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INNOVATIVE FINANCIAL SUPPORT FOR TRANSPORT INFRASTRUCTURE DECARBONISATION UNDER UKRAINE'S POST-WAR RECOVERY

In the context of contemporary global transformations, the transition towards low-carbon models of infrastructure development has emerged as a key dimension of sustainable economic growth and structural modernisation. For Ukraine, this challenge has acquired particular significance in the context of post-war recovery, which requires the reconciliation of large-scale reconstruction efforts with the fulfilment of international climate commitments [1] and deeper integration into the European economic space [2; 3]. As a fundamental component of mobility provision, logistics connectivity, and external economic activity, transport infrastructure remains one of the largest consumers of fossil fuels and a major source of greenhouse gas emissions. Against this backdrop, the decarbonisation of the transport sector should be viewed not merely as an environmental objective, but as an essential element of economic reconstructing aimed at enhancing productivity, resilience, and long-term competitiveness.

However, the successful implementation of low-carbon transport infrastructure projects increasingly depends on the ability of the economy to mobilise long-term capital under affordable financing conditions rather than solely on the availability of technological solutions. Consequently, the financing of decarbonisation has evolved into a distinct policy challenge and an increasingly important determinant of both structural transformation and post-war recovery in Ukraine. A defining characteristic of transport infrastructure decarbonisation projects is their high capital intensity, substantial demand for long-term investment resources, and strong sensitivity to the cost of capital. As a result, financing conditions play a crucial role in shaping the pace and scale of low-carbon modernisation within the transport sector.

To assess the implications of financing conditions for the implementation of decarbonisation projects, the railway sector was selected as a representative case study. Rail transport constitutes one of the

most capital-intensive areas of low-carbon modernisation while simultaneously offering the greatest potential for reducing fossil fuel consumption through the expansion of electric traction. At the same time, the current state of the sector reveals substantial investment requirements and accumulated structural imbalances. Between 2000 and 2023, the number of diesel locomotives declined from 2,741 to 1,958 units, electric locomotives from 1,796 to 1,595 units, and passenger railcars from 9.0 thousand to 3.7 thousand units [4] (Table 1). These trends indicate a gradual erosion of the sector's productive capacity and point to growing financing requirements for the renewal and modernisation of rolling stock.

Table 1

Railway ROLLING STOCK in Ukraine, 2000–2023

Rolling stock	2000	2010	2014	2023
Diesel locomotives, units	2741,0	2539,0	2152,0	1958,0
Electric locomotives, units	1796,0	1861,0	1720,0	1595,0
Steam locomotives, units	140,0	51,0	24,0	22,0
Freight wagons, thousand units	185,7	120,6	111,5	118,3
Passenger railcars, thousand units	9,0	7,3	5,4	3,7

Source: compiled by the author [4]

The challenge extends beyond the decline in the size of the rolling stock fleet to its pronounced physical and technological obsolescence. As of 2023, more than 69% of electric locomotives, 41.7% of diesel locomotives, and 82.4% of passenger coaches had been in operation for over 40 years [3]. This indicates a substantial investment backlog in the renewal of railway assets and highlights the need for large-scale capital investment, not only to maintain the operational capacity of the sector but also to support its low-carbon transformation.

A further infrastructure constraint is the insufficient level of railway electrification. While the share of electrified railway lines increased from 41% in 2000 to 47% in 2017, more than half of the network continues to reply on diesel traction [4]. This dependence on fossil fuels limits the decarbonisation potential of the railway sector and underscores the scale of investment required to achieve a sustainable transition towards low-carbon transport infrastructure.

The evidence presented above suggests that achieving the decarbonisation objectives of Ukraine's transport sector will require substantial financing resources. According to available estimates, the investment required for the electrification of railway infrastructure alone exceeds UAH 224 billion, excluding expenditures associated with rolling

stock renewal, traction substation modernisation, the deployment of digital traffic management systems, and related infrastructure upgrades [5]. Consequently, the challenge of transport infrastructure decarbonisation increasingly assumes a financial and investment dimension.

The empirical analysis reveals a strong relationship between monetary conditions and investment activity in the transport sector. Assessed on data for 2015 – 2024, a significant positive correlation was identified between the policy rate of the National Bank of Ukraine and the average lending rates applied to non-financial corporations (r = 0.74), reaching 0.88 – 0.92 in the pre-war period. The results further indicate that a one-percentage-point increase in lending rates is associated with an approximately 1.5% decline in capital investment in the transport sector. These findings confirm the critical role of financing costs in determining the scale and pace of infrastructure modernisation.

To assess the practical implications of capital costs for decarbonisation projects, the electrification of railway infrastructure was examined as a representative case. The results indicate that the annual operational benefits generated by replacing diesel traction with electric traction amounts to approximately UAH 1.91 billion. This benefit is primarily driven by lower fuel consumption and reduced rolling stock maintenance costs. However, for a project with an estimated investment requirement of UAH 224 billion, annual capital servicing costs range from UAH 19.9 billion to UAH 38.5 billion, depending on the cost of financing. Consequently, projected operational gains remain significantly below annual financing requirements, underscoring the pivotal role of financing mechanisms in determining the feasibility of large-scale decarbonization investments (Table 2).

Table 2

Operational benefits versus financing costs of railway electrification

Indicator	Symbol	Value
Initial investment requirement	I_o	UAH 224 billion
Estimated annual operational benefit	*CF*	UAH 1,91 billion
Evaluation period	*T*	20 years
Cumulative operational benefit (undiscounted)	*CF x T*	UAH 38,2 billion
Annual financing cost at 8.9% interest rate (2021 p)		UAH 19,9 billion
Annual financing cost at 14.1% interest rate (2022 p)		UAH 31,6 billion
Annual financing cost at 17.2% interest rate (2023 p)		UAH 38,5 billion
Annual financing cost at 14.9% interest rate (2024 p)		UAH 33,4 billion

Note: I_o represents the estimated investment requirement for the electrification of diesel-operated railway sections, calculated proportionally on the basis of the planned investment programme of Ukrainian Railways (JSC Ukrzaliznytsia) through 2030.

Source: author's calculations based on [6]

The findings suggest that the implementation of transport infrastructure decarbonization projects increasingly depends on the effectiveness of capital mobilization mechanisms and the availability of financing on sustainable terms. The gap between annual financing costs (UAG 19.9 – 38.5 billion) and the estimated operational benefits of railway electrification (UAH 1.91 billion per year) highlights the limitations of conventional financing approaches and points to the need for a transition towards an innovative financing framework. Such a framework may combine the resources of international financial institutions, blended finance instruments, state guarantees, climate funds, and public-private partnership mechanisms. The potential of these instruments to support the low-carbon modernization of Ukraine's transport infrastructure warrants further investigation, particularly in the context of post-war reconstruction and sustainable economic development.

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