Bioenergy with Carbon Capture and Storage (BECCS) in the EU

Challenges and Opportunities

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Scope and Objectives

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Understanding BECCS in the EU Context

- This report examines Bioenergy with Carbon Capture and Storage (BECCS) within the European Union, focusing on its potential role in meeting ambitious climate targets.
- We will explore the associated challenges and opportunities for its large-scale implementation.

Key Areas of Analysis

- **Policy Landscape:** A deep dive into the EU framework, specifically the Carbon Removals Certification Framework (CRCF), the Renewable Energy Directive (RED), and potential integration with the EU Emissions Trading System (EU ETS).
- **Deployment Challenges:** Addressing issues such as land use competition, environmental impact, technical and infrastructure limitations, and regulatory and financial barriers.

Report Aims

- **Evaluate the Role of BECCS:** Assessing its contribution to the EU's climate targets, especially in light of the European Commission's 2040 climate target recommendation and IPCC projections.
- **Identify Key Barriers:** Pinpointing obstacles to large-scale BECCS deployment within the European context.

Propose Policy Recommendations: Assessing the adequacy of current EU policy frameworks and suggesting actionable recommendations for BECCS deployment.

The Need for CDR

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IPCC Findings (Sixth Assessment Report - AR6)

- The IPCC unequivocally emphasizes the necessity of CDR to achieve global climate goals.
- Deployment levels of CDR vary significantly based on assumptions about costs, availability, and constraints.
- In modeled pathways limiting warming to 1.5∘C (>50%) with no or limited overshoot, global cumulative CDR from BECCS is projected to be 30-780 GtCO2.
- For pathways limiting warming to 2∘C (>67%), global cumulative CDR from BECCS is estimated at 170-650 GtCO2.

European Commission's 2040 Climate Target

- The Commission recommends a 90% reduction in net greenhouse gas emissions compared to 1990 levels by 2040.
- To achieve this, their modeling assumes a significant role for permanent carbon removals, specifically through Direct Air Carbon Capture and Storage (DACCS) and BECCS.
- By 2040, permanent carbon removals are expected to deliver up to 75 MtCO2 annually – 33 Mt from BECCS and 42 Mt from DACCS.
- Projections for combined DACCS and BECCS range from 16 MtCO2 (S1 scenario) to 155 MtCO2 (S3 scenario).
- The Sustainable Carbon Cycles Communication envisions at least 5 MtCO2 per year from industrial removals (DACCS and BECCS) by 2030, scaling significantly by 2040 and 2050.

Understanding BECCS

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- **What is BECCS?**
  - BECCS is a climate mitigation technology that combines biomass energy production with carbon capture and storage (CCS) to achieve net negative emissions.
- **The Process Explained**
  - **Biomass Cultivation:** The process begins with growing biomass feedstocks (e.g., fast-growing crops, agricultural residues, forestry waste) which absorb atmospheric CO2 through photosynthesis.
  - **Bioenergy Conversion:** This biomass is then used for energy production (heat, power, hydrogen), releasing the carbon stored within it as CO2.
  - **Carbon Capture:** Crucially, instead of being released into the atmosphere, this CO2 is captured at the source.
  - **CO2 Transport and Storage:** The captured CO2 is then compressed, transported (via pipelines or ships), and permanently stored in secure geological formations, such as depleted oil and gas reservoirs, saline aquifers, or deep basalt formations.
- **How BECCS Achieves Net Negative Emissions**
  - The emissions negativity in BECCS originates from the biological carbon cycle. Normally, upon combustion, biogenic carbon would return to the atmosphere, creating a carbon-neutral cycle. BECCS intercepts this return flow by capturing the CO2 at the point of combustion and permanently storing it underground, thereby preventing it from re-entering the atmosphere. This intervention effectively removes the carbon that was initially absorbed from the atmosphere from the active carbon cycle.
- **BECCS in Climate Models**
  - BECCS is a non-negligible feature in Integrated Assessment Models used to project pathways for limiting global warming to 1.5∘C or 2∘C.

Policy Landscape

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CRCF

- Adopted in December 2024, establishing the first EU-wide voluntary certification system for carbon removals. BECCS is specifically classified under "Permanent Carbon Removal" within the CRCF.
- **Key QU.A.L.ITY Criteria:**
  - **Quantification:** Demonstrating a net carbon removal benefit using standardized or activity-specific baselines with conservative accounting for uncertainties.
  - **Additionality:** Activities must go beyond statutory requirements and rely on certification incentives for financial viability.
  - **Long-term Storage:** For BECCS, permanent storage (several centuries) must be verified through monitoring rules aligned with the CCS Directive (2009/31/EC) for geological storage and liability mechanisms for reversals.
  - **Sustainability:** Activities must cause no significant harm to environmental objectives and generate co-benefits.
- Methodologies for each activity, including BECCS, will be developed as legally binding Delegated Acts.

EU ETS Directive

- The EU ETS is the primary cap-and-trade mechanism for reducing GHG emissions.
- **Current Status:** The EU ETS *does not* recognize or include carbon removal (e.g., from BECCS) as a compliance instrument. Companies cannot use negative emissions to offset their obligations.
- **Future Revisions:** A 2026 review could redefine compliance pathways, potentially including dual targets for emissions reductions and removals, and adjustments to the cap by introducing a net-negative emissions budget post-2040.

Policy Landscape

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RED

- While RED does not directly regulate BECCS, its detailed biomass governance provisions establish a *de facto* regulatory framework for BECCS pathways in the EU.
- **Sustainability Requirements for Biomass:**
  - Must not originate from ecologically sensitive areas (primary forests, old-growth forests, highly biodiverse ecosystems, high carbon stock areas, agricultural land designated for nature protection).
  - Maintenance of forest carbon stocks and biodiversity through sustainable harvesting practices.
  - Biomass energy pathways must demonstrate minimum GHG savings relative to fossil fuels (e.g., ≥70% for advanced biofuels and solid/gaseous biomass post-2021 installations).
- **Cascading Use Principle:** Prioritizes material use of biomass over energy use to increase resource efficiency and avoid locking high-value biomass into low-efficiency energy applications. This has significant implications for BECCS, which often uses woody biomass.
- **Restrictions on Public Support:** Member States are prohibited from granting direct financial support for energy production from saw logs, veneer logs, industrial-grade roundwood, stumps, and roots.
  - *Note:* It is currently unclear if these restrictions will extend to BECCS methodology under CRCF, and there's a perspective that it might be inappropriate.
- RED treats biogenic CO2 emissions as carbon-neutral under specific conditions, assuming reabsorption by new biomass growth.

- The CRCF is designed to align with RED's sustainability rules as a baseline for eligibility.

Policy Landscape

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LULUCF Regulation

- Establishes the legislative framework for emissions and removals from the land use sector for 2021-2030.
- Provides the accounting framework for biogenic carbon removals achieved through biomass cultivation, which is the "Bioenergy" component of BECCS.
- The "no-debit" rule requires Member States to ensure accounted emissions do not exceed accounted removals from land use.

Challenges

Lack of Integration with the EU ETS

- The EU ETS is currently structured to *reduce* emissions, not *reward* removals.
- Under existing EU ETS rules, biogenic CO2 emissions are considered "carbon neutral" (emission factor = 0). This means capturing and storing them does not yield tradable credits or financial rewards.
- Without a mechanism to monetize these negative emissions, BECCS projects lack a crucial revenue stream to cover significant capital and operational costs, including CCS infrastructure and biomass supply chains.

- **Carbon Price Mismatch**
  - Even if BECCS were fully integrated into the EU carbon trading system, current EU Allowance (EUA) prices, ranging from €50–100/tCO2, are insufficient to incentivize deployment, as The estimated costs for BECCS are currently conservatively estimated €100–200/tCO2.
  - This significant disparity means that revenue from selling EUAs would not cover the full cost of BECCS deployment, leaving a substantial funding gap that requires additional financial policy or instruments.
  - Carbon Contracts for Difference (CCfDs) are being considered as a policy tool to bridge this gap by guaranteeing a fixed carbon price for project developers, hedging against market volatility.

- **Eligibility of Biomass Use for Energy under RED**
  - RED, particularly through its emphasis on the cascading use principle and stringent sustainability criteria for biomass utilization, imposes significant constraints on the potential scale of BECCS deployment.
  - The prioritization of biomass for material uses (e.g., timber, paper) and the exclusion of certain feedstocks from direct energy production directly constrain the achievable scale of BECCS deployment within the EU context. This can lead to potential unintended consequences regarding feedstock exclusion for carbon removal crediting.

Case Study: the BECCS Stockholm Project

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The BECCS Stockholm project, led by Stockholm Exergi, is a large-scale BECCS initiative at the Värtan bio-cogeneration plant in Stockholm, Sweden. It aims to capture up to 800,000 tonnes of CO2 annually from biomass combustion, a volume greater than Stockholm's total road traffic emissions. This makes it one of the largest negative emissions projects globally. The project is backed by a €260 million loan from the European Investment Bank (EIB) – its first for a carbon capture project – and €180 million from the EU Innovation Fund, alongside private purchases of negative emission certificates.

- **Technical and Operational Details**
  - **Feedstock:** The plant utilizes forestry and sawmill residues, such as wood chips, branches, and treetops, ensuring the captured CO2 is biogenic and results in net carbon removals.
  - **Capture Technology:** It will employ Capsol Technologies' carbon capture solution, which incorporates inherent heat recovery. Heat recovered from the capture process will be integrated into Stockholm's district heating network.
  - **Storage:** The captured CO2 will be liquefied and permanently stored in sedimentary bedrock beneath the North Sea.
- **Crediting Mechanism**
  - The project operates a crediting mechanism where the quantity of CO2 removed is monitored, reported, and verified according to emerging CDR certification protocols. For each verified tonne of CO2 sequestered, a corresponding Carbon Removal Certificate (CRC) is issued. These CRCs are sold to corporate buyers, like Microsoft, on the voluntary carbon market.
  - Companies use these CRCs to offset their own greenhouse gas emissions, contributing to their self-imposed net-zero or climate neutrality targets.
  - The carbon removals will be accounted for outside the sum of Scopes 1 to 3 as neutralization of residual emissions in a company’s value chain.

Recommendations

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Integration of BECCS in the EU ETS

- **Formal Recognition:** BECCS should be formally recognized as a compliance instrument within the EU ETS.
- **ETS Directive Amendment:** The EU would need to amend the ETS Directive to allow regulated entities to use verified, permanent carbon removals from BECCS to meet part of their compliance obligations. This would create a direct market incentive, similar to how captured and stored CO2 from fossil sources is treated.
- **Robust MRV Protocols:** Integration requires the development and enforcement of stringent MRV protocols to ensure environmental integrity, permanence, and avoid double counting. These protocols would need to:
  - Quantify net-negative emissions across the full lifecycle of biomass (cultivation, harvesting, transport, processing, conversion).
  - Require independent, third-party verification of removal claims, as specified in the CRCF Regulation.
  - Align with the CRCF's QU.A.L.ITY criteria (Quantification, Additionality, Long-term storage, and Sustainability).

Rigorous LCA Approach in BECCS Methodology and RED Iterations

- **Comprehensive Accounting:** Future iterations of RED and BECCS methodologies must be fully based on a rigorous and comprehensive accounting of all greenhouse gas emissions and removals across the entire BECCS value chain.
- **Genuine LCA:** To ensure environmental integrity, the assessment framework must adopt a genuine Life Cycle Assessment (LCA) methodology, as defined by international standards like ISO 14040/44 and IPCC Guidelines.
- **Scope:** A robust LCA-based BECCS methodology should systematically quantify both direct and indirect GHG fluxes, encompassing all stages from biomass production to permanent CO2 storage, including transport, manufacturing processes, product use, and final disposal (or energy production). The scope must extend beyond the facility itself to capture upstream, downstream, and system-wide effects.

Recommendations

Bridge the Carbon Price Mismatch for Early Movers

- **Transitional Financial Policies:** To cover the funding gap and accelerate market uptake, the transitional implementation of additional financial policies and instruments for early movers is desirable.
- **Carbon Contracts for Difference (CCfDs):** CCfDs are under consideration as an appropriate funding instrument to mitigate risk and bridge the cost gap. While effective for costs, they must be designed carefully to avoid indirectly distorting the carbon price signal.
- **Design Conditions for Support:** If such measures are deemed necessary, they should meet two key conditions:
  - **Temporality:** Mechanisms like CCfDs should be explicitly time-bound, with clear sunset clauses or phase-out criteria linked to market maturity or cost thresholds.
  - **Project-Specificity:** Financial support instruments should target specific early-mover projects rather than entire sectors to minimize market distortion and government exposure.

- **Public Purchasing Programs:** The development of public purchasing programs for certified carbon removals could also stimulate early-stage project development and provide revenue certainty for pioneering BECCS facilities. DG CLIMA is currently exploring options for an EU purchasing program for permanent CDR.

Questions for discussion

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- **Is it possible and/or desirable to deploy BECCS at scale in the EU?**
- **What policy frameworks are needed to advance BECCS deployment in the EU?**