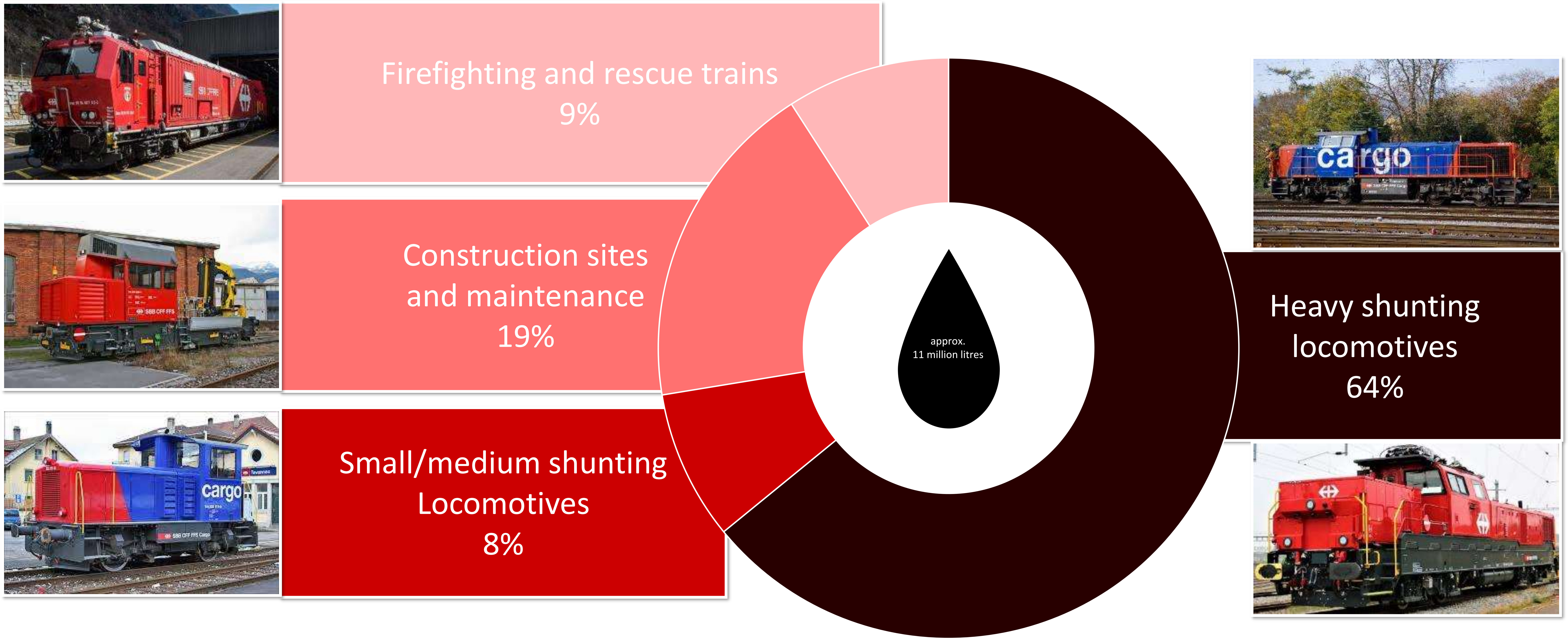
Challenges in procurement.
Sustainability
Availability
Pricing

Summary and outlook.
What have we already achieved?
Future challenges

Greenhouse gas emissions of SBB.



What do we still need diesel fuels for?



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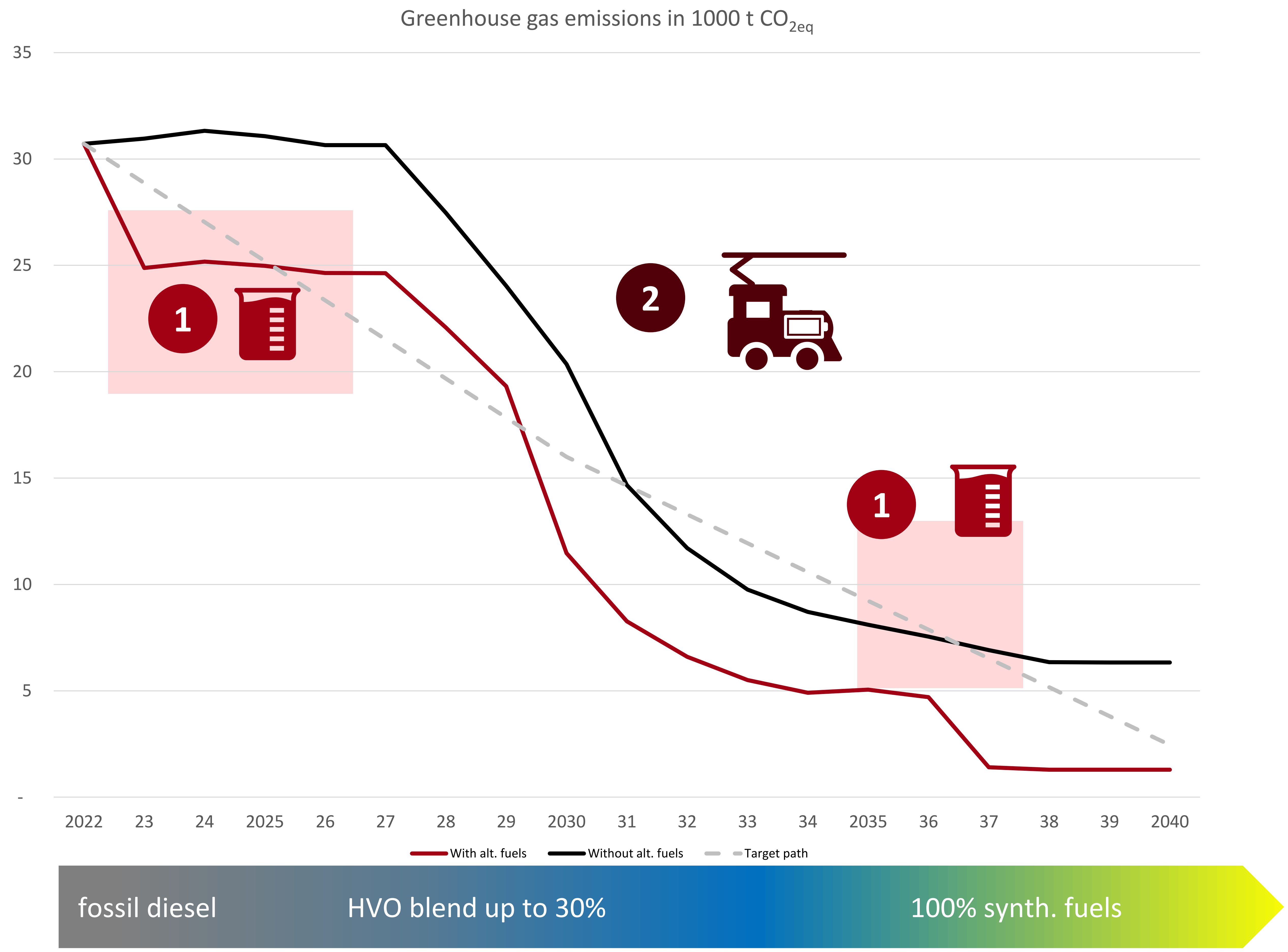
Transition phase and electrification of diesel-powered rail vehicles.



Quantity structure today:

- Around 11 million litres of diesel per year for around 1'000 SBB diesel-powered rail vehicles (infrastructure, cargo, passenger transport)
- Responsible for around 30'000 t CO_{2eq}/a, which corresponds to 35-40% of SBB's CO_2 emissions.

Decarbonisation in two steps:

1. Alternative diesel fuels as a transitional solution
2. Electrification of the essential fleets through replacement procurement with battery-electric drive systems

The advantages of HVO are recognisable.

HVO (hydrogenated vegetable oils)
Paraffinic diesel from residual and waste materials EN15940

Petroleum diesel
Standard crude-oil based diesel
(B0, 10 ppm sulphur content) EN590

- HVO belongs to the paraffinic diesels (like SynFuels and e-Fuels) and is a pure hydrocarbon compound.
- HVO is a so-called **drop-in fuel**: it can be **used as an admixture (blend)** and **pure**
  - The **blend with up to 30% admixture to conventional diesel** meets the previous standards (EN 590) and can be used in all diesel engines.
  - **100% HVO complies with the EN 15940 fuel standard**, and many diesel engines - including a majority at SBB - have already been approved for it.

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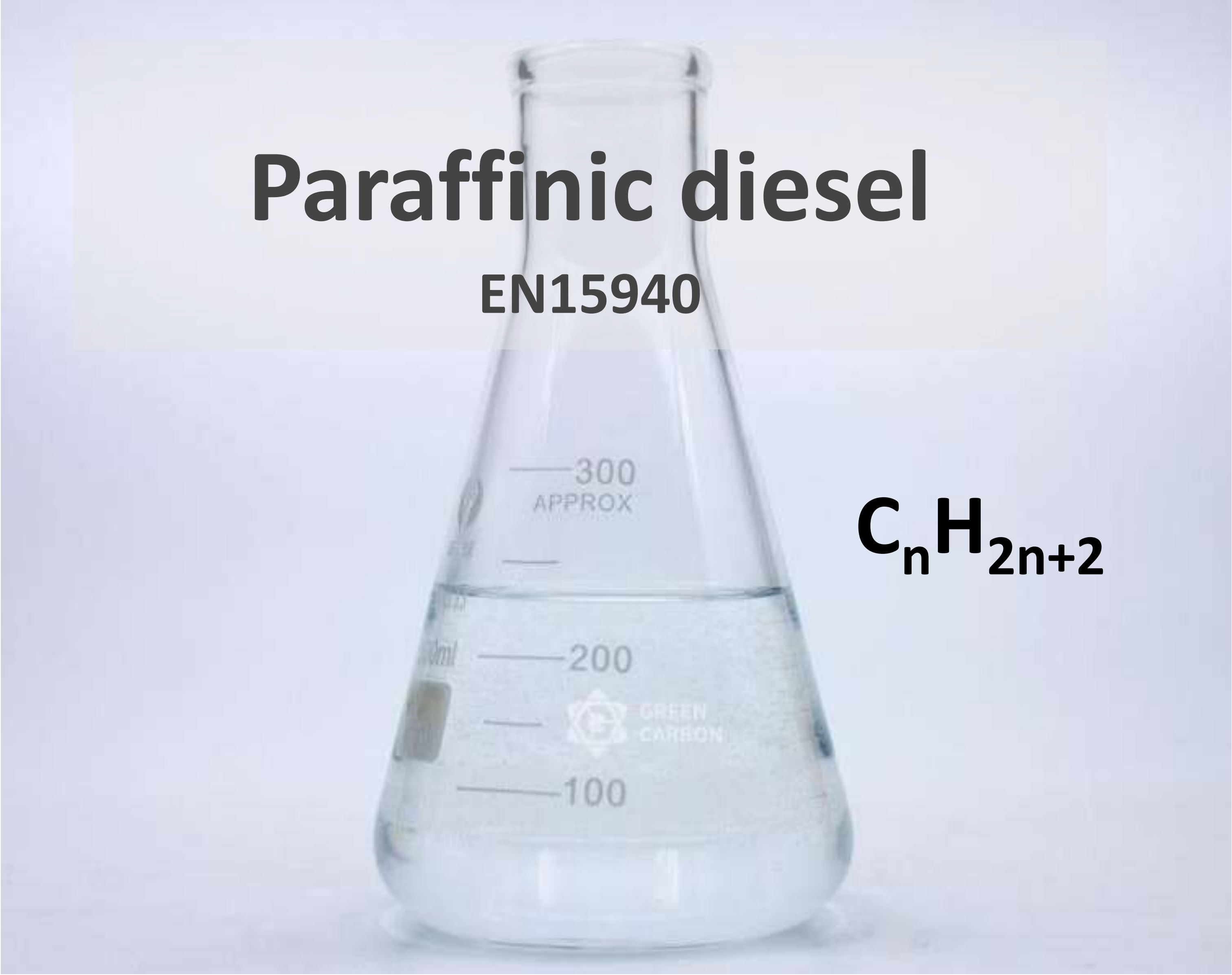
HVO is often mistaken for conventional biodiesel.

Residual and waste fats, vegetable oils

Esterification	Hydrogenation & hydrocracking / isomerisation
FAME biodiesel	**HVO diesel** (Hydrogenated Vegetable Oils)



Initial situation at SBB.

Own **filling station network** for the supply of rail vehicles with 64 locations:

- Single fuel strategy (one product per pillar)
- No refund of mineral oil tax.

A **variety of diesel engines**, some with long product life cycles:

- Vehicle service life 25-50 years
- Over 15 manufacturers and 65 types.

Diesel demand tends to **fall** due to electrical replacements:

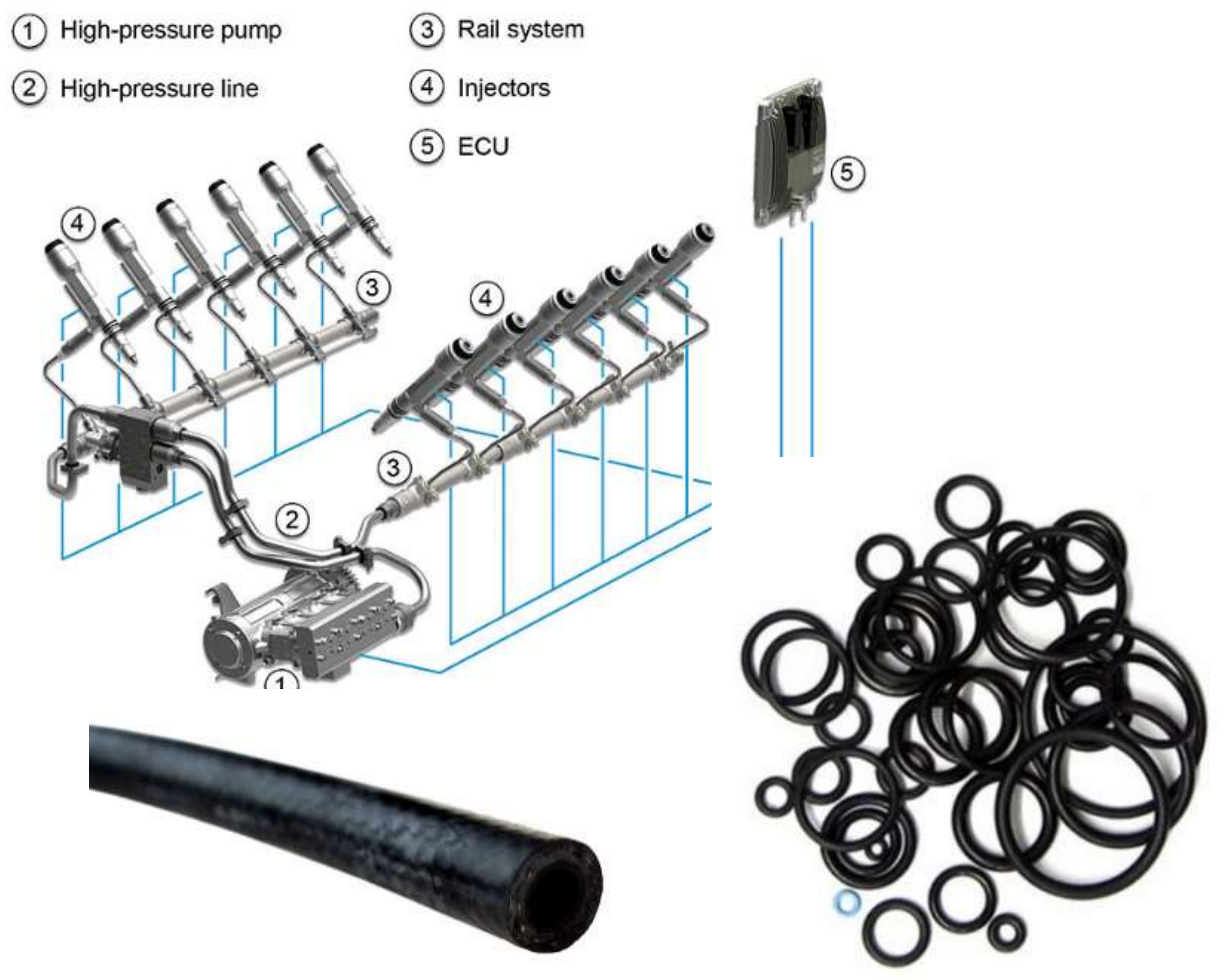
- A relatively low diesel requirement compared to other market participants.
- No FAME biodiesel content permitted for reasons of shelf life.

Technology: Compatibility of the existing fleet with HVO.

Alternative Fuel Conformity

DEUTZ paraffinic Diesel (HVO, GtL) & B30 (EU) / B20 (US) appro

	D 2.2	TD 2.2	TCD 2.2	D 2.9	TD 2.9	TCD 2.9	TD 3.6	TCD 3.6	TCD 4.1	TCD
T 3 / Stage IIIA										
B100	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
B20 (US)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HVO / Gtl	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
T 4i / T 4f, Stage IIIB / IV*										
B100	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
B20 (US)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HVO / Gtl	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Stage V**										
B30	✓	✓	✓	✓***	✓	✓	✓	✓	✓***	✓***
HVO / Gtl	✓	✓	✓	✓***	✓	✓	✓	✓	✓***	✓***



Goal: Official fuel approvals.

- Analysis of the engine fleet and discussions with manufacturers and service partners.
- Not only engines, but also auxiliary units are affected (e.g. auxiliary heaters)

Reason: Material compatibility & performance.

- Injection systems have to cope with the lower density and possibly lower lubricity of HVO.
- Elastomers that come into contact with HVO must not swell/shrink.

Action: Engine tests for Legacy engines.

- Older engines no longer receive subsequent approval from the manufacturer. Own tests are sometimes necessary.
- SBB has already carried out such tests on important series.

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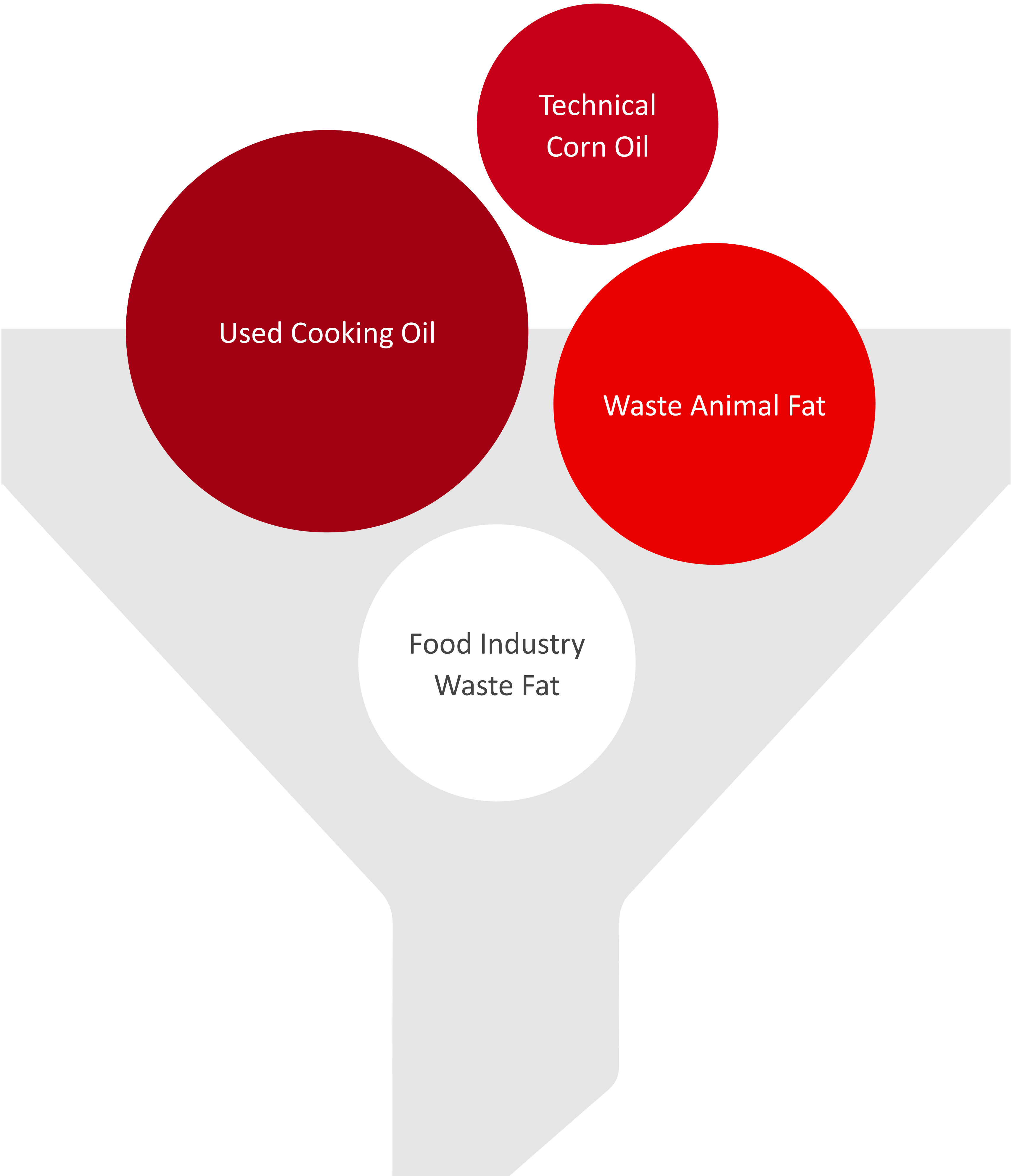
Procurement: Sustainability.

The choice of raw materials to produce HVO is crucial. Around 70% of the raw materials for waste-based HVO come from outside Europe (source: INFRAS, 2021).

The regulations in Switzerland differ significantly from those in the EU (mass balancing vs. segregation). The certification standard is BTCert.

The product must be exempt from mineral oil tax (MinÖSt) by the Federal Office for Customs and Border Security (BAZG). Biofuels that are exempt from the MinÖSt are generally regarded beyond doubt from an ecological and social perspective. Their origin is transparently documented and verifiable. The MinÖSt exemption regulation is limited in time and is expected to be valid until 2030.

Comparable is the fulfilment of the **criteria of "advanced biofuels" according to EU RED** which do not cause indirect land use change (e.g. palm oil derivatives such as PFAD). This certificate is not recognised in Switzerland.



CO_2-neutral: Waste-based HVO reduces greenhouse gas emissions by around 85% compared to fossil diesel.

(typical values according to EU RED 2, Annex V, Table A).

Status of HVO-Rollout at SBB.

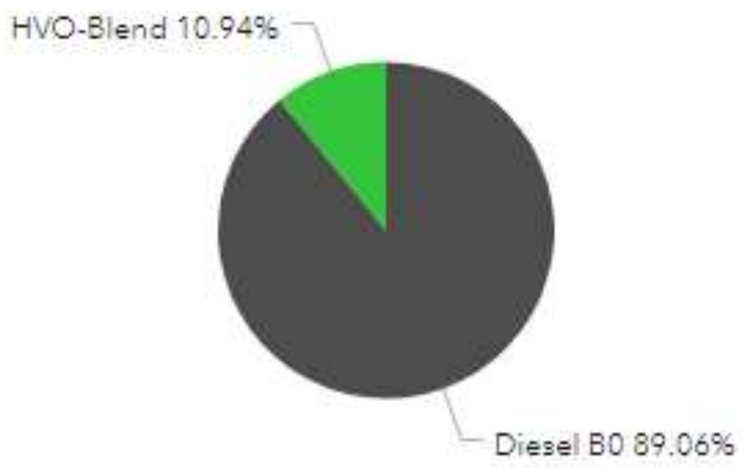
HVO Ausgangsdepot

- Muttenz
- Cressier
- Rothenburg
- Landquart
- Balerna

TTA Status HVO-Rollout

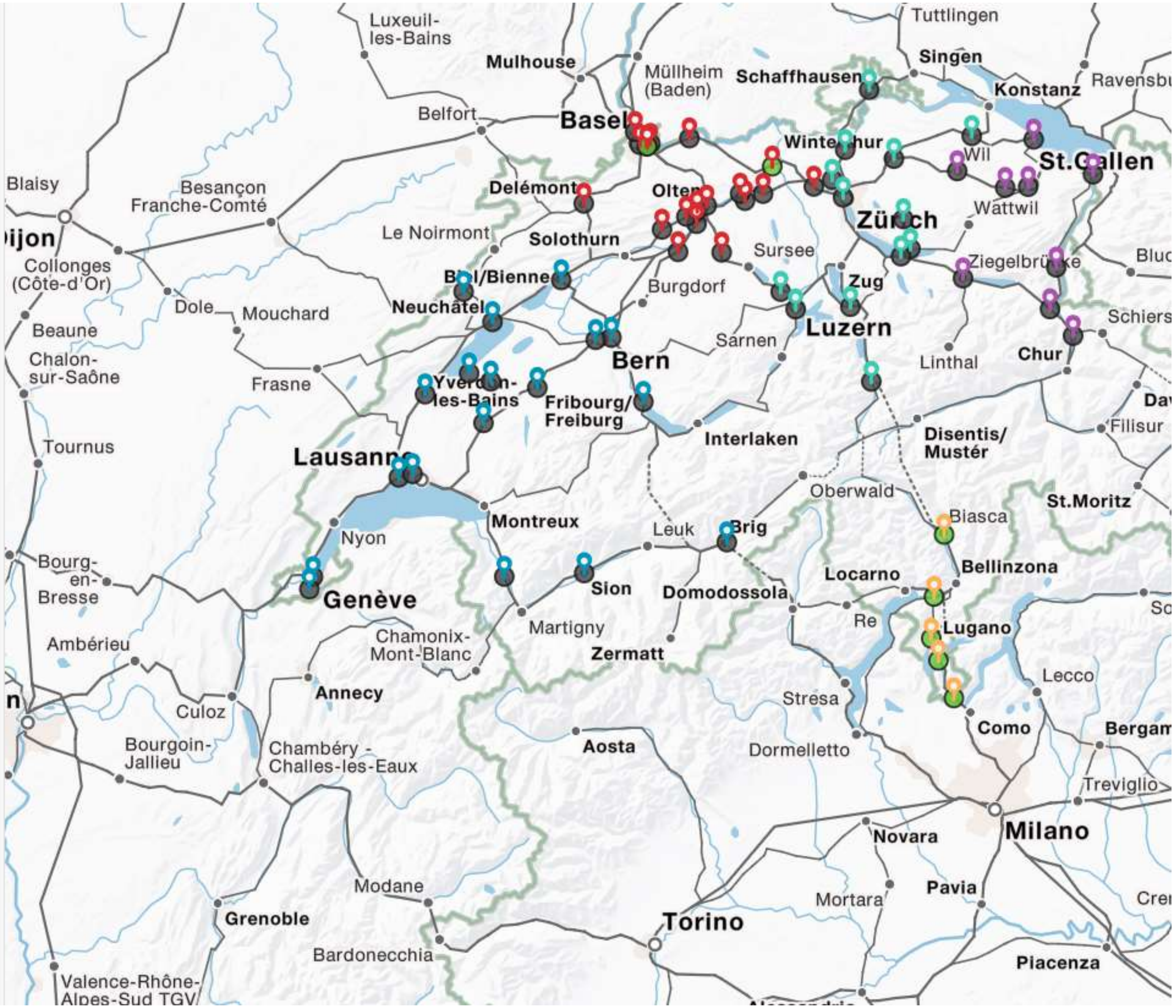
Produkt

- Diesel B0
- HVO-Blend



Suchen...

- TTA-0333 Brugg seit 31. Mai 2024
- TTA-0356 Muttenz RB 95 seit 31. Mai 2024
- TTA-0353 Bioggio-Lugano seit 10. April 2024
- TTA-0509 Melide seit 10. April 2024
- TTA-0329 Biasca seit 4. April 2024
- TTA-0337 Cadenazzo (Contone) seit 4. April 2024
- TTA-0339 Chiasso seit 4. April 2024



Launch.
What does SBB need diesel for?
SBB's climate targets

HVO in our strategy.
Transitional solution
Advantages of HVO

Challenges in technology.
Mix-up
Background
Compatibility

Challenges in procurement.
Sustainability
Availability
Pricing

Summary and outlook.
What have we already achieved?
Future challenges

Summary of the introduction of HVO blend.

_ 7500 tonnes CO2eq
reduction per year.
≈ 2.5 - 3 million litres of diesel

6 people
in the core team
CFT fuels.

4 years
Lead time from idea to rollout

- 20 %
Particle reduction in the exhaust gases - protects the particle filter.

Additional costs
Permitted additional costs compared to fossil diesel approx. 10%.

04.04.2024
First filling station supplied with HVO blend.

100% HVO
We are working on this. This is the next step.

What the future may bring: from HVO blend to SynFuels.

HVO blend (up to 30% HVO)

- From 2024 onwards
- Blended with fossil diesel at all filling stations
- Suitable for all engines

HVO 100% (partial)

- Isolated operation of individual sub-fleets, alongside HVO blend
- For engines produced after 1990.

HVO 100% (full coverage)

- Condition: All motors must be EN15940 compliant.

SynFuels 100% (full coverage)

- Potential successor to HVO, produced from renewable electricity and CO_2.
- Also EN15940-compliant

fossil diesel → HVO blend up to 30% → 100% synth. fuels

Kontakte.

Philipp Haudenschild
Fachspezialist alternative Kraftstoffe & Antriebe
Projektleiter Einführung HVO
philipp.haudenschild@sbb.ch

Roland Aeschbacher
Projektleiter Energieeffizienz
roland.aeschbacher@sbb.ch


SBB CFF FFS
Thank you, danke, merci
& grazie.

Workshop timeline

14:50	Use of biofuels & Biodiesel (B100)	SNCF
15:15	HVO & Fatty Acids/Methyl Esters (FAME) tests outcomes	LINEAS
15:40	Panel discussion	
16:00	Closing words Networking mini cocktail	

INTERNATIONAL UNION
OF RAILWAYS

SNCF

Use of biofuels & Biodiesel (B100)

Alexandre Lehoux

National (bio)fuel technical manager

UIC Alternative fuels workshop, 11 June 2024

INTERNATIONAL UNION OF RAILWAYS

Alternatives Fuels



17/06/2024

SNCF VOYAGEURS

SUMMARY

01.
SNCF COMMITMENTS & CARBON ISSUE

02.
SUSTAINABLE FUELS OVERVIEW

03.
FIELDS TESTS & FEEDBACKS

SNCF VOYAGEURS

01.

SNCF COMMITMENTS & CARBON ISSUE

SNCF COMMITMENTS

Diesel engines are keys components of railways fleet. For Freight, Infrastructure, and Regional Traffic, powerpack or diesel hydraulic traction are widely used. Taking into account of these rolling stock, SNCF engagements to achieve environmental goals are described below

GHG

30 %

By 2030, **reduce the Group's Greenhouse Gas (GHG) emissions by 30%** in the trasnportation sector, compared to 2015

Energy

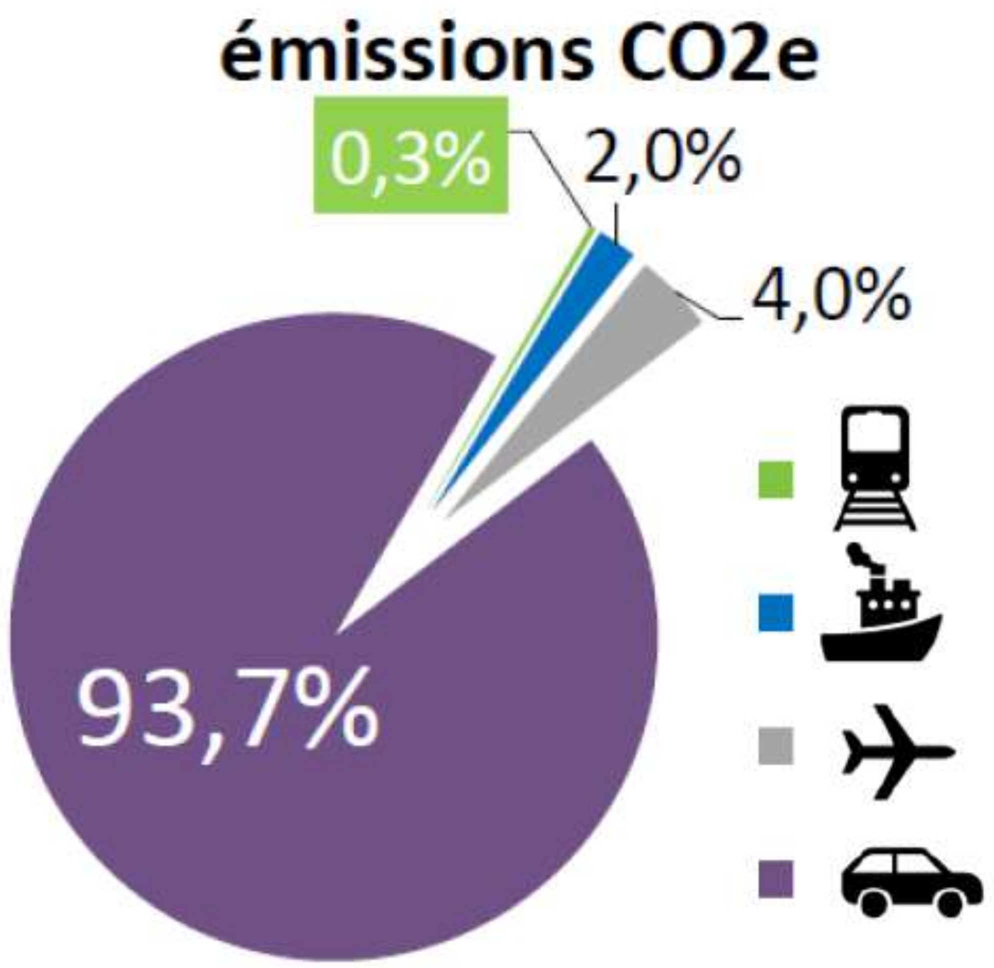
Reduce diesel fuel for rail with the development of alternative energies (biofuel, battery, hydrogen)

2050

Achieving **carbon neutrality** by 2050

FRENCH REGIONAL TRAFFIC FOCUS

French railways emit only 0,3% of all the modes' emissions in France. Emissions are mainly due to regional traffic



1100

Trains (combustion engine & bimode) are used for French Regional Traffic fleet

40%

Of « train.km » are made in Diesel (Regional traffics)

61%

Of Regional Traffics GHG emissions from diesel traction

02.

SUSTAINABLE FUELS OVERVIEW

SNCF VOYAGEURS

SUSTAINABLE FUELS: ONE OF THE TRANSITION SOLUTION

The emergence of sustainable fuels on the EU markets

Fatty Acid Methyl Esters (FAME)

- Fame is produced from vegetable oils, animal fats or waste cooking by transesterification
- Rapeseed is only raw material select by SNCF
- Modifications (seals, piping) are required for used at 100% pure (B100)
- Several productions sites in France

Hydrotreated Vegetable Oil (HVO)

- Produced by hydrotreating vegetable oils, animal fats or waste cooking with hydrogen and catalysts at high temperature and pressure
- Requires no engine adaptation because fuel properties similar to fossil fuel
- Around 2 producers in Europe

Power-To-Liquid (PTL)

- PTL is a synthetically liquid hydrocarbon
- Produced by splitting water (H_2O) into hydrogen (H_2) and oxygen (O_2) using electricity and a chemical process
- PTL ambition is to be completely CO_2 neutral if electricity used for electrolysis comes from renewable energy sources
- No product available on industrial scale

SNCF VOYAGEURS

03.

FIELDS TESTS & FEEDBACKS

VOYAGEURS

VOYAGEURS

FIELDS TESTS & FEEDBACKS

FAME has been tested in France since 2019 and HVO in summer 2023

RÉGION NORMANDIE

Paris Granville

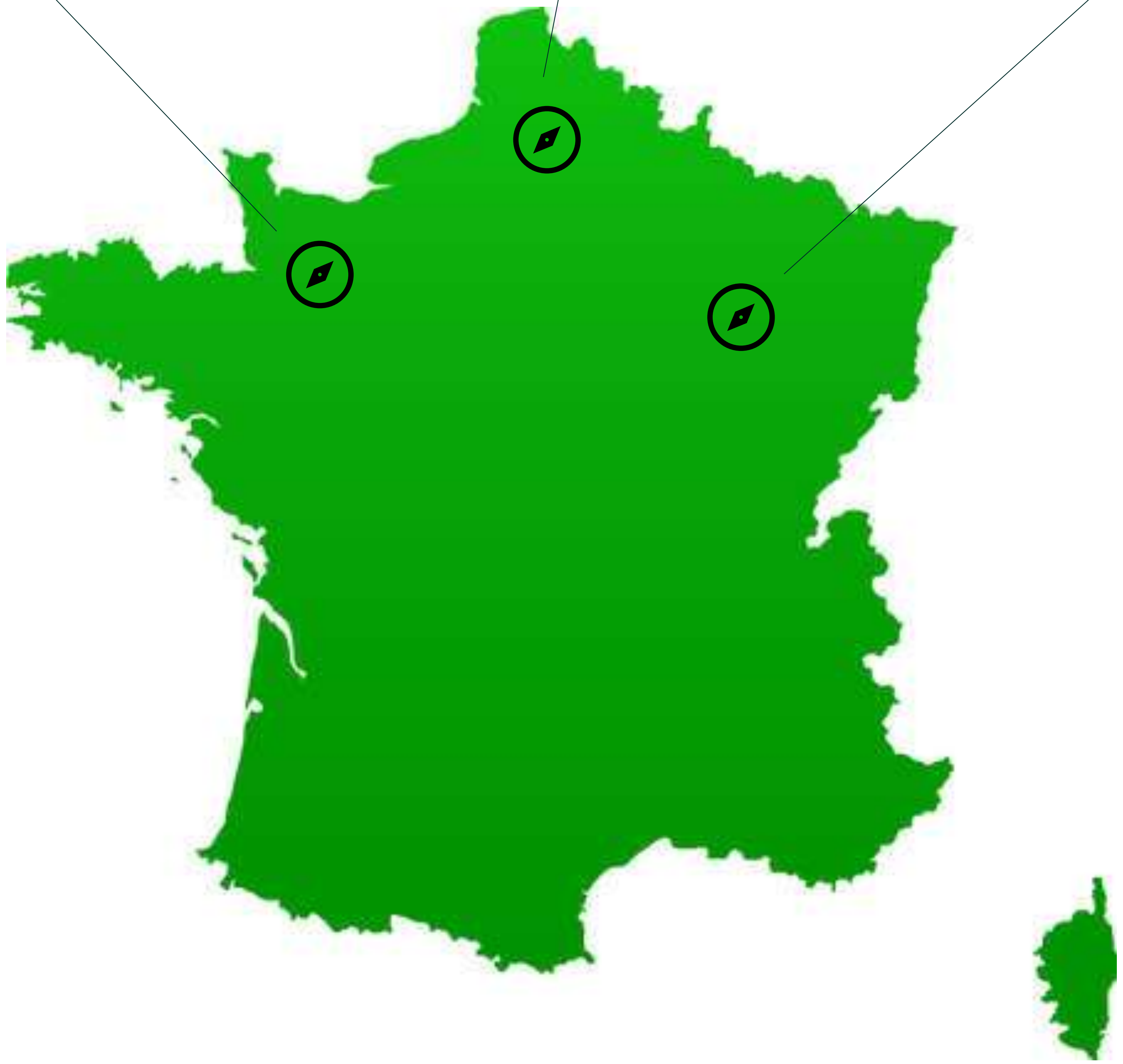
15 REGIOLIS – Passenger train bimode

From 04/05/2021 to 12/31/2023

More than **6,2 MKms**

More than **21 000 Tonnes CO2 Economy**

Région Hauts-de-France



RÉGION BOURGOGNE FRANCHE COMTE

SNCF VOYAGEURS

THANKS

17/06/2024

SNCF VOYAGEURS

Workshop timeline

15:15	HVO & Fatty Acids/Methyl Esters (FAME) tests outcomes	LINEAS
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INTERNATIONAL UNION
OF RAILWAYS

Lineas

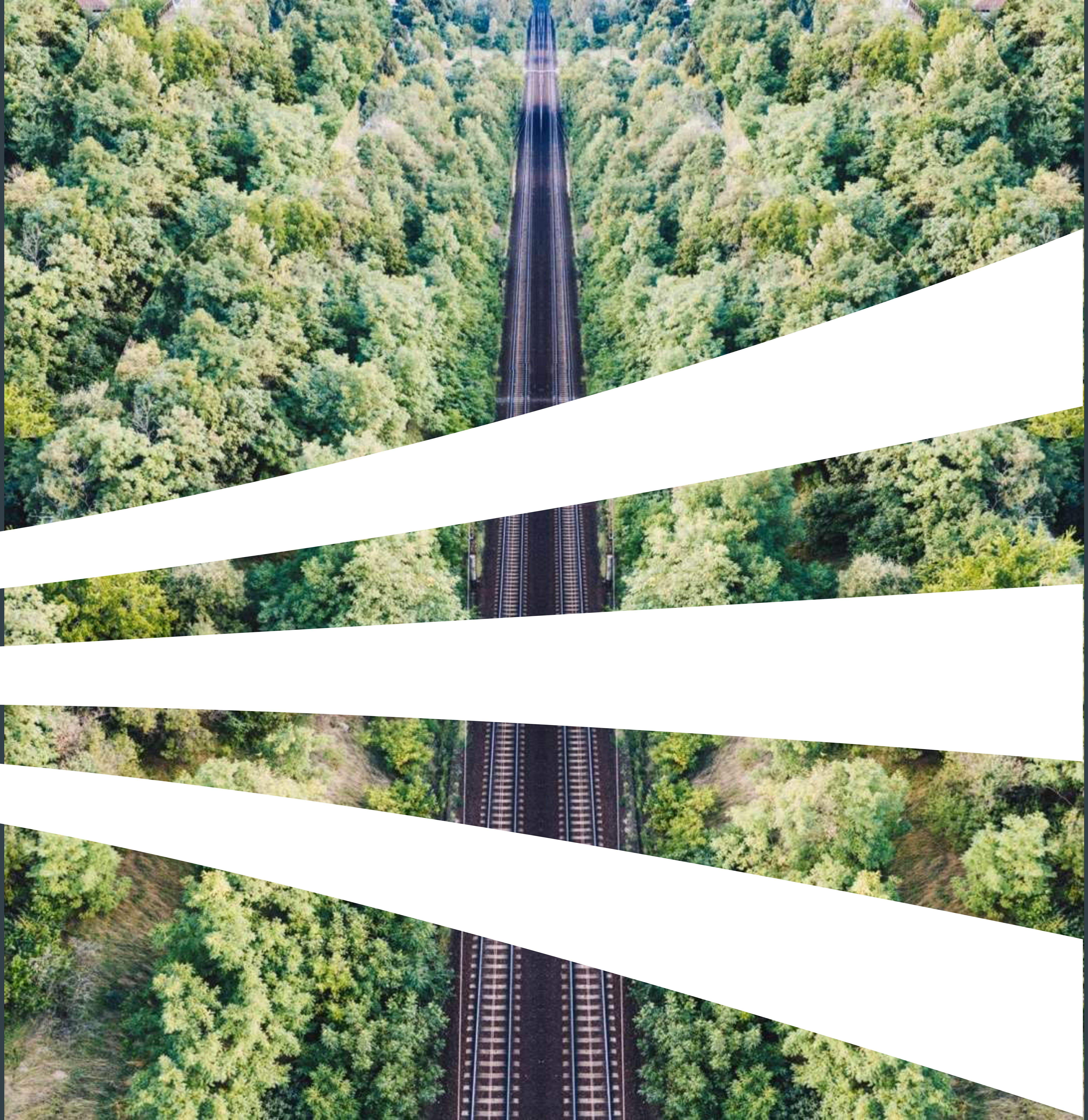
HVO & Fatty Acids/Methyl Esters (FAME) tests outcomes

Wouter Lammens

Locomotive Planning Manager

UIC Alternative fuels workshop, 11 June 2024

BIOFUELS TESTING IN T77 LOCOMOTIVES



LINEAS

1. About Lineas
2. Lineas ESG goals
3. T77 Locs
4. Which fuels tested
5. HVO test details
6. FAME test details
7. Project streams and next steps

LINEAS

WE DECARBONIZE YOUR SUPPLY CHAIN

37,500
TRUCK
REDUCTION
PER YEAR

1,3 MIO
TON
CO2 SAVED
PER YEAR

LINEAS

LINEAS, THE BIGGEST PRIVATE RAIL FREIGHT OPERATOR IN EUROPE

- Our mission: we decarbonize the supply chain of our customers, being a key enabler for their growing ESG objectives
- Belgium headquartered company, but truly multi-national
- Operating in Western/Central Europe with all capabilities to deliver internationally
- Very strong ties with major North Sea Ports: Antwerp, Ghent, Zeebrugge, Rotterdam
- Rail undertaking + intermodal and conventional operator
- Digitalizing the supply chain
- 1750 employees with passion for rail
- Pool of +/- 500 national and international drivers
- Diversified rolling asset base (250 locomotives, 6700 wagons)

A strong ambition in CO_2 reduction and ESG

ESG brochure

Our CO_2 reduction commitments by 2030:

- Reduce scope 1 and 2 GHG emissions by 42%
- Reduce scope 3 GHG emissions by 25%
- Increase renewable electricity from 16% to 75%

Ambition to become Ecovadis gold by 2027:

- Building sustainable value chain
- Valuing human capital
- Reach "best employer" status by 2027

First results:

- Ecodriving is reducing consumption from 14 to 12 Wh/tonkm
- Tests with sustainable fuels:
  - Genk: tests are completed with HVO (Hydrogenated Vegetable Oils)
  - Gent: tests are ongoing with 2nd generation FAME (Fatty Acid Methyl Ester)

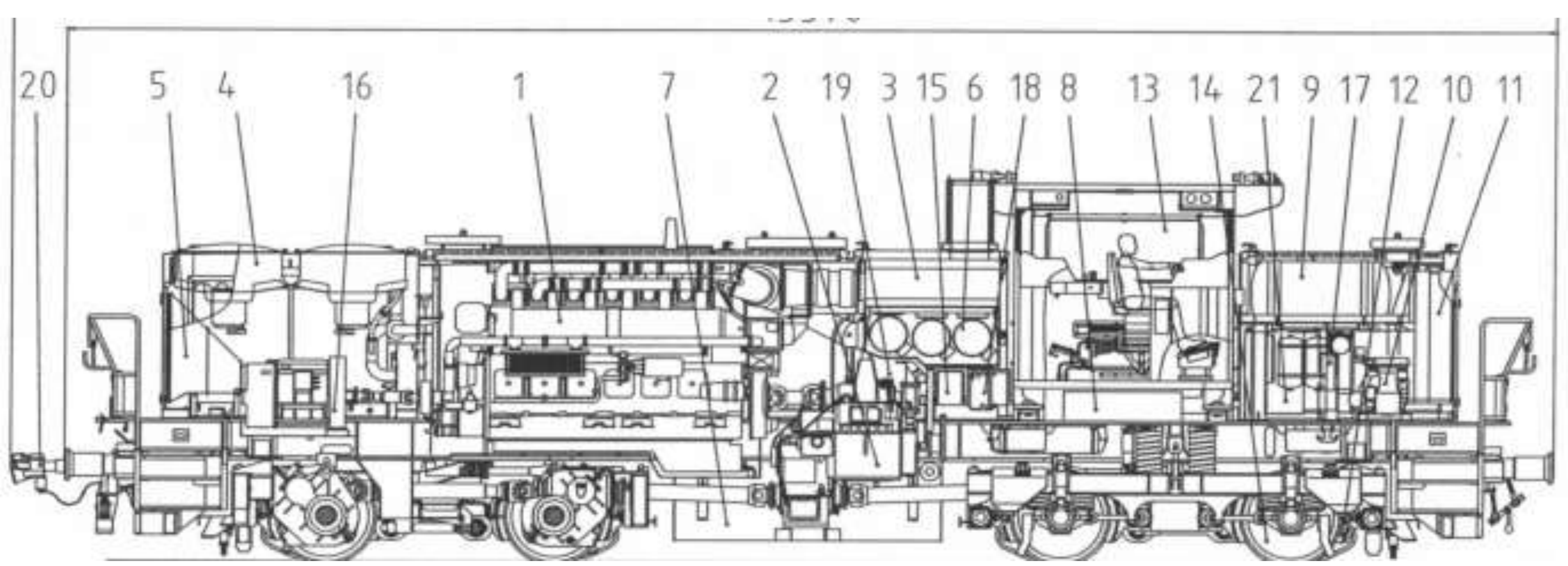
Targets currently submitted to the SBTi organization, still awaiting their validation that is expected in the second half of the year

BIOFUELS TESTING IN LINEAS

T77 LOCOMOTIVES – TECHNICAL DETAILS

ABC Engine 6 DXZ :

Cycle :	4 stroke	Nominal power :	1326	Kw
Cylinder:	6 inline	Nominal Speed :	1000	Rpm
Bore :	256 mm	Piston speed :	10.3	m/s
Stroke :	310 mm	Displacement :	95.7	liter
Compression : 12.1/1		Turbo & Intercooler :	yes	



Provider
Siemens

Siemens Hvac, Convertissor

Engine Abc

Hydraulic Transmission Voith

Frame Vossloh

Year of construction of locomotives 1999 to 2005

- Owner is Beacon Rail
- ECM is Lineas

LINEAS

We test 2 types of biofuels

HVO (Hydrotreated Vegetable Oil)
= Renewable diesel

Producer: Neste
Standard: EN 15940
HVO100
Test place: Genk & Antwerp
Delivery by Truck

FAME (Fatty Acid Methyl Ester)
= Biodiesel

Producer: Cargill
Standard: EN 12414
B100
Test place: Ghent, tanking in Seatank Terminal
Delivery by truck
UCOME (used cooking oil)

- Both products offer app to 75-90% less emissions compared to regular diesel
- HVO: 1 year test had been completed without any technical problem (verified by a revision where whole engine is opened in the workshop)
- FAME: Tests ongoing, no issue captured at the moment, tests are to be finalized by the end of 2024 latest

BIOFUELS TESTING IN LINEAS

HVO

- 2 Locomotives tested
  - 2023/01 – 2023/05 : 1500 hours
  - 2023/01 – 2023/09 : 2000 hours

- No modification is done on the loc

- Followed up following items during the tests
  - Engine oil samples taken to check particles, presence of water and fuel in the oil
  - Fuel sample to check for formation of algea
  - Checks on vibrations, smoking, visual controls of the engine itself
  - Checking injection pumps and injectors after 2000 h
    - Minor pollution of the injectors noticed but no big issue (lower than Fame)

Conclusion: HVO can be used without any modifications on the engine/maintenance plan. Pumps and injectors needs to be followed up against clogging.

BIOFUELS TESTING IN LINEAS

FAME

- 2 locomotives are tested (7853 as of June 2023, 7855 as of December 2024)
- No modifications are done on the locs
- FAME used: Initially regular UCOME,
    - winter version is used during the colder months (includes additive)

LINEAS

BIOFUELS TESTING IN LINEAS

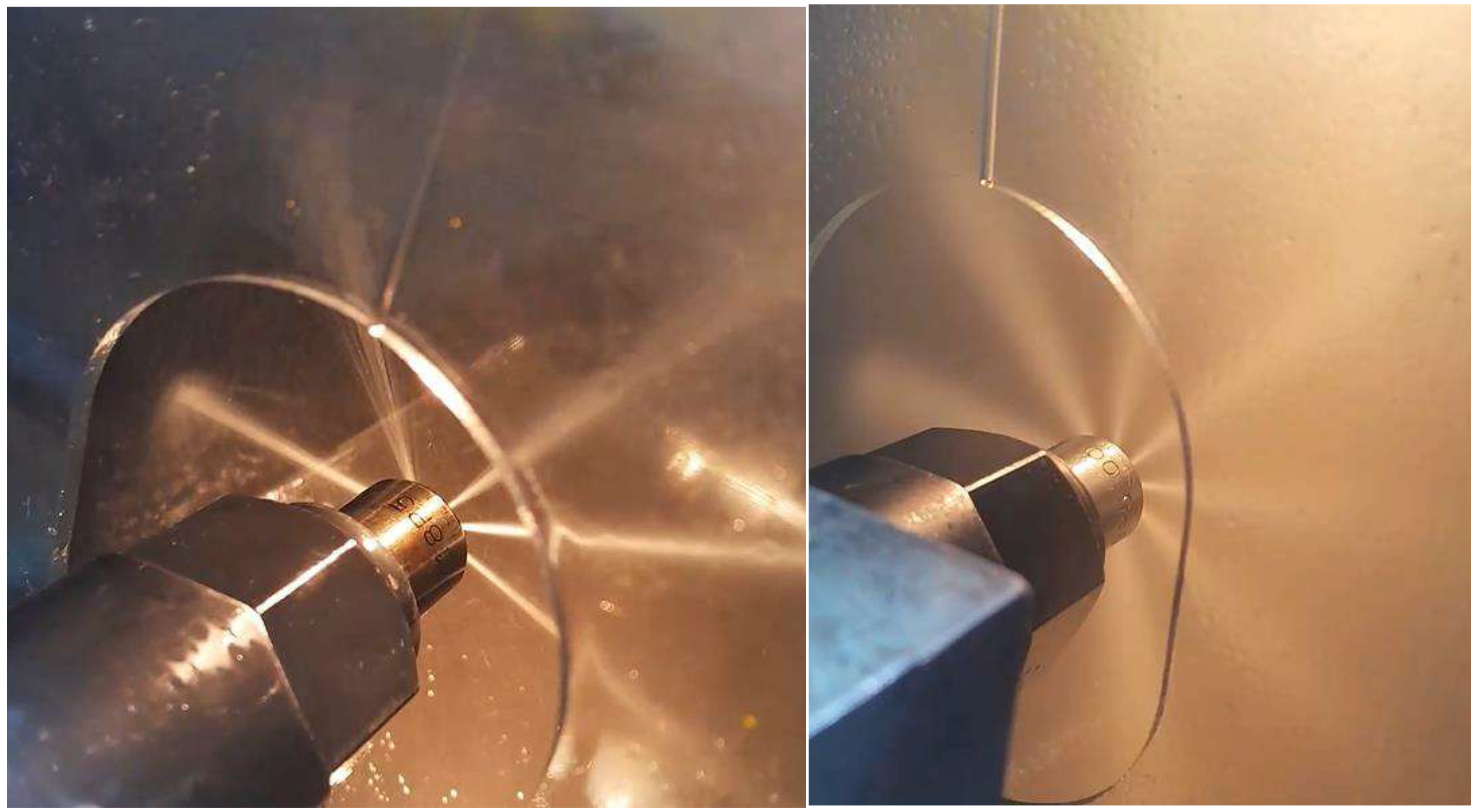
FAME

- First reflection on the test:
  - Smell in loc cabin noticed by some drivers
  - Cold start due to increase of viscosity in cold weather → additive by Cargill added
  - Fuel pump failed 2 times and in the last inspection report it showed pumps are dirtier compared to regular diesel
  - Injectors are clogged easier: Picture in next slide
  - Testbench carried out on the engine to measure and certify the real impact of using Fame fuel versus B7 diesel (gas emissions, energy content of the fuel)
    - SNCB/NMBS hires an external company to realize the measures. Results will be presented per emission components according to ISO 8178-4 norm.
      - CO, Nox, HC (g/kWh)
      - PM (g/kWh)
      - PN (#/kWh)

BIOFUELS TESTING IN LINEAS

FAME

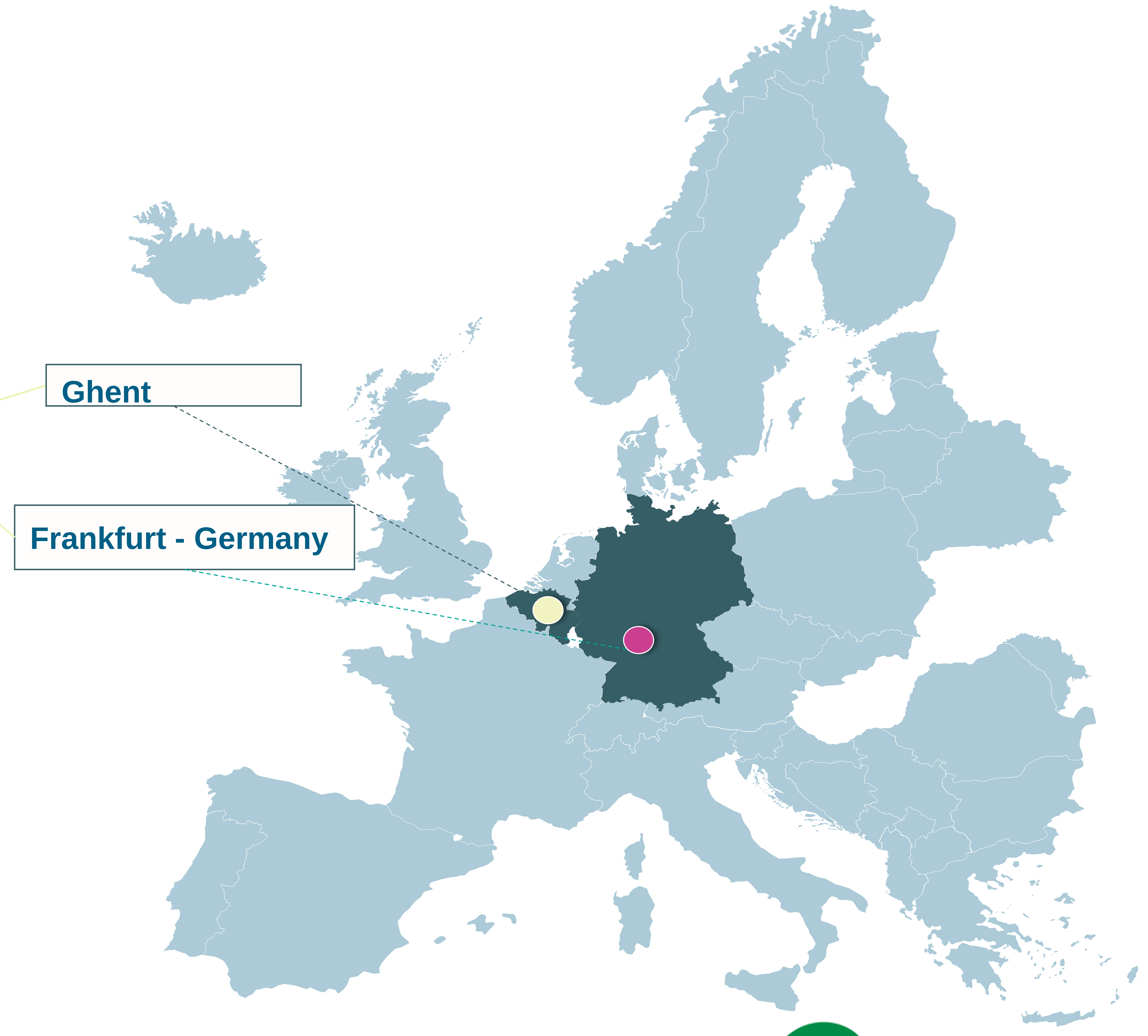
- Injectors: impact of injector clogging
  - spray quality is lower
  - combustion is less efficient
  - In certain cases, going to extremes, the injection holes can become blocked.



- Next steps
  - 7853 to go into revision in July with more than 3000 operating hours, 7855 will run with FAME till the end of 2024

Cargills Biodiesel offers a superior quality compared to other biodiesel in the market

	Standard EN 14214 Quality	Cargill Biodiesel
CFFP April-Oct/ Nov-Mar	-10 °C / -10 °C	-10 °C / -20 °C
Ester Content	> 96.5%	> 97.5%
Sulphur (UVF)	< 10 mg/kg	< 5 mg/kg
Water Content	< 500 mg/kg	< 200 mg/kg
Monoglyceride content	< 0.7 mg/kg	< 0.3 mg/kg
Metals Group I (Na + K)	< 5 mg/kg	< 1 mg/kg
Metals Group II (Ca + Mg)	< 5 mg/kg	< 1 mg/kg
Phosphorus Content	< 4 mg/kg	< 1 mg/kg
Total Contamination	< 24 mg/kg	< 10 mg/kg
Cloud Point	- 3 °C	- 5 °C
Oxidation Stability 110 °C	> 8 hrs	> 10 hrs
Filter Plugging Tendency	-	< 1.5 °C
Saturated Esters	-	10%
Sterol Glucosides	-	< 5 ppm



Cargill

BIOFUELS IN T77 LOCOMOTIVES

ESG

How to ensure a positive impact on the supply chains carbon footprint?

SBTI is validated, supplier certifications validated. Future way of working is still under investigation

Technical

Is the fuel compatible with our locomotive?

Locs had been running without any major issue

Streams

Commercial

How will we sell this product and at what price?

Looking into the possibility to enable our customers to benefit from less CO2 emissions by starting offering on request solution first

Logistics

How will we put the fuel in our

locomotives?

During test phase – via trucks. Long term possibilities is still under investigation

Streams

LINEAS

THANK YOU!

As a conclusion:
Tests of Biofuels are promising, next step is to find logistical solutions and looking into the possibility to enable our customers to benefit from less CO2 emissions

Workshop timeline

15:40	Panel discussion	
16:00	Closing words Networking mini cocktail	

Panel discussion
Questions and answers

DB Cargo

SBB

SNCF

Lineas

Workshop timeline

15:40	**Panel discussion**	
16:00	**Closing words** **Networking mini cocktail**	

INTERNATIONAL UNION
OF RAILWAYS

Media to be made available on the event page

Thank you
for your attention

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Christophe Gueudar Delahaye, SNCF

Philippe Stefanos, UIC