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Integrating climate in macroeconomic modelling: A Nordic Perspective

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Introduction

This Policy Brief summarises key messages from a webinar series hosted by the Integrating climate in macroeconomic modelling (ICMM) project during the second half of 2022 and the first half of 2023.

In the wake of recent climate policy discussions at the EU, Nordic and national levels, the webinars were meant to promote the advancement of expert and policy-planning knowledge and at the creation of networks among model developers and model users from different Nordic countries.

The main goal of this project is to foster discussions regarding modelling approaches and to identify future Nordic and international opportunities for collaboration at both expert and policy-planning levels.

1. Key messages

- **Computable General Equilibrium (CGE) models** have been applied to study a range of economic challenges and are widely used to evaluate impacts of climate policies on economic activity and welfare, including production, consumption, employment, taxes and savings, and trade. CGE models are the preferred tool to measure the long-term impacts of climate policies.
- There are different **types of CGE models**. Frequently, the models are classified in terms of how the required data are collected – or the results are computed – at the desired level of granularity (top-down vs bottom-up approaches), and particularly in terms of how the different modules are integrated (hard vs soft links). There is also a distinction between models aiming at forecasting short-term business-cycles as opposed to models concentrating on more structural change. Climate policy is usually modelled focusing on structural transformations.
- **The institutional setup of national governance systems has a big impact on model structure and development**. Often, decentralised governance systems are associated with modular modelling structure (soft-links), whereas integrated models (hard-linked) are more frequently found in countries with centralised governance systems.
- **Model design choices have implications for policy use.** Soft-link models potentially have a higher degree of precision and granularity but require more detailed data inputs and stronger coordination between government departments. Hard-link models usually have lesser data requirements and enable more control and transparency over modelling assumptions. However, they often have less precision and granularity.
- **CGE models face different challenges when it comes to the integrating climate in macroeconomic modelling**. Key obstacles identified in the ICMM project include: limited access to granular data, difficulties to document assumptions in a transparent way, difficulties in modelling technological change and limitations related to modelling specific carbon-intensive industries, including agriculture.
- **Nordic CGE climate models share many similarities but also important differences**. Collaborative networking among Nordic experts, exchange of lessons learned, and peer-to-peer discussion can ensure continuously improved models and contribute to address the most relevant and pressing policy questions faced by decision makers in the region.

3. The Nordic perspective: modelling landscape and tradition

All of the Nordic countries have embarked on low-carbon development pathways by setting ambitious mid-term (2025-2035) climate targets and seeking carbon neutrality before or by 2050. Due to their ambitious goals, the Nordic countries are considered frontrunners within the European climate policy landscape. Each Nordic country has developed specific modelling tools which can help to identify cost-efficient economic and financial measures to achieve the climate targets while minimising potential negative socio-economic impacts (Krook-Riekkola et al., 2013).

During a series of webinars hosted by the ICMM project (see Textbox 1) several of the modelling initiatives undertaken in the Nordic countries were discussed, providing insights into the specific strategies implemented in each country for modelling the effectiveness of different policies towards the climate goals as well as their impacts (summary in Table 1 and more detailed information on the models in Appendix 1)

Textbox 1: About the ICMM project and the ICMM Network

The Integrating Climate in Macroeconomic Modelling (ICMM) project started in 2022 with the intention of strengthening Nordic cooperation between experts and practitioners designing, working and using macroeconomic models for policy design.
The main objectives of the project were:

- to advance expert and policy-planning knowledge and networks among the Nordic countries on modelling decision when it comes to integrating and assessing climate and finance policies;
- to enhance the Nordic countries' international outreach and engagement by advancing common experiences and results from climate and finance integrated models;
- to identify future Nordic and international collaborative opportunities at both expert and policy-planning levels.

The ICMM project established an international network composed by 30 experts working on the integration of climate and finance policies in each and all of the Nordic countries. The project hosted four Technical workshops (focused on the technical aspects of various Nordic models) and two Policy workshops (debating the models' policy impacts). Comprehensively, the ICMM events gathered more than 100 single participants.
More information: Integrating climate into macroeconomic modelling (ICMM) | Nordregio

The degree of maturity of the Nordic CGE models, the acceptance and anchoring within the political system and the role of the Ministries of Finance in the formulation of climate policies, all constitute opportunities for Nordic leadership in assessing climate and finance policies in an integrated way. The seminar series in the ICMM showed how the different Nordic models have many similarities but also important differences in nature, focus, application, usage, as well as ownership and governance. This emphasises the importance of collaborative networking among experts from the different countries. The significance of exchange of lessons learned, and peer-to-peer discussion were highlighted to ensure that models can continuously improve and address the most relevant and pressing policy questions faced by decision makers in the region.

Table 2 – Integrated climate-CGE models in the Nordic Region

Name	Country	Hosting Institution	Type of Model	Type of Link	Summary of key features
Green REFORM	Denmark	DREAMgruppen	CGE	Hard link	59 sectors plus 27 types of energy and 14 emissions in physical quantities. It has several fully integrated submodules for specific sectors and features that can be turned on/off as needed and can be used independently of one another.
FINAGE	Finland	Collaboration between the Centre of Policy Studies in Melbourne and Finnish researcher	Dynamic AGE model	Soft Link	100 industries and 150 commodities, especially focusing on energy data. The model has a regional extension (at NUTS 3 level), and it covers households by age, income decile and by socioeconomic group.
SNOW	Norway	Statistics Norway	CGE	Hard link (previous versions tested soft links)	It represents the Norwegian economy, with 46 producing sectors and various household and public consumption sectors.
EMEC	Sweden	National Institute of Economic Research (NIER) Konjunkturinstitutet	CGE	Hard link	It specifies firms in 35 production sectors, together producing around 43 different products (this can vary year to year). In the last version (4) the Model disaggregated the road transport substantially (specification of 6+ vehicles and 5+ fuels). It also specifies 6 household types differentiated by income (low/high) and residential area (rural/small, urban/large) to study income distribution
IntERACT	Denmark	Initiated by The Energy Agreement and embedded in the Danish Energy Agency	Hybrid model	Hard link	The IntERACT model setup integrates a general equilibrium model with a technical energy system model TIMES-DK.
Nordic-TERM	Nordic	Nordic Council of Ministers (Nordregio)	CGE	Soft link	Model developed for a Nordregio project- Ensuring inclusive economic growth in the transition to a green economy (EnIGG) -to study the distributional effects of climate policies in the Nordic countries. Five Nordic countries plus Rest of Europe (RoE), 26 (NUTS2) regions within the Nordic countries, 53 industries, 39 occupations, eight wage-bands, and 30 household types (for Denmark, Finland and Sweden)

4. Looking ahead: key challenges and opportunities for integrated macroeconomic modelling

Integrated CGE models have made important contributions to the analysis of the impacts of climate change on the global economy (Berrittella et al., 2006; Böhringer, 1998; Nelson et al., 2014; United Nations Development Programme, 2016; van der Mensbrugghe, 2013) and have been extensively used for the assessment of the costs and benefits of climate mitigation policies on macroeconomic variables (Elliott et al., 2010), firms and trade (Paltsev et al., 2007), and households (Boccanfuso et al., 2013). Key climate mitigation policies and strategies in scope include carbon taxation, emission reduction targets, emission trading, energy efficiency, and renewable energy production technologies (Kaushal and Yonezawa, 2022; Kiuila and Rutherford, 2013; Koljonen et al., 2021; Lankoski and Ollikainen, 2011).

Textbox 2: ICMM project Steering Group
The main role of the Steering Group (SG) was to act as an advisory body for the ICMM project and to provide inputs on the direction, objectives and thematic focus of the different technical and policy workshops. Steering Group members were recommended by the ICMM network members and invited after discussion with the Scientific Advisor of the Project (Juha Honkatukia, Merit Economics). Three main meetings were scheduled during the duration of the project (between May 2022 and March 2023). The SG was composed of: • **Professor Christoph Böhringer** - Professor of Economic Policy at the University of Oldenburg (Germany) focuses on the impact analysis of environmental, energy, and trade policies. • **Professor Markku Ollikainen** - Finnish environmental economist, professor Emeritus and Research director at the University of Helsinki, and Chair of the Finnish Climate Change Panel (2014–2023). • **Hans Jakob Eriksen** - Senior Adviser, Environment, Nordic Council of Ministers. • **Michael Sterner** - Senior Advisor, Growth and Climate, Nordic Council of Ministers

With a Nordic focus, the 2023 Nordic Economic Policy Review explores the implications of new EU-wide climate policies in the Nordic countries from a multi-dimensional perspective (Flam et al., 2023).

Building on the core climate-economy modelling tools in each country and looking ahead, based on the discussions held in the ICMM network and the feedback received from the Project's Steering Group (see Textbox 2), the following points summarise the general research areas, application fields, operational and methodological challenges that will potentially attract greater research interest in the years to come, in the Nordic and European contexts:

i) Selected thematic priorities for integrated CGE models:

- **Rapid decarbonisation**: Economic and socio-economic impacts of net-zero targets by 2050 and adjustment cost to rapid decarbonization in view of technological options (sector coupling).
- **Technology substitution**: For instance, fossil-free green steel and cement production using hydrogen or carbon capture and storage are examples of new technologies that should be considered in model development to improve deep decarbonization scenarios.
- **Carbon pricing**: Incidence and impact of carbon pricing and emissions regulations, particularly considering alternative rebating rules for revenues from carbon pricing.

- **Carbon leakage**: Competitiveness impacts and effectiveness of unilateral carbon policies in inter-dependent economies, in the face of potential carbon leakage.
- **LULUCF**: Detailed exploration of the role of Agriculture, Land Use, Land Use Change and Forestry (LULUCF) in the following generation of climate mitigation policies.
- **Climate financing**: The role of climate funds and specific financial tools aimed at increasing cost-efficiency (e.g. reversed auctioning).
- **Distributional effects**: Comparative analysis of emissions pricing vs alternative emission regulations across households, regions and generations.
- **Multilateral burden sharing**: Contribution of multilateral and multi-domain policy frameworks – EU policy, Nationally Determined Contributions (NDCs) and climate financing, including competitiveness effects of fragmented climate policies for emissions-intensive and trade-exposed (EITE) sectors, including sub-global action or national policies with very different ambition levels.

ii) Remaining operational challenges for integrated CGE models:

- **Data granularity**: Availability of detailed data at sub-national and sub-industry level (e.g. household disaggregation based on income-expenditure data).
- **Regulatory details**: Consideration of regulatory specificities in selected industries (e.g. use of satellite environmental data in combination with Global Trade Analysis Project -GTAP- to include process emissions for industries such as cement).
- **Technology transitions**: Modelling technological change, e.g. bottom-up foundation of top-down models to represent sector coupling options based on engineering or technological information (e.g. power-to-X technologies).
- **Dynamic CGE modelling**: This approach is necessary to investigate optimal adjustment paths (speed of decarbonization) in combination with issues of capital malleability (putty-clay).
- **Behavioural change**: Incorporate social and consumer behaviour based on discrete choices.
- **New policies**: Appropriate translation of real-world policy proposals such as Carbon Border Adjustment Mechanism (EU-CBAM) into model baselines and scenarios.
- **Climate adaptation**: Integration of the financial costs of climate risks and ancillary benefits of climate change adaptation measures, including nature-based solutions, on ecosystem services.

5. Concluding remarks

The Integrating Climate in Macroeconomic Modelling (ICMM) project has strengthened the Nordic cooperation between experts and practitioners designing and using macroeconomic models. More than 100 experts and policy makers with different backgrounds and profiles have participated in the six technical and policy workshops organised by the project. These discussions have emphasised the relevance of integrated macroeconomic models for the design of a new generation of fair and cost-effective climate policies.

The following years will show if the policies informed by the models and designed by the experts in the ICMM network, will be effective in producing successful societal and technological transitions towards carbon-neutral economies, consistent with Our Vision 2030, the Nordic ambition to become the most sustainable and integrated region in the world. What is certain is that the capacity to steer those transitions in the right direction will largely depend on the ability of policy makers to understand the implications of their own policies, considering also multi-scalar inter-dependences and sectoral trade-offs.

Integrated models are powerful tools to enable such understanding by breaking policy silos. However, decision makers should bear in mind that the models are developed for the insights they produce about the most efficient way to deliver on the decarbonisation goals, not for the precision of their estimates. More important than the numeric results per se, which can be obtained in various ways and can never be exact (e.g. models can simulate a rapid de-carbonisation of the road transport sector by assuming a petrol price of 5 euro per liter), the models are useful to understand the assumptions that lead to a given result (e.g. additional blending of biofuels), and the mechanisms at play (e.g. rising world market prices of biofuels and its implications on land use change).

It is hence important that the exchange of knowledge between those involved in the design of the modelling tools continues in the future. This informal, yet structured, exchange of experiences can enable an effective cross-fertilisation and mutual enrichment of the specific genealogies of models in each of the Nordic countries. This shall not only contribute to more robust and meaningful advice of climate policies within each of the countries, making them more sustainable, but also to a more effective coordination of policies across the Nordic Region, making it more integrated. Moreover, this work can also provide a good opportunity to enhance the international outreach of Nordic integrated climate-economy models and influence international modelling work and policy discussions on climate policies.

6. Appendix

Model	Country	Hosted by	Type	Key features	Main challenges/ opportunities	References
Green REFORM / Grøn REFORM	DK	DREAM gruppen	CGE model	Dynamic CGE model that enables the analyses on short and long run effects. It has 59 sectors plus 27 types of energy and 14 emissions in physical quantities. It has several fully integrated submodules for specific sectors and features that can be turned on/off as needed and can be used independently of one another. Model is scalable, requiring consistent data. It is modular by design, meaning that the CGE-model is fully functional on its own as well as each of the sub-components.	Limitation concerning data availability and its integration in the model (it depends on access to detailed national statistics) Challenges still exist concerning the modeling of future technological change (how to support a bottom-up approach with sufficiently detailed and updated data on costs and potentials of future technology?). Important to ensure that assumptions are documented in a transparent way. Challenges underlined also on how to model carbon-intensive and export-oriented industries like cement, oil refineries etc.	(Dahl and Kirk, 2022) (Danmarks Statistik, 2023) (Dreamgroup, 2023)
FINAGE	FI	Collaboration between the Centre of Policy Studies in Melbourne and Finnish researchers	Dynamic AGE model	FINAGE is a dynamic AGE model based on Monash/VU models influenced by models developed in the Centre of Policy Studies in Australia, with adaptations to the Finnish institutional setting. FINAGE is very detailed, covering the economy at a level of some 100 industries and 150 commodities, especially focusing on energy data. The model has a regional extension (at NUTS 3 level), and it covers households by age, income decile and by socioeconomic group. FINAGE enables anticipation more than forecasting, as the methodology here is more based on sectoral expert opinions on what the technological landscape will be in 10 years.	Challenges concerning institutional setup: Complex institutional settings (like the one in Finland) and the widening of the policy scope point to the need to much more specific sectoral analyses. Challenges in sectoral modelling: sometimes sectoral modelling implicitly assumes that policies necessary for reaching sectoral targets are in fact in place. Challenges in modeling innovation and technological change: As models cannot predict new technologies, it is important to have expert insight to help in those decisions, e.g. engaging with business and engineering communities and their predictions to input those insights in the models.	(Honkatukia et al., 2019) (Koljonen et al., 2021)

SNOW	NO	Statistics Norway	CGE	The SNOW-NO model is a recursive dynamic computable CGE model developed for the Norwegian economy. The model finds equilibrium prices and quantities by simultaneously solving the set of equations that satisfy the profit-maximisation and utility-maximisation conditions. The solution determines production, consumption, export and import levels for all goods, input use in each industry, relative prices of all goods and input factors (labour, capital and energy resources), as well as greenhouse gas emissions. The model is calibrated to the Norwegian national accounts and environmental accounts from Statistics Norway, with base year 2018. Norway is modelled as a small, open economy, while the rest of the world is reduced to imports and exports. The model represents the Norwegian economy, with 46 producing sectors and various household and public consumption sectors.	The SNOW-NO model incorporates the complexities found in the real-world for the Norwegian economy (e.g., the existing policies including various types of taxes and subsidies). It allows the identification of sectorial and macroeconomic impacts of emissions targets and introduction of climate related taxes. Recursive models provide greater flexibility in details of the modelling and policies that can be analysed, compared to forward-looking models. Challenges when modelling technological change: as technology changes rapidly, and technology choices and developments are important for costs of policies, it is important to include more knowledge on technologies under development or adoption. Limitation linked with learning effects, technology spillovers and network externalities that are not modelled.	(Fæhn et al., 2010) (Martinsen, 2011) (Bjertnæs et al., 2013) (Fæhn et al., 2013) (Kiuila and Rutherford, 2013) (Fæhn and Isaksen, 2016) (Bye et al., 2018) (Fæhn et al., 2020) (Bye et al., 2021) (Kaushal and Yonezawa, 2022)
EMEC	SE	National Institute of Economic Research (NIER) Konjunktur-institutet	CGE	EMEC (Environmental Medium Term Economic Model) is a standard single country CGE model based on the Swedish National and Environmental Accounts. The model is currently in its fourth version. It specifies firms in 35 production sectors, together producing around 43 different products (this can vary year to year). In the current version the model disaggregated the road transport sector substantially (specification of 6+ vehicles and 5+ fuels). It also specifies 6 household types differentiated by income (low/high) and residential area (rural/small, urban/large) to study income distribution effects. The model has been used to study interactions between the economy, energy use and emissions of several pollutants in Sweden to support policymaking. The model allows for analysis of the long-run impacts of several energy and environmental policies on the economy and emissions of several pollutants and about how these policies can be designed in effective, cost efficient and equitable ways.	One of EMEC´s main advantages is that it is a micro-economically consistent and comprehensive representation of price-dependent interactions between the different product markets, production factor markets and the public and private sector in the Swedish economy. Concerning limitations, EMEC is not suited to make forecasts for the short run but only to study the plausible ways in scenarios for the long run	(Krook-Riekkola et al., 2017) (Östblom and Berg, 2006) (Otto and Below, 2023)

IntERACT		Initiated by The Energy Agreement and embedded in the Danish Energy Agency	Hybrid	The IntERACT model setup integrates a general equilibrium model with a technical energy system model: it is a hybrid model, which provides a comprehensive description of the Danish economy and the Danish energy system, with keen attention to the interactions between the two. The IntERACT setup consists of a top-down macroeconomic model and a bottom-up energy system model (TIMES-DK). The top-down model describes the macroeconomic relationships, i.e. economic flows between firms, households, the public sector and international trade. TIMES-DK describes the Danish energy system using a detailed technical modelling of both production and use of energy. The TIMES energy system modelling framework is used in more than 60 countries, including Norway, Sweden and Finland, and the TIMES modelling framework model is developed and maintained within the IEA-ETSAP community.	One strength of the IntERACT model is the combination of consistent macroeconomic modeling with a detailed and technical description of the energy system, allowing it to provide insights on both economy and energy system wide effects of Danish climate and energy policy. The hybrid modelling methodology is ideally suited for ex-ante calculations of the effects of policies set to meet the EU energy efficiency directive obligation. It keeps track of issues related to additionality, energy efficiency gap and rebound effects. It captures overlapping policies related to emissions, renewable energy, energy efficiency, biodiversity, environment and competition. Challenge: using large numerical models for policy decisions requires a strong commitment from policymakers and a continuous supply of resources for both model development and maintenance.	(Termansen et al., 2019) (Kristoffer Steen Andersen et al., 2019) (Balyk et al., 2019) (Kristoffer S. Andersen et al., 2019) (Fortes et al., 2014)
Nordic-TERM	Pan Nordic	Nordic Council of Ministers (Nordregio)	CGE	TERM stands for "The Enormous Regional Model". The TERM-NORD model identifies: - 53 industries - 5 Nordic countries plus the rest of Europe (RoE) - 26 regions within the Nordic countries (NUTS2 regions) - 39 occupations - 8 wage-bands - 30 household types in each of DK, FI and SE (no data on Iceland and Norway)	Model developed for a Nordregio project- Ensuring inclusive economic growth in the transition to a green economy (EnIGG) -to study the distributional effects of climate policies in the Nordic countries. The Nordic-TERM model is the first model which covers almost the entire Nordic Region, consisting of the five Nordic countries Denmark, Finland, Iceland, Norway, and Sweden as well as the autonomous territory of Åland. Greenland and the Faroe Islands, which also form part of the Nordic Region, could not be considered in the model due to data limitations.	(Rimmer et al., 2023)

7. References

Andersen, Kristoffer Steen, Dockweiler, S., Klinge Jacobsen, H., 2019. Squaring the energy efficiency circle: evaluating industry energy efficiency policy in a hybrid model setting. Squaring the energy efficiency circle: evaluating industry energy efficiency policy in a hybrid model setting.

Andersen, Kristoffer S., Termansen, L.B., Gargiulo, M., Ó Gallachóirc, B.P., 2019. Bridging the gap using energy services: Demonstrating a novel framework for soft linking top-down and bottom-up models. Energy 169, 277–293. https://doi.org/10.1016/j.energy.2018.11.153

Balyk, O., Andersen, K.S., Dockweiler, S., Gargiulo, M., Karlsson, K., Næraa, R., Petrović, S., Tattini, J., Termansen, L.B., Venturini, G., 2019. TIMES-DK: Technology-rich multi-sectoral optimisation model of the Danish energy system. Energy Strategy Reviews 23, 13–22. https://doi.org/10.1016/j.esr.2018.11.003

Berrittella, M., Bigano, A., Roson, R., Tol, R.S.J., 2006. A general equilibrium analysis of climate change impacts on tourism. Tourism Management 27, 913–924. https://doi.org/10.1016/j.tourman.2005.05.002

Bjertnæs, G.H., Tsygankova, M., Martinsen, T., 2013. Norwegian climate policy reforms in the presence of an international quota market. Energy Economics 39, 147–158.

Boccanfuso, D., Savard, L., Estache, A., 2013. The Distributional Impact of Developed Countries' Climate Change Policies on Senegal: A Macro-Micro CGE Application. Sustainability 5, 2727–2750. https://doi.org/10.3390/su5062727

Böhringer, C., 1998. The synthesis of bottom-up and top-down in energy policy modeling. Energy Economics 20, 233–248. https://doi.org/10.1016/S0140-9883(97)00015-7

Böhringer, C., Rutherford, T.F., 2009. Integrated assessment of energy policies: Decomposing top-down and bottom-up. Journal of Economic Dynamics and Control 33, 1648–1661. https://doi.org/10.1016/j.jedc.2008.12.007

Braendle, T., 2021. Introductory note on integrating climate into macroeconomic modelling: Drawing on the Danish experience (PARIS COLLABORATIVE ON GREEN BUDGETING No. GOV/PGC/SBO(2021)9). OECD.

Bye, B., Fæhn, T., Rosnes, O., 2018. Residential energy efficiency policies: costs, emissions and rebound effects. Energy 143, 191–201.

Bye, B., Kaushal, K.R., Rosnes, O., Turner, K., Yonezawa, H., 2021. The road to a low emission society: Costs of
interacting climate regulations, in: Discussion Papers 972. Statistics Norway.

Dahl, G., Kirk, J.S., 2022. Analyse af CO2-afgift. Dreamgruppen.

Danmarks Statistik, 2023. Datagrundlag til GrønREFORM [WWW Document]. URL https://www.dst.dk/da/Statistik/emner/miljoe-og-energi/groent-nationalregnskab/energi-og-emissionsregnskaber/datagrundlag-til-groenreform (accessed 4.16.23).

Dreamgroup, 2023. DREAM | Publications [WWW Document]. Publications. URL http://dreamgroup.dk/publications/ (accessed 4.16.23).

Elliott, J., Foster, I., Kortum, S., Munson, T., Pérez Cervantes, F., Weisbach, D., 2010. Trade and Carbon Taxes. American Economic Review 100, 465–469. https://doi.org/10.1257/aer.100.2.465

Fæhn, T., Gulbrandsen, M.U., Lindegaard, A., 2010. Hva vil Norges klimakur koste? Artikkel, Samfunnsøkonomen 5/2010, 4-15.

Fæhn, T., Isaksen, E.T., 2016. Diffusion of Climate Technologies in the Presence of Commitment Problems. The Energy Journal 37.

Fæhn, T., Isaksen, E.T., Rosnes, O., 2013. Kostnadseffektive tilpasninger til togradersmålet i Norge og EU fram mot 2050 (No. Rapporter 2013/39). SSB.

Fæhn, T., Kaushal, K.R., Storrøsten, H., Yonezawa, H., Bye, B., 2020. Abating greenhouse gases in the Norwegian non-ETS sector by 50 per cent by 2030 - A macroeconomic analysis of Climate Cure 2030 (No. Reports 2020/23). Statistics Norway.

Flam, H., Hassler, J., Silbye, F., Sørensen, P.B., Hansen, L.G., Liski, M., Vehviläinen, I., Ollikainen, M., Golombek, R., Hoel, M., Fæhn, T., Nøstbakken, L., Von Below, D., Carlén, B., Mandell, S., Otto, V., Ferguson, S., 2023. Nordic
Economic Policy Review 2023: EU versus National Climate Policies in the Nordics. Nordic Council of Ministers. https://doi.org/10.6027/nord2023-001

Fortes, P., Pereira, R., Pereira, A., Seixas, J., 2014. Integrated technological-economic modeling platform for energy and climate policy analysis. Energy 73, 716–730. https://doi.org/10.1016/j.energy.2014.06.075

Honkatukia, J., Alimov, N., Huovari, J., Ruuskanen, O.-P., Lehtomaa, J., 2019. Alueellisen taloustiedon tietokanta (sarjajulkaisu). Valtioneuvoston kanslia.

Kaushal, K., Yonezawa, H., 2022. Increasing the CO2 tax towards 2030. Impacts on the Norwegian economy and CO2 emissions (No. Reports 2022/43). SSB.

Kiuila, O., Rutherford, T.F., 2013. The cost of reducing CO2 emissions: Integrating abatement technologies into economic modeling. Ecological Economics 87, 62–71. https://doi.org/10.1016/j.ecolecon.2012.12.006

Koljonen, T., Honkatukia, J., Maanavilja, A., Ruuskanen, O.-P., Similä, L., Soimakallio, S., 2021. Carbon-neutral Finland 2035 – climate and energy policy actions and impacts (HIISI) : Synthesis report – Conclusions and recommendations.

Krook-Riekkola, A., Berg, C., Ahlgren, E., Söderholm, P., 2013. Challenges in Soft-Linking: The Case of EMEC and TIMES-Sweden, Working Paper No. 133. National Institute of Economic Research, Stockholm, Sweden.

Krook-Riekkola, A., Berg, C., Ahlgren, E.O., Söderholm, P., 2017. Challenges in top-down and bottom-up soft-linking: Lessons from linking a Swedish energy system model with a CGE model. Energy 141, 803–817. https://doi.org/10.1016/j.energy.2017.09.107

Lankoski, J., Ollikainen, M., 2011. Biofuel policies and the environment: Do climate benefits warrant increased production from biofuel feedstocks? Ecological Economics 70, 676–687. https://doi.org/10.1016/j.ecolecon.2010.11.002

Martinsen, T., 2011. Introducing technology learning for energy technologies in a national CGE model through soft links to global and national energy models. Energy Policy 39, 3327–3336. https://doi.org/10.1016/j.enpol.2011.03.025

Nelson, G.C., Valin, H., Sands, R.D., Havlík, P., Ahammad, H., Deryng, D., Elliott, J., Fujimori, S., Hasegawa, T., Heyhoe, E., Kyle, P., Von Lampe, M., Lotze-Campen, H., Mason d'Croz, D., van Meijl, H., van der Mensbrugghe, D., Müller, C., Popp, A., Robertson, R., Robinson, S., Schmid, E., Schmitz, C., Tabeau, A., Willenbockel, D., 2014. Climate change effects on agriculture: Economic responses to biophysical shocks. Proceedings of the National Academy of Sciences 111, 3274–3279. https://doi.org/10.1073/pnas.1222465110

Östblom, G., Berg, C., 2006. The EMEC model: Version 2.0, Working Paper No. 96. National Institute of Economic Research, Stockholm, Sweden.

Otto, V.M., Below, D. von, 2023. The Environmental Medium-Term Economic (EMEC) Model:

Version 4 (WORKING PAPER NO. 156). National Institute of Economic Research (NIER).

Paltsev, S., Reilly, J.M., Jacoby, H.D., Gurgel, A.C., Metcalf, G.E., Sokolov, A.P., Holak, J.F., 2007. Assessment of U.S. Cap-and-Trade Proposals. Working Paper Series. https://doi.org/10.3386/w13176

Rimmer, M., Dixon, P., Honkatukia, J., Tapia, C., Gassen, N.S., 2023. Industry, employment, distributional and macro-economic effects in the Nordic countries of their greenhouse policies [WWW Document]. Presented during the 26th Annual Conference on Global Economic Analysis (Bordeaux, France), Presented during the 26th Annual Conference on Global Economic Analysis (Bordeaux, France). URL http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=6885

Termansen, L.B., Dockweiler, S., Hegelund, A.Z., Gersfelt, B., Næraa, R., Andersen, K.S., 2019. What is IntERACT - Introduction (WORKING PAPER NO. 01). Working Paper Series represent work in progress, and do not necessarily represent those of the Danish Energy Agency or policies of the Danish Ministry of Climate, Energy and Building.

United Nations Development Programme, 2016. Climate Change and Labor: Impacts of Heat in the Workplace.
van der Mensbrugghe, D., 2013. Modeling the Global Economy – Forward-Looking Scenarios for Agriculture. Handbook of Computable General Equilibrium Modeling 1, 933–994.

Wilson, D., Swisher, J., 1993. Exploring the gap: Top-down versus bottom-up analyses of the cost of mitigating global warming. Energy Policy, Policy modelling for global climate change 21, 249–263. https://doi.org/10.1016/0301-4215(93)90247-D

About the publication

This policy brief summarises key messages from a webinar series hosted by the Integrating climate in macroeconomic modelling (ICMM) project during the second half of 2022 and the first half of 2023. The main goal of the project was to foster discussions about a new generation of fair and cost-effective climate policies and how relevant integrated macroeconomic models are in the process. Additionally to find collaboration opportunities between experts and policy makers from countries within and outside the Nordics.

In the wake of recent climate policy discussions at the EU, Nordic and national levels, the webinars were designed to grow expert and policy-planning knowledge and expand networks among model developers and model users from different Nordic countries. More than 100 experts and policy makers with different backgrounds and profiles have participated in the six technical and policy workshops organised by the project.

Ultimately, the ICMM project strives to enhance the capacity of policymakers to develop climate policies that are both sustainable and integrated, aligning with the Nordic region's "Our Vision 2023" ambition to become the most sustainable and integrated region in the world.

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