

Anonymised Management Summary

Railway infrastructure is significantly more expensive to maintain and renew than road infrastructure and despite receiving additional funding between 2022 and 2035, Banedanmark's backlog is increasing. Against this background, the Danish Ministry of Transport commissioned an analysis and assessment of the cost level of Denmark's railway infrastructure, comparing it to other countries' infrastructure as well as to the road sector.

The analysis focuses on maintenance and renewal costs. **Maintenance** refers to activities that help to maintain the condition and capability of the existing infrastructure or to optimise asset lifetimes. **Renewal** is defined as more substantial works involving major substitution work on the existing infrastructure not changing its original performance. To perform the analysis a mix of qualitative and quantitative methods was used.

This management summary presents the key findings of the report. It begins with the main outcomes specific to Denmark's rail infrastructure. The second section provides a benchmark comparison with other major European rail infrastructure managers. The third section highlights key findings from the rail-road comparison, including the road equivalent of rail across the benchmarking participants' countries. To protect confidential information from international peers, the results have been anonymised.

1. Railway infrastructure in Denmark

The comparative cost analysis included Banedanmark's main lines, regional lines and S-Bane as well as Danish private lines. In the report, we define performance as utilisation and transport volume throughout. In summary, **a significant financing gap is present for Banedanmark's network segments** as almost DKK 23 billion DKK are not financed in the period 2022-2030 (Figure 1). This may result in deferred renewals and a degrading network condition, leading to potentially larger maintenance and total lifecycle costs as well as reduced performance levels.

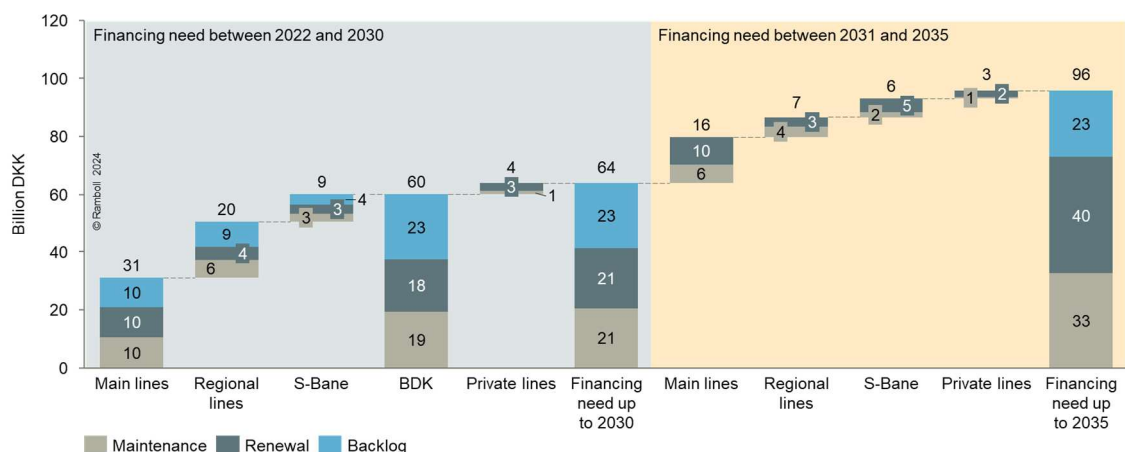


Figure 1: Overview of costs for Danish railway infrastructure

The situation regarding financing needs and performance differs across the different network segments:

- S-Bane is the best performing network segment due to a balanced relationship between costs and performance. Although costs are relatively high compared to its network size, they decrease in relation to their high utilisation and passenger volumes. Like main lines, around 1/3 of the necessary renewal works are in backlog. Though, S-Bane is prioritized due to its high utilization and more money is spent on renewal than on maintenance. The distribution of costs across asset categories differs from other network segments, due to higher electrification levels and the new signalling system. Still, track is the most influential.
- Main lines exhibit comparably high costs due to the network size, and like S-Bane costs per passenger-km and freight-tonne-km are relatively low. Main lines are the only network segment with a higher level of freight transport. The network utilisation is on a medium level, closer to regional lines than S-Bane. Signalling and predominately track activities account for more than 70% of costs. The backlog, accounting for one third of the financing need, presents a risk for main lines, potentially increasing the total cost of ownership.
- Regional lines have the lowest network utilisation and the highest costs in relation to passenger volume. The composition of the financing need reveals that the backlog for regional lines, consisting mainly of works on track and bridges, accounts for almost 50 % of their financing need and that maintenance is prioritized over renewal. The backlog may cause higher costs and deteriorate the network condition in the future. In sum, regional lines require detailed analysis to identify which lines account for the backlog and / or are underutilised.
- Private railways exhibit the lowest financing need on a total level and claim to have no backlog. Network utilisation on these lines is relatively high, while the passenger volume is the lowest. This leads to an average cost level per passenger-km which is lower than at Banedanmark's

regional lines. Compared to regional lines, the costs per kilometre of track are lower, probably because private railways can realise lower unit costs for maintenance and renewal activities. However, it should be noted that the available data carries a higher degree of uncertainty compared to Banedanmark's evaluations, potentially leading to an underestimation of the actual costs. Additionally, the absence of a backlog should be interpreted with caution.

Across all network segments, track is the asset category contributing most to maintenance, renewal, and backlog costs. In near future, bridge renewals are prevalent for Banedanmark. Once network segments are electrified, catenary is also an influential asset category. Furthermore, the introduction of ERTMS increases costs for Banedanmark.

2. Railway infrastructure benchmarking analysis

The benchmarking analysis for maintenance and renewal costs for railway infrastructure included the main and regional network of four European infrastructure managers. All cost data is presented in DKK and normalized using the Price Level Indexing (PLI), aligning different price levels with those of Denmark for comparability. The analysis resulted in the following highlights:

- The backlog is a core concept in this analysis, defined as the gap between the real financing need and the allocated, constrained budget. The allocated budget alone often fails to reflect the funding required to maintain a railway network in steady-state condition. Across European railway managers, financing needs typically exceed available funds, leading to backlogs. For meaningful comparisons, it is essential to consider the true financing need, including all measures required to maintain the network's condition and functionality without budget constraints. A backlog indicates that the technical-economic lifespan is exceeded, infrastructure functionalities are reduced, and maintenance costs may increase due to more frequent repairs.
- The financing needs of infrastructure managers are calculated using various methods, with three of the international infrastructure managers utilising some of the most advanced Life Cycle Cost (LCC) models. However, since the factors and scenarios included in each model differ, comparability is limited, and certain aspects of the comparison may remain uncertain.
- Banedanmark's absolute average annual costs for the regional and mainline network are the lowest in the sample. Two of the peers need twice the budget while one requires a four times higher budget. (Figure 2)

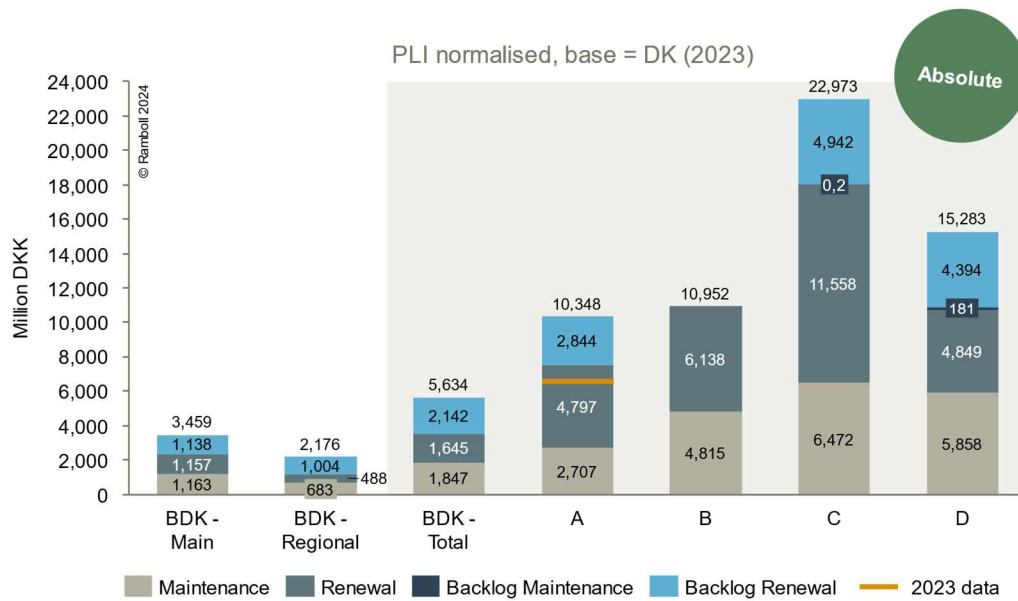


Figure 2: Overview of costs (absolute value)

- In relation to network size, Banedanmark's spending is average within the group and closest to company B. (Figure 3)

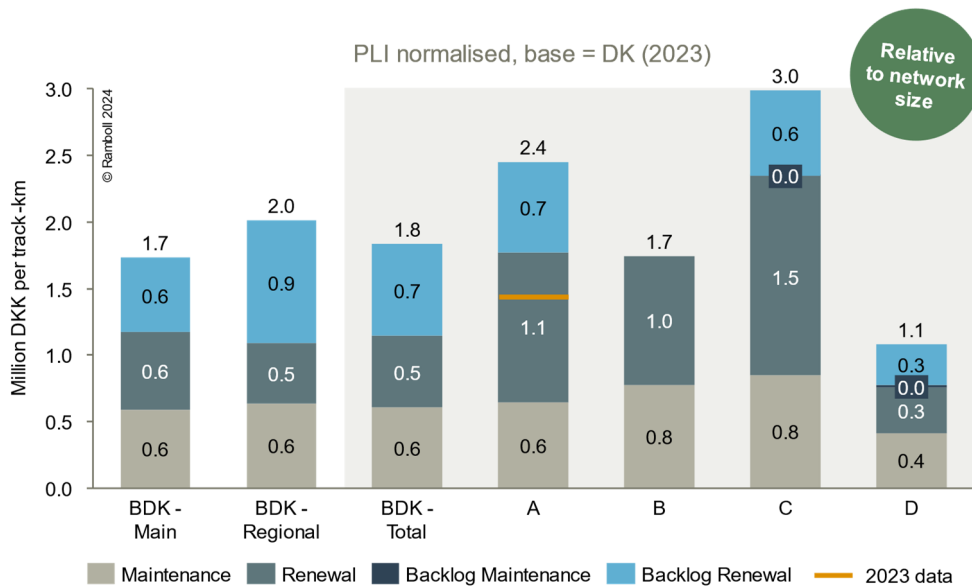


Figure 3: Overview of costs per track-km

- When relating costs to train-kilometres, Banedanmark is comparable to Company C and D with 107 DKK per train km. (Figure 4)

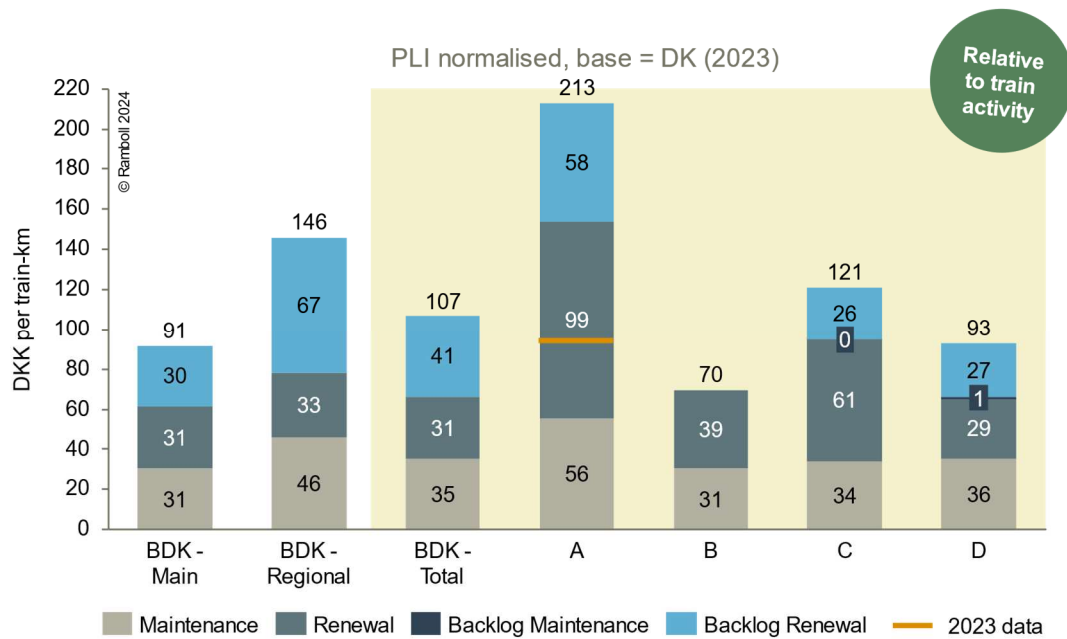


Figure 4: Overview of costs per train-km

- In relation to passenger volumes, Banedanmark's main line costs are similar to C and D. Regional lines are more than twice as expensive indicating potential to reduce costs. (Figure 5)

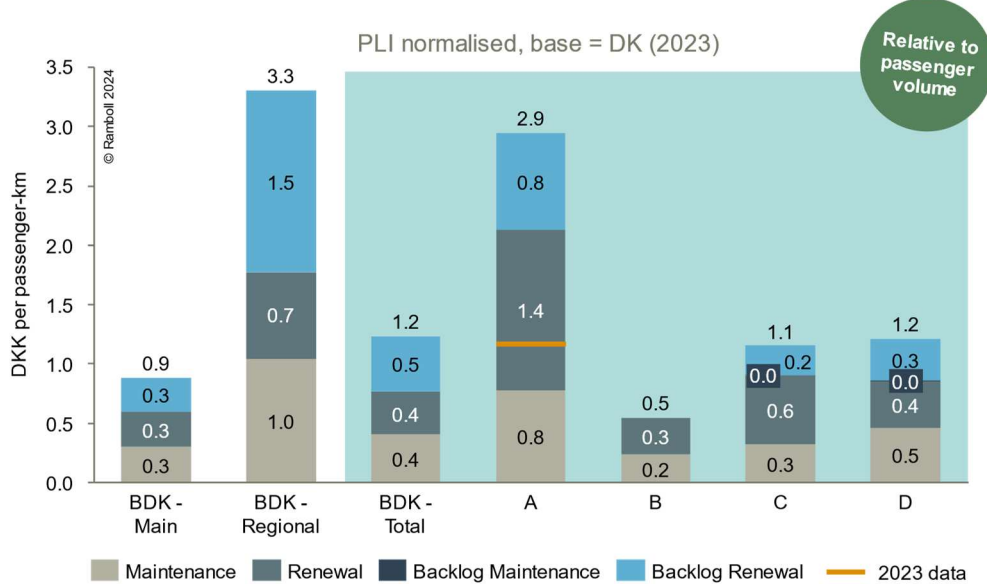


Figure 5: Overview of costs per passenger-km

- All infrastructure managers except for one show a backlog. Banedanmark's backlog is highest, except for company A.

- Other infrastructure managers spend more on renewals than on maintenance in comparison to Banedanmark.
- The asset categories track and signalling are absorbing most of the budget. Hence, their optimisation is relevant. The infrastructure managers expressed their concerns that ERTMS has a cost-reduction potential only in the long run.

Moreover, Banedanmark's costs for regional lines are compared to private lines in Denmark and abroad. The costs of Denmark's private infrastructure managers seem to be competitive in comparison, while the regional lines' financing need per train-kilometre is more than twice as high as the other private lines. Banedanmark is the only infrastructure manager indicating a backlog in this comparison and strongly focusing on maintenance.

As part of the qualitative analysis, possession regimes and their impact are analysed. Overall, **maintenance and renewal activities should be given a higher priority** when defining possessions. Longer time slots and full closures result in increased workforce safety, higher operational efficiency and help to adapt to current market conditions, e.g. increasing competition and shortage of skilled workforce. Hence, enabling maintenance and renewal activities to take place during weekdays and daytime hours is becoming more essential for in-house activities and outsourced contracts. The analysis of the market environment revealed that infrastructure managers observe **large price increases** and expect further price increases in the future. Furthermore, it is recognised that more flexibility and a partnership approach with contractors are required.

3. Road benchmarking analysis

The benchmarking analysis for the road infrastructure includes four road infrastructure companies and focuses on the state roads in their networks. Though, the composition of the networks and their complexity differ across the countries. Hence, the comparability was limited. The costs for maintenance and renewal in Denmark amount to DKK 0.03 per passenger-km and to DKK 0.07 per freight-tonne-km. In the sample, **Danish state roads are the least cost-intensive**, amounting 20 % or less of the costs in the other networks. Moreover, Danish state roads exhibit no backlog.

Cost comparison including externalities for road and rail infrastructure

As the analysis aims to investigate a more comprehensive view of the costs of rail and road infrastructure, external costs for both networks are included. However, these costs only refer to costs for renewal and maintenance, including the backlog and societal effects represented by external costs. System costs, such as operational costs, vehicle costs, subsidies, and taxes, are not taken into account.

The calculation of the external costs is based on a method by the European Commission and focuses on external costs for accidents, air pollution, climate change, noise, congestion, well-to-

tank emissions, and habitat damage. Across the considered networks external costs for rail are significantly lower than the external costs for road. In Denmark, the external costs for rail are one third of the external costs for road.

The comparison between the infrastructure costs including external costs for rail and road in the sample revealed differing results for passenger and freight transport.

- In Denmark, for passenger traffic, when including externalities, costs for rail are higher than for road, which is also the case for country D. In countries B and C the unit costs for passenger-km are very similar for rail and road. In country A rail is significantly less expensive when including external costs (Figure 6).

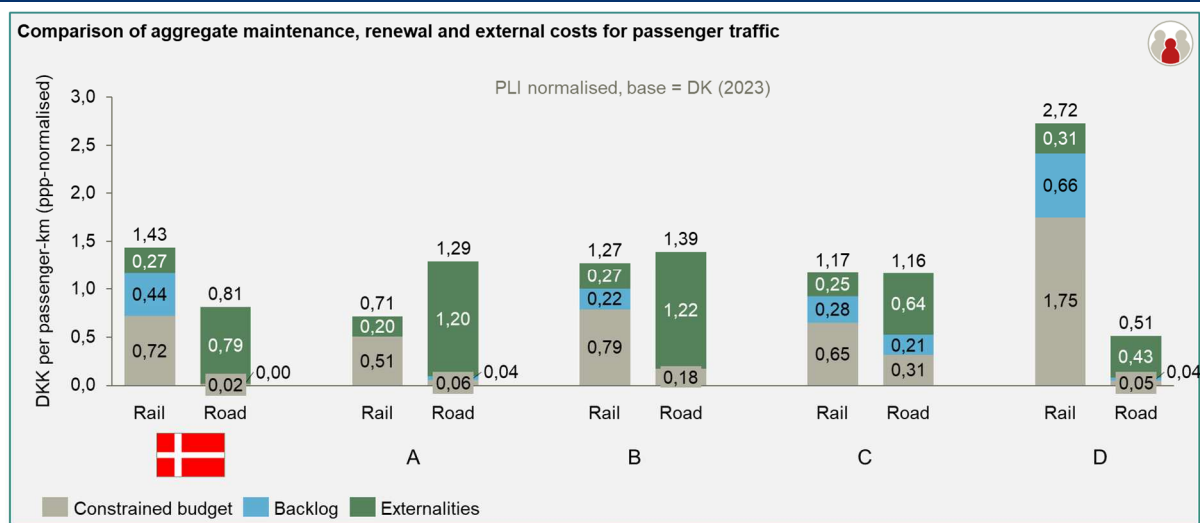


Figure 6: Cost comparison between road and rail for passenger transport

- When looking at freight transport, the picture changes significantly. In all countries except country D, freight transport on the road becomes considerably more expensive. In Denmark, the cost of road freight transport is more than double that of other modes, highlighting the higher external costs associated with road (Figure 7).

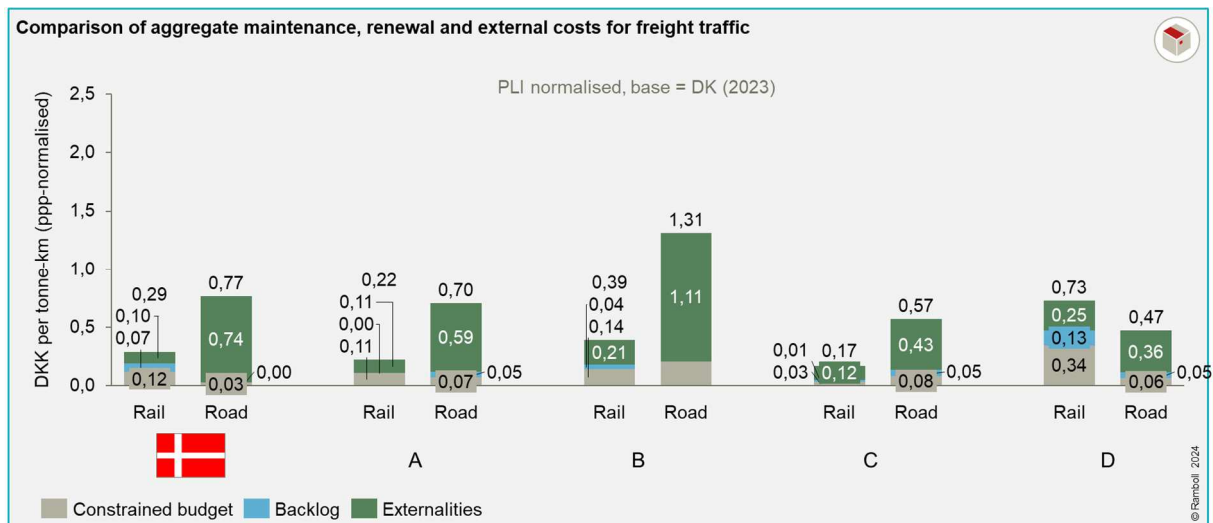


Figure 7: Cost comparison between road and rail for freight transport

To enhance the competitiveness of rail transport compared to road one can either increase passenger volume, without increasing costs, or reduce costs for maintenance and renewal.

However, increasing passenger volumes has been a long-standing goal in European politics for decades. It is therefore unlikely that there is a potential for significant growth in rail use without a significant increase in expenditure, making cost-reduction measures important.

Cost-reduction measures

As part of the analysis, a set of cost-reduction measures is proposed and their transferability to Banedanmark's network segments is assessed (Figure 8:). Banedanmark has already initiated initiatives regarding closer contractor relationship and reduction in switch density. Banedanmark agrees that there is a potential in reducing cost by optimizing asset management, which is already a part of Banedanmarks strategy. Furthermore, Banedanmark remarks, that extended possession

management can lead to a cost reduction, but should always be offset relative to securing the train traffic on the main line.

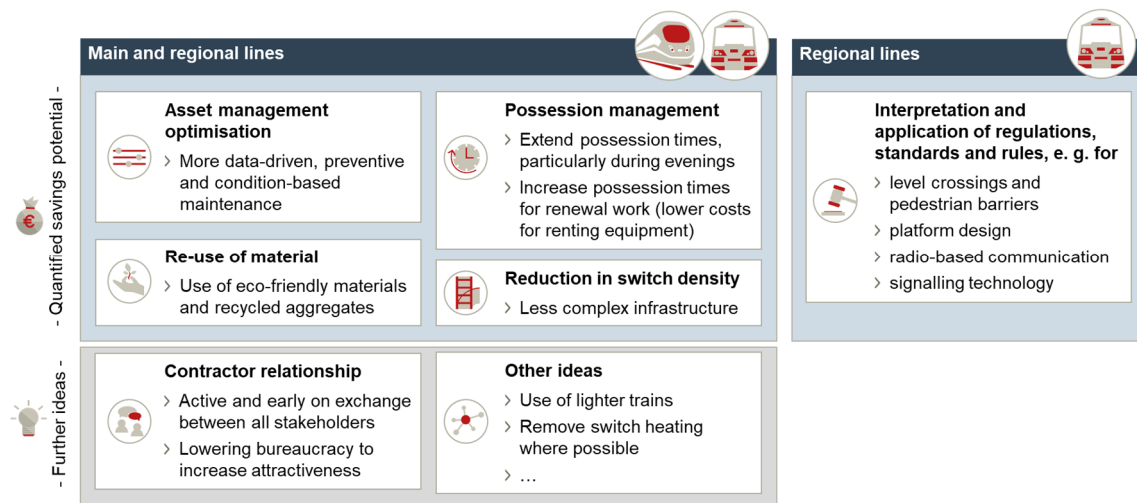


Figure 8: Overview of potential cost reduction measures

Recommendations

In Denmark one third of the financing need for Banedanmark's network segments until 2030 consists of the **backlog**. The backlog potentially leads to deferred renewal, a sub-optimal network condition, and more failures (as indicated by quality parameters), decreasing the quality of Banedanmark's network performance. Thus, more corrective maintenance and higher total costs can occur in the future.

To mitigate these consequences, the reduction of the backlog for main lines and regional should be prioritised, focusing on main lines. For regional lines a further assessment on a line-by-line basis is needed to identify their specific cost benefit ratios. Furthermore, **transparency** regarding the condition of asset categories in the network segments needs to be increased to be able to closer monitor its development.

The analysis revealed that the competitive position of Banedanmark's regional lines is weaker than that of its peers in Denmark and abroad. Hence, the future of **individual regional lines** and their competitiveness should be further assessed in detail and decisions need to be taken on a case-by-case basis. The analysis can help to assess which kind of cost-reduction measure is most suitable to reduce costs:

- Lowering technical standards for viable regional lines
- Discontinuing specific line segments for underutilized and costly lines
- For lines with very low passenger volumes, exploring a shift from rail to road transport (both public and private) with a strict focus on electrifying the designated road segments and developing the necessary infrastructure

- Analysing ways to adapt rail freight services to better meet customer needs, promoting a shift from road to rail for freight transport

Furthermore, cost-reduction measures for **main and regional lines** should be considered:

- Optimization of the current possession management regime by considering a prioritization of maintenance and renewal activities
- Implementation of state-of-the-art asset management practices by consequently moving on towards a data-driven, preventive, and condition-based maintenance approach
- Reduction of the complexity of the network by lowering the number of assets such as switches both in Banedanmark's main and regional lines
- Investigation of the potential of recycling and reuse of material
- Further explore the consequences of climate change and their impact on future financing needs and the performance of railway infrastructure