Potentials of Negative Emissions in the Design of Climate Agreements

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Overview

In many scenario simulations performed with integrated assessment models, where the goal is to maintain a temperature change below 2^{o}C at the end of the century, negative emissions play an important role, starting in 2050 and permitting reaching a zero-net emission regime around 2070. The options of choice to produce negative emissions are biomass fueled power plants with carbon capture and sequestration (BECCS) and Carbon Direct Removal (CDR) technologies, and more precisely Direct Air Capture (DAC).
The aim of this paper is to explore the long-term relevance of negative emissions generated by DAC and BECCS for the attainment of Paris agreement goals. For this purpose we extend to the horizon 2100 a burden sharing model that we used to explore climate policies in [1, 2, 3] and we introduce DAC and BECCS activities as part of the strategies that different groups of countries can adopt in the long term. In the simulations performed with this extended model we can observe the possible impact of the introduction of these technologies on the definition of a fair sharing of a cumulative emissions budget.

Methods

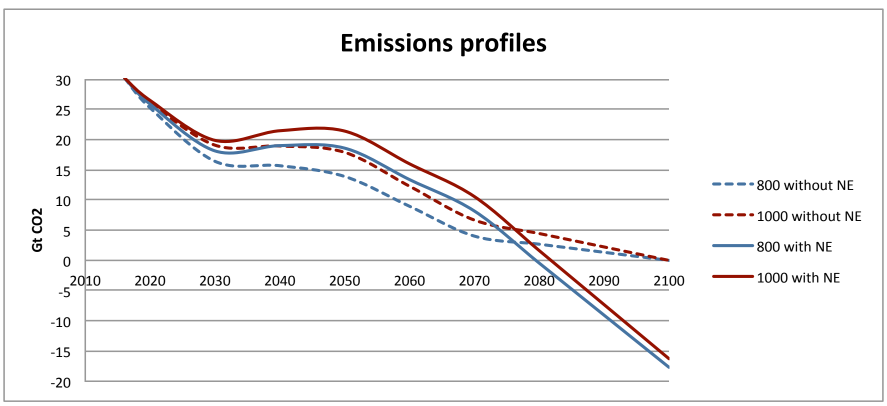
An objective toward a "good" probability of reaching the 2^{o}C target is to limit the cumulative emissions budget over the period 2015 onwards to 800-1000 $GtCO_2$. Therefore, as a consequence of the Paris agreement, all the parties, jointly should limit their cumulative emissions to this safety budget. The idea that a climate policy should be oriented toward a fair sharing of cumulative emissions has been developed in [1, 2, 3], using a Meta-game model that we intend to extend to capture the possible impact of DAC and BECCS technologies. We consider m = 11 groups of countries, or coalitions, like e.g., E-U, US-Canada, Emerging countries, Developing countries, etc. In each group there are several countries sharing similar economic structure. As indicated above, the burden sharing issue reduced to the sharing of the safety cumulative emissions budget. To assess the economic consequences of a proposed sharing rule, one must assume that an "optimal" use of the global emissions budget will be made, or, at least that a "second best" solution should be reached, corresponding to an equilibrium among the parties. For that purpose we assume that an international market for emissions permits will be implemented and that the participating countries will have full banking and borrowing options to manage their respective emissions budget shares. A strategic variable is the supply of permits that each group of countries forming a party will put on the market at each time period. The total supply of permits will determine a world price of carbon and emissions abatement levels that equate the price to the respective marginal abatement costs in the different parties. This will also determine the welfare losses, with respect to a BAU situation, the gains in the terms of trade, and the buying and selling of permits. Other strategic variables are the level of activity in DAC and BECCS. Through the use of these technologies, countries can generate negative emissions, which replete their respective emissions budgets. At each period, the net cost for a coalition is the sum of the welfare losses plus the DAC/BECCS cost minus the gains from the terms of trade and the gains (minus the cost) from the selling (buying) of permits. The "second best" solution is obtained by assuming that the parties play a Nash equilibrium with payoffs defined by minus the discounted sum of their net costs over the rest of the 21st century plus the discounted cost over an infinite horizon of the limit steady state solution with zero-net emissions. This equilibrium result will permit a comparison of the relative welfare losses, expressed as the discounted sum of GDP losses relative to the BAU situation. In this study we compute fair (Rawlsian) burden sharing solutions minimizing the maximum of the relative welfare losses (with a 3% discount factor).
We use the GEMINI-E3 model to calibrate the dynamic game model. GEMINI-E3 is a worldwide multi-country, multi-sector, computable general equilibrium (CGE) model that has been specifically designed to assess energy and climate change policies. GEMINI-E3 is used to compute the CO2 emissions and economic variables within the business as usual (BAU) scenario and calibrate the payoff functions. The methodology used to calibrate our game theory model using an applied CGE is detailed in our previous papers. In short, various climate policies are simulated by GEMINI-E3, then we perform econometric estimations of the abatement cost and gains from term of trade functions. However, the time horizon of GEMINI-E3 is limited to the first part of our century (i.e. up to 2050), therefore we have to implemented procedure that extend the variables for the years 2070 and 2100. We use a

versatile representation based on a steady state growth approach for the end of our century. Potentials and costs for DAC and BECCS among regions are based on literature estimates.

Results

In this section, we present the preliminary results of four numerical simulations with and without DAC/BECCS technologies and for two emissions budgets, ie, 800 and 1000 $GtCO_2$. The following Table gives, for each scenario, the emissions allocations equalizing GDP losses among regions, the associated GDP losses and the CO2 prices evolutions. Figure below displays the emissions profiles by 2100.

	Without DAC/BECCS		With DAC/BECCS	
Budget (in GT)	800	1000	800	1000
Budget share				
USA	8.6%	9.5%	11.9%	12.1%
EUR	10.0%	9.8%	8.3%	9.5%
CHI	17.9%	18.9%	28.0%	23.7%
IND	7.7%	7.2%	3.1%	1.9%
RUS	5.3%	5.1%	0.0%	2.5%
GCC	4.4%	4.7%	3.1%	5.9%
OEE	13.3%	13.4%	19.7%	18.7%
ASI	14.0%	13.5%	9.3%	7.4%
LAT	3.9%	3.8%	0.0%	1.1%
ROW	14.9%	13.9%	18.8%	17.2%
Welfare loss (equalized GDP losses among all countries)				
	3.7%	2.3%	1.4%	1.0%
CO_2 prices in US$ per ton of CO_2				
2030	700	446	231	167
2050	1857	1183	418	301
2070	4996	3191	753	543
2100	4859	4551	1778	1268



Conclusions

Our preliminary results demonstrate the importance of considering the potential of negative emissions technologies in the design of long-term climate agreements. GDP losses can be divided by a factor higher than 2 (from 2.3 to 1.0% and from 3.7 to 1.4%) if DAC/BECCS technologies are introduced after 2030. The impact on CO2 prices is even larger as DAC/BECCS avoids to implement very expensive abatements to attain a zero-net emission regime and allows one to postpone a part of emissions reduction after 2070. Our numerical results also show that countries with high potentials of DAC/BECCS (including sequestration) are receiving less allocations (eg, LAT, ASI, GCC, RUS) in the design of fair agreements.

References

[1] F. Babonneau, A. Haurie, and M. Vielle. A Robust Meta-Game for Climate Negotiations. Computational Management Science, 10(4):299– 329, 2013.

[2] F. Babonneau, A. Haurie, and M. Vielle. Assessment of balanced burden-sharing in the 2050 EU climate/energy roadmap: a metamod- eling approach. Climatic Change, 134(4):505–519, 2016.

[3] F. Babonneau, A. Haurie, and M. Vielle. From COP21 pledges to a fair 2 degree C pathway. Economics of Energy & Environmental Policy, to appear.