The Impact of Carbon Sink Uncertainty on Mitigation Strategies

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Objectives

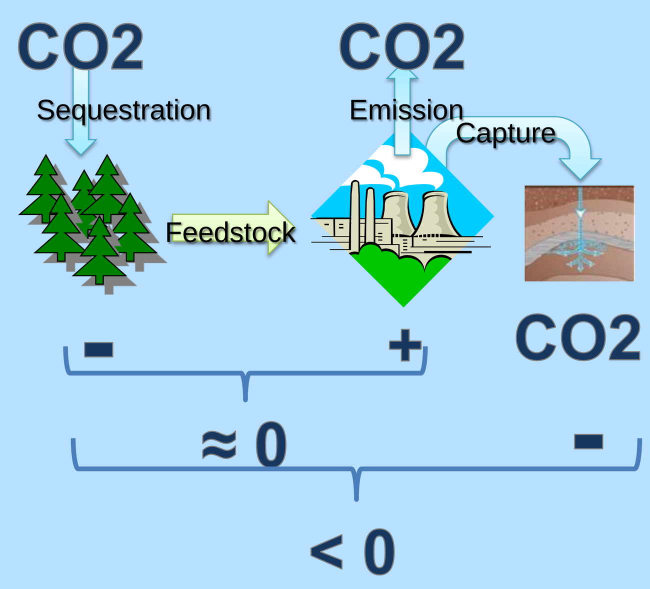
- Optimal composition of a mitigation portfolio given the uncertainty surrounding key variables
- Natural sink modelled stochastically and as a function of atmospheric Greenhouse Gas (GHG) concentration accounting for possible climate feedbacks
- Analyze different emissions targets and identify best hedging strategies in the technosphere given the uncertainty in the biosphere with explicit focus on their interrelation
- Examine the role of bioenergy with carbon capture and storage (BECCS) when accounting for natural sinks and the potential climate feedbacks

Model

- A global decision maker plans abatement and negative emission technology (NET) deployment bound by a cumulative emission target over the 21st century
- Three periods: 1) Short-term (2010-2030), 2) Medium-term (2030-2050), and 3) Long-term (2050-2100)
- Select most cost-effective policy plan with two available options: (1) abatement and (2) deployment of NETs consisting of BECCS and direct air capture (DAC). The technologies differ in their cost structure and mitigation levels.
- CO_2 sink modelled similar to Friedlingstein et al. (2006): feedback between atmospheric CO_2 concentration and the sink, with additional stochastic shocks representing extreme events like forest fires, pests, etc. (Probability of shock occurrence modelled as being positively dependent on the cumulative emissions)

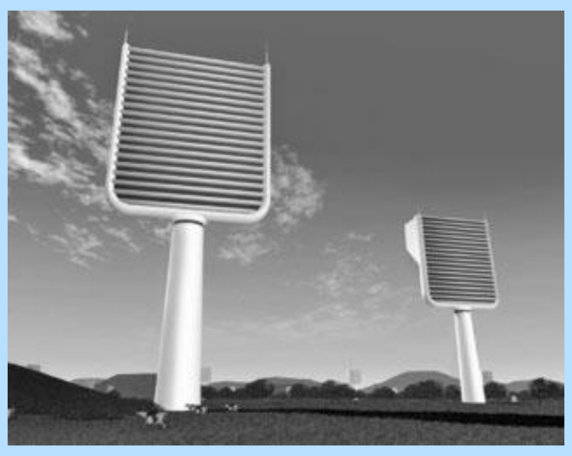
BECCS

- Bio-energy in combination with carbon capture and storage
- Using biomass to produce bio-energy, then capturing and diverting the CO_2 produced during combustion/processing into a long-term geological storage facility
- CO_2 fixation by photosynthesis (i.e. bio-energy under certain criteria, is considered to be carbon neutral) plus capture and storage of CO_2 from biomass combustion (negative emissions)



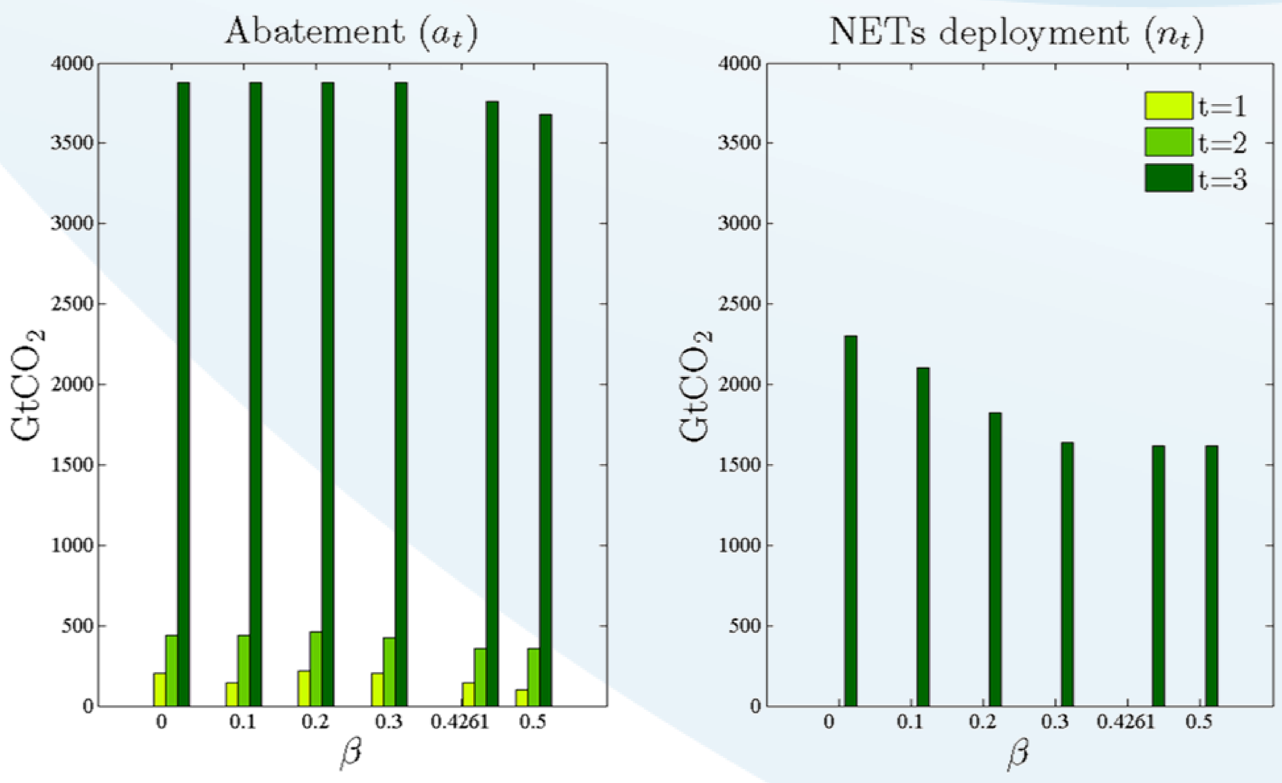
DAC

- Direct Air Capture
- Using chemical reactions to remove CO_2 directly from the air
- Currently expensive, i.e. DAC is much higher on the abatement curve than BECCS and will only be deployed if all other potentials are exploited



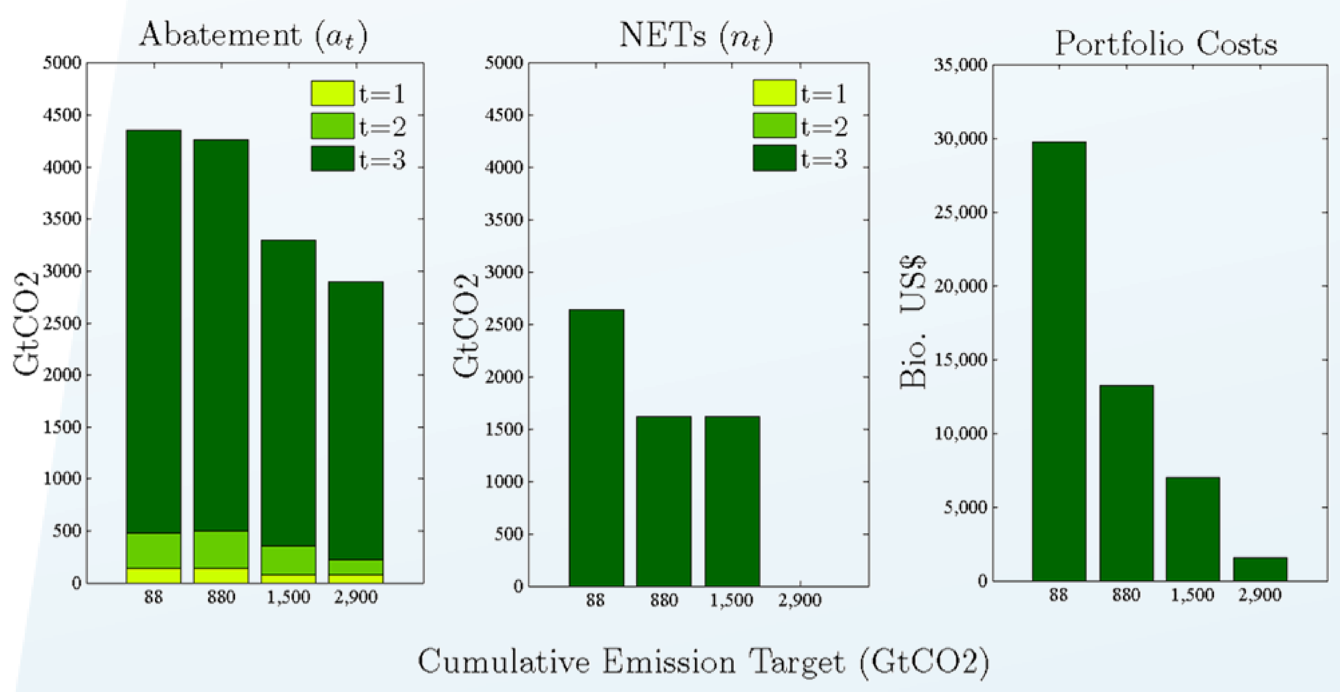
Sink Sensitivity to Atmospheric CO_2

- Deployment of BECCS (and DAC) very much dependent on sink's sensitivity to atmospheric CO_2 (β)
- For high CO_2 fertilization effect: NETs are a relatively stable share in the mitigation portfolio, which is equal to the maximum BECCS potential.
- For a lower effect: amount of CO_2 abated with NETs increases, i.e. deployment of DAC starts and increases.
- Result as expected because "free" mitigation through uptake by natural sinks decreases and NETs have to make up for the difference



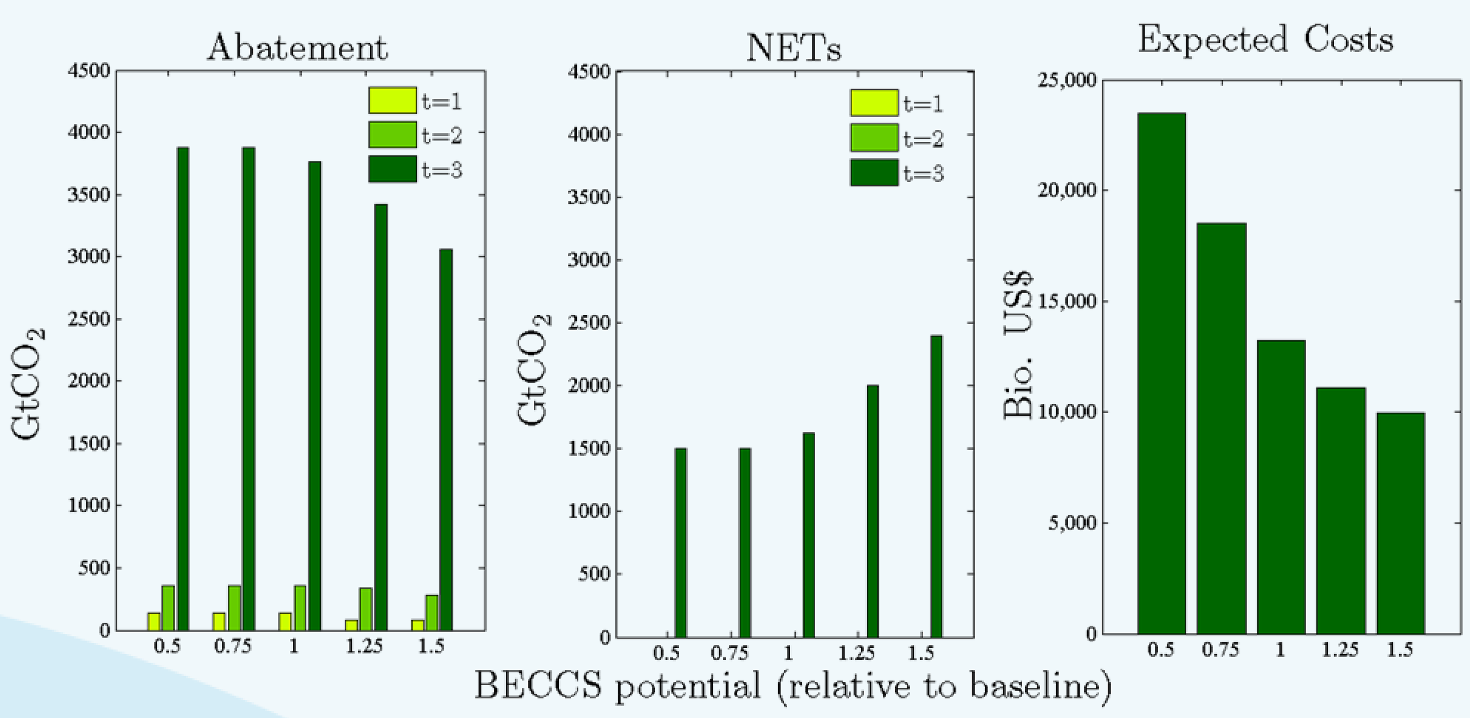
Cumulative Emission Target

- Least stringent cumulative emissions target (2,900 $GtCO_2$): NETs are not part of the optimal portfolio anymore.
- Most stringent target (88 $GtCO_2$): in last period maximum amount of BECCS (1,605 $GtCO_2$) plus 1,035 $GtCO_2$ of DAC, as so much abatement in the last period needed that DAC becomes cheaper than marginal unit of abatement
- Abatement need in first period similar with different targets (140 $GtCO_2$ for the 88 and 880 $GtCO_2$ targets to only 80 $GtCO_2$ for the 1,500 and 2,900 $GtCO_2$ targets)
- The present value (PV) of the portfolio cost increases exponentially with the stricter cumulative emissions targets



BECCS potential

- Even though BECCS is used only in the third period, its potential has direct impact on the optimal abatement already in the first and second periods.
- Increase of 50% in potential of BECCS is reflected in an over 40% (20%) decrease in the first (second) period abatement.
- If BECCS potentials are higher than in our baseline the present value (PV) of the portfolio costs decrease relatively little, as we deploy more BECCS.
- If BECCS potential is lower than in the baseline, however, the PV of the costs almost doubles because of the increased deployment of DAC



Shocks to the Carbon Sink

- With increasing shock size, more mitigation needs to be carried out to meet the target in the last period in total.
- The larger part of this increase is achieved through NETs deployment. As the potential of BECCS is already fully exploited in the baseline case, the increase can here only happen via a deployment in DAC.
- With a higher probability of a shock to the sink, this increase gets steeper with the shock size