Institute of Transport Economics
Norwegian Centre for Transport Research

ENGLISH **Summary**

Advancing the NOREG 2 Macroeconomic Model for Assessing Norway's Transition to a Low-Emission Society by 2050

Expanding the Modeling Framework

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This report documents the further development and adaptation of the regional general equilibrium model NOREG 2 to better analyse Norway's transition to a low-emission society by 2050.

The model enhancements include:

- **Explicit modelling of greenhouse gas emissions, covering both energy-related and process emissions, as well as the inclusion of climate policy instruments in the model.**
- **Updating the model's base year to 2022.**
- **Greater detail in modelling foreign trade.**
- **Linking the model to the national passenger transport models.**

The updated general equilibrium model is soft-linked to both freight and passenger transport models, and routines for iterative analyses using the integrated modelling framework have been developed.

NOREG 2 is a regional Spatial Computable General Equilibrium (SCGE) model calibrated with data for Norwegian counties and municipalities. The model is designed for detailed regional or local analyses, enabling assessment of the long-term economic impacts of policy changes or external shocks.

NOREG 2 is developed and maintained as a collaboration between the Institute of Transport Economics (TØI), Statistics Norway (SSB), Vista Analyse, and Menon Economics.

This report describes the adaptation and further development of the NOREG 2 model to analyze the transition of the Norwegian economy toward a low-emission society by 2050.

Further development of NOREG 2 for climate transition analysis

Through the Climate Act, Norway has legally committed to becoming a low-emission society by 2050. This report documents the NOREG 2 consortium's efforts to improve and adapt the model to better analyze long-term structural changes in the Norwegian economy and transport sector during this transition. The project includes updating and preparing NOREG 2 to analyze policy packages aimed at achieving the low-emission target.

The need for such analytical tools is substantial: climate policy will reshape industrial structure, activity location, and transport demand at both national and regional levels. The model extension makes it possible to study how various climate policy instruments (quotas, taxes, subsidies, etc.) affect emissions, production, employment, and transport demand—both in total and distributed across regions and industries.

The development work has been organized into four main thematic components:

1. Adapting NOREG 2 for climate transition analysis
2. Updating the model's base year to 2022
3. Adding greater detail to the export market
4. Strengthening links to passenger transport models

Modeling of emissions and climate policy instruments

The emissions module distinguishes between energy-related (combustion) emissions and process emissions, and includes six greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) expressed in CO_2-equivalents. It also separates emission trading system (ETS) and non-ETS sectors.

The data are based on Statistics Norway's official emission statistics for both territorial emissions (relevant for national climate targets) and emissions from Norwegian economic activity, combined with facility-level data from the Norwegian Environment Agency. This allows emissions to be allocated across NOREG 2's industries and regionalized to municipalities.

Carbon taxes are calibrated using Statistics Norway's data to calculate effective carbon prices per industry.

With this extension, NOREG 2 can perform scenario analyses of individual measures or combinations of instruments, identify which sectors and regions are most affected, estimate emission reductions per industry and region, and analyze transport demand impacts. The model can also assess how compensatory tax adjustments in other sectors could mitigate negative GDP effects, and how the policy impacts differ geographically due to variations in regional industrial structure. Together, these capabilities provide a stronger basis for targeted and geographically balanced climate policy.

Updating the model's base year to 2022

In NOREG 2, the national input-output tables from Statistics Norway have been regionalized down to the municipal level, capturing economic differences and linkages across Norway. In this work (NOREG 2 version 2.4), the base year has been updated to 2022.

Several improvements have been made alongside this update:

- The agriculture sector has been geographically distributed with higher precision using data from the Norwegian Agriculture Agency on subsidies, land use, livestock numbers, and sales to dairies and slaughterhouses, providing a more realistic picture of where production actually occurs.
- The industrial classification has been refined by separating fishing and catching from aquaculture, reflecting their different geographic structures, cost profiles, and growth paths.

These updates provide a more accurate and balanced empirical foundation for modeling regional economic development in Norway and strengthen NOREG 2 as a tool for analyzing industrial and climate policies across sectors and regions.

Foreign trade

In the further development of the model's trade module, emphasis has been placed on improving the geographical precision of export and import data. By combining information from previous projects (such as the Norwegian Export White Paper) with new datasets, a more detailed regional distribution of exports has been established. This provides a more realistic picture of where export revenues are generated, improving the basis for analyzing regional impacts of international trade.

While export levels per industry remain based on the input-output framework, the regional and international distribution has become much more precise. New estimates have been developed for export destinations, using detailed commodity-level trade data (HS codes) linked to NOREG industries through OECD concordance keys.

A corresponding methodology has been developed for imports, combining input-output data, OECD keys, and trade statistics to identify which products are imported and from which countries. These enhancements provide a comprehensive view of Norway's trade system, both inbound and outbound, and strengthen the analytical basis for assessing how global changes affect Norway's economy and regional industries.

Linking to the passenger transport models

In this development phase, NOREG 2 has been connected to the national passenger transport models (RTM/NTM6), in addition to the existing link to the National Freight Model (NGM). The objective has been to implement commuting behavior in the model, allowing households to live in one region and work in another. This creates a more realistic representation of the Norwegian labor market and a stronger analytical basis for examining interactions between the economy, demographics, and transport infrastructure.

Previously, each region's labor force was assumed to match its resident population. In the new version, residence and workplace are decoupled using register data for all employed persons (from microdata.no, A-melding, and the business register). This enables realistic commuting flows at the municipal level, disaggregated by education level. Income now flows between residence and work regions, improving the model's ability to represent how value creation, income, and consumption are geographically distributed.

The link to transport models is implemented through a dedicated CUBE application that aggregates data from RTM/NTM6 on trips, transport modes, travel purposes, distances, times, and costs between all Norwegian municipalities. These data are used both for base-year calibration and as exogenous scenario inputs for 2050, where changes in transport costs and travel demand determine annual growth rates that influence commuting and private consumption in NOREG 2.

Commuting is modeled endogenously using a logistic probability distribution, driven by firms' labor demand and the generalized travel cost between regions. Thus, commuting flows are affected by both economic changes (wages and employment) and transport system developments (costs and accessibility).

In addition, household transport expenditure is directly linked to private consumption in NOREG 2, so changes in transport costs and travel behavior from RTM/NTM are reflected in the consumption of transport services. This ensures consistency between transport and economic models, providing an integrated framework for analyzing how transport policy and infrastructure investments affect the labor market, consumption, regional development, and welfare over time.

Development og soft-linking routines between NOREG 2 and the transport models

Soft-linking refers to the manual integration of separate models where information is exchanged iteratively. NOREG 2 has previously been soft-linked to the National Freight Model (NGM), and in this phase, it has also been linked to the passenger transport models.

In this methodological project, iterative processes between the models have been used to capture the full dynamics of the low-emission transition. NOREG 2 uses transport cost data from both NGM (freight costs per zone pair and industry) and RTM/NTM6 (travel costs per zone pair and purpose) as exogenous parameters. Conversely, NGM relies on trade volumes from NOREG 2, while NOREG 2 provides regional employment and demographic projections that can feed back into the passenger models.

The soft-linking routine for establishing a reference pathway involves five main steps:

0. Define the underlying development trends and transport network for the reference case.
1. Calculate transport costs per commodity and zone pair in NGM, and per travel purpose and transport mode in RTM/NTM6.
2. Run NOREG 2 using the defined policy set and transport costs from step 1.
3. Run NGM with freight flow trajectories from NOREG 2 (step 2).
4. Establish the reference pathway through iterative runs between NOREG 2, NGM, and the passenger transport models.

Reference scenario and example strategies

The analyses in this report use Statistics Norway's 85 economic regions as the geographic unit.

To assess the effects of climate policy measures, NOREG 2 requires a reference pathway describing how the economy would evolve under current policies. This pathway serves as a benchmark for the alternative strategic scenarios, and maintaining a clear distinction between them is crucial for analytical validity.

The reference pathway represents a business-as-usual development, where production, consumption, trade, prices, and emissions follow assumptions about population growth, productivity, technology, and existing policies. It is not a forecast but a normative baseline providing a consistent foundation for evaluating the effects of new policy interventions.

Two reference pathways have been defined:

0. Reference Pathway (business-as-usual / frozen-policy) – assuming Norway develops in line with the projections in the 2024 Perspective Report (White Paper 31 (2023–2024)).
1. EU Pathway – largely based on the same assumptions as step 0 but incorporating EU requirements related to reduced GHG intensity in shipping and Sustainable Aviation Fuel (SAF) blending mandates.

Four example strategies have been developed to illustrate potential pathways for the Norwegian transport sector toward a low-emission society by 2050. All assume near-zero transport emissions by 2050 and are evaluated against the reference pathway in NOREG 2:

- UFF Pathway
- UF Pathway
- Technology Pathway
- Cost-Effectiveness Pathway

Iterative Analysis Setup

For each of the example strategies, the iterative analyses across the model tools follow the same stepwise procedure:

Step 1: The transport models are run with the climate policy instruments that apply to the transport sector.
Step 2: NOREG 2 is run using the exogenous changes in transport costs from Step 1, along with the climate policy measures and adjustments modeled within NOREG 2.
Step 3: The National Freight Model (NGM) is run using the projected freight flows from NOREG 2 (Step 2) to calculate future freight volumes by transport mode for each example strategy. For larger structural changes, it is assessed whether it is appropriate to update the population development in the passenger transport models based on endogenous migration results from NOREG 2.

The four sets of policy packages defined in the example strategies include both sector-specific measures for transport, financing mechanisms for these climate adaptations, and measures targeting other sectors of the economy.

Assumptions Underlying the Reference Pathway

The reference pathway in NOREG 2 is based on the same assumptions used in the Government's 2024 Perspective Report (PM2024). This yields different regional outcomes due to variations in population growth, industrial structure, trade patterns, and educational composition across Norwegian regions.

The regional development assumptions follow those of the 2024 Perspective Report:

- **Population growth:** Based on SSB's 2024 municipal population projections.
- **Labor force:** Projected using population data for ages 16–74, with participation rates from DEMEC. Between 2024 and 2050, participation remains around 71–72 percent for this age group.
- **Education:** Educational attainment follows Cappelen et al. (2020), with demand for education assumed to rise in line with attainment levels.
- **Petroleum sector:** Expected to decline by about 60 percent by 2060 relative to 2024.

- **Public consumption growth:** Based on DEMEC—just over 1.5% annually (real terms) until 2036, tapering thereafter, averaging 1.3% per year from 2024–2060.
- **Defense and education:** Strong defense growth is assumed in the first 12-year period; lower birth rates imply weaker growth in education, consistent with PM2024.
- **Productivity growth:** Based on DEMEC—just over 0.7% annually in private industries and just under 0.5% in public services between 2024 and 2060.
- **Energy efficiency:** Assumed to improve by almost 1% annually, following CEPII (EconMap, 2016).

The reference pathways in NOREG 2 are thus regionalized versions of the Perspective Report baseline, calibrated to align with national macroeconomic aggregates and assumptions. NOREG 2 therefore produces regional perspective pathways consistent with the national one.

The reference pathway presented in this chapter, however, is a demonstration case developed through iterations between NOREG 2 and the transport models (RTM, NTM6, NGM). Within the project timeframe, it has not been possible to fully calibrate the pathway to the 2024 Perspective Report, the 2025 National Budget, and the SNOW model.

As such, the results should be regarded as methodological illustrations, not as forecasts or policy-ready outputs. The work provides valuable experience in coordinating the models and advancing soft-linking routines, but further calibration and quality assurance are required before the results can inform policy decisions.

Evaluation of Example Strategies

The four example strategies comprise integrated policy packages that include sector-specific measures for the transport sector, their financing, and related policies targeting other parts of the economy.

The project's main focus has been methodological development—both refining NOREG 2 to better analyze the transition toward a low-emission society by 2050, and developing soft-linking routines between NOREG 2 and the transport models (NGM and the passenger models). In parallel, significant effort has gone into designing the policy packages and long-term strategic pathways for achieving low emissions in the transport sector.

The findings and lessons from this methodological project will inform future work. The model results presented here should be interpreted as illustrative examples, not forecasts. The example strategies were developed jointly by the National Transport Plan (NTP) methods group and researchers at TØI, through a process involving continuous assessments of what is appropriate both from a strategic transport policy perspective and a modeling perspective. Throughout, trade-offs were made between the need for model calibration and quality assurance and the need for progress and delivery within the project timeline.

This marks the first time the entire modeling system—NOREG 2, RTM, NTM6, and NGM—has been integrated and run jointly, including the use of newly developed simplified versions of RTM. The experience gained provides valuable insights for future methodological and model development, though the current calculations must be interpreted with caution. Further model refinement, calibration, and validation will be necessary before the results can serve as a solid basis for policymaking.

When aggregated to the national level, the results indicate that the UF pathway has the most significant overall impact on the Norwegian economy.
The report presents results both by individual industries and by economic regions, as well as an estimate of the socioeconomic cost of transitioning to a low-emission society by 2050.

The analyses of the example strategies reveal considerable variation between strategies when examined at the regional or sectoral level. However, much of this variation becomes less pronounced when the results are aggregated across sectors and zones and presented as national averages.

Further Work

The further development of NOREG 2 is progressing both within the framework of the ten-year research project funded by the Research Council of Norway's DEMOS program and through commissioned projects. In cooperation with the Norwegian transport agencies, the model has been expanded to strengthen its capacity to analyze the transition to a low-emission society by 2050.

This work has involved improvements to the model itself, the establishment of routines for linking with the transport models (RTM, NTM6, NGM), and testing through example strategies. The next step is to apply the tool to real strategic analyses that can be incorporated into the National Transport Plan (NTP).

Before the models can be used directly for policy formulation, several additional development steps are required:

- **Recalibration of NOREG 2** using updated freight flow matrices from the ongoing development project for the National Freight Model (NGM).
- **Establishment of a policy-consistent and validated reference pathway**, ensuring projections are aligned with the 2024 Perspective Report and the 2025 National Budget, including the implementation of sector-specific technology assumptions from the Ministry of Finance's SNOW model.

Other planned extensions that will improve the model's ability to analyze the transition to a low-emission economy include:

- **More detailed modeling of electricity price zones** to capture regional variations in power prices and their effects on industrial location.
- **Further exploration of iterative linkages** between NOREG 2 and the transport models, enabling mutual feedback between changes in population, employment, and destination attractiveness.
- **Integration of the Norwegian continental shelf** as a new geographic component of the model. Offshore activity will be divided into five petroleum regions, with associated onshore supply chains mapped using AIS shipping data and industrial datasets. This will enable analysis of regional impacts of changes in petroleum and offshore wind activity, and strengthen the connection between the offshore and mainland economies.

Overall, these enhancements will provide a more precise, geographically detailed, and integrated modeling framework, better suited for evaluating long-term industrial, climate, and transport policy strategies toward 2050.