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Regulatory Preconditions for the Deployment of Bioenergy With Carbon Capture and Storage in Europe

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Paris-compatible climate scenarios often consider bioenergy with carbon capture and storage (BECCS) as an important technology for carbon dioxide removal (CDR). Although the main barrier to BECCS deployment is often associated with lack of economic policy incentives, unfavorable regulations can also impede investments. Over the past decade, the regulatory conditions at the UN and on the EU level have developed to be more permissive toward BECCS. For instance, CDR accounting guidelines have been developed by the UN, and the EU CCS Directive regulates responsibilities regarding storage of CO_2. However, several existing regulations still cause deployment hurdles. Taking a European viewpoint, this perspectives article takes stock of recent regulatory developments and provides a discussion on legal acts that need to be reformed in order to facilitate BECCS deployment. Although the European trend is characterized by developing a regulatory regime that is more supportive of BECCS, we identify three areas for further improvement: (1) allowing EU Member States to use negative emissions from BECCS to comply with their obligations under the legislative pillars that underpin the EU's climate objectives: (2) amending the CCS Directive to exempt physical leakage of biogenic CO_2, attributable to sustainably sourced biomass, from the requirement to surrender emission allowances in the EU ETS or, if BECCS has been economically rewarded, the penalty for leakage should correspond to the level of the reward; and (3) pushing to erase the last few barriers due to multilateral regimes, such as clarifying whether BECCS is covered by the geoengineering moratorium maintained by the UN Convention on Biological Diversity. These proposed reforms would further improve the regulatory preconditions for BECCS deployment in the EU.

Keywords: bioenergy with carbon capture and storage (BECCS), carbon dioxide removal (CDR), negative emissions, European Union (EU), climate policy, regulation

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INTRODUCTION

The pathways for restraining global warming to 1.5°C rely on carbon dioxide removal (CDR) to offset emissions. In several climate change scenarios, bioenergy with carbon capture and storage (BECCS) is a key CDR mitigation technology (IPCC, 2018) that could be used to offset residual emissions in sectors that are difficult to fully mitigate, such as agriculture, construction, and

heavy industries (Fuss et al., 2014; Honegger et al., 2021b). While the technical conditions for capturing and storing CO_2 exist, BECCS is still under development. If deployed, BECCS has the potential to achieve negative emissions by capturing and storing biogenic CO_2 that, in turn, has been sequestered from the atmosphere through photosynthesis (Fuss et al., 2018). However, a gap remains between the current lack of BECCS deployment and its theoretical potential (e.g., Geden et al., 2018). Although some countries have started drafting CDR policies (Schenuit et al., 2021) and planned projects and promising pilots exist, few are currently operating at scale. Tamme and Beck (2021) argue that the commercialization gap is primarily explained by high costs and lack of infrastructure for CO_2 transport and storage. In addition, Fridahl et al. (2020a) argue that the gap can, to a large extent, be explained by a lack of policy incentives. On the other hand, every year of non-deployment of CDR techniques like BECCS and DACCS will incur extra costs to meet the European CO_2 targets (Galán-Martín et al., 2021).

By emphasizing the need to address barriers to BECCS if it is to contribute to EU climate action, this perspective article will focus on regulatory preconditions for BECCS deployment. While noting the severe lack of economic policy incentives to commercialize BECCS, this article will instead primarily focus on regulations that can create an administrative burden and thus extra transaction costs or other types of barriers that can hinder the deployment of the entire BECCS chain, from capture, to transportation, to storage of biogenic CO_2. Applying a European viewpoint, this article provides a discussion on how several multilateral and EU regulatory barriers have recently been lowered or erased and points out the most crucial remaining barriers to BECCS deployment. The article ends with policy recommendations to address and eliminate the remaining regulatory barriers to BECCS deployment.

BECCS Falls Between the Cracks of the Three EU Climate Policy Pillars

First and foremost, with current accounting rules negative emissions from BECCS cannot be used to achieve the EU's climate objectives. While it is possible for EU Member States to report negative emissions from BECCS, such negative emissions cannot be used to comply with obligations under any of the three legislative pillars designed to deliver the EU's economy-wide objectives for 2030 and 2050, i.e., the EU Emissions Trading System (EU ETS), the Effort Sharing Regulation (ESR), and the Land-Use, Land Use Change, and Forestry (LULUCF) Regulation. In other words, negative emissions from BECCS can be recognized for information purposes but not to achieve Member States' obligations, and thus the current EU regulations do not encourage Member States to incentivize BECCS within their jurisdictions.

It should be noted that the European Commission recently proposed a target to remove 5 $MtCO_2$ in 2030 using technological CDR (EU, 2021c). Even if this is a rather modest target, and even if it is likely possible for the EU to report such removal as contributing to achieving the EU's Nationally Determined Contribution to the UNFCCC's Paris Agreement, the current regulations would not allow the EU Member States, in which the engineered CDR method would be deployed, to use the resulting negative emissions to comply with EU-internal obligations. Addressing this shortcoming is vital for incentivizing BECCS deployment in the EU.

Regarding the EU ETS, it establishes a cap-and-trade system in the EU with the aim to cost-effectively reduce greenhouse gas emissions (EU, 2003, 2018a). The EU ETS sets a cap on total emissions allowed from all facilities that are covered by the system. Each year, the facilities must surrender tradable emission allowances corresponding to their actual emissions, thus creating an incentive to reduce emissions. In 2021, the European Commission proposed reforms to strengthen the system in line with the new and more ambitious economy-wide 2030 EU target, i.e., to reduce emissions by at least 55% by 2030 compared to 1990 levels (EU, 2021a). However, the current EU ETS Directive does not acknowledge *negative* emissions from facilities that apply BECCS. While the EU ETS acknowledge biogenic CO_2 emissions from facilities covered by the Directive, for example, biomass co-fired powerplants, the emission factor for biomass is set to zero. Consequently, if such facilities capture and store biogenic CO_2, the stored CO_2 will have to be accounted for as zero rather than negative emissions. As such, negative emissions from BECCS cannot be used to compensate for the need to surrender allowances. The climate benefit of biogenic CO_2 stored permanently could, in principle, offset an emission pulse of an equal amount of fossil CO_2, at least if the removal and the emissions were to occur at about the same time (Zickfeld et al., 2016; Fridahl et al., 2020b). As is, BECCS is not allowed to offset fossil emissions, as clarified by the European Commission in answer to a question on this topic posed by the Norwegian government (EC, 2020). The European Commission confirms that there is a lack of legal support in the EU ETS to allow stored biogenic CO_2 to be recorded as a negative emission at the capture facility (EC, 2020). The Commission pointed out that incentives for BECCS should be created in other ways (EC, 2020), yet have also noted elsewhere that "CCS-biomass projects with a clear and verifiable climate benefit could potentially benefit from recognition pursuant to Article 24a of the revised EU ETS Directive" (EU, 2021c, p. 16). Article 24a does not, however, imply an inclusion of BECCS in the EU ETS, and it instead mandates the European Commission to issue allowances or credits from emission reduction projects in Member States provided that the sources are not already covered by the EU ETS. In other words, Article 24 provides a basis to establish an offsetting system *external* to the EU ETS. Rickels et al. (2021) also present a comprehensive analysis of various possibilities for reforming the EU ETS to incentivize BECCS, including how emission allowances could be linked to negative emission credits without eroding incentives to phase out fossil emissions. The fact that biogenic emissions are generally recognized in the EU ETS, even if accounted for as carbon neutral, opens the door for allocating allowances for free to BECCS facilities. Yet, if such an approach were to be implemented, it should be noted that the EU ETS does not cover installations that exclusively use biomass, which would lower the potential of BECCS negative emissions (Rickels et al., 2021). In the Commission's proposal

for EU ETS reforms (EU, 2021a), emitters of biogenic CO_2 from biomass of unsustainable origin—as defined in the Renewable Energy Directive (EU, 2018c) with proposed amendments to strengthen the criteria (EU, 2021d)—would have to surrender emission allowances. If eventually approved as EU law, this would generate incentives for BECCS fueled with *unsustainably* sourced biomass, i.e., incentives to use BECCS for emissions reductions rather than removal. As is, neither the current nor the proposed revised EU ETS Directive would provide economic incentives for generating negative emissions using BECCS.

The ESR supplements the EU ETS by setting a target for emissions reductions in the non-trading sectors and by allocating individual commitments to the EU Member States (EU, 2009a, 2018b, 2020a). Neither the current ESR regulation (EU, 2018b) nor the recently proposed ESR revision to strengthen the 2030 target from 30 to 40% compared to 2005 levels (EU, 2021b) allow an accounting for negative emission via BECCS. Analogous to the lack of recognizing BECCS in the EU ETS, the fact that the ESR does not allow negative emission via BECCS to reach national reduction targets constitutes a barrier to BECCS deployment.

The LULUCF Regulation does in fact already recognize some forms of CDR (forest sinks and harvested wood products). It requires the EU Member States to maintain their existing LULUCF sinks (the no-debit rule), and the European Commission is proposing to further increase the volume of aggregated, obligatory removal by 2030, to expand the regulation to managed land by 2026, and to extend the regulation to all non-CO_2 emissions and CDR from agriculture from 2031 onwards, including emissions from soils and from other agricultural sources, e.g., enteric fermentation, manure management, liming, and use of fertilizers (EU, 2021e). A prime focus of BECCS in many scenarios underpinning mid-century net-zero targets is to offset residual emissions in agriculture (Geden et al., 2019; Buylova et al., 2021). Thus, moving agriculture from the ESR to the LULUCF Regulation would strengthen the case for recognizing BECCS in the LULUCF Regulation. Allowing BECCS to be used to offset residual emissions from agriculture could alleviate pressure on forestry to increase the carbon sink. This could be an important service provided by BECCS because demand for wood-based products is likely to increase with an increasing need to find substitutes for fossil-intense products. While there are possible trade-offs between using biomass from forests as a fuel and generating an increasing carbon sink in forestry, the technical potential for BECCS in the pulp and paper industry as well as biofuel production is likely to continue to be high in the foreseeable future. Realizing this potential could help to achieve the no-debit obligation under the LULUCF Regulation if BECCS were to be acknowledged in this sector. However, this would require the use of sustainably sourced biomass in BECCS facilities or else the climate benefit of BECCS would be undermined. At the same time, it should be noted that the BECCS supply chain spans several sectors, including the energy and industrial sectors. Thus, deciding to recognize BECCS under the LULUCF Regulation is not straightforward. If BECCS is included in the LULUCF Regulation, this may raise questions about consequential amendments regarding the existing flexibility between LULUCF and ESR and may require an evaluation of the need to adopt new flexibility between the LULUCF Regulation and the EU ETS.

Accounting Guidelines for BECCS Are Improving Rapidly

The IPCC's accounting framework to account for negative emissions from BECCS—even if BECCS cannot be used to fulfill EU Member States' commitments or achieve joint objectives—has developed rapidly in the last couple of years. The international accounting guidelines developed by the IPCC, used as a basis for agreeing on accounting rules in the UNFCCC and the EU (EU, 2009b; UNFCCC, 2019a,b), constitute a favorable basis for allocating the storage of biogenic CO_2 as negative emissions. However, the accounting framework needs to be further developed to enable transparent, internationally comparable reporting of negative emissions in order to incentivize CDR, including BECCS. As stressed by Tamme and Beck (2021), accounting is important to verify that CDR is achieved. Sustainability safeguards, for example, are not well developed. In the IPCC guidelines, it is assumed that emissions (and removal) associated with biomass harvest (and growth) are reported in the LULUCF sector. With this assumption, point source emissions from processes using biomass should be accounted for as climate neutral because the biomass-related emissions and removal should already be accounted for. It follows, therefore, that if BECCS is deployed to remove and store a point source emission pulse, the zero emission baseline means that this stored emission pulse should be reported as a negative emission. From a system perspective, however, the climate benefit of BECCS would be undermined by unsustainably sourced biomass. Therefore, it is positive that further clarity on monitoring and accounting is in the policy pipeline. Three examples of this are noteworthy, namely the strengthened sustainability criteria under the Renewable Energy Directive, the proposal that emitters of biogenic CO_2 have to surrender allowances under the EU ETS unless the biomass meets the new sustainability criteria defined in the Renewable Energy Directive, and the inclusion of managed land under the LULUCF Regulation from 2026 onwards and agriculture from 2031 onwards. The European Commission is also developing a proposal for a carbon removal certification scheme that is expected to be completed within a few years (EU, 2020c). The certification scheme will tentatively be proposed in the last quarter of 2022 (EU, 2021f) and will constitute a key building block of the circular economy action plan (EU, 2020c). It will most likely allow comparing the removal quality of different types of carbon removal, which, as noted by Fridahl et al. (2020b), is necessary to guide political discussions on prioritizations among CDR options and to standardize more refined carbon decay functions in the accounting of various CDR methods, analogous to the agreed half-times of different types of harvested wood products.

New CDR Market on the Horizon

Based on the proposed certification scheme, the European Commission has also signaled an intent to support the voluntary, or even establish a new market, for CDR in the land sector,

starting with what it refers to as "nature-based" removal (EU, 2021c,e). It seems likely that such a market will be proposed to serve under the no-debit rule in the LULUCF Regulation so that land-based CDR will be allowed to compensate for land-use, forestry, and agriculture emissions much like forest sinks are already allowed to compensate for forest emissions sources.

The certification scheme, and new and more refined accounting of CDR, would make various CDR methods comparable, allowing one to weigh the value of engineered CDR against nature-based CDR, i.e., it would make different types of CDR fungible. As such, the proposed CDR market could be expanded beyond nature-based approaches to also include engineered CDR. Integrating BECCS into this market could be facilitated by regulating it under the same legislative pillar, i.e., LULUCF. This has the potential to strengthen cost-efficiency by diversifying supply and increasing liquidity and to improve preconditions for achieving the EU's ambition to become a net greenhouse gas sink after 2050. On the other hand, the aspiration of the EU to become net negative beyond 2050 necessitates what Geden et al. (2019) refers to as a comprehensive CDR approach, requiring a substantially higher amount of removal than the net-zero target. A comprehensive CDR approach with a higher EU ambition and a focus on long-term provision of CDR after 2050 is likely to entail a change in political priority and governance. This would mean that the focus on methods to achieve CDR would have to expand, which could translate into encountering new and as yet unidentified regulatory barriers.

It should be stressed, however, that the European Commission has not provided any clear guidance on how it envisages the scope for expanding a new nature-based CDR market to include BECCS and other engineered CDR, nor how such an expanded market could be linked to a regulatory home for BECCS among the legislative pillars that underpin the climate objectives of the EU. This regulatory unclarity, heavily linked to the issue of creating economic incentives for BECCS, requires the full attention of the European Commission in order to scale up BECCS deployment.

Sustainability Safeguards, the Taxonomy for Investments, and State Aid Rules

The UN Convention on Biological Diversity (UNCBD) is a global treaty aimed at preserving biological diversity and to assure the sustainable use of components of biological diversity. In 2010, the parties to the CBD decided on a moratorium on geoengineering, which stated that because there is no transparent global control mechanism for geoengineering, no climate-related geoengineering activities that might affect biodiversity should take place before sufficient scientific knowledge exists to justify such activities, a decision that was reaffirmed by the UNCBD in 2016 (CBD, 2010, 2016). However, in the moratorium the capture and storage of CO_2 from fossil fuels are excluded. Moreover, the moratorium contains no definition of geoengineering, and thus it is hard to interpret if BECCS is covered, yet the CCS exemption does not refer to BECCS explicitly. In addition, the general confusion on how geoengineering is defined and interpreted in the context of CDR further complicates this dispute (Honegger et al., 2021a). The ambiguity of how to interpret and apply the moratorium may introduce uncertainty that can translate into an investment barrier for BECCS. Although it is important to clarify the definition and how the moratorium is to be interpreted, the moratorium likely constitutes a relatively low barrier compared to other legal obstacles, not least because the legal force of the UNCBD decision is disputed (Fridahl et al., 2020a).

A future global or European market for negative emissions could lead to increased demand for biomass, which may have negative consequences for biodiversity. However, the Renewable Energy Directive (EU, 2018c) states that biofuels must meet specific sustainability criteria as well as criteria for reducing greenhouse gas emissions from a life cycle perspective in order to be considered renewable. The proposed amendments to the Renewable Energy Directive to strengthen the sustainability criteria include provisions such as applying existing land criteria for biomass from agriculture to biomass from forests, avoiding sourcing biomass from diverse forests and peatlands, and requiring Member States to design biomass support schemes to avoid the use of high-quality roundwood for the production of electricity, biofuels, and heat (EU, 2021d). The European Commission is currently also working on an implementation regulation to guide actors in how to demonstrate that their use of forest biomass meets the new sustainability criteria for renewable bioenergy, as well as to update and strengthen the biomass sustainability criteria (EU, 2021d).

In June 2020, the EU adopted an investment taxonomy, a framework aiming to make it easier for investors to identify environmentally sustainable investments through a standardized classification system (EU, 2019, 2020b). To classify CCS, including BECCS, as sustainable, it is necessary to verify that the total physical leakage of CO_2 from capture to storage does not exceed 0.5%. In addition, the operator needs to comply with ISO standards for geological storage of CO_2 (EU, 2020b). For CO_2 capture to be classified as a sustainable activity, the regulation states that the transport and storage must also meet the required sustainability criteria (EU, 2020b). Further, the EU guidelines on state aid (EU, 2022) provide regulatory conditions that facilitate state investments for the deployment of BECCS beyond 2021. However, the limited time horizon for state aid, capping aid approval to 10 years, could complicate aid schemes targeting BECCS whose technical lifetimes often extend well beyond 10 years (Fridahl and Lundberg, 2021).

CO_2 Transport and Storage Regulation

Geological sub-seabed storage is regulated in several international treaties. The London Protocol, originating in the International Maritime Organization's London Convention, aims at limiting marine pollution (IMO, 1996). The London Protocol prohibits all types of dumping of all types of waste or other substances in international waters and in the territorial sea of the constituent Parties, but sub-seabed storage of CO_2 has been exempted since 2006 (IMO, 2006). The Oslo-Paris (OSPAR) Convention, also aimed at limiting marine pollution, adjusted its rules in line with the London Protocol in 2007 (OSPAR Commission, 1992). While the OSPAR Convention

and the London Protocol have been amended to allow sub-seabed storage, the Convention on the Protection of the Marine Environment of the Baltic Sea Area (the Helsinki Convention) does not allow sub-seabed storage (HELCOM, 1992). While sub-seabed storage is allowed by the EU CCS Directive, the Helsinki Convention has legal superiority. Therefore, if not harmonized with the CCS Directive, the Helsinki Convention will constitute a barrier to geological storage in the Baltic Sea. For the most part, however, sub-seabed storage is now allowed in EU territories.

However, access to storage sites often requires cross-border transport, and the London Protocol prohibits export of CO_2 intended for sub-seabed storage. Although an amendment to the London Protocol was agreed on in 2009, which allows for the export of CO_2 (IMO, 2009), several ratifications are still missing and must be obtained before the amendment's entry into force clause can be fulfilled. In anticipation of more ratifications, the Parties to the London Protocol have adopted a resolution that allows provisional application of the 2009 amendment (IMO, 2019). This enables CO_2 export, but the provisional application requires a bilateral agreement between the states concerned.

The CCS directive enables and provides rules for geological storage (EU, 2009b). In addition, as emphasized by Fridahl et al. (2020a), it offers a secure arena and a clear base for planning BECCS investments. Even so, there are important issues to be resolved. For instance, all physical leakage of geologically stored CO_2 requires the surrendering of EU ETS allowances. This applies irrespective of the origin of the CO_2 because the CCS Directive does not distinguish between fossil and biogenic CO_2. If biogenic CO_2 is emitted into the atmosphere at a point source, it is generally accounted for as carbon neutral and therefore not associated with a cost under various pricing mechanisms such at the EU ETS or national carbon taxes. However, if it is captured, stored geologically, and then leaks, the leaked CO_2 is associated with a cost. If in the future a policy is adopted to establish economic incentives that reward BECCS, then it also makes sense that physical leakage of biogenic CO_2 should be associated with a cost. It is not obvious, however, that this cost should correspond to the allowance price in the EU ETS. Perverse incentives to catch and release biogenic CO_2 might be created if the reward is higher than the penalty. If the reward is lower than the penalty, this creates an investment risk that would increase the cost of BECCS.

Another related issue with the CCS Directive is that domestic sub-seabed storage in areas close to territories outside the EU might be hindered if a geological storage site extends to territories outside the EU. One example is a possible geological storage site in the southern Baltic Sea that includes Russian territory (SOU, 2020).

As noted by Fridahl and Lehtveer (2018), deployment of BECCS technology can differ between regions due to resources and technical conditions. Similarly, differences in existing infrastructure and access to geological storage may affect the existence of possible regulatory barriers. Countries lacking opportunities for safe storage of CO_2 are reliant on CO_2 storage in other regions. For these countries, legal obstacles to the cross-border transport and storage of CO_2 need to be harmonized. Moreover, access to existing infrastructure for CO_2 transport and storage would increase interest among investors and operators to build new capture facilities (Tamme and Beck, 2021). This highlights the need to determine how bilateral agreements between the country in which the capture facility is located and possible storage countries might be formulated. According to the London Protocol, the agreements must include stated consent for the activity and an allocation of responsibilities. In order to reduce the administrative burden of agreeing to such contracts, it ought to be possible to share experience and provide basic templates for treaty design.

Finally, it is worth recognizing that the existing EU regulation requires the operator of capture facilities to also be responsible for leakage during transport. Operators of capture facilities are expected to subcontract transport of CO_2, meaning that operators of capture facilities are responsible for leakage during transportation despite their lack of control over the transport. This requires, as noted by Jordal et al. (2022), contractual arrangements between the capture and transport operators regarding responsibilities, which may increase the transaction costs for BECCS. However, the European Commission has proposed to amend the EU ETS Directive so that transport operators will become responsible for any leakage during transportation (EU, 2021a), a reform that would simplify subcontracts for capture facilities that want to implement the full BECCS technology chain. Tamme and Beck (2021) also underline the Trans-European Energy Networks Regulation, which lists development of transport infrastructure for captured CO_2 as a priority area for the EU.

POLICY RECOMMENDATIONS

The lack of policy leverage to compensate for the high costs of CO_2 capture, transport, and storage infrastructure are crucial for BECCS commercialization. However, regulatory preconditions also have an important role in filling the commercialization gap. Over the past decade, regulatory conditions for BECCS have become more permissive. For instance, accounting guidelines have been developed by the IPCC, and several multilateral agreements have been amended to allow CO_2 export and sub-seabed storage. Several other regulatory reforms are in process and are pending adoption by the European Parliament and the Council, including clarification of approved means of transportation of CO_2 and of responsibilities for physical leakage of CO_2 during transport. However, the current regulatory regime still contains gaps and raises barriers that must be addressed to facilitate BECCS deployment. The significance of regulation is only going to increase as economic policy instruments, designed to incentivize negative emissions, are likely to develop in the coming years, both on the EU level and in Member States. The most urgent regulatory reforms are to:

1. Allow EU Member States to use negative emissions from BECCS to comply with their obligations under one or several of the legislative pillars that underpin the EU's climate objectives, i.e., the Effort Sharing Regulation, the EU Emissions Trading System, and the Land-Use, Land Use Change and Forestry Regulation.

2. Amend the CCS Directive to distinguish between physical leakage of fossil and biogenic CO_2 from geological storage sites. The share of leakage that could be attributed to sustainably sourced biomass, in accordance with sustainability criteria in the Renewable Energy Directive, ought to be exempted from the requirement to surrender emission allowances in the EU ETS or, if BECCS has been economically rewarded, the penalty for leakage should correspond to the level of the reward to avoid creating perverse incentives and/or investment risks.
3. Erase the existing barriers provided by multilateral regimes, such as clarifying whether BECCS is covered by the geoengineering moratorium maintained by the UN Convention on Biological Diversity.

Alongside the key issue of agreeing on economic policy incentives for BECCS, addressing the proposed regulatory barriers is crucial to further encourage BECCS deployment.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. The datasets analyzed for this study can be found in online legal repositories of the UN, regional multilateral organizations, and the EU. The names of the repositories and accession numbers can be found at: https://treaties.un.org; https://unfccc.int/documents; https://docs.imo.org; https://www.cbd.int/cooperation/about/documents.shtml; https://www.ipcc.ch/documentation; https://www.ospar.org/meetings/archive; https://helcom.fi; and https://eur-lex.europa.eu.

AUTHOR CONTRIBUTIONS

The article was planned by MF. TN made the first draft of the article. Thereafter, in collaboration between MF and TN, the article was discussed and revised in all parts including new text and references. Both authors approved the submitted version.

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