

New Zealand's energy transition: Evaluating potential technology trajectories and costs of CO₂ emissions in transportation using the NZIES model

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Abstract: This study presents the New Zealand Integrated Energy System (NZIES) model, a linear programming TIMES (The Integrated MARKAL-EFOM System) model designed to optimize New Zealand's energy system transformation. The NZIES model considers a wide range of energy carriers, including oil, natural gas, coal, hydroelectric power, wind power, solar power, and biomass energy, and covers a time from 2015 to 2050, divided into five five-year periods.

The NZIES model comprises decision variables, objective functions, and constraints. Decision variables represent the options available to decision-makers, while the objective function represents the goal pursued using the decision variables. Constraints are the limitations on the decision variables, expressed as inequalities or equations.

Using the NZIES model, this study predicts fuel selection, energy technology pathways, and CO₂ emissions for different policies currently or potentially implemented in New Zealand's energy sector. The model mainly considers the advantages of the transportation sector, including technical details and the interaction between traditional fossil fuels and renewable energy sources such as hydrogen. Energy demand is divided into several sectors: industrial, transport, building, agriculture, fisheries, and other industries. While the transport sector is divided into sub-sectors, including road, air, maritime, and rail transport, each with different energy service demands.

The study uses the NZIES model to calculate the costs of reducing CO₂ emissions and the potential for reducing emissions of different transportation technologies to develop a cost-effective path for New Zealand's transportation sector. It constructs the marginal abatement cost curve (MAC) of emissions and examines the influence of New Zealand's 2050 net-zero goal, the energy consumption preferences of electric vehicle drivers, and other unpredictable factors on the technological trajectory of the transportation industry. The study subdivides the transport sector into three sub-sectors: urban passenger transport, intercity passenger transport, and freight transport. The study aims to answer questions such as the carbon emission reduction trajectory of the urban passenger transport sector when almost all travel modes are examined and how the three sub-sectors bear the cost of reducing emissions. The study also examines the impact of policies, energy prices, discount rates, transportation demand, and other factors on the potential for reducing emissions and the MAC of the transportation sectors.

In summary, the NZIES model provides policymakers with a valuable tool to choose and develop effective low-carbon technologies to reduce the total carbon emissions of New Zealand's transportation sector. The study's results can help design and implement policies and measures that promote sustainable development and help achieve New Zealand's net-zero emissions target by 2050.

Keywords: *Transport emissions, NZIES model, marginal abatement cost curve*