

Title: A PROTOCOL FOR TRANSPORT DECARBONISATION: THE ITALIAN RAILWAY CASE

Short Abstract: Decarbonising transport is a critical challenge for Europe's energy transition, yet current analytical tools remain fragmented. This seminar presents a novel five-step Protocol for holistic decarbonisation analysis, validated on the Italian railway system. By integrating energy demand modelling, renewable optimisation at station level, and national energy system scenarios, the framework bridges infrastructure-level modelling with whole-system planning. Results show that conventional aggregated models systematically underestimate infrastructure costs and investment needs. Offering specificity, robustness, and transferability, this approach delivers evidence-based policy recommendations for governments and operators, fundamentally reshaping investment priorities compared to fragmented, traditional approaches.

Long Abstract: The decarbonisation of the transport sector remains one of the most persistent challenges of the European energy transition. Despite ambitious policy frameworks like the European Green Deal and Italy's PNIEC, analytical tools for transport planning remain fragmented: demand models, techno-economic assessments, and national energy system optimisation are typically developed in isolation, preventing coherent evaluation of infrastructure investment, energy supply, and policy targets.

This presentation introduces a replicable five-step Protocol for holistic decarbonisation analysis, applied for the first time at full scale to the Italian railway system. The Protocol integrates: a unified system taxonomy; bottom-up energy demand models for stations and rolling stock; techno-economic optimisation of renewable integration at station level; and a disaggregated national Energy System Optimisation Model (ESOM) with multi-criteria assessment, culminating in evidence-based policy recommendations.

Rail is selected as the proof-of-concept sector due to its high electrification rate and strategic relevance. The framework demonstrates that conventional aggregated national models systematically underestimate railway infrastructure costs and misrepresent the value of demand-side management. By linking infrastructure modelling to national energy scenarios via open-source tools, the Protocol meets four criteria of evidence-based policymaking: specificity, robustness, attribution, and transferability. The research shows that integrated modelling fundamentally changes cost estimates and policy priorities, offering a transferable analytical architecture for governments, railway operators, and energy planners designing credible, transparent decarbonisation strategies.