Bioenergy Carbon Footprint
Implications on market development

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Brasilia
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Motivation

Avoid Climate Change Risk

Select Best existing biofuels

Encourage New/better technologies pathways

LCA (Carbon Footprint) emerges as an useful communication tool for scientists, policymakers, companies, NGOs...

- Dialogs on policies, Incentive mechanisms, market protection
3 Main policies in the biofuels world

- **Renewable Fuel Standard RFS2 – US Federal:**
  - Volume: 36 billion gallons in 2022: Cellulosic (min 16BG), advanced (min 21), renewable (max 15), biodiesel (TBD).
  - Market segregated according to GHG savings and feedstock.
  - RIN market.

- **Low Carbon Fuel Standard LCFS – State of California:**
  - 10% reduction on total GHG emissions by 2020.
  - No segregation. Each biofuel pathway has its own Carbon Intensity (CI) value.
  - Carbon Credits according to CI values.

  - Minimum GHG savings for qualification.
  - 20% renewable energy in transport in 2020, of which 10% biofuels
  - Additional sustainability criteria.
  - Actually a new proposal by the EU Commission regarding iLUC.
### Rules of the game

<table>
<thead>
<tr>
<th></th>
<th>EPA RFS2</th>
<th>CARB LCFS</th>
<th>EU RED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GHG reduction thresholds</strong></td>
<td>20% Renewable 50% Advanced 60% Cellulosic</td>
<td>10% for the fuel mix</td>
<td>At least 35%. 50% after 2017 60% after 2018</td>
</tr>
<tr>
<td><strong>Type of LCA</strong></td>
<td>Consequential (comprehensive)</td>
<td>Attributionnal and consequential</td>
<td>Attributional and consequential</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Well to wheels</td>
<td>Well to wheels</td>
<td>Well to wheels</td>
</tr>
<tr>
<td><strong>Functional unit</strong></td>
<td>MJ of fuel (LHV)</td>
<td>MJ of fuel (LHV)</td>
<td>MJ of fuel (LHV)</td>
</tr>
<tr>
<td><strong>Impact assessment</strong></td>
<td>Lifecycle emission savings compared to fossil</td>
<td>Lifecycle emission savings compared to fossil</td>
<td>Lifecycle emission savings compared to fossil</td>
</tr>
<tr>
<td><strong>Fossil comparator</strong></td>
<td>Gasoline (93 gCO₂eq/MJ)</td>
<td>Gasoline (96 gCO₂eq/MJ)</td>
<td>Gasoline (84 gCO₂eq/MJ)</td>
</tr>
<tr>
<td><strong>LUC and iLUC</strong></td>
<td>Both are considered</td>
<td>Both are considered</td>
<td>LUC yes, depends on the project</td>
</tr>
<tr>
<td><strong>Constituents of emissions and GWP</strong></td>
<td>CO₂: 1; CH₄: 21; N₂O: 310 (NRC 2010)</td>
<td>CO₂: 1; CH₄: 25; N₂O: 298 (IPCC 2007)</td>
<td>CO₂: 1; CH₄: 23; N₂O: 296 (IPCC 2001)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Also: VOC: 3.1; CO 1.6</td>
<td></td>
</tr>
<tr>
<td><strong>Tools for calculating</strong></td>
<td>EPA spreadsheets and GREET1.8_C</td>
<td>GTAP + CA-GREET</td>
<td>No. Biograce software is available.</td>
</tr>
<tr>
<td><strong>Co-product treatment</strong></td>
<td>System expansion (displacement)</td>
<td>System expansion (displacement)</td>
<td>Recommends allocation (energy). Cogeneration has a particular interpretation.</td>
</tr>
</tbody>
</table>

Source: ICONE, original data from EPA, CARB, RED/Biograce
## System boundaries

<table>
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</tr>
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<tbody>
<tr>
<td>Extraction and/or production of feedstock</td>
<td>yes</td>
<td>yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Capital goods</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Transport and distribution</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Final combustion</td>
<td>yes (only the emissions of N2O and CH4, CO2 biogenic)</td>
<td>yes (only the emissions of N2O and CH4, CO2 biogenic)</td>
<td>Zero (biofuels 100% biogenic)</td>
</tr>
<tr>
<td>Land Use Change</td>
<td>yes (direct and indirect)</td>
<td>yes (direct and indirect)</td>
<td>Officially yes; but No in most cases</td>
</tr>
<tr>
<td>Other indirect effects</td>
<td>yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Chemical inputs</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

Source: ICONE, original data from EPA, CARB, RED/Biograce,
Comparable GHG results: sugarcane ethanol

- CARB has highest LUC+iLUC emissions
- EPA agriculture is extremely influenced about assumption on N2O cycle. (use of perennial grasses instead of sugarcane)
- RED has highest transport emissions

Source: EPA, CARB, Khatiwada et al 2012, ICONE
LCA estimates (different pathways)

Source: Khatiwada et al. 2012, original data from EPA, CARB
Developing a new LCA pathway

- Jet fuel (kerosene)
- Reference year 2022
- Consumed in Brazil
- Use of trash in cogeneration system
- **Two** different methodological approaches
  - No changes in agricultural step
  - Adapted industrial step
  - Updated iLUC calculations (for CARB)

Special thanks to: IDB, Boeing, EMBRAER, WWF and Amyris
System description

Seabra and Moreira
Objective: Communication (Demo flight Rio+20) (2012)

- Sugar cane cultivation and transport
- FENE production
- Transport
- Hydrogenation
- Transport
- Fuel use

150 km by trucks

EPA's RIA

Amyris estimates

IPCC's emission factors

Moreira, Seabra and Gurgel
Objective: Scientific Paper (under development)

- Sugar cane cultivation and transport
- FENE production
- Transport
- Hydrogenation
- Transport
- Fuel use

150 km by trucks

ARB Staff Report

Amyris projection

IPCC's emission factors

Amyris estimates
Main parameters

- Projected production pattern in 2022
  - 150 million liters in 2022 (CARB)

- Agricultural yield:
  - EPA: 78.2 (direct LCA); 94 (land use model).
  - CARB: 75 (direct LCA); 81 (land use model).

- Yield 27 t cane/ FENE

- Electricity:
  - Production 195 Kwh/ t cane
  - Consumption 68 Kwh/ t cane

- Hydrogenation 1.04 t renewable jet fuel/t FENE.
## Results of the studies (g CO₂eq/MJ)

<table>
<thead>
<tr>
<th>Process</th>
<th>Emissions (g CO₂eq/MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugarcane production Include LUC</td>
<td>50.7</td>
</tr>
<tr>
<td>FENE production</td>
<td></td>
</tr>
<tr>
<td>Chemicals</td>
<td>1.9</td>
</tr>
<tr>
<td>Biomass combustion</td>
<td>3.4</td>
</tr>
<tr>
<td>Electricity Surplus</td>
<td>-45.7</td>
</tr>
<tr>
<td>Yeast</td>
<td>-0.6</td>
</tr>
<tr>
<td>FENE transport</td>
<td>0.3</td>
</tr>
<tr>
<td>Hydrogenation</td>
<td>4.3</td>
</tr>
<tr>
<td>Biojet fuel transport</td>
<td>0.3</td>
</tr>
<tr>
<td>Biojet fuel use</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Net emissions</strong></td>
<td><strong>15.2</strong></td>
</tr>
</tbody>
</table>

*Preliminary numbers. Do not quote or cite*
Discussion: maturity of carbon footprint analysis for biofuels

- Direct LCA method is mature
  - (some important questions remain on co-product treatment...)
- iLUC Models are improving, results are getting closer
- Better data is required in both direct and indirect emissions calculation

- The major risk regarding iLUC is to make the wrong assumptions.
Discussion: biofuels carbon footprint analysis developments

- Requests on LCA (our experience)
  - Scientific development
  - Avoidance of unfair trade barriers
  - Corporate image (suppliers and buyers)
  - Corporate strategy/product development

- LCA can be an useful tool to guide policies, but conditions must be respected.
  - Respect scientific development
  - Keep improving knowledge on sensible areas
  - Limit the political interventions on LCA
Thank you
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www.iconebrasil.org.br