Review of NZ Climate Change Commission Modelling

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Overview

The NZ Climate Change Commission (CCC) has undertaken a modeling exercise to estimate the potential impacts to the NZ economy as a result of taking various pathways to net zero GHG emissions by 2050. The initial estimates and model documentation were provided to 5 climate policy modeling experts for review in November 2020. Reviewers were tasked assess whether the models and scenarios are an appropriate framework to provide insight as to how the NZ's economy could evolve over the next 30 years based on various policy prescriptions and constraints. The modeling 'system' included three main models/components: ENZ, C-PLAN, and DIM which covered all sectors of the economy. Given my primary expertise on the NZ and global land use sector, I will largely focus my comments on that component of the modeling system.

Overall, I found that the documentation shared with experts to date coupled with the detailed discussions with CCC modelers over the past month do not raise any red flags in terms of how the overall model framework could provide useful insight into achieving net zero targets. That is, I do not see anything so seriously flawed about the modelling of the land use sector – or any other sectors of the NZ economy – that would prevent the CCC from publishing the work done to date. Furthermore, the CCC should be confident that they can continue their modeling efforts based on the framework that they have developed and presented. As a result, this review will focus largely on the highlights of my review findings and suggestions on how model outputs and documentation could be improved in future iterations of this work.

Documentation

Model documentation made available for review included a) several presentations that have been given during CCC modeling meetings over the past few months, b) four draft chapters of evidence that document some of the model capabilities, methodology, and scenarios, and c) a series of spreadsheets with model output that were provided on request by the expert review panel. Collectively, there is a lot of information that allowed for a relatively thorough review. However, the piecemeal approach left some potential gaps in the analysis and subsequent understanding of what was and was not included in the model and scenarios. Further efforts should attempt to bring all this information into a single document.

Reference Case Policy Assumptions

Overall, I do not see any issues with how the reference case was constructed. The current policy reference case incorporates future land use sector impacts as a result of the implementation of Essential Freshwater policies. Further, it models sectors currently covered in the NZ ETS – including forestry but not agriculture – through to 2050 using a flat price of $35/NZU. These are logical choices, as these policies are already 'locked in' and thus should be accounted for in the model baseline. Further, the land-based commodity price assumptions, which are largely constant over the next 30 years, is also appropriate given the uncertainty about the future of how the sector may evolve. It is uncertain whether other commodity prices also follow this constant-price assumption, which could have an effect of the relative value of land across uses.

Exogenous Land Use Assumptions

Land use is exogenously constrained in both the reference case and policy scenarios. These constraints are largely based on input from input provided by MPI. In the reference case, sheep-beef land is estimated to continue to decline in area (0.65 Mha), and shift primarily to exotic forestry, largely following historical trends. There is minimal change in other land uses, including horticulture and native forest. Other NZ climate and land use modeling efforts have either exogenously assumed or endogenously estimated similar trends. Given the uncertainty about how much farmers are truly willing to shift into forestry – even if it is more profitable than their current enterprise – these constraints are appropriate for this modeling exercise. Additional sensitivity analysis, such as that undertaken for the reference case afforestation scenarios, could provide further insight on the relative impact of land use assumptions on overall findings.

Reference Policy Emissions Estimates

The two main sources of net emissions reductions over the next 30 years in the reference case are transport energy and forestry (See Ch 8, Fig 1). The large increase in C removals from forestry is to be expected given a) the current age class and harvest distribution of exotic forests in NZ due to the large amount of planting in the 1990s, and b) the exogenous assumption that there will be a steady increase in afforestation over the model period. These estimates are logical, but it should be noted that one potential risk is that NZ may again face large amount of harvesting (and thus less C removals) from 2050-2060 as many of NZ's currently planted forests again reach their optimal rotation age.

The sensitivity analysis in the reference case that evaluates the effect of MPI's high and low afforestation scenarios does provide some useful insight, and highlights that the amount of annual forestry removals has a noticeable level of uncertainty (16.0 to 31.7 MtCO2e/yr in 2050) and are sensitive to C prices. Given this wide range, more documentation should be provided on the mechanism that is driving these changes in MPI's model that informs this work. Future work may wish to consider explicitly incorporating an endogenous forest sector model to further evaluate the sector and broader land use change and emissions sensitivity to C prices.

Scenario Analysis

The modeling establishes a baseline or current reference case that estimates NZ's emissions and economic output. Chapter 8 introduces four policy scenarios that are modeled in ENZ. Chapter 12 mentions that C-PLAN models four "target-aligned" or "target pathway" (TP) policy scenarios. More details on C-PLAN policy assumptions were provided on slide 8 of the "CPLAN model results summary" presentation, but there is no explanation about how well these are aligned with the ENZ scenarios. Both ENZ and C-PLAN scenarios vary the rate of uptake of various technologies, which then contributes to the relative mitigation from various sources of GHG abatement and sectors of the economy. As some of the key abatement "technologies" include afforestation and methane vaccine/inhibitor adoption, it is apparent that the land use sector is an important component in the CCC's scenario analysis. As a result, future documentation should focus on better documenting the CPLAN scenarios and explaining how they may differ from the ENZ scenarios. Further, a clear summary on the relative importance of each of the key differences across the scenario assumptions would be useful.

Methane Reduction Technologies (e.g., vaccine)

The CCC modeling assumes exogenous improvements in technologies such as breeding and methane inhibitors/vaccines that contribute to biogenic methane reductions. These assumptions are consistent with technologies and scenarios evaluated by the NZ Biological Emissions Research Group (BERG)[1]. Model estimates for the CCC net zero analysis have indicated that the uptake of these technologies is the second largest contributor to emissions reductions from the land use sector after afforestation. The sensitivity analysis about the rate and cost of uptake on sector and economy-wide estimates produces logical results. The findings are consistent with other research on the topic of emerging technologies in NZ agriculture and thus appears to be appropriately modeled.

ENZ

ENZ includes seven land uses that represent the primary sources of emissions and removals from NZ's land sector. Land use and emissions are modeled at the national level, which I interpret as it uses 'average' farm/forest productivity and emissions/removals from across NZ. While doing so is consistent with how other sectors of the economy were modeled, I would expect the land use sector to have more geographically variable impacts than most sectors. Further, more details on how the national level estimates are used to inform the regional distributional impacts in DIM would be useful.

Assumptions on levels of afforestation in the policy scenarios are based on "evidence and judgement". ENZ used a manual refinement process of exotic forestry planting area to 'goal seek' and ensure the net zero target for long-lived gases is met by 2050 or earlier. New native forest is assumed to be established on unproductive land and have no impacts on livestock numbers or production. These assumptions are reasonable given how the model was constructed, however in theory native forest could also be planted on productive land if that is proven to be the more profitable option. Additional documentation on the value of native versus exotic forests under different carbon prices could be useful here.

Figure 8:26 highlights that productive agricultural land is lost relative to 2018 in all modeled scenarios. Further, it shows that about 1 Mha of *all* the ~14 Mha of land in 2018 disappears. I am assuming that this is because that land is exogenously converted to non-productive uses like lifestyle blocks, but the documentation could be clearer about where this land goes. As this loss in land is consistent across all scenarios, it should not have any effect on evaluating the impact across each scenario. This should be clarified in the documentation.

C-PLAN

[1] https://www.mpi.govt.nz/dmsdocument/32125/direct

C-PLAN is a recursive-dynamic CGE model that estimates climate mitigation primarily through abatement cost. Sectors are designated using the GTAP framework, where there are 5 land use "sectors" and 5 secondary land use processing sectors. The model splits out biogenic methane from livestock from all other GHGs. Agriculture can mitigate GHGs by reducing output or changing land use (including to forestry). The model's forestry sector does not respond to abatement cost, which is common a for CGE models due to the complexity of modeling the sector in an economy-wide framework. The total amount of land in the model is exogenously fixed, as was done in ENZ. Model estimates are produced at the national level.

Chapter 12 presents some results from C-PLAN's reference and four target-aligned scenarios and indicate that climate policy will reduce physical milk output by 5% and increase meat output by 2% relative to the reference case. Forestry output remains nearly constant. However, the results appear to be different than those presented in slide 19 of the "CPLAN model results summary" presentation, which show a larger reduction in meat products (in NZD) than dairy compared to the reference case. While dairy is a more GHG-intensive industry, it is also more profitable. Thus, either result is plausible. Interestingly, forestry output in slide 19 goes down for some of the policy scenarios. I believe this is explained by the difference in share of new exotic and native forest across the different scenarios, where native does not produce any harvest output over the study period (nor does much of the new exotic forest). More detail could go into highlighting some of the impacts between different rates of afforestation in general, but also the split between new native and exotic planting.

The results in slide 17 of the presentation show the sensitivity of the methane technology to carbon prices. These responses are logical and highlight the potential impacts to various parts of the land use sector from differing rates of adoption. While scientists and policymakers are confident that there will be a methane reduction technology available, a future sensitivity analysis could consider the effect if that is not the case, thereby highlighting the strength of that assumption on model results (similar to what happens in 2049/50 for TP2 when abatement is exhausted).

Finally, more recent estimates provided by the CCC highlighted the impacts to the overall terms of trade. Future documentation could break this out by major sectors of the economy, including agriculture and forestry.

DIM

The DIM model takes national-level estimates from C-PLAN and disaggregates them to show regional-level impacts on regional employment. There is limited documentation on the methodology of the DIM model, and results in chapter 12 are largely qualitative. Initial results indicate that there could be some job losses in the dairy, and sheep and beef sectors and increases in forestry and logging employment relative to the reference case, which is to be expected if land and output shifts from pasture to forest. The relative impacts to these sectors are estimated to diminish over time, although there is limited information on why this is the case. Future work should include more details on how DIM incorporates C-PLAN estimates into the model as well as how and why sectoral employment shifts over time.

Harvested Wood Products

The carbon stored in harvested wood products is simulated by changing the factor for averaging emissions from 17 to 22 years. However, this number does not appear to include any feedback from changing the product mix, which could occur if more forestry is used to produce biofuels or a greater proportion of durable wood products that could emerge as climate change induces a substitution from fossil- to wood-based building materials (e.g., cross-laminated timber). While I expect that this effect may be relatively small compared to other sources of abatement such as utilization of electric vehicles or biogenic methane reduction technologies, the effect could be tested relatively easily through sensitivity analysis.

Impact of COVID-19

The impact of COVID-19 has affected economies across the globe and is at the forefront of the minds of policymakers and the general public. While one may initially think that COVID-19 will have a major impact on the global economy for the indefinite future, it more logical to expect that most impacts will subside over a relatively short time period, as has been the case for most economic shocks over the past 50 years. Thus, I believe that the CCC has made a very reasonable choice by not explicitly incorporating the effects of COVID-19 into their analysis.