A Sequential Optimization-Simulation Approach for Planning the Transition to the Low Carbon Freight System with Case Study in the North Island of New Zealand

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Abstract: Freight movement has always been, and always will be an essential activity. Freight transport is one of the most challenging sectors to transition to net-zero carbon. Traffic assignment, mode allocation, network planning, hub location, train scheduling and terminal design problem- solving have previously been used to address cost and operation efficiencies. In this study, the interdisciplinary transition innovation, management and engineering (InTIME) methodology was used for the conceptualization, redesign and redevelopment of the existing freight systems to achieve a downshift in fossil energy consumption. The fourth step of the InTIME methodology is the conceptualization of a long-term future intermodal transport system that can serve the current freight task. The novelty of our approach stands in considering the full range of freight supply chain factors as a whole, using an optimization-simulation approach as if we were designing the low-carbon system of 2121. For the optimization, ArcGIS software was used to set up a multimodal network model. Route and mode selection were delivered through the optimization of energy use within the network. Complementarily, Anylogic software was used to build a GIS-based discrete event simulation model and set up different experiments to enhance the solution offered by the network analysis. The results outline the resources needed (i.e., number of railway tracks, train speed, size of railyards, number of cranes and forklifts at terminals) to serve the freight task. The results can be backcast to reveal the most efficient investments in the near term. In the case of New Zealand's North Island, the implementation of strategic terminals, with corresponding handling resources and railyards, could deliver 47% emissions reduction from the sector by 2030, ahead of longer lead-time upgrades like electrification of the railway infrastructure.