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Summary

Developing methods and processes for analyzing strategies towards a carbon-neutral transport sector in 2050

New modelling approaches and example strategies

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How can we plan for a carbon-neutral transport sector in 2050? Such planning requires a systematic process for identifying policy packages that can drive the transport sector towards the target. This type of process may be referred to as *backcasting*. In this project, we further develop the backcasting approach by specifying alternative strategies in a way that makes them suitable for testing in both transport models and macroeconomic models. This enables assessing the strategies quantitatively.

We have also developed a process for coordinated execution of the different models— often referred to as soft-linking. Using this modelling framework, we have tested four example strategies. The soft-linking setup produces reasonable and consistent results. Although some parts of the modelling framework still require further refinement, the overall system provides a solid foundation for continued work. The approach demonstrates that combining backcasting with existing modelling tools can be an effective way to analyse transport strategies and be useful in developing the National Transport Plan.

In 2025, the Norwegian Ministry of Transport is considering whether *vision-led planning* can become part of national transport planning. The ministry has commissioned the National Transport Plan methods group to assess how and to what extent the analytical basis for evaluating goal attainment and future transport demand can be improved. This includes testing a *backcasting* process and identifying which methods are best suited to support vision-led planning. The Institute of Transport Economics has provided support and expertise for this process, which involves:

1. establishing a methodology for translating backcasting into modelling and analysis,
2. developing a process for coordinated use of a suite of transport models and a regional macroeconomic general equilibrium model,
3. testing this new modelling process on example strategies for achieving a carbon-neutral transport sector by 2050,
4. and assessing how societal benefits of selected projects may vary under different strategic assumptions.

An eight-step process for selecting policy measures for strategies

The report presents an eight-step process designed to analyze alternative strategies for achieving a low-emission society, using the transport models RTM (regional transport models for short trips up to 70 km), NTM6 (a national transport model for passenger trips above 70 km), NGM (freight transport model), and NOREG 2 (a macroeconomic model). The process bridges early-stage qualitative work—such as trend analyses, scenario development, and goal definition— with the **identification of strategies and concrete policy packages that can be analyzed in quantitative models**.

In parallel, an Excel-based tool was developed to support the process, allowing systematic assessments (both individually and in groups) and decisions to be made at each step leading up to the model-based analyses. The Excel file also includes a comprehensive list of potential policy instruments, with descriptions of how they can be implemented in the models.

The eight steps of the process are outlined in the report, and each step is explained in detail through a running example. The process starts by establishing a reference pathway ("Frozen Policy") and an EU policy implementation pathway (where *ReFuelEU Aviation* and *FuelEU Maritime* are implemented), before analyzing remaining emissions in 2050, identifying measures addressing these emissions, assessing their qualitative effect, prioritizing the most effective ones, and linking them with supporting policy instruments. Finally, combinations of measures are assembled into four strategic pathways based on the *Avoid–Shift–Improve (ASI)* framework, each aiming for a carbon-neutral transport sector by 2050.

The modelling of these four example strategies was carried out using RTM, NTM6, NGM and NOREG 2. The coordinated use of these models (*soft-linking*) allows the systems to exchange results iteratively, thereby achieving partial convergence. The soft-linked framework now operates efficiently and produces reasonable, internally consistent results. While some model components require further development, the overall framework provides a robust foundation for subsequent analyses.

Insights from the eight-step process

Insight 1: Regardless of whether *ReFuelEU Aviation* and *FuelEU Maritime* are treated as part of the reference pathway or as a common component of all strategy pathways, these EU regulations are highly influential. They are likely to deliver the largest emission reductions along the pathway from the "Frozen Policy" baseline towards a zero-emission transport sector, and they also account for a large share of the total costs of achieving the low-emission society.

Insight 2: Achieving zero emissions from transport by 2050 requires that all transport activities are based on zero-emission solutions, meaning that transport must have a CO_2 intensity of zero per unit of energy used—through electric propulsion, advanced biofuels, synthetic fuels, or muscle power in active transport. This follows directly from the *transport emission identity*. Given that transport cannot occur without energy use, the CO_2 intensity of fuels must be reduced to zero. In the ASI framework, *Improve* must therefore play a crucial role, while *Avoid* and *Shift* primarily affect the distribution of costs between different parts of society and over time between 2025 and 2050.

Insight 3: When analyzing a zero-emission transport sector in 2050, assuming that the target is achieved, *the situation can effectively be modelled as an absolute requirement for zero-emission solutions across all transport modes*. Whether this is represented by a very high CO_2 price or by an explicit regulatory requirement makes no difference for 2050 outcomes or cost-

efficiency. Thus, an absolute requirement for zero-emission solutions by 2050 constitutes one of the central policy measures in all strategies.

Insight 4: How the costs of meeting such absolute zero-emission requirements are distributed is a key distinction between strategies. If costs are borne by transport users (as in the strategies focused on *Shift* and *Avoid*), this will induce *Shift* and *Avoid* adaptations. If, on the other hand, users are shielded and the additional costs are covered through public subsidies (as in the *Improve*-oriented strategy), there will be no direct incentive to change travel or freight patterns—though higher taxes to finance the subsidies may indirectly reduce demand.

Insight 5: For a consistent comparison of strategies, technological development must be treated as exogenous. This means that unit costs for, for example, sustainable aviation fuels, electric trucks, or carbon-neutral ammonia for shipping are assumed to be identical across strategies in 2050. What distinguishes the strategies is who bears the costs and how these costs affect behavior in the transport sector and the wider economy.

Insight 6: Projections indicate that in 2050, the most significant remaining emissions in a "Frozen Policy" reference scenario will come from aviation and freight transport by truck and ship. Strategies for a zero-emission transport sector should therefore prioritize measures addressing these sources.

Insight 7: For some transport modes, zero-emission technologies are expected to have lower operating costs in 2050 than current fossil-based alternatives, such as electric trucks and electrified rail. However, major investments in charging and refueling infrastructure are required before 2050. How these investment costs are financed will strongly influence the modal distribution and cost-effectiveness of each strategy.

Conclusion

The report assesses to what extent the process from qualitative backcasting to quantitative modelling provides a satisfactory operationalization of strategies. We show that the methodology works well as a structured framework for developing logically consistent policy packages tailored to different strategic profiles. Through the first six steps of the eight-step process, it enables systematic identification and prioritization of measures that address residual emissions in the reference pathway and facilitates the implementation of these measures in quantitative models.

The process also demonstrates that existing transport models—traditionally applied in *predict-and-provide* planning—can be used for *vision-led* planning when combined with a structured backcasting approach. By linking qualitative strategy development with an enhanced and soft-linked modelling framework, it becomes possible to quantify effects, costs and robustness across strategies. The ASI framework has proven valuable for structuring these assessments, illustrating that *Improve* is indispensable for reaching zero emissions by 2050, while the degree of emphasis on *Avoid* and *Shift* will depend on the future cost level of zero-emission technologies and the broader societal objectives considered.

The soft-linking process between the models demonstrates that they function well as a combined system. Despite some initial challenges, the coordination between models has become more streamlined, and the results appear reasonable and internally consistent. The integration between the macroeconomic model NOREG 2 and the transport models is particularly valuable, as it enables analysis of how various policy measures influence different sectors and freight transport. While NOREG 2 may underestimate the overall costs of transition, it provides a credible picture of the *direction of changes* in sectoral output. The four example strategies exhibit distinct and logical pathways towards a carbon-neutral transport sector, which the model framework captures consistently.

Overall, the methodology and modelling framework constitute a solid foundation for future work. The process demonstrates that bridging qualitative backcasting and quantitative modelling is both feasible and useful, and that soft-linking existing models can generate relevant and credible results for future strategic analyses. With further development and calibration, the model system will be well suited for analyzing fully elaborated strategies in future phases of the National Transport Plan.