Science-based applications on TIAM-FR to meet the net zero emissions

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OUTLINE

- Net zero emissions and Aligning NDCs with the PA
- Climate change mitigation through CDR
- Prospective implementation
- Scenario set up in TIAM-FR
- Results
- The water module
- Conclusion and future work
ACHIEVING NET ZERO EMISSIONS

1. The Paris Agreement and the Net Zero (NZ) target

The PA article 4.1 “as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century basis of equity, and in the context of sustainable development and efforts to eradicate poverty.”

2. Aligning the NDCs with the long-term objective

3. Considering energy and land emissions and removals

Source: IPCC WG3, Chapter 12, 2022
CARBON DIOXIDE REMOVAL APPROACHES

« Anthropogenic activities removing carbon dioxide (CO2) from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products” (IPCC, 2021)

1 Natural solutions
   - Afforestation/Reforestation [0.5–3.6 GtCO2/year]
   - Biochar [0.5–2 GtCO2/year]
   - Soil Carbon Sequestration (SCS) [up to 5GtCO2/year]
   - Coastal blue carbon

2 Technologies
   - Enhanced Weathering [2–4 GtCO2 /year]
   - Direct Air Capture (DAC) (and storage, DACS) [0.5–5 GtCO2/year]
   - Ocean Alkalinity enhancement

3 Combined
   - Bioenergy Carbon Capture and Storage (BECCS) [0.5–5GtCO2/year]

“1 & 3” use photosynthesis to capture CO2
“2” uses a chemical reaction for carbon capture

Potentials are in brackets for an assessment of sustainable global NET potential in 2050 by Sabine Fuss et al 2018 Environ. Res. Lett. 13 063002
CLIMATE CHANGE MITIGATION THROUGH NATURAL CDR

Key Figures:

- 21 pathways were identified for GHG reductions, where some aim to enhance sinks → managing and restoring activities
- Practices such as reforestation, conservation agriculture, biochar deployment can deliver up to 37% of GHG mitigation globally
- For the United States maximum potential of 1.2 GtCO2eq/year (Fargione et al (2018))
- Global mitigation potential across ecosystems (cost-effective potential achieved at <100$/tCO2eq)
TIMES INTEGRATED ASSESSMENT MODEL (TIAM-FR)

The French version of the TIMES Integrated Assessment Model representing the world energy model in 15 regions, with a time horizon until 2100.

Reference Energy System (RES) of TIAM-FR model

TIAM-FR regions
GLOBIOM-G4M

- GLOBIOM is a partial equilibrium land use model, which can assess competition for land-use between agriculture, bioenergy, and forestry.

- Main sectors are agriculture and forestry, production of crops and energy crops and are represented according to their profitability, and finally animal production.

- The model is solved recursively dynamic and can provide projections up to 2100.

- International trade.
ENERGY-LAND: TIAM-FR x GLOBIOM

Soft-Link with GLOBIOM emulation:

- Understand the “Reference Land System”
- Determine the input parameters for TIAM-FR
  - GHG mitigation
  - Prices of GHG (12 prices in USD/tCO2eq)
  - Bioenergy prices: seven prices in USD/GJ
  - SSP2
- Regional linkages
- Constraints on land for forestry and agriculture
- Emissions and removals

Land use evolution by type of cover with GHG00 and BIO13 (Base scenario)
MODELING IN TIAM-FR

Natural Sinks
- Afforestation
- Forest Management
- Other LUC

Natural sources
- Deforestation
- Forest Management
- Other LUC
SCENARIOS

1. NDC: SSP4-3.4
   - includes updated NDC with Net zero commitments until 2050/2060 and 2070. For countries with 2030 targets, the emissions on the long-term must stay under 2030 levels.
   - NDC CO2 concentration evolution (Climate parameters AR6 from UCL)

2. PA: Paris Agreement targeting 1.5 degrees increase by the end of the century (no constraint on overshoot)
Decarbonization of the electricity sector relies less on technological options in a scenario with afforestation and coal phase out is earlier.

Renewable energy represents almost the same (29% and 32% in 2050 for NDC and NDC+aff respectively, and 34% by 2100 for both) while BECCS are always preferred in these scenarios.
APPLICATION OF WATER MODULE

Water use in the energy sector (extraction, power plants)

Withdrawals and consumptions

- Account for the heat to be discharged (mechanical work of the plant, fuel used, thermal efficiency)
- Additional water requirements for carbon capture technologies
- Consider different types of cooling technologies

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<tr>
<th>Updates and/or Analysis</th>
<th>Objective</th>
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<td>Conformity of water use in the processes</td>
<td>Implementation of the water module</td>
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<tr>
<td>Mitigation solutions</td>
<td>Climate constraints impact on water use and emissions variations</td>
</tr>
<tr>
<td>Regional water withdrawal</td>
<td>Contribute SDG6.4.2 indicator</td>
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</table>
RESULTS-FRESH WATER WITHDRAWALS

- Reduction of biomass use in AFR leads to less freshwater withdrawal
- Water consumption decrease in MEA for a less stringent scenario (NDC)
- China’s transition is critical in terms of water stress (it is in the third most water stressed region [FAO, 2019])
“Sustainable carbon removal balances those goals in order to meet the needs of the future without compromising the ability of current generations to meet their own needs” (Morrow and Nicholson, 2021)

1. Integrated approach: Interactions between sectors, solutions and SDGs (1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 14, 15)

2. Provide metrics and guide for the national policies

3. For CDR, it is useful for studying their sustainability rather than target achievement

4. SDGs in the EU (Eurostat, 2022):
   - SDG6 and SDG15 are in moderate movement away for the European region
   - SDG7 in the EU: renewable energy sources accounted for 22.1% of gross final energy consumption in 2020
   - SDG9 + SDG13: EU transportation emissions have fallen by 9.2% since 2015 with the largest drop in 2019 to 2020

Source: www.un.org/fr/sustainable-development-goals
CONCLUSION AND FUTURE WORK

- The enhancement in representing abatement technologies including CDR would provide a solution for decarbonizing the “hard-to-abate” sectors
- The expansion of the sectoral coverage of NDCs and their regular updates require a multi-sectoral approach which is possible through accounting for the AFOLU sector and water use in TIAM-FR
- Other questions are related to the impact of some CDR solutions to adaptation to climate change i.e talking about co-benefits
- The relationship between energy production and water use can guide the policy setting in water scarce region i.e policies for water efficient cooling technologies. Water consumption can reduce the available water for other sectors and end-uses
- Water accounting in the upstream bioenergy sector
Thank you for your attention!

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REFERENCES


1. Energy Security and Sustainable development

2. Bioenergy represents around 60% of the total renewable energy in the EU in 2019

3. Stabilization of carbon in the forests and soils

<table>
<thead>
<tr>
<th>Energy Crops</th>
<th>Agriculture</th>
<th>Forestry</th>
<th>Waste</th>
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<tbody>
<tr>
<td>Primary</td>
<td>Dry and wet manure coming from cattle and that can be gasified</td>
<td>Roundwood: Logging residues, pre-commercial thinnings</td>
<td>Residues from landscape care management, roadside verges and abandoned lands</td>
</tr>
<tr>
<td>Secondary</td>
<td>Olive pits</td>
<td>Covers woodchips and pellets, sawdust and black liquor</td>
<td></td>
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<tr>
<td>Waste sector (solid/tertiary)</td>
<td>The waste obtained from pruning of permanent crops (namely orchards, vineyards, olives, citrus, nuts) and the straw and stubbles residues.</td>
<td></td>
<td>Biomass residues from different industries and municipal solid waste.</td>
</tr>
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Source: ENSPRESO - an open, EU-28 wide, transparent and coherent database of wind, solar and biomass energy potentials
CARBON DIOXIDE REMOVAL IN POLICY

Relevant modifications

Modifications to the Renewable Energy Directive (REDII) 2018/2001:

- New target of renewable energy reaches 40% by 2030
- Sustainability criteria for the use of bioenergy

Modifications to the Land Use, Forestry and Agriculture Regulation Regulation (EU) 2018/841:

- Carbon removals by natural sinks that will need to remove 310 million tons of CO2 emissions by 2030
- Stricter regulations for accounting for emissions
- EU Biodiversity and EU Forest Strategies are included

+ Consistency between both amended regulations
THE ROLE OF FORESTS

La FAO estime qu’au niveau mondial la déforestation et la dégradation des forêts est responsable d’environ 11% des émissions de CO2

Inra, "Quel rôle pour les forêts et la filière forêt-bois françaises dans l’atténuation du changement climatique ?," p. 8

Source: Forest Loss, Global Forest Review, WRI
a) Fresh water withdrawals in 2050 for NDC scenario