

FUEL CELL VS DIESEL

Maintenance insights for fuel cell rail vehicle.



Motivation

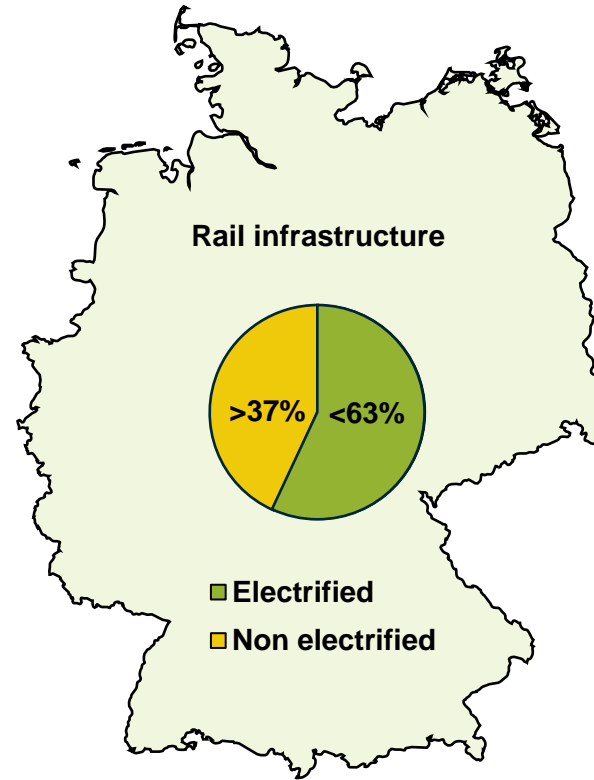
Social aspect



Source: [Mobilitätswende: Reaktivierung von Bahnstrecken](#) | VDV

- Increase accessibility to the rail transportation system.
- Reopening of discontinued routes.

Environmental aspect



Source: [Allianz pro Schiene](#)

- Higher costs of route electrification.
- Non electrified routes: Diesel propulsion system.

Electrified



Source: [FLIRT Triebzug](#) | Stadler

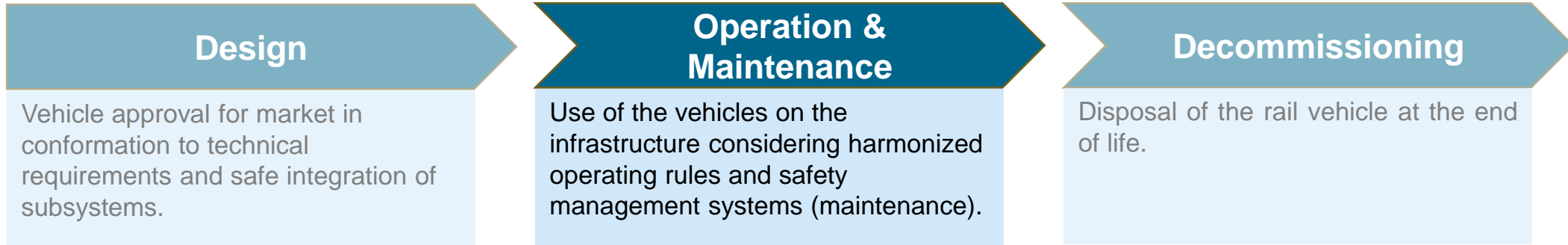
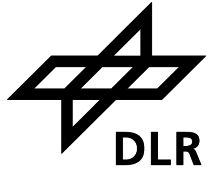
Non electrified



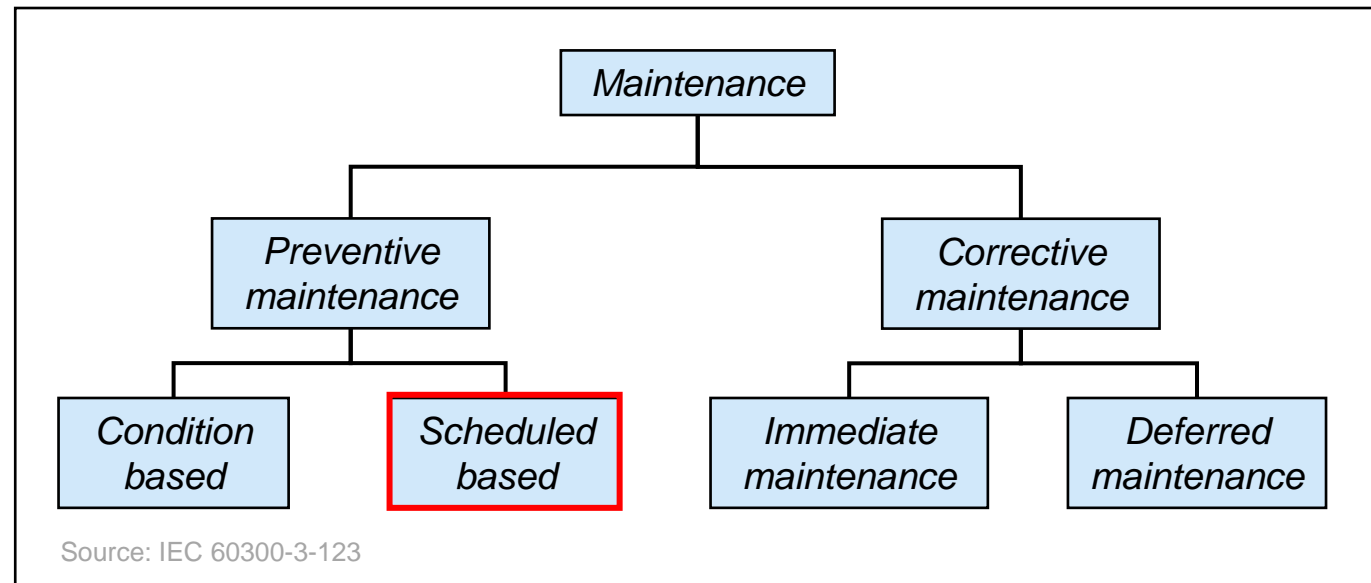
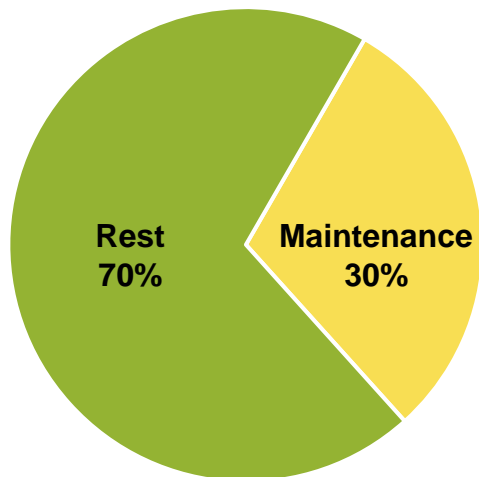
Source: [heros-rail.com](#)

Considering climate goals, use of fuel cell propulsion for non-electrified routes can be better a choice.

Analysis scope



Operating costs¹



Development and comparison of scheduled maintenance plan for fuel cell propulsion system.

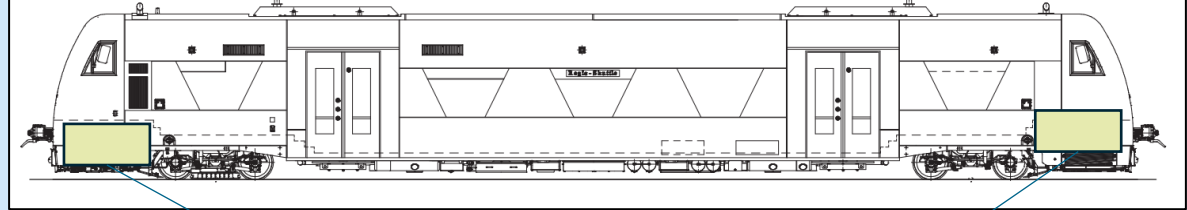
Maintenance scope for conventional vehicle

Reference vehicle considered for comparison: Regio Shuttle RS-1

$$\text{Maintenance Cost} = \text{Labour costs}^1 + \text{Material costs}$$

$$1: \text{Labour costs} = \text{Maintenance efforts} * \text{Labour rate}$$

Source: Regio Shuttle data sheet, Stadler Rail



Diesel engine with gear system and coupling.

Maintenance plan for RS-1*

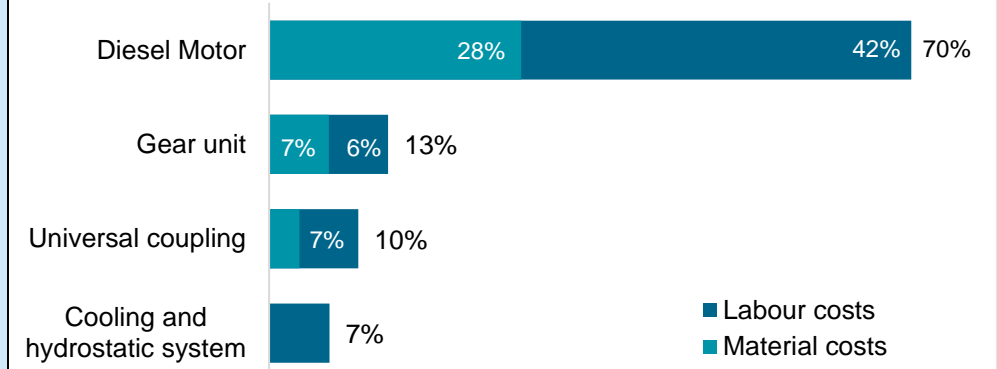
Component	Task	Interval	MMH	Quantity of components	Total MMH
Gear unit	Visual inspection	IS1	0.35	2	0.7
	Check oil level	IS1	0.25	2	0.5
	Exchange of oil and oil filter	IS4	1.15	2	2.3
	Exchange	HU2	3.35	2	6.7



Material costs derived from maintenance data



Maintenance costs

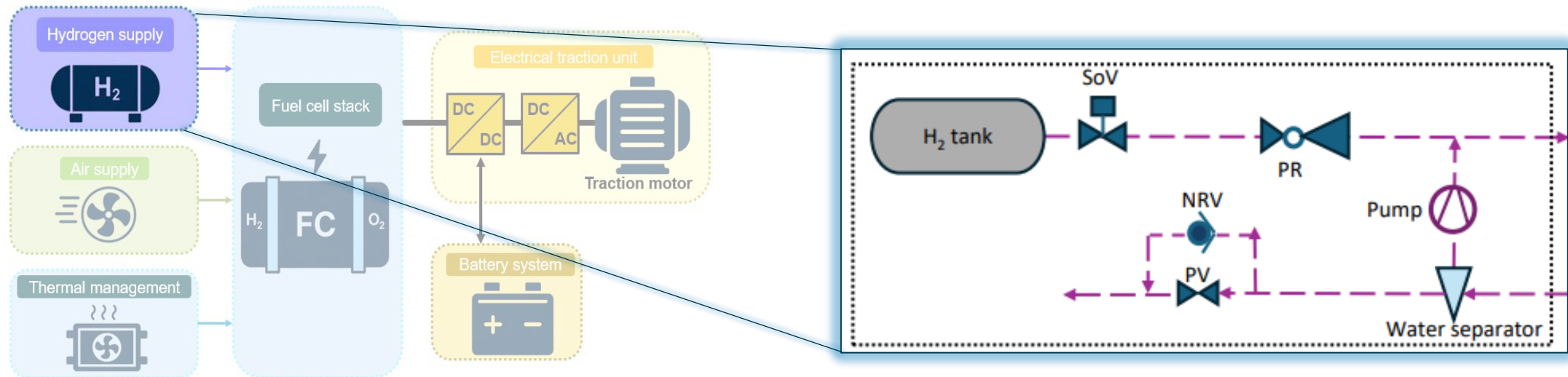
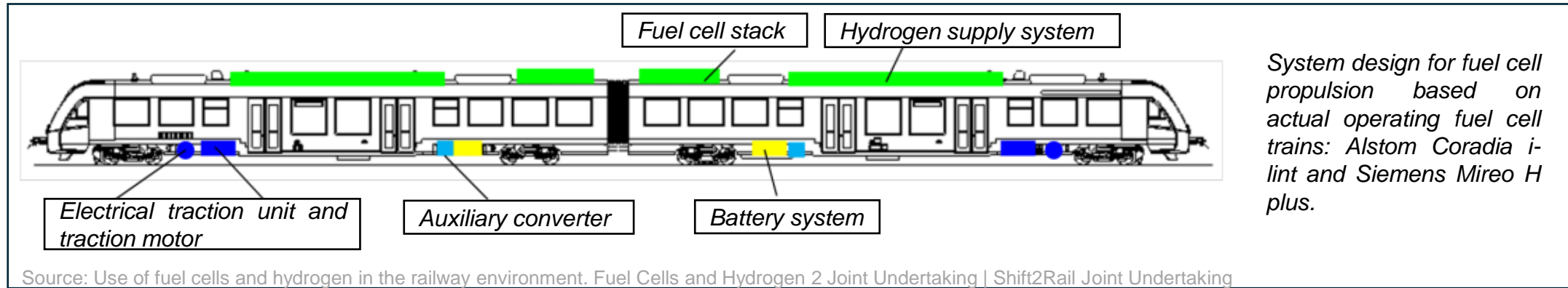


Conventional maintenance plan taken as reference for maintenance plan development of fuel cell.

*Note: MMH = Maintenance Man Hours, IS = Instandhaltungsstufe, HU = Hauptunterhaltung, ZU = Zwischenunterhaltung
 IS1 = 15,000 Kms/ 469 Operating hours/ 45 Days , IS4 = 120,000 Kms/ 3750 Operating hours/ 360 Days, HU2 = 1,200,000 Kms/ 37,500 Operating hours/ 10 Years

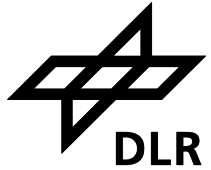
Maintenance scope for fuel cell system

System design



Component level of depth in system design is essential for appropriate maintenance task development.

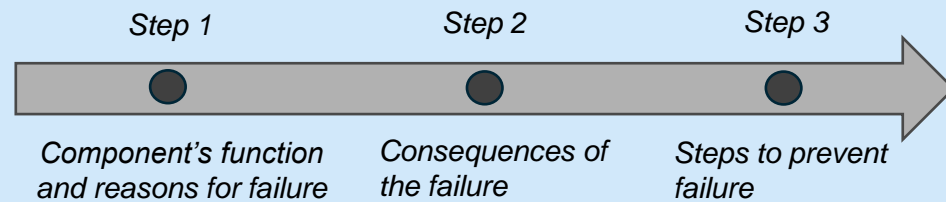
Maintenance scope for fuel cell system



Maintenance plan development

Maintenance tasks

Derived by assessing



Maintenance intervals

- Maintenance levels structured according to conventional system
- Gathered from conventional MPD, standards and literature

IS2 = 15,000 Kms/ 469 Operating hours/ 45 Days

IS3 = 30,000 Kms/ 938 Operating hours/ 90 Days

IS4 = 120,000 Kms/ 3750 Operating hours/ 360 Days

Maintenance efforts

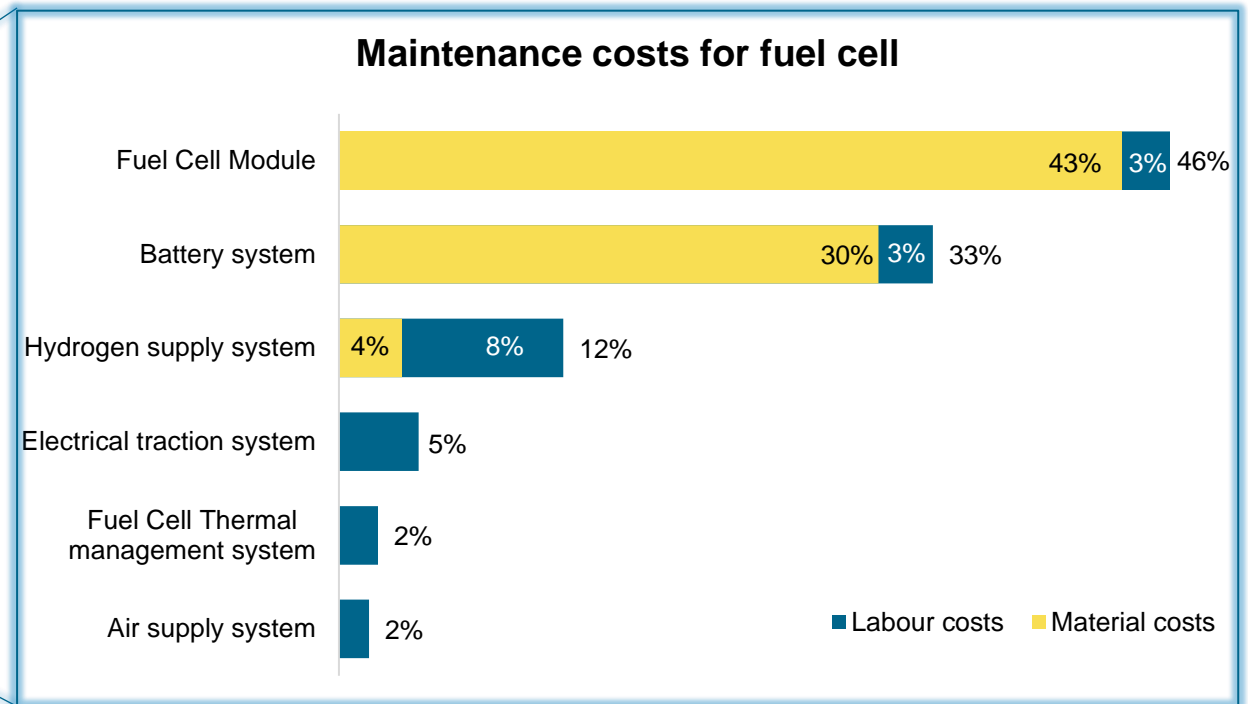
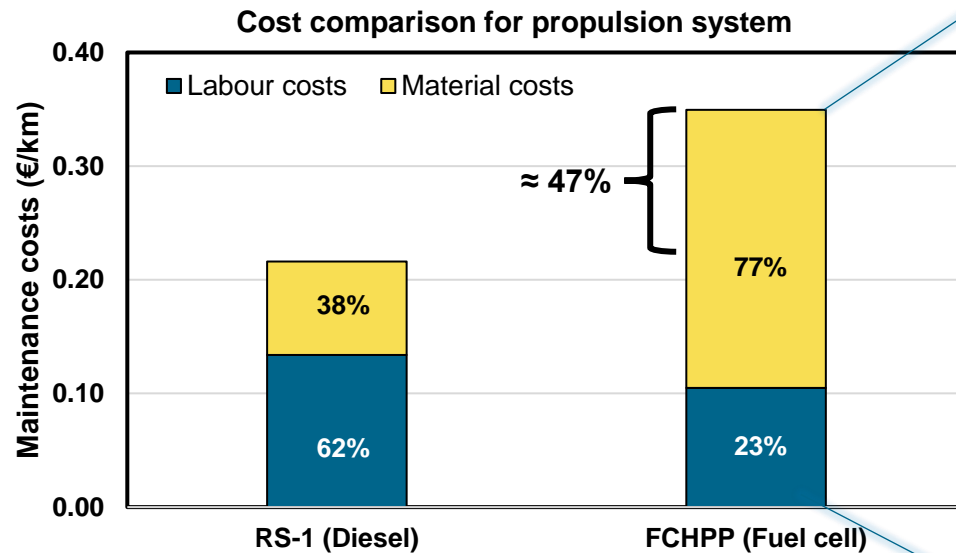
Referenced from conventional MPD and literature

Component	Task	Interval	MMH	Quantity of components	Total MMH
Hydrogen supply system					
Hydrogen Tank	Strength testing	840,000 kms or 7 years	2	16	32
	Detailed inspection	240,000 kms or 2 years	1	16	16
	Exchange	1,800,000 kms or 15 years	0.4	16	6.4
Hydrogen filter	Visual inspection	IS3	0.15	4	0.6
Pipes	Strength testing HP	840,000 kms or 7 years	3	1	3
	Strength testing MP	840,000 kms or 7 years	3	1	3
	Detailed inspection for Leakage check (HP)	240,000 kms or 2 years	2	1	2
	Detailed inspection for Leakage check (MP)	240,000 kms or 2 years	2	1	2
Recirculation pump	Visual inspection	IS2	0.1	1	0.1
	check for leakages and sealants	IS4	0.1	1	0.1
Safety valve, check valve	Visual inspection	IS4	0.2	2	0.4
	Functional check	IS4	0.4	2	0.8
Shutt-off valve	Visual inspection	IS4	0.2	16	3.2
	Functional check	IS4	0.4	16	6.4
Pressure regulator	Visual inspection	IS4	0.2	4	0.8
	Functional check	IS4	0.4	4	1.6
Pressure sensor	Functional check	IS4	0.92	4	3.68
Leakage sensor	Functional check	IS4	0.92	4	3.68

MMH, intervals and quantity of components as inputs for determination of maintenance costs.

Comparison between fuel cell and diesel

Maintenance costs

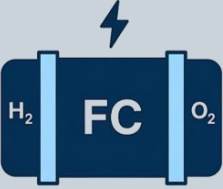

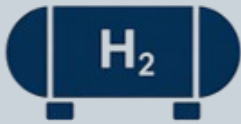


$$\text{Maintenance costs} = \text{Labour costs}^1 + \text{Material costs}$$

Maintenance costs for fuel cell is estimated to be $\approx 47\%$ more costlier, of which, the majority costs are material costs of fuel cell stack, battery and H_2 tanks.

Comparison between fuel cell and diesel

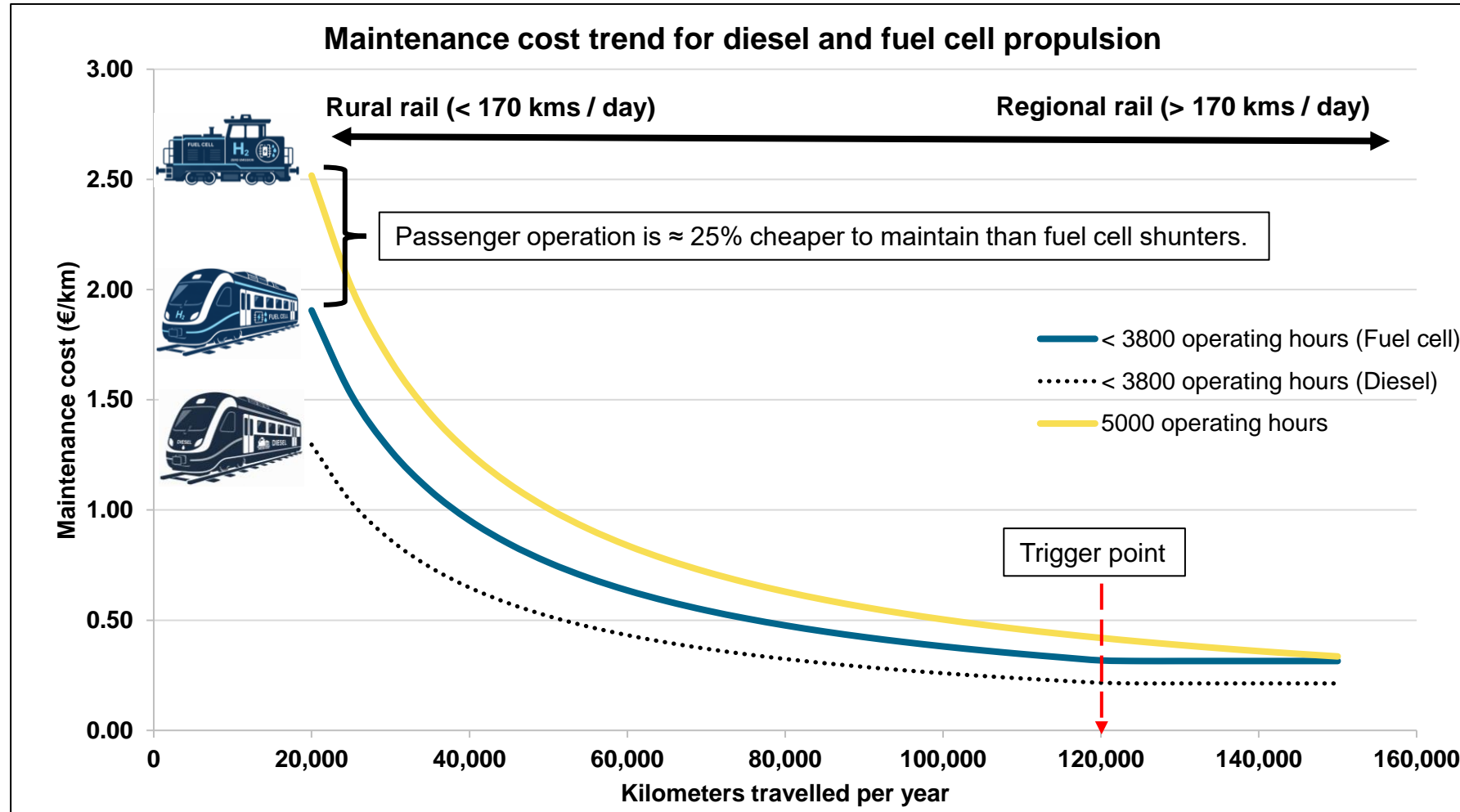
Replacement of components

Component	Failure modes	Prevention
Fuel cell stack 	<ul style="list-style-type: none"> • Decrease in open circuit voltage (OCV) • Increase in H₂ crossover current 	Monitoring Membrane Electrode Assembly (MEA) for mechanical and chemical degradation <ul style="list-style-type: none"> • Temperature • Humidity • Contaminants in supply gases
Battery 	<ul style="list-style-type: none"> • Capacity loss • Internal short circuit • Thermal runaway 	<ul style="list-style-type: none"> • Monitoring temperature (robust BTMS) • Monitoring usage (prevention of over charging and over discharging)
Hydrogen tank 	<ul style="list-style-type: none"> • Fatigue failure • Liner collapsing • Leakage 	<ul style="list-style-type: none"> • Monitoring of increase in temperature due to rapid fueling-defueling process • Optimization of filling pressure

Monitoring the factors that degrade the component's life can increase the interval of replacement.

Comparison between fuel cell and diesel

Use case insights



Maintenance for rural rail is ≈ 60% more labour intensive and costlier as compared to regional rail.

Thank you for your attention!



Comparison

*Fuel cell propulsion is estimated to be **47%** more costlier to maintain than diesel propulsion system.
Reason: High material costs.*

Optimization

*The material costs can be reduced by increasing the replacement intervals
How?: By monitoring the degradation factors for the components.*

Use case

*Maintenance costs for rural rail are estimated to be **60%** more costlier than regional rail.*

Seems interesting? Check other research topics at our department!



Topic: **Fuel cell vs Diesel: Maintenance insights for rural rail**

Date: 05.05.2026

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