Project goal

To assist the Government of Brazil to strengthen its technical capacity in supporting the implementation of its mitigation actions of greenhouse gas emissions in key economic sectors (industry, energy, transport, household and services, AFOLU, waste management and other cross-sector alternatives).
Outcomes

/// Sectoral mitigation alternatives identified and their respective potentials and costs quantified for the 2012-2050 period.

/// Integrated analysis of the different mitigation alternatives in an integrated optimization framework, considering the non-additivity of the different mitigation alternatives and other economic considerations; and an evaluation of the possible impacts of different climate policies on the Brazilian economy; testing domestic measurement, reporting and verification (MRV) of proposed mitigation alternatives.

/// Capacity building for federal, state and 2014 FIFA World Cup host cities government institutions, as well as civil society organizations, for implementation of mitigation actions of GHG emissions in key economic sectors of Brazil.
Integrated Analysis of Scenarios
Integrated analysis of scenarios

- Economic scenarios
- Social Accounting Matrix
- Macroeconomic model
- CGE Model
- Energy system scenarios (bottom-up models)
- MESSAGE Model
- AFOLU scenario (OTIMIZAGRO)
- Energy and AFOLU matrices
- Strategic projections of experts
- Scenarios of technological changes and preferences
- Econometric projections

Economic impacts

- Sensivity analysis
- Analysis of barriers and opportunities
MESSAGE – Brasil 8000 Model (MSB-8000)

- Partial equilibrium – entire energy system,

- Emissions include fossil-fuel combustion from all sectors, industrial sectors, industrial processes, waste treatment, and fugitive and fugitive emissions. Emissions from LULUCF are not included in
Iterative procedure:
EFES — Sectoral models — MSB-8000 — Otimizagro model
Optimization: linear programming (LP)

/// Important considerations about LP

/// Important to understand some “Technology Restrictions”

/// Method: Minimization of the objective function (total system cost)

/// Perfect competition

/// Intertemporal optimization model (perfect foresight)

/// **One single discount rate** *(may be different from specific sectoral txs)*

/// Restrictions:

/// Demand has to be met

/// Physical limitations (flow/stock)

/// Technological limitations (technical, economic and market potentials)
MSB 8000 – Upgrades performed during the course of the project (time resolution)

- Base year: 2010 – Kept
- Horizon: 2010-2050 each 5 years – Kept
- Seasonality: 4 seasons
- Load curve: 5 sections

- 12 months
- 24 hours
MSB 8000 – Upgrades performed during the course of the project (spatial resolution)

3 regions
(only electricity system)

6 regions
(electricity, gas, oil, oil products and CO₂)
MSB 8000 – Upgrades performed during the course of the project (much more details for energy commodities)

5 basic energy levels:
- Resources: 4 types
- Primary energy: 8 types
- Secondary energy: 18 types
- Final energy: 20 types
- Useful energy: 22 types

5 levels of basic “commodities”:
- Resources: 10 types
- Primary energy: 10 types
- Secondary energy: 21 types
- Final energy: 22 types
- Useful energy: 121 types

2 levels of energy “dummies”:
- 6 types

18 levels of “commodity” “dummies”:
- 266 types
MSB 8000 – Upgrades performed during the course of the project (technology details)

Roughly 300 validated technologies represented

Roughly 8,000 validated technologies represented (more than 200 low-carbon technologies)
Integrated Modeling: MSB-8000 – sectoral models iteration
Iterative procedure: EFES-Sectoral Models-MESSAGE

EFES

- VA por valores de carbono
  - $0/tCO\textsubscript{2} (base)
  - $25/tCO\textsubscript{2} (1)
  - $50/tCO\textsubscript{2} (2)
  - $100/tCO\textsubscript{2} (3)

Modelos Setoriais Automat. (Demanda)

- Demanda para diferentes valores de carbono
  - (base)
  - (1)
  - (2)
  - (3)

Modelos setoriais to MESSAGE (Automat.)

- Transferência no padrão MESSAGE
  - (base)
  - (1)
  - (2)
  - (3)

MESSAGE

- Cenários de emissões e intensidade de energia (IE)
  - (IE base)
  - (IE 1)
  - (IE 2)
  - (IE 3)

IE to EFES
Integrated Modeling: MSB-8000 – Otimizagro iteration
### Consumo de energía por tipo energético

<table>
<thead>
<tr>
<th>Año</th>
<th>Elect</th>
<th>LPG</th>
<th>Fueloil</th>
<th>Diesel</th>
<th>Charcoal</th>
<th>Biomas</th>
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**MSB 8000**

### Producción de biocombustibles (Mtoe)

- **15-20 US$/t**
- **20-30 US$/t**
- **30-45 US$/t**
- **45-60 US$/t**
- **60-100 US$/t**

### Datos básicos

<table>
<thead>
<tr>
<th>Año</th>
<th>Datos</th>
<th>Descripción</th>
<th>Máximo (Exp)</th>
<th>Máximo (Real)</th>
<th>Diferencia</th>
<th>Diferencia %</th>
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**Mitigation Options of Greenhouse Gas Emissions in Key Sectors in Brazil**
Integrated Modeling: EFES iteration
<table>
<thead>
<tr>
<th>MSB 8000</th>
<th>Sectoral models</th>
<th>EFES</th>
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<tbody>
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<td></td>
<td>Otimizagro</td>
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</table>
Baseline assumptions:

- Available technologies and their respective learning curves.
- No abatement measures and/or energy efficiency.
- No specific mitigation policies.
- Sectoral perspective dominates modeling.
- Model runs with less freedom for optimization.
Baseline

- Primary energy consumption (EJ).
- Sectoral GHG emissions (tCO2e).
- Power generation (TWh).
- Oil refining (kbpd in atmospheric distillation units): revamp + greenfield.
Low-carbon scenarios: Low-carbon and low-carbon with innovation

/// For the different sectors (2010-2050):

/// Energy (power sector, oil and gas, biofuels etc).

/// Transport (passenger and freight, including the different modes).

/// Buildings (households and services).

/// Industry (all subsectors).

/// Waste management.

/// Their emissions.

/// Their carbon intensities.
Low-carbon scenario: $BC_0$

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Assumptions for low-carbon $BC_0$:

- **Best Available Technologies (BATs).**
- **Various abatement measures and/or energy efficiency.**
- **Less restrictions with respect to the technology profile.**
- **Model runs with a higher degree of optimization freedom.**

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**No carbon value associated**: options which have economic potential, but are not but are not implemented in the baseline due to market barriers. In particular, optimization
Low-carbon scenario: BCx

/// For the same different sectors (2010-2050).

/// Same level of technology freedom of BC₀. Carbon value (x) ranging from 0 to 200 US$/tCO₂ (constant dollars) → cost internalization in the objective function

/// Some sensitivity analyses performed.

/// BCx economic impacts.

/// Analysis of political barriers and opportunities.

/// Results showed some not-yet-mature technologies becoming important starting from 2030-2040 at higher carbon values and when some restrictions were imposed on some Technologies.
Will there be a $CO_2$ transport capacity?

Regulatory aspects + transaction costs.
**CCS: Chemical**

![Graph showing emissions over time](image)

**BC\textsubscript{50}**
CCS: pig iron and steel
Final Considerations

Some important issues and challenges

Integrated models are complex, require high-quality, detailed sectoral information and experts capable of interpreting results of the model runs.

Soft links not always work well, being time consuming and prone to errors. Ideally, integrated models should aim at having hard links between the different sectors involved in the modeling exercise.

On the other hand, only truly integrated models can really grasp the complexities of reality, capturing all interactions between the different sectors of an economy, avoiding double counting and incongruencies in the results.

MSB-8000 is now evolving from a national model to a regional model (Latin America) and also to a global model.

Only a global integrated assessment model can identify if national pathways are in line with a 1.5-2.0 C world, as agreed upon during COP21 in Paris in December 2015.
Thanks!

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