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The post-carbon society: Rethinking the international governance of negative emissions

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Abstract

This article makes an early attempt at connecting political science insights on the politics of carbon sequestration to a growing demand for knowledge about the potentials of negative emissions. Negative emissions from sequestering carbon is likely to be vital for fulfilling the 2°C target. Thus, this article is a reality check on what states *actually* plan to do. Based on key states' nationally determined contributions (NDCs) to the international climate regime and off-the-record interviews with senior country representatives to the 2016 climate meeting in Marrakech, we find that states generally do *not* have policies to promote large-scale carbon sequestration or negative emissions. However, many states wish to make the most of terrestrial sinks, using current regime rules as part of their mitigation portfolios. We suggest that national strategies to promote negative emissions will remain absent until the international climate regime formalizes rules and incentives for such efforts, recognizing them as legitimate national contributions. Without a governance framework that admits such efforts, national initiatives on large-scale negative emissions cannot fulfill the purpose of climate policy in a two-level setting matching national interests and international commitments.

Detailed Response to Reviewers

Changes since the previous version:

Proofread text and tables.

In the paragraph below table I, added a number of sentences and a few references on how the article ties in with energy transitions articles previously published in ERSS.

Changed the title after discussing it with the editors.

The post-carbon society: Rethinking the international governance of negative emissions

1. Introduction

The Paris Agreement commits states to keeping the increase in global average temperature this century to “well below” 2°C (UNFCCC, 2015, p.3). The task of staying below this 2°C target has been left to the sum of what states present in their Nationally Determined Contributions (NDCs) to the international climate regime. The hope and assumption is that in time the sum of national actions will converge towards achieving this shared ambition (Höhne et al., 2017). It is a “coordination light” approach to a formidable task (Victor, 2016).

So far, the sum of all stated NDC pledges are however patently insufficient to put us on a global trend to meet the target. Even with all pledged actions put into effect, we will see warming of 2.9-3.4°C (Le Quéré et al., 2016; UNEP, 2016). Achieving the 2°C target will most likely imply that global greenhouse gas (GHG) emissions have to turn *net negative* in the second half of the century (Edenhofer et al., 2014), as in “the deliberate removal of CO_2 from the atmosphere by human intervention” (Fuss et al., 2014, p.850). In other words, we need to create a post-carbon society. Of the Intergovernmental Panel on Climate Change (IPCC) scenarios consistent with reaching the 2°C target by more than a 50% likelihood, 87% assume widespread negative emissions (Edenhofer et al., 2014). This essentially means that taking the Paris Agreement seriously requires that we engage with the relatively unproven and controversial class of mitigation measures called negative emissions technologies (NETs).

The question then becomes; if it is improbable that we reach the 2°C target without NETs on a large scale, should we not expect states to spend considerable effort on developing NETs? This we however do not see. This article therefore seeks to answer if and why (not) states pursue policies that correspond to the fact that the backbone of successful collective action on climate change mitigation rests on the use of NETs.

While the NETs literature is rapidly increasing, it is still small, in 2015 accounting for only 1% of the overall climate change literature.[1] Of these articles, less than 5% are from the social sciences (Minx et al., 2017).[2] Even fewer contributions have studied NETs in global climate governance from a political science perspective, although recent headlines now report that governments are beginning to add NETs research to public budgets. The United Kingdom in 2017 allegedly became the first country to set aside funding specifically for NETs research, and the US Department of Energy also has grants for carbon-capture technologies. However, so far the sums are negligible (£8.6 million and $26 million) (Economist, 2017), and in general, the governance of NETs has been given very little attention.

[1] Much of this literature underlines the need for more knowledge of their material consequences, warning of wide-ranging adverse effects on biological diversity, freshwater and nutrient restraints, and land-use conflicts from putting NETs to work (Fuss et al., 2014; Jones et al., 2016; Smith et al., 2016).

[2] Out of roughly 3000 NETs articles since 1991, only 5.4% address institutions and governance. While social science articles have increased in absolute numbers, they account for a smaller percentage of the overall pool of articles now than in 1991. Thus, in 2016 more than 95% of the articles on NETs came from the natural sciences, agricultural sciences and engineering and technology (Minx et al., 2017).

Some worry that the global governance of NETs has moved *too fast* without a proper scientific understanding, as seen with the Convention on Biological Diversity's (CBD) decisions to discourage geoengineering in 2010 (Victor et al., 2013). Others suggest that the problem is *too little* policy at the international level, arguing that we will not see much experimentation with NETs unless a governance framework to encourage this is established (Williamson, 2016). Either worry demonstrates the importance of studying NETs politics and governance.

Given the knowledge gaps and the importance of the issue, this article attempts to add to a few pertinent contributions. The NDCs submitted to the international climate regime meeting in Paris in 2015 and, one year later, to the climate regime meeting in Marrakech, provide us with a great opportunity to take stock of how and to what extent states are prioritizing negative emissions, at present and for the future. Our data is based on the NDCs available by the Marrakech meeting in 2016, in combination with personal interviews with senior representatives from the delegations of seven of the world's 15 largest GHG emitting countries, present in Marrakech.

NETs *per se* has not to any great extent yet been studied empirically. Thus, to tie prospective NETs to what we actually *can* study on empirical terms, this article draws on the assumption that support for other carbon sequestration-based mitigation concepts represents a necessary step one for a policy that will eventually embrace carbon stock maintenance from NETs. Most NETs are based on carbon sequestration in one way or another, but not all carbon sequestration yields net negative emissions. However, there *are* empirical examples of carbon sequestration in global climate politics that in theory may yield negative emissions, and as such conform to a broad definition of NETs as all types of measures that remove CO_2 from the atmosphere by human intervention, even if they are not commonly described as NETs. The three most obvious include the climate regime's rules for accounting for anthropogenic activities from Land-Use, Land-Use Change and Forestry (LULUCF), the international mechanism for Reducing Emissions from Deforestation and forest degradation in Developing countries (REDD+), and methods for geological carbon sequestration using CCS methods. We suggest that the politics of these approaches to carbon sequestration are key to assessing the politics of sequestration leading to net negative emissions. For example, Bio-Energy CCS (BECCS) warrants an operational CCS value chain. Similarly, LULUCF is all about afforestation and reforestation (A/R), as is REDD+ when it comes to intermingling so-called "fossil" and "biological" carbon in national mitigation portfolios. If the world's emitters are planning for any large-scale carbon sequestration based on existing frameworks for geological storage or biomass-based carbon sinks, we argue that this implies adhering to the worldview of the IPCC and research community at large; namely that an global effort is needed not only to curb carbon *flows* but also to manage carbon *stocks* to achieve substantial negative emissions. What we however find, is that this is certainly not the case.

After systematizing a bewildering array of NETs-related concepts, we suggest using the framework of international politics as a two-level game as a vantage point to analyze NETs. States need simultaneously to balance national interests and international norms, as NETs need to fulfill *a political purpose* for states (Harrison & Sundstrom, 2010; Keohane & Oppenheimer, 2016; Putnam, 1988). Few NETs, however, actually do that under the current regime. What comes closest to fulfilling a political purpose are activities under the LULUCF rules, as the Paris Agreement offers liberal carbon counting rules for national, terrestrial carbon sinks. But while the Paris Agreement's NDC mechanism may prove helpful for mounting national ownership to *some* mitigation actions, this does not apply to most other

NETs under the current governance framework. Our suggestion is that as long as the climate regime does not reward states for national efforts on NETs, and as long as NETs do not serve any political function in the two-level game, the Paris agreement's "coordination light" approach will be insufficient for new NETs to become public policy to a degree where it actually makes a difference in curbing emissions. Thus, it comes as no surprise that, with the exception of LULUCF, efforts have so far been very limited, as the empirical section establishes that states' efforts on carbon sequestration and NETs fall far short of the implicit Paris Agreement recommendations. More governance efforts are probably required for new NETs to be realized, with the lack of an international framework for the experimentation with NETs for climate policy purposes a key impediment.

2. Concepts and literature

Besides the Fuss et al. (2014) emphasis on the deliberate removal of CO_2 from the atmosphere by human intervention, negative emissions and negative emissions technologies (NETs) have also been labeled "geoengineering" (Bellamy et al., 2013), "carbon dioxide removal" (CDR) from the atmosphere (Meadowcroft, 2013) or "greenhouse gas removal" (Lomax et al., 2015). Because CDR implies manipulating the global carbon cycle, most CDR also fits the controversial "geoengineering" category (Meadowcroft, 2013; Williamson, 2016).[3] Note however that all "geoengineering" activities are not NETs, as the former is preoccupied with modifying any climate relevant earth system.[4] NETs, in contrast, is focused solely on CO_2 removal. Unlike traditional mitigation measures, NETs are also less concerned with whether the removed CO_2 stems from humans or from natural flows.[5] Thus, most NETs are by definition based on carbon sequestration and the two terms are used interchangeably in the following.

By *carbon sequestration* we understand all approaches to "capturing and securely storing CO_2 that would otherwise be emitted to or remain in the atmosphere" (Herzog & Golomb, 2004, 277).[6] Conceptually, without considering system boundaries and re-growth times, this may be done based on photosynthesis by increasing CO_2 uptake in the climate system's reservoirs and sinks. A/R are the most notable photosynthesis-based methods for enhancing terrestrial sinks (Humpenoder et al., 2014).[7] In the ocean, iron could potentially be used as a fertilizer to stimulate primary production (Duprat et al., 2016). One might also capture CO_2 from the atmosphere using mechanisms besides photosynthesis. Such options include soil carbon management techniques, like biochar (Smith, 2016). Direct Air Capture (DAC) is a label for chemical engineering-based measures to extract CO_2 from air (Lackner et al., 2012). In the ocean, it may be possible to boost the geochemical fixation of CO_2 uptake using lime or silicate (Erbach, 2015; McGlashan et al., 2012).

Beyond capturing CO_2 from reservoirs in the climate system, there is traditional CCS as we know it from industrial value chains, or "non-NETs carbon sequestration from other sources" (Metz et al., 2005). CCS conceptualizes a sequence of technologies where CO_2 is captured,

[3] The IPCC, however, defines only CO_2 capture from the atmosphere as Carbon Dioxide Removal (CDR), directly fitting the NETs definition (Allwood et al. 2014, 1254). "A set of techniques that aim to remove carbon dioxide (CO_2) directly from the atmosphere by either (1) increasing natural sinks for carbon or (2) using chemical engineering to remove the CO_2, with the intent of reducing the atmospheric CO_2 concentration."

[4] Focusing on carbon removal excludes so-called "geoengineering" techniques that do not remove carbon, such as for instance solar radiation management (Goes, Tuana, & Keller, 2011; Meadowcroft, 2013).

[5] Mitigating emissions from anthropogenic activities has been the preoccupation of the international climate regime (Allwood et al., 2014).

[6] Irrespective of the CO_2 source or whether the CO_2 is stored in sinks or geological reservoirs. Other parts of the literature only consider biological sinks as carbon sequestration (Allwood et al., 2014, 1271).

[7] A sink is "any process, activity or mechanism that removes a greenhouse gas (…) from the atmosphere" (UNFCCC, 1992).

transported and finally stored away from the atmosphere in geological formations (Gibbins & Chalmers, 2008a). Such "traditional" industrial CCS is included here because it constitutes the pre-required sequestration processes for key NETs concept BECCS. While CCS was originally intended for fossil fuels, BECCS expands the scope to include CO_2 from biomass, turning CCS value chains into a NET (Vuuren et al., 2015).

BECCS, although hardly attempted at any scale, and A/R are considered the key NETs with a feasible, global potential (Edenhofer et al., 2014; Fuss et al., 2014; Muratori et al., 2016; Smith et al., 2016; Vergragt et al., 2011).[8] Table I highlights the theorized ways of carbon sequestration, emphasizing potential NETs.

Table I: Conceptual overview of carbon sequestration approaches

			Carbon storage	
			Biological reservoirs	*Geological storage*
	From air (CDR)	Photosynthesis	*On land*: Afforestation, reforestation, fertilization, other land-use practices *Ocean*: Fertilization for increased primary production	(BECCS*)
Carbon capture		Chemical engineering	*Ocean*: Various geochemistry measures (liming, silicate).	Direct Air Capture
	From other sources	Chemical engineering	-	CCS (BECCS*)

*BECCS implies "double" carbon capture from both photosynthesis and biomass combustion.

Even within the most recent literature, there are remarkably few empirically based social science studies of NETs. We do however have a rich literature on energy transitions, and a post-carbon society would indeed be an important part of such a transition. Thus, *Energy Research & Social Science* has carried an ongoing energy transitions debate spanning multiple volumes. Smil (2016) argues that while there are examples of rapid energy transitions on the national level, all global energy transitions have been gradual and prolonged affairs, and that it will be especially difficult to replace the carbon used for producing cement. Fouquet (2016) writes that transitions take at least 30 years, but that in some instances governments have created institutional settings that have speeded up the process, and that given the political will, this could be replicated. Sovacool (2016) as well as Kern & Rogge (2016) assert that we can find many examples of transitions that have taken less than a decade at the national scale and that one cause for optimism is the increased awareness and the greater possibility for international governance in this area than has been the case with previous energy transitions. What they all emphasize is how these are long-term processes often fought and resisted by incumbents, but that there are cases where an institutional or regulatory framework has been crafted, thus speeding up of the transition process. These are arguments that are of relevance. Indeed, what we propose is that it is exactly the lack of international governance that has so far given NETs a very peripheral status amongst the world's largest carbon emitters.

[8] Finally, one could envision putting captured CO_2 to use in long-lasting products, but it is hard to imagine a product-based displacement of carbon of the magnitude and permanence required to help close the emissions gap (Markewitz et al., 2012).

That said, a focus specifically on NETs and even more so NETs *policymaking* has been a conspicuous neglect of the literature. Granted, in this very journal last year, Markusson et al. (2017) did a fine job of conceptualizing the political economy of NETs, as well as explaining the persistent allure of NETs as a technical fix, but without dealing with what actions the major emitters have formally pledged to carrying out, for example in their NDCs to the international climate regime. Thus, the lack of attention to the politics of NETs is a regret; see for instance Anderson and Peters (2016), who warn us that out of 76 climate scenarios consistent with a likely chance of not exceeding 2°C none seriously discuss whether the rollout of NETs is technically, economically and socially viable. Instead, this is simply just assumed, while policymakers also fail to comprehend the "pervasive and pivotal role of negative emissions in mitigation scenarios, [leading to] their almost complete absence from climate policy discussions…" (Anderson & Peters, 2016, p. 182). While empirical examples of NETs politics are few, contributions that map public opinion on such options constitute notable exceptions (Bostrom et al., 2012). For instance, Fridahl (2017) shows how delegates to the international climate meetings in 2015 have only limited confidence in the problem-solving potential of BECCS. Similar assessments find that independent technical experts believe that NETs will not deliver at the scale foreseen in the Integrated Assessment Models (IAMs) (Vaughan & Gough, 2016).

As mentioned in the introduction, despite very little empirical data on NETs *per* se, we *do* have examples of analogous carbon sequestration, and the politics of LULUCF, REDD+ and CCS each have their own academic followings. Similarly to how the governance of NETs struggles with scientific uncertainty and the highlighting of potential side-effects, for over a decade the LULUCF literature has demonstrated the intricacies of global decision-making when scientific arguments and political interests clash on a highly complex, high-stakes issue (Fry, 2002; Lövbrand, 2004). Likewise, much of the REDD+ literature highlights the opportunities and challenges of creating a cooperation mechanism across the North-South divide in global politics (Dooley & Gupta, 2016; Gupta et al., 2013). The CCS literature, moreover, has pointed to the firm relationship between fossil energy production and CCS-based mitigation strategies, in addition to underlying the political implications of skeptical popular perceptions in some countries (L'Orange Seigo et al., 2014; Meadowcroft & Langhelle, 2009; Røttereng, 2018).

The NDCs allow us to analyze and draw inferences about NET policies more in general, both in terms of what states are already doing and what they perceive themselves as doing in the future. In combination with interviews, to our knowledge, this exercise has not been carried out in the literature before. It provides the scant governance literature on NETs with a very useful addition: combining a proposed explanation for why states' efforts on NETs are falling short in every respect, bar potentially for LULUCF with the mapping and systematizing of states' actual pledges with respect to NETs.

3. Theory and methodology

What explains states' behavior with respect to NETs? And why does the large majority of existing initiatives fall under the heading of LULUCF? Below, we suggest that the answer is found in viewing international politics as a two-level game, where policy options to pursue NETs need to fulfill *a political purpose* for states.

In many ways there is however already a default hypothesis; these are unproven and not yet cost-effective technologies, and that is why NETs have not progressed further. There is obviously considerable sense to this. However, stopping there prevents any deeper understanding of how politics and economics interact. Internationally available data makes it very clear that more cost-effective measures, such as carbon pricing – highlighted in several of the 15 NDCs – is not setting us on course to attain the 2°C target. Many economists argue that we should pick the lower-hanging climate fruits first, postponing higher-hanging ones – like NETs – until technologies are further advanced and costs have come down. In contrast, what we argue, is that while states routinely prioritize the short term over the long term, they also prioritize according to regulatory incentive structures. Cost-effectiveness in NETs is unlikely to happen fast, not just because the technologies are in their infancy, but because no regulatory framework rewards states for efforts within NETs. Thus, the incentive structures are not conducive to NETs ever becoming cost-effective. Granted, NETs might be too controversial for states to allocate large amounts of funding, but again, there are no international regulatory structures that legitimize efforts on NETs, removing this disincentive. What we suggest, is that states have implemented carbon sequestration measures exactly in those areas where they fulfill a political purpose, irrespective among other things of cost-effectiveness concerns (CCS is for instance far more expensive than REDD+, even if LULUCF is comparatively cheap). Thus, rather than settling for the arguably parsimonious explanation that cost-effectiveness and technological maturity is what has hampered NETs, for a more profound understanding, below we suggest a political science-based explanation, originating from Putnam (1988).

The two-level dynamics and three purposes of climate policy

Viewing climate politics as a two-level game means that a state needs to simultaneously balance national interests *and* international norms in mutually acceptable ways at both levels (Harrison & Sundstrom, 2010; Keohane & Oppenheimer, 2016; Putnam, 1988). At the international level, the state is committed to climate action within the international climate regime and to observe other regimes to which it is a party. Climate action and upholding international commitments are two international norms (Bernstein, 2012; Finnemore & Sikkink, 1998), and openly failing to adhere to such norms weakens a state's legitimacy as an international actor. Domestically, winning coalitions of domestic actors determine what the "national interests" are (Moravcsik, 2008). National actors typically seek to avoid the costs of climate policy-imposed behavioral change. Theories of political economy for instance suggest that mitigation policies that cause transformative changes to the energy system are particularly hard to agree on because of vested interests (Moe, 2015; Unruh, 2000). Policymakers therefore need to find climate political solutions that simultaneously balance national interests and international obligations (Evans et al., 1993). Some mitigation measures, as conceptualized ways of reducing emissions, may serve as the basis for such mutually acceptable *political solutions* (Harrison, 2010; Røttereng, 2016). In short, NETs can only become public policy if they help states solve the two-level game.

There are three concrete ways that policies to promote mitigation measures, such as NETs, contribute to help bridging the gap between potentially contradictory concerns at the national and international levels. The argument is that unless a NET can be used for either of the below mentioned purposes, it will not become subject to state strategy in international climate politics. These three purposes are not mutually exclusive, but we believe the following conceptualization to be helpful in highlighting what realistically matters when states determine their national climate policy contributions. First, climate policy can aim to fulfill a state's *formal obligations*. This importantly includes actions for meeting quantified emission targets (Dubash et al., 2013; Höhne et al., 2017; Lachapelle & Paterson, 2013). It also extends to providing the “climate finance” for use in the global south that industrialized states have committed to (Pickering et al., 2015). Such formal fulfillment requires that mitigation measures are recognized and eligible within the relevant international governance framework that states participate in. It could also help asserted cost-effectiveness if such institutions allow for states to finance and account for emission reductions obtained from outside national borders, along the lines of the flexible mechanisms of the Kyoto Protocol (Yamin, 2005). Second, states may impose policies for the purpose of *regime formation*. This could include offering concessions that do *not* fulfill states’ formal obligations but improve prospects for long-term cooperation (Bernstein & Cashore, 2012; Keohane & Victor, 2011). Getting other parties onboard is important for the problem-solving capacity and legitimacy of international climate governance. Thus, this requires a global consensus on a concept’s mitigation potential, scope, risks and other non-climate related effects. Third, a *symbolic signaling* of commitment is another known strategy for states struggling with the two-level game (Cass, 2009; Newig, 2007; Tiberghien & Schreurs, 2010). This happens if states wish to signal norm adherence towards the external audience, while simultaneously avoiding the behavioral changes associated with the norm at the national level. Ultimately, an economic rationale for undertaking mitigation actions is also necessary, in addition to practical and technological feasibility aspects (Gibbins & Chalmers, 2008b; Lomax et al., 2015).

Data was gathered from the 2016 NDCs (and 2015 INDCs when NDCs were not available) of the top 15 GHG emitting states (the EU here treated as a unitary party to the international climate regime), accounting for roughly 80% of annual global GHG emissions. The 15 NDCs and INDCs were read in full. This we prioritized over a more quantitatively based key word search from a larger amount of NDCs and INDCs, as it better enabled us to fully ascertain whether the documents made explicit or implicit mentions of NETs, or if the documents contained descriptions of areas and policies that can be seen as analogous to or potential substitutes for NETs (e.g. LULUCF, REDD+, CCS).

There are a total of 149 NDCs and 165 INDCs. While our sample of 15 is not representative, and may potentially overlook initiatives in smaller states, these countries (including the EU) were selected because as of 2012 they accounted for 80% of annual global GHG emissions (WRI CAIT, 2016), which is by default where we find the bigger potential for emissions reductions in absolute terms. In addition, during the November 2016 Marrakech meeting we were lucky enough to receive access to representatives from seven of these 15 states, enabling us to execute seven roughly one-hour, off-the-record, personal interviews with senior government representatives from these states.[9] These seven account for approximately 50% of global annual emissions, and include both industrialized and developing countries from different continents. The interviews serve as a robustness check on the contents of the NDCs to better understand individual states’ positions on NETs. In agreement with the informants, we refrain from sharing the identities or affiliations of these representatives due to the topic’s political potential as part of the international negotiations.

4. Empirical findings: Exploring the politics of carbon sequestration and NETs

The empirical findings are structured around four broadly painted cases. The rationale behind the first three – LULUCF, CCS, REDD+ – is that they constitute cases of carbon sequestration that are essentially analogous to prospective future NETs, which is the fourth

[9] USA, China, EU (France), India, Japan, Indonesia, South Africa.

case. Thus, if there are political or institutional lessons to be learned from these, they should be immediately applicable to NETs. The first is the inclusion of carbon flows from land-use activities in the international climate regime; the so-called LULUCF rules. Second is the process of introducing CCS as a mitigation measure in global climate politics. Third is the climate regime's mechanism for Reducing Emissions from Deforestation and forest degradation in Developing countries (REDD+). Finally, we present a fourth and forward-looking case, summarizing what the NDCs and informants said about other potential constellations of NETs-related concepts, as summarized in chapter II. Table II below reports on states' NDCs as far as they are relevant for this analysis.

Table II: Overview of states' NDCs relevant to NETs

Top 15 emitters (80% of global totals, including LULUCF in 2012)	**National mitigation target in NDC/ INDC**	**Wil use terrestrial sinks/ LULUCF to achieve mitigation target**	**Mentions CCS as priority category**	**Mentions REDD+ as priority category**	**Mentions Negative emissions**
China (25.3%)	Peak emissions by 2030; Lower emissions per GDP by 60-65% from 2005 level	Yes, planned afforestation	Yes	No	No
USA (14.4%)	Reduce emissions by 26-28% below 2005 levels in 2025	Yes	No*	No	No
EU28 (10.16%)	At least 40% domestic reduction in GHG emissions by 2030 compared to 1990	To be determined	Yes	No	No
India (6.96%)	Reduced emissions intensity of GDP by 33-35% by 2020 from 2005 level	Yes, planned afforestation	No	No	No
Russia (5.36%)	70-75% of 1990 levels by 2030	Yes	No	No	No
Japan (3.11%)	25.4 % reduction by 2030 from 2005 level	Yes	Yes	No	No
Brazil (2.34%)	37% below 2005 levels by 2025	Yes	No	Yes	No
Indonesia (1.76%)	29% reduction from business-as-usual (BAU) in 2030	Yes, for forests and "blue carbon"	No	Yes	No
Mexico (1.67%)	25% reduction from BAU in 2030	Yes	Yes	No	No
Iran (1.65%)	4% reduction from BAU in 2030	No	No	No	No
Canada (1.65%)	30% reduction from 2005 in 2030	Yes	Yes	No	No
Republic of Korea (1.6%)	37% reduction from BAU in 2030	To be determined	No*	No	No
Australia (1.5%)	26-28% reduction 2005 level in 2030	Yes	No*	No	No
Saudi Arabia (1.22%)	130Mt CO2-eq. reduction in 2030 from BAU	Yes, for "blue carbon"	Yes	No	No
South Africa (1.07%)	Not possible to quantify	Yes	Yes	No	No

* Røttereng (2018) has shown that these countries have some public policy to promote CCS, even if it is not currently foreseen as a future way of achieving national mitigation targets.

The controversial inclusion of LULUCF

The inclusion of terrestrial sinks in the shape of LULUCF represents the first inclusion of NETs in the international climate regime, as A/R on managed lands. It has however been controversial, as the land-use sector was *not* counted in industrialized states' quantified emission targets under the Kyoto Protocol (2008-12). This led to discussions over whether or not terrestrial sinks could be used to offset "fossil" emissions on a sound basis, scientifically and ethically (Fry, 2002; Lövbrand, 2004). The EU and the developing countries feared that adding "biological" carbon to the Kyoto Protocol's quantified commitments would water down incentives for developed states to reduce "fossil" carbon emissions. Following an IPCC special report on the issue, the other industrialized states' position eventually prevailed so that LULUCF activities were allowed on a voluntary basis in 2001 (Noble et al., 2000). It meant that GHG emissions and removals from such economic activities could be counted by industrialized states for meeting their 2008-12 Kyoto Protocol targets. In the Kyoto Protocol's second commitment period (2012-20), LULUCF reporting is mandatory (UNFCCC, 2016). For the post-2020 Paris Agreement, states are free to report on LULUCF on a less uniform basis, as long as they follow "IPCC Good Practice" (IPCC, 2006; UNFCCC, 2015). It remains to be seen if the Paris Agreement should be understood as confirming full interchangeability between emissions from fossil sources and biological sinks (Dooley & Gupta, 2016).[10] In their NDCs, 12 out of the 15 top emitters plan to use LULUCF to achieve their mitigation targets, and among the informants, the emphasis on A/R initiatives in general was near unanimous, even if it was also nearly unanimously recognized that agriculture and other types of land-use allocations constitute major limits as to how much negative emissions this can accomplish. In most states large-scale A/R will at a fairly early stage bump up against agricultural interests. Out of the top 15, the three hesitant parties are Iran, the EU and South Korea. The latter two will determine their LULUCF positions in the coming years, partly pending methodological clarifications. If included, it still remains undetermined if reduced emissions from LULUCF should have its separate target or be included in the economy-wide one.

The limited internationalization of CCS

While some states have sequestered carbon in geological formations since the 1990s, CCS became subject to international coordination only in the 2000s. In 2005, the IPCC launched a special report on CCS suggesting how capturing and storing carbon could be done as a mitigation measure (Metz et al., 2005). That same year, the G8 countries issued common policy on the need for ramping up CCS globally. Increased government support for CCS followed in most industrialized states, including Australia, Canada, the EU and the US (Tjernshaugen, 2008). In many parts of the world, however, stakeholders remained unconvinced of geological carbon sequestration. In Germany for instance, the concept seems almost tainted, associated with the coal industry and with business as usual, rather than contributing to any *Energiewende* (Inderberg & Wettestad, 2015). Within the international climate regime, Norway and other CCS proponents pushed for a formal recognition for CCS as a mitigation measure, including as an eligible activity under the Kyoto Protocol's Clean Development Mechanism (CDM) (Bakke et al., 2010; Røttereng, 2016). Some developing countries were skeptical, but CCS was allowed into the CDM in 2011 (Dixon et al., 2013). However, while CCS proponents keep envisioning transnational CO_2 pipelines and shared storage under the seabed, transporting CO_2 across borders may still be banned by the London Convention on Marine Pollution (Dixon, 2015).[11] Thus, although CCS gained formal recognition as a mitigation measure, the diffusion of CCS largely failed in the sense that almost no CCS plants were built in the 2000s. As of 2016, only a miniscule 7Mt CO_2 per year is captured, stored and adequately monitored (IEA, 2016). This modest outcome is also reflected in states' NDCs, where only seven out of 15 states report that they plan to engage with CCS to meet their mitigation target. This may sound like a modest success, but of these only a few, Canada especially, seem particularly dedicated, and amongst the informants, only

[10] Article 4.1. says that the parties aim to undertake rapid reductions of emissions "to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases (…)" (UNFCCC 2015: art. 4.1).
[11] "Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972".

one emphasized CCS, and only as a solution that still lies considerably into the future. As actors increasingly come to see CCS as an alternative for reducing emissions from industry, not only applicable to fossil energy generation, global CCS implementation could however see an upsurge (GCCSI, 2016).

REDD+: All institutionalization, no implementation?

Although the climate regime from the outset recognized the importance of forests as carbon sinks, it had not considered large-scale international cooperation to curb deforestation (Buizer et al., 2014). This changed in 2005, when Papua New Guinea and Costa Rica suggested a separate mechanism within the regime to incentivize reduced emissions from deforestation in developing countries (RED) (Kasa, 2013). As negotiations progressed, the scope was expanded to include forest degradation (REDD) and, later, "conservation, sustainable management of forests, and enhancement of forest carbon stocks" (REDD+). By 2013, negotiations over the REDD+ mechanism were completed (UNFCCC, 2013). Agreeing on REDD+ was important to rally support across the north-south divide for global climate governance within the UNFCCC setting, not least in the pretext to the 2009 COP15 Copenhagen meeting (Gupta et al., 2013). In its current shape, REDD+ aims for self-sustaining mechanisms where forested countries are payed *ex post* for "avoided emissions results" against an agreed reference level. The system scope is national and when a national forest cover is a net sink, REDD+ becomes a mechanism to promote negative emissions. So far, the primary focus in REDD+ thus has been on reducing deforestation.

Despite a relatively swift process, agreeing on REDD+ was not without controversy. There were considerable discussions over environmental and social "safeguards", on monitoring, reporting and verification, on reference levels and benefit sharing, to name some bottlenecks (Nepstad et al., 2013; Wilson Rowe, 2015). Importantly, although some industrialized countries wanted this, REDD+ results still cannot be used to offset financing countries' national emissions (Dooley & Gupta, 2016). Except for some countries' experimental bilateral arrangements, and despite the mechanism attracting significant attention at the climate regime negotiations, REDD+ has failed to trigger implementation at a level that corresponds with its potential (Lash & Dyer, 2014). With REDD+ finance being based on ODA in the first few years, fostering sufficient, long-term finance continues to be a significant challenge (Norman & Nakhooda, 2014; Vijge et al., 2016). Of the 15 top emitters, only Brazil and Indonesia specifically mention REDD+ as a priority. The informants were in general more positive, but the impression from the interviews as well was that states are lukewarm and noncommittal. One respondent for instance explicitly mentioned that REDD+ cannot be used to meet national emissions targets.

Looking forward: What about other potential NETs?

After looking at present-day examples of carbon sequestration activities with a potential for negative emissions and their respective institutional arrangements, we now turn to prospective future methods for obtaining negative emissions more specifically. Table II shows that none of the top 15 emitters' NDCs and INDCs have developed explicit policies for NETs or even mention the term. The interviews also consistently confirmed that governments have not put net negative emissions or novel NETs on their agendas.

BECCS may be eligible for national emissions reductions under IPCC 2006 guidelines for carbon accounting, but no states include BECCS in their national strategies. One sole informant included BECCS on the list of climate mitigation measures, but was distinctly noncommittal, stressing that this is still far into the future. DAC, too, could potentially be eligible for national mitigation results, counting as CCS with CO_2 capture from air and negative emissions (Kemper, 2015). But in addition to controversially *not* addressing anthropogenic activities *per se*, DAC struggles with capture technology costs, and like other CCS, lack of off-the-shelf storage capacity and unfavorable economic incentives (Lackner et al., 2012).

Most other non-terrestrial biomass-related NETs currently seem to be out of the picture. Geoengineering options in the ocean are prohibited until further notice by the CBD because of the potential for adverse, unmanageable biological diversity consequences (CBD, 2010; Tollefson, 2010). So far, the CBD's operative decisions have trumped any potential unilateral actions in this area. It would also be hard to operationalize a scheme where states are incentivized for reducing emissions using international waters: "Carbon credits from the ocean is crazy," in the words of one informant. Table III below summarizes the status of these carbon sequestration options.

There may however be three exceptions if we think about carbon sequestration more generally. The first is A/R and concerns China's and India's plans for large-scale afforestation on national territory as a means to achieving national mitigation targets. Still, several informants informally flag doubt that these grand-scale plans can be carried out for reasons of spatial constraints and land-use conflicts.

Second, except for the EU, most countries seem anxious to make the most of national, terrestrial sinks and related activities to meet their national mitigation targets. As NDCs expectedly become increasingly ambitious over time, most informants underline the mounting political importance of terrestrial sinks in global climate politics. Worst case, it might lead to states "reducing" their emissions from land-use and land-use change from more sophisticated methods of measurement and accounting rather than from any substantive change. South Africa exemplifies one country that assumes that its forests represents a net sink that may be deductible from other emissions, but where imprecise methodology currently inhibits inclusion into national accounts. Some informants feared that mitigation would suffer in a context with liberal carbon accounting rules for such carbon flows under the Paris Agreement if fossil emissions are not also substantially reduced.

Third, Saudi-Arabia is the only state to formally promote so-called "blue carbon", i.e. the growing of biomass in coastal waters (such as mangrove). It is not included in the IPCC inventory guidelines and thus cannot be used to meet national emission targets (Grimsditch et al., 2013). The need for covering "blue carbon" and coastal wetlands in a climate regime setting was reiterated by informants from industrialized countries. Indonesia thus hosted a Marrakech side-event dedicated to promoting the inclusion of "blue carbon" in global climate governance. Some states have argued for both the inclusion of "blue carbon" and "soil carbon" within LULUCF and REDD+, but without success yet.

Intriguingly, few states see CCS or CCS-based value chains as vehicles to substantially reducing national emissions. Of the seven states that mention CCS, only a few were particularly enthusiastic, and even countries that have experimented with CCS in the past, like South Korea and the USA, refrain from highlighting CCS in their NDCs. Informants universally talked about CCS as a technology that may only become relevant in the future, citing little practical experience and high costs, and not a reliable way of curbing national emissions. If anything, the interviews suggested less enthusiasm than the NDCs.

As NETs are in their infancy, are states possibly working on NETs beyond what they report in their NDCs and INDCs? This could obviously be true, and NETs have certainly moved on since Marrakech (e.g. Economist, 2017). However, the response from the informants indicate that in these seven states, the thinking on NETs has not progressed far. What the informants nearly unanimously emphasized was that the only area in which everyone is involved is A/R, but that there are practical limits as to how far this can be pursued.

Table III: The status of different carbon sequestration options in international climate politics

Policy concept/term	**NET potential**	**Formal regime status**		**Global consensus**	**Economic case**	**NDCs mention**
		*Formal recognition as mitigation measure**	*Financing implementation outside national borders may be used for meeting national target*	*Perceived risks and side-effects well understood*	*Proven potential for cost-effective mitigation*	
LULUCF	X	X	X	X	X	12/15
CCS		X	X**			7/15
REDD+	X	X		X	X	2/15
BECCS	X	X				0/15
Direct Air Capture	X	(X***)	(X***)			0/15
Ocean geoengineering	X					0/15
Blue carbon	X					1/15
Soil carbon	X					0/15

* Accounted for in IPCC Guidelines and not excluded by other international regimes
** Currently only included under the CDM, which lasts until 2020. Arrangements for international implementation efforts after 2020 remain undetermined.
*** This only applies if DAC is considered as a class of other CCS.

5. Analysis

LULUCF: A wide basket category to help meeting national mitigation targets

With the aforementioned framework in mind, it is safe to argue that LULUCF has made the necessary fit in many states' two-level games in at least two ways. Most importantly, terrestrial sinks-related activities, operationalized through LULUCF, can be used by industrialized states to meet formal, quantified emission targets under the Kyoto Protocol and by all states under the Paris Agreement. The inclusion of terrestrial sinks thus represents an important norm change within the international climate regime – from a strict focus on fossil emissions towards a similar emphasis on biological carbon flows, preparing the ground for photosynthesis-based NETs as mitigation policy. This expansion of the "mitigation portfolio pie" was also a method of promoting cost-effective mitigation action for industrialized countries. In many countries with net forest growth, the inclusion of LULUCF may yield "free" mitigation results if states can argue for such sinks on a sound scientific basis. The analysis of the NDCs and the interviews shows how LULUCF is now integral to most states' goal attainment. It is safe to conclude that LULUCF serves a political purpose for states. That it can be used to reach national mitigation commitments in a cost-effective way within national borders is a significant part of its success.

CCS: More than symbolic signaling?

In a political perspective, CCS has the benefit of being formally recognized within the climate regime as a mitigation measure and may be used to fulfill national emissions targets. But there is a lack of consensus on the importance, relevance, and even desirability of CCS in different countries. The economic case for CCS, which assumes implementation based on economies of scale, is still not valid.[12] Consequently, individual CCS plants have only materialized in particularly dedicated states where significant public funds have been specifically set aside. Conspicuously, the countries advocating CCS are generally those with fossil energy extraction interests, using CCS to help solve their long-term two-level game between national petroleum interests and international commitment to climate action (Røttereng, 2016, 2018; Tjernshaugen, 2008). But when considering that CCS has hardly produced emission reductions to date, despite its proclaimed global problem solving potential, so far pro-CCS strategies primarily represent symbolic signaling for states that seek to show commitment to climate action on a normative basis without abandoning national fossil energy interests. This may change if CCS is applied to non-fossil CO_2 sources, as discussed above.

REDD+: Regime building in the past and climate finance in the future?
REDD+ served the purpose of regime building during the pre-Paris years, as an initiative to build bridges across the north-south divide. Now that REDD+ is formally a mechanism under the post-2020 regime, future implementation may be at risk unless the demand for REDD+ results is backed up by sufficient long-term funding. This is mirrored by how states refer to REDD+ in their NDCs. Only two of the 15 largest emitters – forested suppliers Brazil and Indonesia – mention REDD+ in their NDCs. This is conspicuously low for a mechanism designed to make a real dent into global GHG emissions. A plausible explanation is that financing countries cannot use REDD+ to meet their national mitigation targets, as also specifically highlighted by one informant. This obviously affects states' priorities. REDD+ may become a vehicle for the industrialized states' pledged annual $100 billion of climate finance by 2020 to support developing countries (OECD, 2016), but the value of REDD+ as a channel for such funding remains to be seen.

Prospects for NETs in the current climate regime: Terrestrial sinks within national borders
The current climate regime allows for negative emissions that fit within the LULUCF, CCS and REDD+ categories. Of these, only LULUCF-relevant options, notably A/R, seem desirable by a substantial number of states. In the short run, this means that national land management will become ever more important as vehicles to promote NETs. Given that NDCs should become progressively more ambitious, it is likely that national, terrestrial sink-based activities will increase in importance. This was confirmed to us in Marrakech, where informants underlined the mounting political importance of terrestrial sinks to national climate policy. In contrast, until large-scale CCS from industrial sources materializes, CCS remains a niche option mainly for a few petroleum-producing states. Unleashing the potential for trans-border economies of scale for CCS (and BECCS) will both require economic incentives and a favorable international regulatory framework, such as amending the London Convention on Marine Pollution. If REDD+ cannot be used to meet national mitigation targets for financing parties, its purpose would be limited to delivering on financial commitments and providing non-formal concessions to developing countries. These political purposes have so far proven insufficient to mobilize adequate funds from developed countries. It is therefore intriguing that a few states still advocate counting carbon categories that remain controversial at the international level. This notably extends to "blue carbon" for Saudi Arabia (and possibly Indonesia), and for *total* national forest cover for Russia. Other potential NETs (DAC, soil carbon, ocean geoengineering) that do not fit the current governance framework remain unaddressed. This particularly applies to methods of ocean geoengineering, which is effectively discouraged by the CBD. Table IV below summarizes

[12] In the EU, plans for CCS plants failed when the EU emissions trading scheme failed to generate sufficient funds for the purpose. Popular skepticism was also persistent in some states. In developing countries, no plants were built, despite CDM and ODA incentives.

what political purpose the covered carbon sequestration methods serve under current global governance structures.

Table IV: Political purposes currently served by NETs	**LULUCF (A/R)**	**CCS**	**REDD+**	**BECCS**	**Direct Air Capture**	**Ocean geoengineering**	**Blue carbon**	**Soil carbon**
Requirements for serving political purpose for states in climate politics								
Formal recognition as mitigation measure	X	X	X	X	(X)*			
External financing parties (mainly industrialized states) may use results for meeting national target		(X)**						
Global consensus on implications	X		X					
Cost-effective economics	X							
Potential for serving political purpose								
Formal obligations: Emission target	X	(X)						
Formal obligation: Finance			(X)					
Regime building			X					
Symbolic signaling		X						

* This only applies if DAC is considered as a class of CCS.
** This is valid for the CDM, which currently lasts until 2020. Its future under the Paris Agreement is undetermined.

6. Final discussion and conclusions

The striking empirical finding is that despite increasing awareness that NETs are crucial for keeping the 2°C target within reach, states currently do not have plans for large-scale negative emissions – the post-carbon society is not currently within sight. It is conspicuous how CCS and REDD+ – subject to international coordination efforts for more than a decade – do not figure more prominently in the NDCs. Instead, petroleum giant Canada advocates CCS and rainforest countries Brazil and Indonesia support REDD+. These are hardly surprises! Pursuing CCS seems important to a few select countries and counts as a mitigation measure eligible for fulfilling national emission targets, but at present, it makes more sense to interpret national CCS policies as symbolic signaling. That seven out of 15 states mention it in their NDCs probably seriously overstates the importance of CCS in their thinking. What we know from related research (e.g. Røttereng, 2018) is that in absolute terms Norway has allocated more money to CCS than any of these seven. There are very few countries that have spent substantially on CCS, and with the exception of Japan they are all major fossil energy producers.[13] BECCS, which is among the less controversial novel NETs, is subject to few incentives under the current regime and is crippled by similar impediments as traditional CCS. Consequently, it was not mentioned in any of the NDCs, and only fleetingly by one of the informants. REDD+ has been important for regime building purposes, but it remains to be seen if it can play a future role. Only two of the 15 states mentioned REDD+. As long as REDD+ does not help states meet national emissions targets, only forested developing countries will report it as important. This was also reiterated specifically by one of the informants. LULUCF, where states may actually be credited for their terrestrial carbon uptake, is the exception from the reluctance among states to address carbon sequestration-based mitigation options. Thus, LULUCF was embraced by 12 out of 15 states, only Iran rejecting it altogether.

Although the rules may allow for methodological developments to account for soil carbon and blue carbon in the future, our findings indicate that under current rules, little can be done to

[13] The six countries that spent the most on CCS (2007-14), in descending order: Norway, Canada, the US, Australia, UK, and Japan (Røttereng, 2018).

promote other types of NETs beyond LULUCF-eligible activities. Since other novel NETs are not counted as mitigation measures, and some actively discouraged, they cannot serve as the basis for climate policy. This applies to ocean geoengineering in particular. As tables II and III show, with the exception of "blue carbon" in Saudi Arabia, no state gives a single mention to NETs in their NDCs beyond what can otherwise be achieved from LULUCF, CCS and REDD+.

What explains this? As stated earlier, political economy scholarship tells us that because of vested interest resistance, mitigation policies that cause transformative changes to the energy system are especially hard to agree on (Moe, 2015; Unruh, 2000). In the two-level game, states look for climate policy options to balance national interests and commitments to global problem solving. Thus, NETs that do not cause transformative change or disrupt the political economy are more likely to be perceived as serving a political purpose domestically, and less likely to face resistance. Unless there is an international institutional framework that approves of and encourages NETs-related efforts as climate policy, we are likely to see uncoordinated experimentation with NETs at best. This is exactly what we currently experience, as the only NET embraced by a vast majority of countries is the neither transformative nor disruptive LULUCF, which allows for terrestrial sinks-related activities to be used by developed states to meet formal, quantified emissions targets.

Implications and final thoughts

In one way, national, terrestrial sinks-based sequestration such as LULUCF is the light at the end of the tunnel. With the lack of international governance structures, and with NETs probably given greater attention in the future, focusing on forests, land-use, and land-use change is the potential easy-fix. It requires no new and unproven technologies, has few or any transboundary effects or requires much in terms of further international coordination, and may be politically easier than most other proposed measures. But probably, there are also firm physical limits as to the amounts of GHG emissions that can be soaked up by A/R and land-use change. Thus, from another perspective, putting the onus on LULUCF may also lull us into a false sense of security, becoming a pretext for doing too little to curb "fossil" GHG emissions. It is an easy way of producing negative emissions without changing any features of the political economy that caused those emissions to begin with. Thus, it should not detract from the fact that few other NETs have seen success so far, neither in terms of deployment nor in terms of planning.

There are clearly multiple reasons why NETs have yet not caught on – costs and uncertainty as to the speed and direction of technological developments among the most obvious. More research is however also needed to understand what it is that characterizes the negative emissions technologies that may be politically more salient. What we have emphasized here, is why it is important to create a climate regime that *enables* NETs, especially given our distinctly modest chances of reaching the 2°C target without them. One might argue that with NETs constituting highly immature technologies, uncoordinated experimentation is the only conceivable long-run strategy – locking in immature technologies certainly makes for bad planning. However, especially for technologies as far-ahead and as controversial as certain NETs, it is important for the regulatory framework to enable their development on a broad scale, rather than discourage them. Otherwise there is little incentive for states to be frontrunners. And as we have seen, there are precious few frontrunners.

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