Case study: a sugarcane ethanol plant in Brazil

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This case study shows how the methodology could be applied to a biofuels project in Brazil

- Considers a sugarcane ethanol plant in Brazil, based on generic data

- It shows:
  - How the methodology would work
  - Decisions on commercial criteria
  - Questions that remain
  - Sample results
Sugarcane ethanol mill

Pre-processing

Sugarcane input: 2.5 mtpa capacity, with expansion to 5 mtpa

Processing

Juice is converted sugar and ethanol (50:50 split)

Ethanol production

100 - 200 million litres of ethanol per year

Sugar production

170 - 340 kt of sugar per year

Steam & Power Generation

Power and steam for process energy

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### Key decisions

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do we measure sugarcane in, or energy out?</td>
<td>• Energy out - ethanol, power and heat</td>
</tr>
<tr>
<td>What about the sugar?</td>
<td>• Sugar output is not counted&lt;br&gt;• Options to swing/to convert more sugar to ethanol production are considered as lower probability or non-commercial reserves</td>
</tr>
<tr>
<td>Can we count the energy used in the process?</td>
<td>• Yes - power and heat generated for process energy is counted</td>
</tr>
<tr>
<td>What units do we use?</td>
<td>• Wait for conversion document for all renewables&lt;br&gt;• For now, using barrels of ethanol (bbl) and terawatt-hours (TWh) heat and power</td>
</tr>
</tbody>
</table>
Project maturity relies on evidence of technical and commercial maturity

Technical criteria

Commercial criteria

1. Access and entitlement

2. Market and sales connectivity

3. Authorisation and commitment

4. Economic case validation

All of these criteria must be satisfied together to claim a reserve

The most restrictive sets the project lifetime used for the reserve estimate
1. Access and entitlement

Is there evidence of access or entitlement to the land on which to grow the sugarcane?

- None of the feedstock is from land owned by the plant owner

- 90% of the feedstock is from leased land
  - Current lease length $\rightarrow$ **Proved reserves**
  - Lease extensions $\rightarrow$ **Probable reserves**
  - Likely future lease renewal $\rightarrow$ **Probable reserves** or **Contingent resource**

- 10% of the feedstock is bought on the spot market $\rightarrow$ **not booked**

**Question:** What evidence is needed to prove that lease renewal is likely?
2. Market and sales connectivity

Are the conversion plant, storage and transport infrastructure in place to convert feedstock into an energy product? For how long?

- Technical lifetime of the conversion plant (30 years) → **Proved reserves**

- Lifetime extension by capex reinvestment → **Contingent resource**

**Question:** The owner will keep investing in the plant to keep it going as long as possible.

- What is a technical lifetime?
- How can we define lifetime extension?
- Would it be better to set a time period?
3. Authorisation and commitment

Is sanction / financial approval to develop the plant in place, including from any JV partners?

- Current plant is already operating → **Proved reserves**

- An expansion of plant capacity is currently in the final stages of the approval process → **Proved reserves**

- Note that economically viable upgrades / technology enhancements, that are not yet sanctioned would go into **Contingent resource**
4. Economic case validation

Is there an economic model demonstrating commerciality?

If this depends on policy support, what is the lifetime of the policy?

- The plant is commercially viable and no policy support is required \( \rightarrow \text{Proved reserves} \)
The category also depends on the level of certainty and evidence to support this:

- Volumes with lower certainty are put into the **Probable reserves** category, e.g.
  
  - Plant efficiency improvements with learning
  - Average crop yield improvements
  - Swing towards ethanol

- If large scale investment and or a technology breakthrough is required to access additional production → **Contingent category**

- Clearly there some ambiguity exists at the margins between the categories. The guiding principle is the strength of the demonstrable evidence.
## Example results

<table>
<thead>
<tr>
<th>Category</th>
<th>Project</th>
<th>Resource by case</th>
<th>Resource by category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ethanol M bbl</td>
<td>Power+ steam TWh (mmbbl)</td>
</tr>
<tr>
<td><strong>Proved reserves</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing plant (10 yr leases)</td>
<td></td>
<td>6</td>
<td>9 (16)</td>
</tr>
<tr>
<td>Expansion of plant (10 yr leases)</td>
<td></td>
<td>6</td>
<td>9 (16)</td>
</tr>
<tr>
<td><strong>Probable reserves</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional improved crop yields</td>
<td></td>
<td>0.6</td>
<td>0.2 (0.3)</td>
</tr>
<tr>
<td>Lease extension (1 yr)</td>
<td></td>
<td>1</td>
<td>1.1 (2)</td>
</tr>
<tr>
<td>Lease renewal (to plant lifetime of 30 yr)</td>
<td></td>
<td>20</td>
<td>30 (55)</td>
</tr>
<tr>
<td>Increase ethanol split to 60% (30 yr)</td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td><strong>Contingent</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>120</td>
<td>35 (61)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>161</td>
<td>83 (150)</td>
</tr>
</tbody>
</table>
**An alternative view**

60 years

<table>
<thead>
<tr>
<th>Proved: Existing plant (current leases)</th>
<th>Probable: Increase ethanol to 60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proved: Expansion (current leases)</td>
<td>Probable: Lease renewal</td>
</tr>
</tbody>
</table>

**Contingent:** Converting the remaining 40% of the ATR to ethanol would require investment

**Contingent:** Additional plant lifetime would require investment

**Not bookable:** 10% of capacity supplied by spot market sugarcane

**Contingent:** Bagasse to ethanol requires investment

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5 mtpa cane plant capacity, 100% ethanol

Increased yields could affect the box size in different ways depending on capacity constraints.
Conclusions

• Overall, the methodology worked well in this example

• Key design decisions and uncertainties are:
  - Measure the energy out, rather than feedstock in ✓
  - Only book energy outputs, including energy used in the process ✓
  - Use sensible units for now – harmonise later ✓
  - Access to land – what evidence is needed for lease extensions ?
  - Market connectivity - how do we define/limit plant lifetime ?