Environmental and economic impacts of ethanol pipelines in Brazil: A case study

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Abstract

Around 90\% of the ethanol produced in Brazil is trucked. Trucking is a fast, reliable, and widely available mode; however, it also stands out as the most polluting, unsafe, and often most costly. As ethanol production is expected to increase in Brazil, optimizing the ethanol freight system, both for export and domestic distribution, provides opportunities for greenhouse gas mitigation, cost savings, reduced congestion along transportation corridors, and short-term job creation. In addition, improvement in logistics also allows a greater storage capacity for ethanol. This paper assesses the economic feasibility and potential greenhouse gas savings of building new ethanol pipelines in Brazil. The calculations are performed in a standard discounted valuation framework and are applied to an actual pipeline project in development by the consortium Logum Logística S.A. The results indicate that the project will yield substantial value for the pipeline operator (approximately US$305 million in present value) and substantial greenhouse gas savings (approximately 17.5 million Mg over 30 years).

1. Introduction

In Brazil, trucks move the majority of freight tonnage\cite{1}, and diesel is the primary fuel used by this mode\cite{2}. Although typically faster and more widely available (geographically) than other common freight modes, such as rail, barge, ship, and pipeline, trucking stands out as the most polluting, noisy, unsafe\cite{3}, and highest marginal cost\cite{4}.

For most ethanol refineries in Brazil, trucking is the only option available to transport ethanol to domestic distribution centers or export ports, given the lack of infrastructure for other transportation modes. Around 90\% of the ethanol tonnage is moved by trucks, 7\% goes by rail, only 2\% is transported by pipelines, and 1\% is shipped by rivers\cite{5}.

Recently, a dedicated pipeline and river barge project was launched by the consortium Logum Logística S.A., made up of Petrobrás (20\%), Raízen (20\%), Odebrecht (20\%), Copersucar (20\%), Camargo Corrêa (10\%) and Uniduto Logística (10\%). The project is dedicated exclusively to ethanol freight from the Central-west and South-east regions to a central distribution center, and on to export ports and demand centers in the states of Rio de Janeiro and São Paulo. Based on press information, the project is expected to cost around R$7 billion (≈ US$3.3 billion), will have pipelines totaling up to 1,300km\cite{6} with 20 million m\textsuperscript{3}/year of capacity, and is expected to be complete and operational in 2015.

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The first segment, between Ribeirão Preto, SP and Paulínia, SP, was completed in 2013 (Fig. 1), and the second segment, between Uberaba, MG and Ribeirão Preto, SP, is underway.

Fig. 1. Depiction of the pipeline network in development by Logum Logística S.A. Source: Logum Logística S.A [7].

Using this project as a case study, the goal of the current work is to identify the economic feasibility and the greenhouse gas (GHG) emissions of large ethanol pipelines in Brazil, when compared to trucking, the primary alternative freight mode.

2. Method

This paper first evaluates the economic feasibility of each of six segments (from Jataí to Paulínia and Anhembi to Paulínia) of the Logum pipeline system by applying the standard net present value method, as demonstrated in the biofuel pipeline context in Strogen et al. [4]. We exclude the segment from Barueri to Santos due to a lack of available information. The remaining segments in the configuration are existing oil pipelines and are also omitted from the analysis. We then use the framework of Strogen et al. to estimate the life-cycle GHG emissions as a result of the construction and use of each pipeline segment.

2.1. Data Sources

We retain several parameters from Strogen et al. [4], namely the fraction of construction costs assumed to be spent on annual maintenance, pipeline utilization rate, fuel properties, and the GHG intensity of trucking freight. Most other important parameters are taken from Logum [7] or other official documents; however, when unavailable from these sources, parameters are taken from press reporting, estimated using a model, or assumed. Parameters common to all six segments are presented in Table 1. Parameters specific to each pipeline segment are reported in Table 2.

Table 1. Model inputs common to all pipeline segments.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio of hydrous to total ethanol (%)</td>
<td>60</td>
<td>Assumed, based on the approximate national split [1]</td>
</tr>
<tr>
<td>Lifespan of the project (years)</td>
<td>30</td>
<td>Assumed</td>
</tr>
<tr>
<td>Annual maintenance costs as a proportion of initial construction costs (%)</td>
<td>3</td>
<td>Assumed in Strogen et al. [4]</td>
</tr>
<tr>
<td>Construction period for each segment (years)</td>
<td>2</td>
<td>Assumed</td>
</tr>
<tr>
<td>Soil temperature (K)</td>
<td>293.15</td>
<td>Interpreted from USDOC NOAA [8]</td>
</tr>
<tr>
<td>Kinematic Viscosity of Anhydrous Ethanol (m/s²)</td>
<td>1.50×10⁶</td>
<td>Authors’ calculations based on [9]</td>
</tr>
<tr>
<td>Kinematic Viscosity of Hydrous Ethanol (m/s²)</td>
<td>1.92×10⁶</td>
<td>Authors’ calculations based on [9]</td>
</tr>
<tr>
<td>Utilization rate (%)</td>
<td>90</td>
<td>Assumed in Strogen et al. [4]</td>
</tr>
<tr>
<td>GHG intensity of electricity (g CO₂-e/kWh)</td>
<td>593.2</td>
<td>Reported 2013 build margin emissions factor from <a href="http://www.met.gov.br">http://www.met.gov.br</a></td>
</tr>
</tbody>
</table>
2.2. Modeling & Calculation Methods

We retain the standard net present value method for valuing the project as demonstrated in Strogen et al. [4]. The operating GHG emissions are estimated using a first order approximation that assumes a constant GHG intensity for the electricity used in the pipeline, as well as a constant GHG intensity for trucking. Construction GHG emissions are estimated using a quadratic function of pipe diameter, also discussed in Strogen et al. [4]. Potentially important, but higher order, omissions that could affect our GHG calculations are economic general equilibrium effects resulting from the drops in prices of ethanol and ethanol-blended gasoline at the pump and the reduction in the price of trucking freight (the so-called ‘rebound effects’).

We report the estimated cumulative GHG emissions in metric tonnes (Mg) over the 30 year lifetime of the project. In addition, we use the United States Government values for the social cost of carbon (SCC) emitted in different years [12] to calculate a total social value of the GHG emissions. Their reported SCC values are linearly interpolated between years and it is assumed that the first year of construction is 2013.

3. Results

The reference-case results for the net present value and greenhouse gas savings of each pipeline segment are reported in Table 3.

Table 2. Modelling inputs specific to each pipeline segment.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Ribeirão Preto-Paulínia</th>
<th>Uberaba-Ribeirão Preto</th>
<th>Itumbiara-Uberaba</th>
<th>Anhembi-Paulínia</th>
<th>Quirinópolis-Itumbiara</th>
<th>Jataí-Quirinópolis</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (km)</td>
<td>207</td>
<td>143</td>
<td>258</td>
<td>126</td>
<td>112</td>
<td>151</td>
<td>Personal communication (Logum)/press reports/author georeferencing</td>
</tr>
<tr>
<td>Diameter (in)</td>
<td>24</td>
<td>20</td>
<td>18</td>
<td>10</td>
<td>8.39</td>
<td>5.31</td>
<td>Personal communication (Logum)/author interpolation</td>
</tr>
<tr>
<td>Annual flow capacity (million m³ per year)</td>
<td>12</td>
<td>8.9</td>
<td>6.3</td>
<td>5.1</td>
<td>2</td>
<td>0.8</td>
<td>Personal communication (Logum)/Brazil Energy Plan [11]</td>
</tr>
<tr>
<td>Construction costs (R$ million)</td>
<td>2183</td>
<td>1047</td>
<td>1530</td>
<td>231</td>
<td>145</td>
<td>78</td>
<td>Press reports/author interpolation</td>
</tr>
<tr>
<td>Tariff (R$/m³-km)</td>
<td>9.06</td>
<td>11.30</td>
<td>8.36</td>
<td>10.63</td>
<td>9.61</td>
<td>11.03</td>
<td>Logum [10]</td>
</tr>
<tr>
<td>Electricity price (R$/MWh)</td>
<td>216</td>
<td>216</td>
<td>216</td>
<td>216</td>
<td>209</td>
<td>209</td>
<td>Average industrial price by region for 2013 [11]</td>
</tr>
</tbody>
</table>

Under our reference scenario, we find all but one segment of the pipeline to be privately profitable. The full project is privately profitable, totaling around R$671 million (US$297 million) in value for the consortium, and generates
substantial cumulative GHG emissions savings over time. Using the US government social cost of carbon, we estimate the value of these savings to be US$900 million, greatly adding to the value of the project from a social perspective.

The negative NPV result for the Itumbia-Uberaba segment indicates that Logum has used different assumptions in its analysis for this segment. We believe the consortium expects further development in ethanol in the feed-in regions to this pipeline, and thus expect the flow rates to increase over time, whereas our reference scenario assumes constant flow rates over time. In unreported analysis, we find substantial increases in flow rates to be profit improving at the current tariff rates, for all pipeline segments. This suggests that the consortium is oversizing the entire pipeline, in anticipation of higher future throughput.

4. Conclusion

This paper estimates the economic feasibility and GHG savings of the Logum pipeline project in Brazil. It was our goal to make our assumptions realistic where possible, and conservative otherwise. The results indicate the project will yield substantial value for the companies involved, the climate, and, to the extent that savings are passed on, customers at the pump. We believe this qualitative finding is not sensitive to our assumptions. It also indicates both private value and environmental savings for the pipeline segments not yet committed to (the Jataí to Uberaba segments) showing no justification for unconditional public subsidies of the project. Since there are such large private gains to be made, the results also indicate that further sugarcane and ethanol development could be encouraged by further extensions to this network.

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References


Biography

Kenny Bell is a 2nd year PhD student in Agricultural and Resource Economics at UC Berkeley. His interests are in energy, climate change, agriculture, and water pollution. He is originally from New Zealand.

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