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Brazilian biodiesel mandate: challenges and limitations in future scenarios

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1. INTRODUCTION

To mitigate greenhouse gases (GHG) emissions and increase energy security, Brazil plans to increase biofuel use through, among other strategies, mandates of biodiesel (BD) mix on fossil diesel. From March 2024 onwards, BD added to diesel was 14%$_{(v/v)}$ and, from March 2025 on, 15%$_{(v/v)}$ (CNPE 2023). Demand for diesel is expected to nearly double in 2050 (MME/EPE 2020). Thus, BD use will have to expand to cope with both the rise of blend mandates and the increasing consumption of diesel. In Brazil 60% of BD is produced from soy oil (ANP 2023b) but 63% of soy is exported (ABIOVE 2023). This study investigates the GHG mitigation potential of soy BD in mixing mandates by 2050 using Life Cycle emissions (LCA-GHG) and alternative land demand and direct land use change (dLUC) scenarios, as well as the effects on feedstock supplies.

2. METHODS

Diesel demand is estimated from 2015 to 2050, based on official projections (EPE, 2020) and gap filling by linear interpolation. A low and high range of BD blend was considered: (i) B15 that corresponds to the current mandate is assumed to keep at the same level by 2050 and (ii) B20 from 2024 onward as in the claim pushed by the agribusiness sector. GHG savings were estimated with LCA-GHG of soy BD from RenovaBio (ANP 2023a), assuming it as the only feedstock for simplification. Soy's land demand was calculated using productivity data from RenovaCalc (ANP 2020) and CONAB (2023). dLUC emissions were estimated by carbon stock differences and BRLUC (2021) carbon stocks values weighted on soy production. The dLUC scenario assumes that 100% of additional demand is met with soy expansion over moderately degraded pasture, which matches with Brazil's Degraded Pasture Conversion Program (Brasil 2023). A 33% allocation factor for BD was used based on the lower heating value of the co-products.

3. RESULTS AND DISCUSSION

By 2050, diesel use is 3.4 EJ/yr, being 0.5 EJ for BD considering the current mandate (Figure 1). Cumulative BD demand is 11.8 EJ and emissions savings without dLUC range from 458 to 706 $MtCO_{2e}$ since soy BD's LCe varies from 26.4 to 47.5 gCO_{2e}/MJ. For B20 scenario, both emissions savings and annual demand are 33% higher (Table 1). Brazil produced 0.25 EJ of BD in 2023 so it would need to add 0.27 EJ in 2050. Meeting supply with land expansion demands 12 Mha and dLUC emissions could be 150 $MtCO_{2e}$ with values 64% higher for B20 (Table 2). Just crushing the exported soybean instead, adds 0.69 EJ, meeting demand and, thus, avoiding dLUC. Indirect LUC (iLUC) was not assessed.

4. CONCLUSIONS

Current BD mandates would demand 12 Mha by 2050 if met with land expansion; if this dLUC happens over moderately degraded pastures, the blending would avoid 308 to 556 $MtCO_{2e}$; if dLUC does not occur, savings can be up to 706 $MtCO_{2e}$. Anticipating B20 to 2024 increases savings, but it has a larger impact on land demand that would need to be balanced. dLUC emissions can be minimized or avoided by crushing more soybean, but consequences of that, such as iLUC, were not evaluated. Uncertainties concerning LUC calculations are high and a stochastic evaluation would be needed to confirm the robustness of these conclusions.

5. ACKNOWLEDGEMENTS

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Table 1. Cumulative and annual demands for biodiesel by 2050 and total emission savings for the scenarios of current mandate and of adopting B20 from 2024 on.

	Cumulative biodiesel demand (EJ)	Annual demand by 2050 (EJ)	Emission savings without land expansion ($MtCO_{2e}$) - Soybean
Current (B15 in 2024)	11.75	0.52	458 – 706
B20 in 2024	15.59	0.69	609 – 938

Table 2. Land use change emissions for different scenarios to achieve additional biodiesel demand by 2050.

	Additional land demand (Mha)	Emissions from LUC over moderately degraded pasture ($MtCO_{2e}$)
Soybean expansion – Current B15 scenario	11.85	150
Soybean expansion – B20 scenario	19.48	248

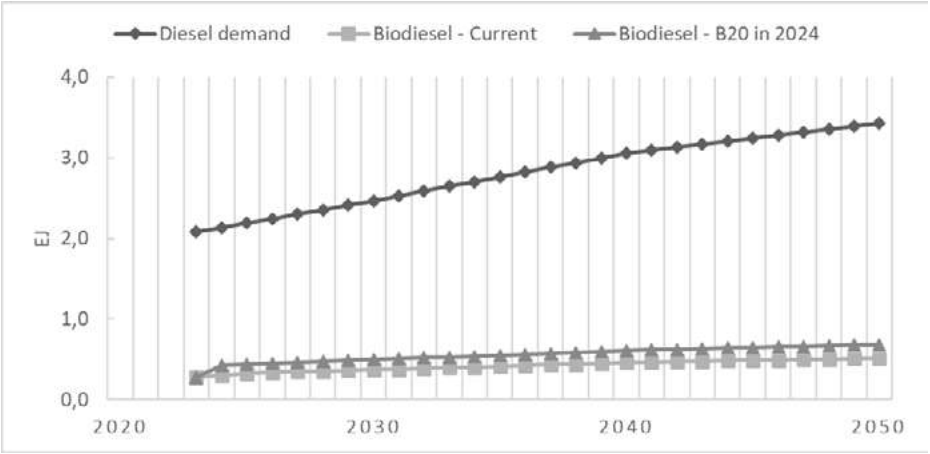

Figure 1. Brazil's diesel and biodiesel demand by 2050 – Estimates based on EPE (2020) and CNPE(2023).