Production and availability of agricultural residues for energy in LAC and EU

learning from the Indian experience.
## Agricultural residues

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Origin</strong></td>
<td>In the field during agricultural practices or during harvest</td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td>Straw, stalks, leaves</td>
</tr>
<tr>
<td><strong>Characteristics</strong></td>
<td>Heterogeneity, Spread over large areas</td>
</tr>
</tbody>
</table>
How much residues are produced? At what conditions are they available for industrial energy production?

- **Agricultural residues for energy production**
  - Abundance and renewability
  - Cheaper biomass than dedicated plantations
  - Complementarity rather than competition with food production
  - Local resource, available in every agricultural area

- **Focus on EU and LAC regions**
- Results and discussion based on the Indian experience in the industrial energy use of agricultural residues
Agricultural uses - Soil - Animal feed

Other uses - Domestic fuel - Construction

Residue-to-product ratios:
- Specific value for each residue
- Estimated from literature
- Ex: 1.3T straw produced / T wheat

Recoverability factors after agricultural or other uses
- Global value for primary and secondary residues
- Estimated from literature
- Ex: 15% and 55% of primary and secondary respectively remain available after agricultural needs

GTP Gross technical potential

NTP Net technical potential

PP Practical potential

Crop residue production

Crop residue availability

Assessment methodology for...
Crop residues selected for productions assessment in EU-28 and LAC

### PRIMARY RESIDUES
- Straw from cereals, soybean, mustard and rapeseed
- Stalks from sunflower, maize and cotton
- Residues from pineapple harvest
- Coconut fronds
- Groundnut haulms
- Sugarcane tops and leaves
- Coffee branches
- Banana rachis

### SECONDARY RESIDUES
- Sugarcane bagasse
- Groundnut shells
- Coconut shell, husks and pith
- Rice husk
- Corn cob
- Oil palm empty bunches, fibers
Crop residues generated by agricultural production in EU-28 and LAC

19% of world prod. High secondary residues prop.

7% of world prod. Low secondary residues prop.

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>LAC Region</th>
<th>EU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>5623</td>
<td>1083</td>
<td>403</td>
</tr>
<tr>
<td>Primary residues</td>
<td>4621</td>
<td>780</td>
<td>390</td>
</tr>
<tr>
<td>Secondary residues</td>
<td>1002</td>
<td>303</td>
<td>13</td>
</tr>
</tbody>
</table>

Annual crop residues production (MT)
Crop residues generated by agricultural production in EU-28 and LAC

In EU-28
- 7% of world crop residues production
- Only 3% secondary residues
- Straws of wheat and barley + stalks of maize and rapeseed = 85% residue production
- France, Germany, UK, Poland and Spain = 5 main producers (60% of EU production)

In LAC
- 19% of world crop residues production
- 72% are primary; 28% are secondary
- Sugarcane bagasse / tops and leaves + Soybean and maize stalks = 81% residue production
- Brazil = 60% of LAC crop residues production
- Brazil, Argentina, Mexico, Colombia
Availability

<table>
<thead>
<tr>
<th>Availability = small part of residues generated (PP = 12-15% of GTP)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary residues</strong></td>
</tr>
<tr>
<td>Fraction dedicated to soil and animal feed</td>
</tr>
<tr>
<td>Fraction dedicated to other uses</td>
</tr>
</tbody>
</table>

**GTP**
- 403 Mt
- 6% secondary

**NTP**
- 65 Mt
- 41% secondary

**PP**
- 49 Mt
- 160 Mt

- Fraction dedicated to soil and animal feed
- Fraction dedicated to other uses

Primary residues
- 85%

Secondary residues
- 45%

6\% secondary

41\% secondary

Milhau A. Fallot A.
Primary residues availability limited by costs and transportation

EXAMPLE WITH RICE

Straw: 5 ton/ha generated (GTP)
0.7 ton/ha potentially available (PP)

In a region where rice use 30% of land

→ 476,000ha are needed to feed a 10MW plant
Learning from the Indian experience

- Assessment of crop residues production and their availability
- Compare with how they are used for energy production through the CDM experience
- Understand conditions in which crop residues can be mobilized for energy production
Learning from the Indian experience

**THE INDIAN CONTEXT**

- 2010, India generated 0.6 billion tons crop residues = 10% world production
- 2004-2010: 136 CDM using crop residues for energy generation → data
  - Installed capacity of 1300MW (0.8% total installed cap.) (9.8MW/project on average)
  - Mainly consume secondary residues: rice husk and bagasse
  - Primary residues poorly exploited: 1-3% PP, mainly cotton stalks
  - Technology: Direct combustion, energy for captive use or sold to the grid
  - Average efficiency: 0.6 kWh/kg residues

**OBSERVED CONSEQUENCES:**

- Exhaustion of a few residues vs. potentials of other remain largely untapped
- Agricultural residues price increases by 30% between 2004 and 2010
- Technology limited for full exploitation of the energy potential
Conditions for the exploitation of residues

- **Financial analysis**, based on IRR, gives information concerning important parameters to maintain viability of projects:
  - Electricity purchase tariff and crop residues cost: most determinant factors.
  - Carbon credits: impulse projects implementation but cannot compensate for fuel cost increase.

![Graph showing required variation to compensate a 10% increase in fuel cost](image-url)

- **Electricity purchase tariff**: 5.8%
- **Plant Load Factor**: 15.1%
- **Project cost**: -15.4%
- **Carbon price**: 52.9%
Conditions for mobilizing residues for energy production

**Availability**

Crop residue generated ≠ available for energy production
Think first: SOIL, ANIMAL FEED AND OTHER USES previously
Global asses.: 15% residues generated are available for energy, must be adjust at local level

**Projects feasibility**

- QUALITY
- PRICE
- QUANTITY
- DISTANCE

Secondary residues are more attractive: food industries can transform crop residues into energy for captive use → economic incentive.

More risky to implement profitable energy plant that have to collect and transport residues to make energy and sell it to the grid.

**Projects viability**

**Constancy of residue production** (Depends on climate, markets, agricultural policies...)

**Price of the biomass** (including transportation cost)
- New market for residues, without regulation → prices rise up
- Risk: residues can be sold for energy with negative impact on soil and agric. production

**Electricity purchase tariff**
- Determinant factor for feasibility and viability of projects
- Needs for politics decision to state on the electricity produced from residues

**Carbon price**: « good to take but not determinant incentive »,
- cannot absorb residue price increase
In LAC, situation similar to India

- Important quantity of residues generated (++ secondary residues) but projects didn’t boomed in LAC as in India
- **Obstacle:** Electricity purchasing conditions limit adoption of projects (Mexico & Colombia, pioneers in small scale)
- Industrial opportunity for economic and environmental competitiveness (Bagasse valorization largely adopted...)
- **Alternative:** residues can be transform into biomaterial
- **Challenge:** improve technology efficiency and provide market for the energy
- **Caution:** projects should be go with measures to prevent take off residues from soils, animals or other uses

In EU-28

- Scarcity of secondary residues limits projects feasibility
- Experiences of large-scale energy production from straw in Denmark, UK...
- **Obstacle:** availability and constancy of resource → residues mixed with other fuels such as wood or coal
- European countries can invest in residue projects in developing countries through CDM
Thank you for your attention.

Antoine Milhau (milhau.antoine@gmail.com)
Abigail Fallot (fallot@cirad.fr)

Questions?
Discussion