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Possibilies of Low-Carbon Logistics Systems in Finland

Part 3: Rail Transport

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Contents

1. Introduction
Rail Transport Overview 1

- **Current status**
  - The share of rail transport in domestically transported roundwood volumes is 28% (Strandström 2026). Timber accounts for approximately half of Finland's rail freight, measured both in tonnes and tonne-kilometres (Statistics Finland 2025).
- **Objectives**
  - The European Commission's (2020) Sustainable and Smart Mobility Strategy aims to increase rail freight transport by 50% by 2030 and to double it by 2050 compared with 2015.
    - EU policy does not set binding rail transport emission reduction targets for Member States, nor obligations concerning the use of renewable energy or biofuels.
  - The EU Green Freight Transport package aims to shift freight transport towards more sustainable and energy-efficient modes, such as rail.
  - Finland's 12-year transport system plan (Transport 12) presents measures for the development of the rail network (Finnish Government 2025).
  - In the forest industry transport climate roadmap (AFRY Management Consulting 2025), shifting roundwood transport from road to rail is identified as the most significant emission reduction measure.
    - Identified measures include, among others, the development of roundwood terminals by the Finnish Transport Infrastructure Agency and investments in transport rolling stock.
    - Rail network electrification is also identified as a further measure related to rail transport.

Rail Transport Overview 2

- **Development outlook**
  - In Traficom's national transport forecast (Moilanen et al. 2022), rail transport of roundwood is expected to increase especially from Kainuu and Western Finland to South-Eastern Finland, as well as from Lapland to Kemi and Oulu.
- **Impacts**
  - CO_2e emissions per tonne-kilometre in rail-based roundwood transport chains are 47% lower for diesel trains and 79% lower for electric trains compared to direct road transport (Poikela and Strandström 2024).
    - The transport chains include emissions from terminal handling of timber and shunting operations.
  - For long transport distances, rail transport is also more cost-effective than road haulage. The cost of road transport for the shipper is 9.6 cents per m^3km, while the rail transport chain, including pre-haulage, costs 4.2 cents per m^3km (Strandström 2026).

Emission Reduction Measures Considered

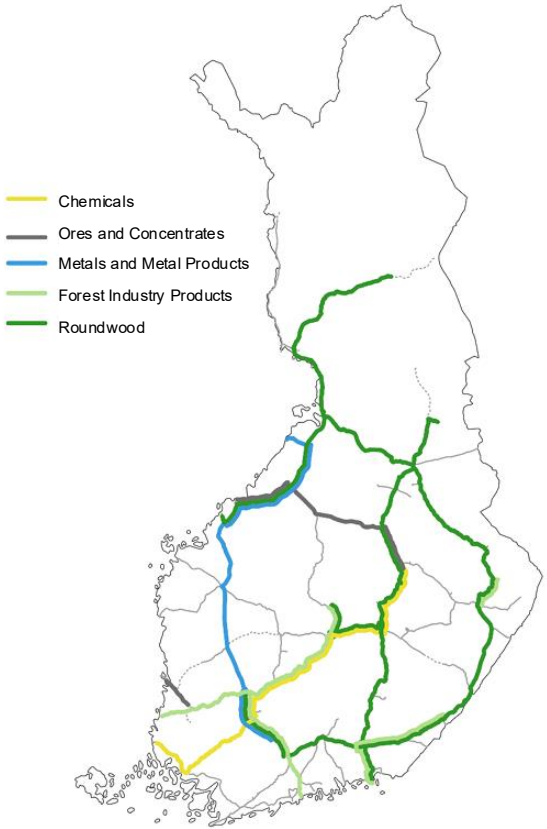
- In this sub-report, emission reduction measures related to rail transport are examined with respect to locomotive propulsion systems and measures to improve the competitiveness of rail transport in terms of rolling stock and infrastructure (see table).
  - With regard to infrastructure, construction and maintenance costs and emissions have not been taken into account.
  - Emission reduction measures related to the operation of rolling stock (e.g. energy-efficient driving) are also excluded.
- Machinery used in terminals, industrial sites and shunting operations is addressed in the main report of the study.

INFRASTRUCTURE
- Electrification - Load-bearing capacity - Capacity and throughput - Loading site network
ROLLING STOCK
- Alternative propulsion systems - Long trains - Larger wagons

2. Infrastructure-Related Emission Reduction Measures

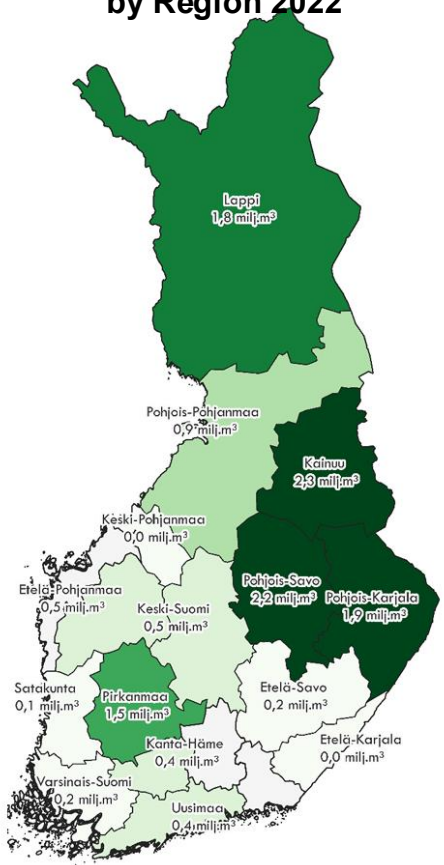
- The key regions and sections of the rail network for roundwood rail transport are presented in slide 7.
- The objectives for the development of the rail network are set out in the Transport 12 plan (Finnish Government … 2025).
  - With regard to rail transport, priority nationwide is given to the maintenance and improvement of the existing rail network in order to reduce disruption sensitivity, improve the reliability and punctuality of train services, and increase operating speeds.
  - Funding allocated to basic transport infrastructure maintenance for railways is targeted in particular at the needs of industry and at improving the capacity of busy single-track sections.
- Information on the national programme package has been compiled on the website https://vayla.fi/ohjelmakokonaisuus.
  - The planning programme (Finnish Transport Infrastructure Agency 2026) increases the readiness of projects included in the investment programme.
  - The most recent investment programme will be published in spring 2026.

Key Rail Transport Corridors by Commodity Type

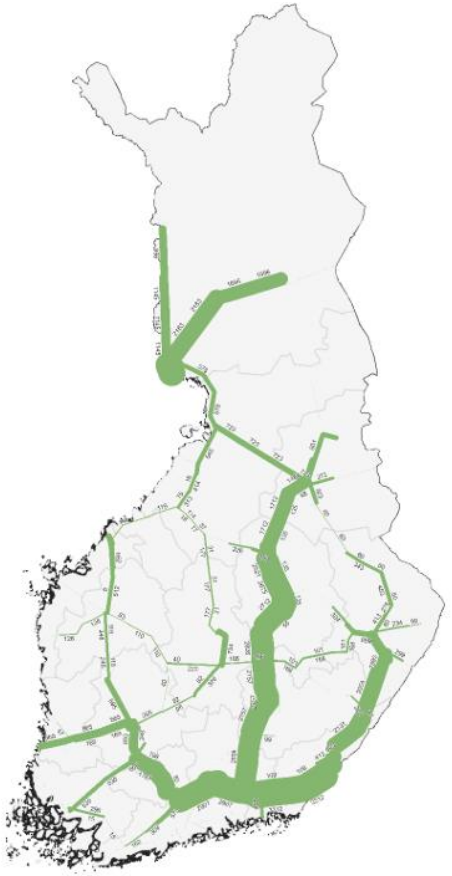


Graph: Finnish Transport Infrastructure Agency 2023

Roundwood Loading Volumes by Region 2022



Roundwood Rail Transport



Graphs: Lapp and Mäkinen 2023

Rail Network Electrification 1

- **Current situation**
  - Of the rail transport performance of industrial roundwood (tonne-kilometres), 81% was operated with electric traction in 2022 (VR Transpoint, cited in Poikela and Strandström 2024).
  - Of the TEN-T core network, 100% is electrified, and of the comprehensive network 92% will be electrified once ongoing projects are completed (Finnish Transport Infrastructure Agency 2023). Outside the TEN-T networks, 82% of the rail network is non-electrified (Tikka et al. 2024).
  - Even on electrified sections, diesel traction is still required. Measured in gross tonne-kilometres, 91% of transport operations on the electrified rail network are operated with electric traction (Tikka et al. 2024).
- **Objectives**
  - In the National Alternative Fuel Distribution Infrastructure Programme (Ojala et al. 2024), the objective is to increase the share of electric traction in total rail transport performance and to restore the share of electric traction in freight transport to over 80%. The share of electric traction declined following the cessation of traffic to and from Russia.
  - The proposed measures to achieve this objective include:
    - implementing rail electrification projects and exploring new opportunities for electrification;
    - identifying cost-effective solutions for electrifying short sections in cases where a lack of electrification leads to the use of diesel traction throughout the entire transport chain.

Finnish Transport Infrastructure Agency 2024 The electrification of the Hyvinkää–Hanko and Laurila–Tornio–Haparanda rail sections was completed in 2025.

Rail Network Electrification 2

- **Development outlook**
  - Key electrification needs and projects relevant to timber transport are presented in the following slide.
  - In addition, there may be a need to electrify short rail sections leading to production facilities and sidings in rail yards.
  - In ports and roundwood loading areas, electrification using overhead lines may be constrained by machinery used for loading and unloading trains.
  - According to the Alternative Fuel Distribution Infrastructure Programme (Ojala et al. 2024), for some rail sections it may be appropriate to assess the cost-effectiveness of battery-electric rolling stock and partial electrification instead of full electrification of the entire rail connection.

Electrification Needs and Projects in the Rail Network

- Planning under way
  - Kontiomäki–Vuokatti
  - Sänkimäki–Ruokosuo (primarily serving roundwood transport; includes electrification of the loading area and its shunting area; construction target completion in 2028)
  - Tornio–Kolari
- Identified needs for further studies (Tikka et al. 2024)
  - Tornio–Röyttä (10-km port connection)
  - Haapamäki star network (Orivesi–Haapamäki–Jyväskylä, Haapamäki–Seinäjoki)
  - Vaasa–Vaskiluoto (a few kilometres from Vaasa city centre to the port of Vaskiluoto)
  - Imatra–Joensuu
  - West of Joensuu
- Electrification needs identified in the rail network overview (Finnish Transport Infrastructure Agency 2023)
  - Joensuu–Viinijärvi–Siilinjärvi (comprehensive TEN-T network)
  - Viinijärvi–Pieksämäki
  - Joensuu–Vuokatti
  - Pieksämäki–Parikkala

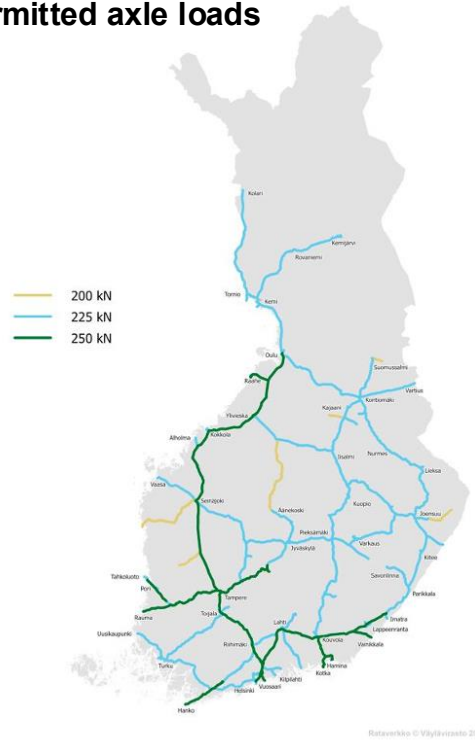
Impacts of Electrification

- **Impacts**
  - The operational CO_2e emissions of electric rail transport of industrial roundwood are 91% lower per cubic metre transported compared to diesel rail transport (Poikela and Strandström 2024).
    - The emission figures include shunting operations, which make extensive use of diesel-powered machinery.
  - Electrifying short, currently non-electrified sections at the beginning and end of transport chains can be a cost-effective way to reduce emissions if this reduces the use of diesel locomotives over the entire transport distance (Tikka et al. 2024).
  - Over the long term, once the electrification projects already under consideration have been completed, the cost-effectiveness of additional electrification may be lower than that of other emission reduction measures (Tikka et al. 2024).
  - This study does not assess the cost impacts of electric rail transport in timber transport. The general impacts of electrification are presented in separate project appraisals by the Finnish Transport Infrastructure Agency.

Load-Bearing Capacity of the Rail Network

- **Current situation**
  - The load-bearing capacity of the rail network affects the permitted axle loads of trains. Axle load limits below 225 kN have made it more difficult to organise roundwood rail transport on certain routes (Finnish Transport Infrastructure Agency 2023). There is also a need to increase axle loads in some rail yards. Permitted axle loads influence the size of train formations that can be operated and, consequently, the utilisation rate of rail capacity (Pitkänen et al. 2020).
- **Objectives**
  - In the development of the rail network, the objective has been a uniform 250 kN (25-tonne) axle load network on the most important transport routes. On lower-standard track structures on lightly trafficked lines, the target is a minimum axle load of 225 kN (Finnish Transport Infrastructure Agency 2023).
- **Development outlook**
  - At present, roundwood transport can operate on parts of the rail network with axle loads of 200 kN. Rolling stock is becoming heavier, and in future the rail network should provide at least a 225 kN axle load. Even in the long term, an axle load network of no more than 250 kN is likely to be sufficient for domestic traffic (Finnish Transport Infrastructure Agency 2023).
- **Impacts**
  - Increasing the load-bearing capacity of the rail network facilitates the introduction of longer and heavier trains and wagons. Larger trains improve transport efficiency and reduce emissions per unit of payload.
  - Operating larger trains also affects the utilisation of rail network capacity. On the other hand, larger trains are slower, which reduces the efficiency gains in capacity utilisation (Finnish Transport Infrastructure Agency 2023).

Permitted axle loads



Finnish Transport Infrastructure Agency 2023

Rail Network Capacity and Throughput 1

- **Current situation**
  - Rail capacity refers to the throughput of train traffic on a route, for example the number of trains per hour. Maximum rail capacity refers to the maximum number of trains that can operate between two locations within a given time period (Pitkänen et al. 2020).
  - Rail capacity is affected by several factors, such as the number of tracks, the number of passing loops and the functionality of yards, the locations of turnouts, track geometry, speed limits, signalling systems, the speed and braking distances of rolling stock, timetable structure (running, stopping and turning times, buffer time, headways), load-bearing capacity, and track lengths (Finnish Transport Infrastructure Agency 2023).
  - Key challenges related to rail network capacity for freight transport, and especially for timber transport, are presented in slide 15.

Rail Network Capacity and Throughput 2

- **Objectives**
  - The objective of the Transport 12 plan (Finnish Government … 2025) for rail transport is to prioritise nationwide the maintenance and improvement of the existing rail network in order to reduce disruption sensitivity, improve the reliability and punctuality of train operations, and increase operating speeds.
- **Development outlook**
  - Rail network projects of significance for freight transport, and especially for timber transport, aimed at addressing capacity constraints are presented in slide 15.
  - To improve rail traffic control, the DigiRail project is under way in Finland. The EU has also prepared a regulation proposal on rail capacity management.
  - In the future, separating passenger and freight rail lines on certain corridors could be a potential solution (Finnish Transport Infrastructure Agency 2023).
- **Impacts**
  - Projects that increase rail capacity can improve punctuality, reduce disruption sensitivity, enable an increase in train services and operation at preferred times, and enhance the flexibility of the rail network to adapt to different traffic situations. In some cases, transport times can also be reduced (Finnish Transport Infrastructure Agency 2023).
  - Improving the efficiency of the use of existing rail capacity without major track investments is a cost-effective and rapid way to increase rail transport and thereby reduce emissions.
  - More detailed impact assessments have been prepared on a project-by-project basis.

Rail Section	Key Rail Network Capacity Constraints (Transport Infrastructure Agency 2023)	Projects and studies
(Helsinki–)Riihimäki-Oulu (Main Line)	No acute capacity constraints on the (Helsinki–)Riihimäki–Tampere and Tampere–Seinäjoki sections, but limited potential for increasing freight traffic. Passing loops on the Riihimäki–Toijala section located on the eastern side of the line	(Helsinki–Riihimäki capacity increase 2025) Tampere–Oulu project appraisal, Liminka–Oulu double track
Kemi–Kolari	Laurila–Pello passing loop	Kolari Line needs assessment and project appraisal 2024
Kontiomäki–Oulu	Kontiomäki–Oulu*	New passing loops on the Oulu–Kontiomäki section
Laurila–Patokangas	Need to increase capacity on the Tervola–Rovaniemi–Misi section	Project appraisal 2025
Kouvola–Joensuu (Karelia Line)	Following the Luumäki–Imatra project, capacity constraints will remain on the Luumäki–Joutseno single track section	Completed studies: Lappeenranta double track (2025), Luumäki–Joutseno double track (2025), Imatra–Joensuu needs assessment (2023)
Kouvola–Iisalmi–Kontiomäki (Savonia Line)	Iisalmi–Kontiomäki*, Capacity coordination on the Kouvola–Pieksämäki section is challenging	Capacity improvement on the Iisalmi–Kontiomäki section included in the Finnish Transport Infrastructure Agency investment program 2025–2032, Planning of speed and capacity increases on the Kouvola–Kuopio section (SO)
Tampere–Jyväskylä	On the Orivesi–Jyväskylä section, challenges related to disruption sensitivity and freight train operations	The first phase of the improvement of the Tampere–Jyväskylä rail section was completed in 2025. Rail planning is currently under way, including proposals for double-track sections and a new Lahdenperä–Jämsä rail realignment.
Tampere–Rauma/Pori	A capacity bottleneck on the Tampere Lielahti–Nokia section reduces the operational performance of westbound freight traffic.	General plan for an additional track between Tampere and Nokia (SO)

**The assessment covers main lines only*
SO = Finnish Transport Infrastructure Agency planning programme 2026–2029

Roundwood Loading Sites

- **Current situation**
  - The rail network includes approximately 80 roundwood loading sites, mainly owned by the Finnish Transport Infrastructure Agency and VR Group. Of the Finnish Transport Infrastructure Agency's roundwood terminals, 17 allow the use of electric traction (Finnish Transport Infrastructure Agency 2025).
- **Objectives**
  - According to the Overview of the Rail Network (Finnish Transport Infrastructure Agency 2023), the primary approach to improving the loading site network is to refurbish and develop existing loading sites. Development projects aim, among other things, to enable full-train operations, expand storage areas, and allow the use of loading machinery or electric locomotives. In the future, the ability to handle energy wood at roundwood loading sites also needs to be taken into account.
- **Development outlook**
  - The development of the use of roundwood terminals was most recently assessed in a study commissioned by the Finnish Transport Infrastructure Agency (Lapp and Mäkinen 2023). Sänkimäki, Naarajärvi, Kitee and Hammaslahti were identified as loading sites for development. New loading sites are mainly required if existing sites have to be decommissioned.
  - An updated situational overview of the roundwood loading site network on the rail network will be prepared. A follow-up study and project appraisal will be launched for a new loading site in Iisalmi; a study for a new site in Ylöjärvi was completed in 2025; and planning for a new loading site in Riihimäki is about to begin.
- **Impacts**
  - The impact of the coverage and location of the roundwood terminal network on timber transport costs has been assessed using optimisation calculations (Lapp and Mäkinen 2023).
  - Environmental impacts have been examined in studies of individual loading sites. Terminal development can support emission reductions in rail rolling stock (by enabling longer trains and electric traction). Relocating a loading site farther away from residential areas can reduce the number of people exposed to environmental impacts (in addition to emissions, noise, dust and light) (Finnish Transport Infrastructure Agency 2023).

3. Rolling Stock Emission Reduction Measures Alternative Propulsion Systems 1

- **Current situation**
  - In Finland, the propulsion systems used in rail transport are currently electric, hybrid, and diesel fuel.
  - The share of electric traction in timber transport is presented in slide 8. VR has an extensive procurement programme for electric locomotives under way. Electric locomotives usually also have a diesel engine, enabling the replacement of diesel locomotives in yards, loading areas, and on short non-electrified sections of track (VR Group, undated).
  - The national distribution obligation for bio-based diesel fuel also applies to rail transport. HVO diesel is used in some of UPM's plywood rail transport operations (STT 2024). Renewable diesel fuel is available from Neste (Neste MY) and St1 (HVO). VR is renewing its existing diesel rolling stock, which will improve energy efficiency.
  - The Alternative Fuels Infrastructure Regulation (AFIR) sets objectives for the use of hydrogen- and battery-powered trains on those sections of the TEN-T rail network that cannot be electrified. On non-TEN-T rail sections that cannot be electrified, the regulation requires an assessment of the use of alternative propulsion systems.
- **Objectives**
  - According to the National Alternative Fuel Distribution Infrastructure Programme (Ojala et al. 2024), the objective for rail propulsion systems is to deploy new propulsion options, such as battery-electric solutions, when they are economically viable and effective in reducing emissions. At this stage, no quantitative targets have been set for new propulsion systems.
    - Proposed measures include improvements in the availability of battery- and hydrogen-powered trains, and the consideration of battery-electric trains in cases where rail electrification is too costly or difficult to implement.
  - The Medium-Term Climate Policy Plan (KAISU) (Ministry of the Environment2025) proposes an increase in the distribution obligation for bio-based diesel fuel.

Alternative Propulsion Systems 2

- **Development outlook**
  - The role of **diesel** rolling stock is expected to remain significant as a propulsion option for several decades, and new, more energy-efficient diesel rolling stock will be introduced (Ojala et al. 2024).
  - Rail network **electrification** is discussed in slides 8–11. In the future, once ongoing projects have been completed, further electrification of the rail network may not necessarily be the most cost-effective solution for reducing emissions. In terminals, electrification using overhead lines may be constrained by mobile machinery operating in the area (Ojala et al. 2024; Tikka et al. 2024).
  - In the near future, liquid **biofuels** are considered to have the greatest potential, as they are generally compatible with the existing diesel rolling stock (Tikka et al. 2024). They are also, for the time being, the only emission reduction measure available on non-electrified rail sections. However, wider deployment is constrained by their high cost.
  - **Battery-electric locomotives** for line-haul freight services are not expected in the near future. Battery-electric rolling stock can be utilised most effectively on partially electrified rail sections and in terminals, where synergies may also arise with the charging needs of work machinery and road vehicles (Ojala et al. 2024; Tikka et al. 2024).
  - In Europe, **LNG- and CNG-powered locomotives** are in limited use, but their suitability for freight transport is poor due to restricted operating range (Tikka et al. 2024). The conversion of diesel locomotives to gas propulsion, which has also been considered, is still regarded as too costly a solution (Ojala et al. 2024).
  - **Hydrogen-powered locomotives** are still at the pilot stage and may therefore only offer potential over a longer time horizon (Tikka et al. 2024).
  - Given the long service life of locomotives, **converting diesel locomotives** to alternative propulsion systems may at some point become a cost-effective option (Ojala et al. 2024).

Alternative Propulsion Systems 3

- **Impacts**
  - The emission reduction impacts of electric trains in timber transport are described in slide 11.
  - The cost and emission impacts of liquid bio-based fuels have not been assessed in this study. Their main advantage is that they are compatible with the existing diesel rolling stock, meaning that transport equipment does not need to be replaced.
  - Responsibilities related to the distribution infrastructure for other propulsion systems (plug-in charging of batteries instead of overhead line charging, and hydrogen distribution) are unclear (Tikka et al. 2024).
  - Hydrogen-powered locomotives are still clearly expensive and therefore not cost-competitive in freight transport (Finnish Transport Infrastructure Agency 2023; Tikka et al. 2024).

Long Roundwood Trains 1

Photo: VR

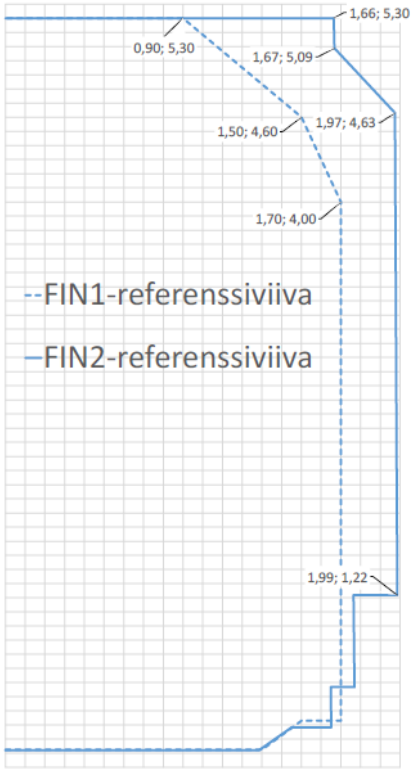
- **Current status**
  - In Sp timber wagons, operations have largely shifted from 24 to 25 wagons per train, and the longest trains comprise 30 wagons. The longest trains using Snps wagons consist of 27 wagons. Trains with 40 GOST wagons operate from the Port of HaminaKotka to the Imatra mills. (MetsäTrans 2023; Pitkänen et al. 2025).
  - In roundwood transport, trains are typically under 600 m in length. Trains longer than 615 m operate on parts of the rail network. In a study by the Finnish Transport Infrastructure Agency, long trains were defined as trains of at least 700 m (Pitkänen et al. 2025).
  - The track lengths of passing loops and yards affect current operations, particularly for roundwood transport. Challenges related to passing-loop track lengths are distributed across Finland. There has also been a need for longer tracks at roundwood loading sites (Pitkänen et al. 2020; Pitkänen et al. 2025).
- **Objectives**
  - The TEN-T Regulation (2024/2019) sets requirements for Member States regarding routes and terminals for trains of at least 740 m in length. These requirements are not directly binding on Finland.

Long Roundwood Trains 2

- **Development outlook**
  - In rail transport for other product groups, trains longer than roundwood trains are already in use, indicating that the rail network offers potential for increasing the length of roundwood trains on certain routes. Modern electric locomotives have higher tractive power, and rail network electrification may therefore also support increases in train length (Pitkänen et al. 2025).
  - Increasing the operation of long trains would require the removal of certain rail infrastructure constraints. A study by the Finnish Transport Infrastructure Agency (Pitkänen et al. 2025) recommends preparing for the operation of trains of at least 750 m in length, particularly on the Main Line, the Savonia line and the Karelia line. Constraints to be addressed may also relate to the lengths of reception tracks and private sidings, marshalling yards and roundwood terminals. For new and upgraded roundwood loading sites, the study recommends tracks with an operational length of at least 700 m.
- **Impacts**
  - The emission impacts of long trains have not been assessed, but they are assumed to generate savings. The cost impacts of longer trains are influenced by factors such as the optimal use of locomotive tractive power, infrastructure characteristics on different routes, and required changes in terminal handling and storage. Therefore, the use of long trains should be assessed on a case-by-case basis (Pitkänen et al. 2025).

Larger Wagons

- **Current situation**
  - In Finland, the FIN1 loading gauge is currently in use for railway wagons. The University of Oulu has investigated the potential for increasing the loading gauge, i.e. widening and raising railway wagons (Hölsä 2024; Hinkkanen 2025). The final report will be completed in summer 2026.
- **Objectives**
  - At present, there are no specific objectives for enabling the operation of larger wagons. Larger wagons would, among other things, promote more efficient utilisation of rail capacity.
- **Development outlook**
  - No national decision has yet been made on the introduction of a new loading gauge.
- **Impacts**
  - According to an earlier assessment, under the FIN2 loading gauge the cross-sectional area of Snps timber wagons would increase by 9.8% and that of Fakks chip wagons by 9.4% at the wagon ends and by 10.8% at the centre of the wagon (Hölsä 2024). The figures will be refined in the final research report. Cost and emission impacts have not been assessed, but they are assumed to decrease per unit of payload.



Hölsä 2024

Taxation

- In Finland, a comprehensive reform of transport taxation and financing (VERA) is under way.
  - Project page: https://valtioneuvosto.fi/hanke?tunnus=LVM013:00/2024
- The first background report on the current situation as part of the reform process has been completed (Ministry of Transport and Communications and Ministry of Finance 2026).
  - Electricity used in rail transport is exempt from energy tax and the security of supply fee by national decision.
  - Diesel locomotives and rail maintenance machinery use fuel oil that is taxed at a lower rate than diesel.
    - At national level, fuel oil used in rail transport will not be included in the emissions trading scheme for fossil fuel distribution starting in 2028.

4. Conclusions and Further Research Needs

- Rail transport accounts for a large share of domestic timber transport in Finland. Conversely, timber transport represents a significant proportion of Finland's overall rail traffic.
  - The development of rail-based timber transport volumes and the reduction of related emissions therefore have an important national role.
- There is very limited publicly available information on the cost impacts of emission reduction measures in rail transport, making it difficult to compare their cost-effectiveness with measures in other transport modes.
- Ongoing rail network electrification projects, as well as the procurement of electric and diesel locomotives by rail freight operators, will reduce emissions from rail transport. In addition, further electrification needs have been identified (including short non-electrified sections that prevent the use of electric locomotives over longer distances).
- Responsibilities related to the distribution infrastructure for new propulsion systems in rail transport are partly unclear (Tikka et al. 2024).
  - The largest roundwood loading sites could also be attractive locations for the electrification of work machinery, highlighting the need to clarify the division of responsibilities.
- In addition to electrification, the study describes other measures that can generally improve the performance of rail transport and thus increase transport volumes (rail network capacity, long trains, and larger wagons). Rail capacity management will develop further through the ongoing DigiRail project.
- This study has primarily drawn on ad hoc assessments by the Finnish Transport Infrastructure Agency concerning propulsion systems and rail infrastructure.
  - To continue describing the current status, development outlook, and identified action needs for emission reduction measures in rail transport, similar assessments will also be required in the future.

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