Review: Modelling for Aotearoa New Zealand climate policy, December 2020

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General background and feedback. In this document, upon request of the Climate Change Commission, we review the models and scenarios used to inform the decision on the next climate budgets and the pathway towards 2050. We received model descriptions and/or presentations about the models, including (preliminary) results, as well as key (draft) chapters of the report that rely on modelling output. In addition, we had the chance to interact with the modelling team and other reviewers on two occasions. Overall, we have been impressed by both scope and detail of the modelling efforts, and believe these provide a robust quantitative framework to support ambitious climate policy proposals of Aotearoa. We highlight some aspects where the modelling toolbox can be improved for future assessments.

Modelling framework. We strongly believe in the usefulness of combining complementary models in a broader modelling toolbox. Using different types of individual models with different strengths can highlight important aspects in more details.[2] The modelling approach taken by the New Zealand Climate Change Commission resembles to some extent the set-up of recent climate policy assessments carried out by the European Commission.[3] As such, we appreciate the approach taken, linking a model with greater sectoral and technological detail (ENZ), an economy-wide CGE model (C-PLAN), and a distributional tool (DIM) that uses the results of the CGE. While these three models represent key components, additional specialised tools could be added for future modelling exercises, or the toolbox can be adjusted for studies on particular issues. We furthermore think that harmonising the baseline or current-policy trajectory in terms of activity levels and emissions across the different models is a valuable step in the analysis, and encourage the modelling teams to continue this harmonisation process in the future, and strengthen where possible.

Detailed sector modelling. The ENZ sectoral model covers emissions and technologies relevant for emissions in New Zealand, with linkages between energy and end-use sectors. While the model is equipped with a module to endogenously determine land use changes, for the final results some important trends are assumed exogenously instead as the model might not be able to reproduce these trends over recent years.

One result that might be surprising at first sight is the fact that the power sector can contribute relatively little to decarbonisation in the near term and remains a net emitter even in 2050. This is at odds with global scenarios, including those for the EU.[4] However, power generation in New Zealand is already featuring a high share of renewable electricity from hydro and geothermal and thus contributes relatively little to overall carbon emissions, limiting the potential in the near future after shutting down coal generation. Regarding the longer term, global modelling studies typically predict

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[1] The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission. Our review is based on our understanding of the modelling tools and the scenarios and we apologize should there have been any misunderstanding on our side.

[2] See Weitzel, M., Vandyck, T., Keramidas, K. *et al.* Model-based assessments for long-term climate strategies. *Nat. Clim. Chang.* **9,** 345–347 (2019). https://doi.org/10.1038/s41558-019-0453-5

[3] Recent assessments include the in-depths analysis for the EU long-term strategy towards climate neutrality by 2050 (https://ec.europa.eu/clima/policies/strategies/2050_en) and the impact assessment of the revision of the 2030 targets (https://ec.europa.eu/clima/policies/eu-climate-action/2030_ctp_en).

[4] See references in footnotes 2 and 3.

the power sector to reach net zero *before* reaching net zero in the whole economy – although often with the use of negative emission technologies. In order to avoid the (admittedly small amount of) carbon emissions from gas, one could think of improving the hydro storage capabilities instead – given the large contribution from hydro, this could potentially squeeze out the remaining fossil emissions of the power sector. We understand that this is not included in ENZ, but an additional modelling study was commissioned to investigate this. Along a similar vein, exploring further demand side management options could find additional storage availability.

Economy-wide modelling. The C-PLAN model is derived from the well-established EPPA model, adjusted to specificities of New Zealand along a number of dimensions. The sectoral aggregation is tailored to the importance sectors in the Aotearoa economy and represents specific abatement technologies, e.g. for methane emissions. The model is able to assess macroeconomic implications of climate policy, is calibrated to reproduce energy and emission trends from the ENZ model and can be used in combination with DIM to assess social aspects for subgroups of the population.

The CGE model has its strength at looking at interactions between sectors and regions. Further, the model is well equipped to analyse different policy options or assess the impacts of policies under different assumptions about the macro economy. This ability could in the future be better exploited, for example by exploring alternative assumptions on the modelling of the labour market (including unemployment), but also different policy options in which the revenues from carbon pricing is used in an alternative way (like reduction of other distorting taxes). Leakage was not extensively discussed, but it might not be a major concern given that some important energy-intensive, trade-exposed industries are assumed to close down already in the baseline scenario. However, given that an output based allowance system is continued in the modelling, it might be interesting to further investigate how different allocation mechanisms or alternative policies to mitigate leakage could be used.

Distributional modelling. The DIM model can downscale results that are reported in C-PLAN for an average, representative household. This is of high policy relevance as this allows finding winners and losers and thus enables policy makers to anticipate challenges and work on plans that can facilitate the transition in a socially fair manner. The distributional modelling with the DIM model is useful to indicate vulnerable workers and businesses that may be affected particularly by climate policy. Revealing concentrated impacts is essential to ensure a just transition to a low-carbon economy. We found the disaggregation of impacts to study how various ethnic groups could be affected insightful, setting an example of how quantitative work can foster inclusive policy-making that could be followed in other regions in the world. The DIM model is therefore a valuable component of the modelling toolbox and as such, is fit for purpose.

In the framing and presentation about job losses (unfortunately still missing in the version of Chapter 12 that was available to us at the time of the review), we think it is important to give the reader the background and perspective required for an appropriate interpretation. In the target-aligned scenarios, does the rate of change in number of jobs from one year to the next exceed the natural pace of change occurring e.g. through retirement of workers?

One important channel through which distributional impacts arise is via price changes of consumption goods and fuels consumed by households. This expenditure-side channel is currently not included in the modelling framework. In Europe, debates around fuel prices tend to dominate discussions around distributional impacts across households. Incorporating this channel in future work can provide insights into both vertical and horizontal equity. For instance, low-income households tend to spend a higher share of their budget on residential energy compared to high-income groups (vertical equity), and rural households may spend more on fuels for transport compared to urban dwellers (horizontal equity, i.e. within income groups). The DIM model could then also be used to assess how different recycling schemes could affect different household groups and how different policy scenarios going beyond an ETS would affect different households.[5]

Other extensions could be added to the wish list, although we admit these are not obvious, and would go beyond the current state-of-the-art. While the data-driven approach has its merits in terms of direct applicability, we believe that further empirical work can give insight into relevant issues such as sectoral labour mobility in New Zealand. Anecdotal evidence on limited labour mobility of farmers was mentioned in the in-depth discussions with the modellers. A good understanding of how the flexibility of the labour market (e.g. a historical perspective) can be an opportunity or a challenge in the transition towards a low-carbon society can be valuable for informing climate policy and complementary measures. Further extensions to the current modelling set-up could be considered to answer relevant questions on the social dimensions, e.g. what share of the ETS revenue would be needed for social and educational expenditures to ensure an equitable transition? Ensuring that ambitious climate policy is equitable can be a key factor in its success. We believe that the use of the DIM model provides a solid basis that can be further developed to inform a just transition to a low-carbon society, along with potential complementary measures.

Linking. The harmonization of the baseline is key to use a modelling toolbox in a consistent way. By calibrating the C-PLAN model to sectoral emission pathways in ENZ, consistency between the two models is ensured, although some small deviations between the models remain. It is difficult to perfectly align models, but where this is not achieved (for valid reasons) it might warrant to look at the sectors in question and investigate what drives the differences. The coupling is described as "loose", which is a pragmatic approach in order to capture the most important trends. This could be expanded in the future, to also cover exchanging of parameters in the scenario runs. One of the advantages of combining the detailed bottom-up ENZ model with the economy-wide C-PLAN model is that this typically gives a more realistic cost representation than when the CGE model operates in stand-alone mode.

Scenarios and use of model results. The scenario architecture to explore different alternatives of reaching net zero is a reasonable in looking at different behavioural and technology options that could play a role beyond a more conservative "headwinds" scenario. The European Commission likewise developed net zero emission scenarios LIFE and TECH, which focus more on behavioural change and technologies, respectively. The overall macroeconomic results in C-PLAN indicate modest costs in achieving the targets. Compared with previous studies for New Zealand, the cost in terms of GDP loss might be lower, but we have no reason to believe that the cost estimates are biased in any particular way.[6] In comparison, the cost for the achieving net zero emissions in the EU,

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[5] Fischer, C., & Pizer, W. A. (2019). Horizontal equity effects in energy regulation. *Journal of the Association of Environmental and Resource Economists*, 6(S1), S209-S237.

[6] Typically, cost estimates for CGE models are higher when the models rely on CES production functions exclusively, especially for very stringent targets, without allowing for high rates of emission abatement in key

as calculated by the JRC-GEME-E3 CGE model, were reported as between 0.39 and 1.3% of GDP in 2050, with having a higher reduction in gross emissions than New Zealand due to a proportionally lower carbon sink. The range in the EU figures further highlights that the GDP implications depend not only on the emission level to be reached, but also on how the policy is implemented and what is assumed for the rest of the world. Beyond the overall economic cost, it would be useful to highlight in the report how this affects the different components of GDP (consumption, investment, net trade).

The specific situation of sectors that are represented by a single or very few firms is taken into account in a reasonable, pragmatic manner, e.g. by exogenously specifying exit dates already in the baseline scenario. As these importantly influence emissions from industry, the choice of the exit years might be relevant for the national emission pathway. Against a *global* decarbonisation and a corresponding demand for clean products, a more bold approach would be to explicitly look at growth potentials in some industries, relying on the renewable energy potential of Aotearoa. While this would require a broader discussion and might not exclusively bring along advantages as more renewable energy capacity would likely needed to be installed, it could be an element of a green growth strategy creating jobs and export potentials. While this would likely be speculative nature, one could potentially explore this in alternative scenarios in the future.

The impacts of the Covid-19 crisis are not explicitly taken into account in the modelling. Rather, in the report, the baseline assumptions are contrasted with alternative projections of emissions in chapter 7. Naturally, the uncertainty surrounding the duration of the economic crisis, the speed and the shape of the recovery are stark, therefore any modelling would likely be highly uncertain. This holds especially for potential trends to persistent behavioural change, such as reduced transport demand due to more use of videoconferences to replace business trips or increased teleworking. Given that these trends would likely reduce emissions[7] (although the magnitude is highly uncertain), the projections reported might be seen as conservative with respect to Covid-19. The energy system model employed in the assessment of the European Commission's assessment of the EU's updated 2030 target indicated lower costs to reach an absolute emission target due to reduced economic activity and assumed trends in the transport sector. However, having said this, the modelling approach of not representing Covid-19 can clearly be justified by the high uncertainty, the difficulty of integrating changes into a harmonized modelling framework in a consistent way, while meeting pre-established deadlines.

Use, maintenance and further development. We are not entirely convinced that this suite of models can be used and maintained in a policy environment alone, i.e. without further continuous support from the modelling experts. Rather, we advise continuing the close collaboration, and maintaining a strong dialogue in subsequent steps in the policy process. Specific policy questions may demand particular modifications and model settings, and we would recommend to further enhance the model framework according to arising needs. Using and maintaining the model in a policy environment seems only realistic when staff receives extensive technical training, or when staff with technical and modelling background is available or otherwise recruited.

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sectors, such as transport, power, and agriculture. C-PLAN captures the abatement options by representing e.g. electric vehicles, various types of renewable electricity, and abatement options for methane.

[7] Keramidas, K., Fosse, F., Diaz Vazquez, A., *et al*. Global Energy and Climate Outlook 2020: A New Normal Beyond Covid-19. JRC report (forthcoming).