Bio-energy and CCS (BECCS): Options for Brazil

BECCS in Brazil – perspectives on development

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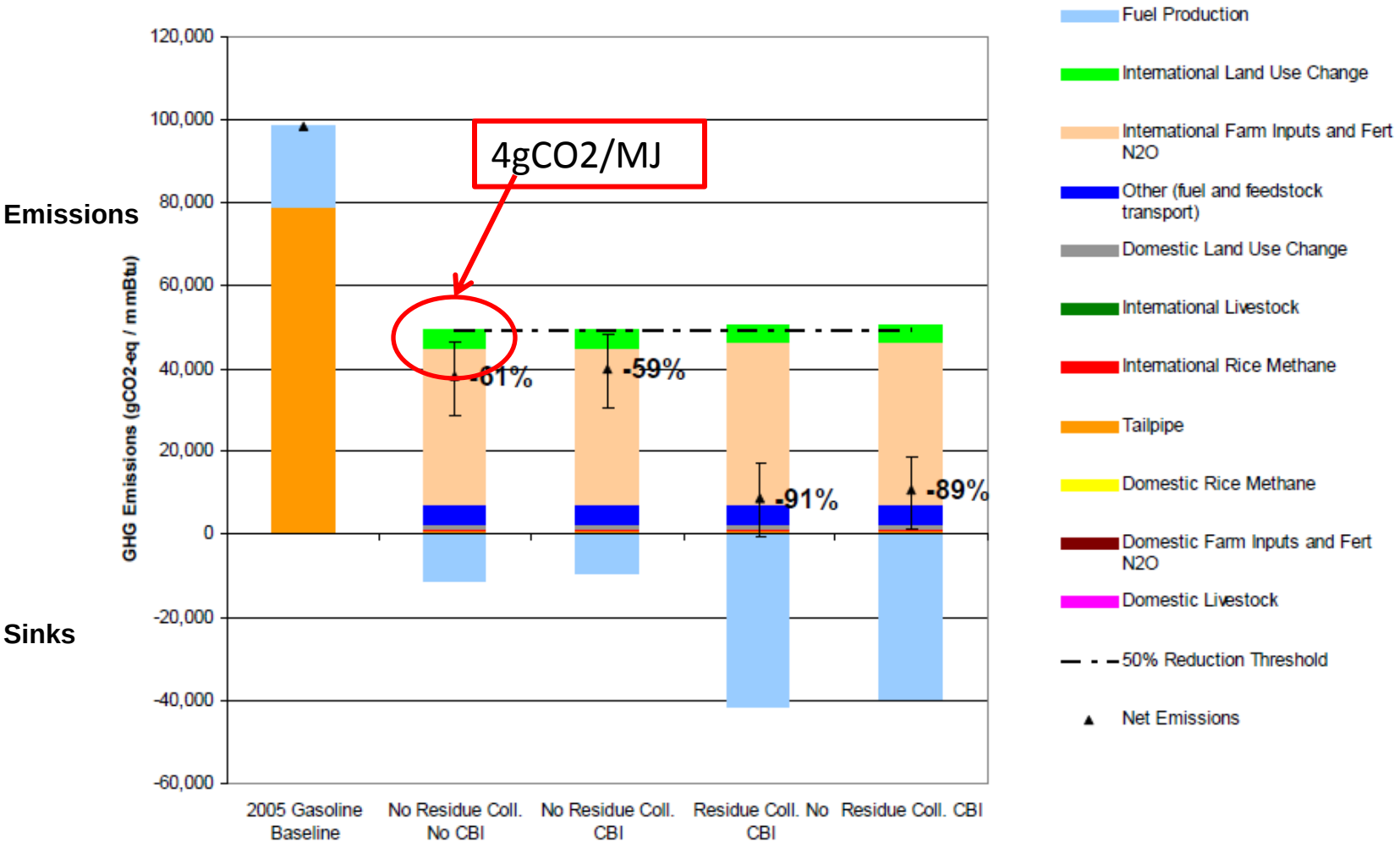
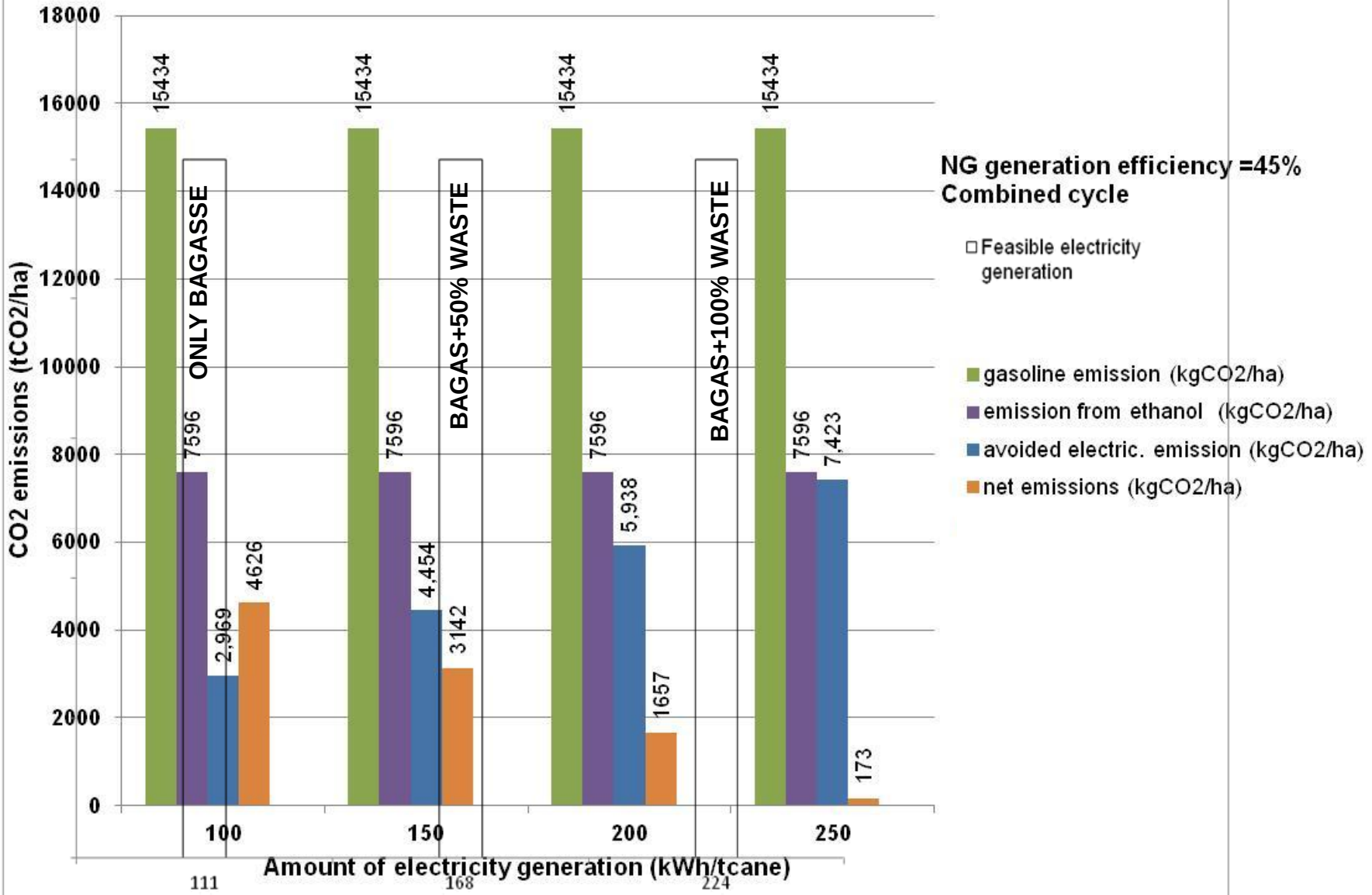
COMPETITION BIOELECTRICITY AND BECCS

Figure 2.6-10. Results for Sugarcane Ethanol by Lifecycle Stage With and without residue collection and CBI



Source: EPA, 2010

CO2 emissions of gasoline and ethanol considering bioelectricity generation from bagasse wastes - Brazil



Sugar cane biomass and its potential CO2 offsets - Proalcool Program in Brazil From 1975 to 2007 (32 years)

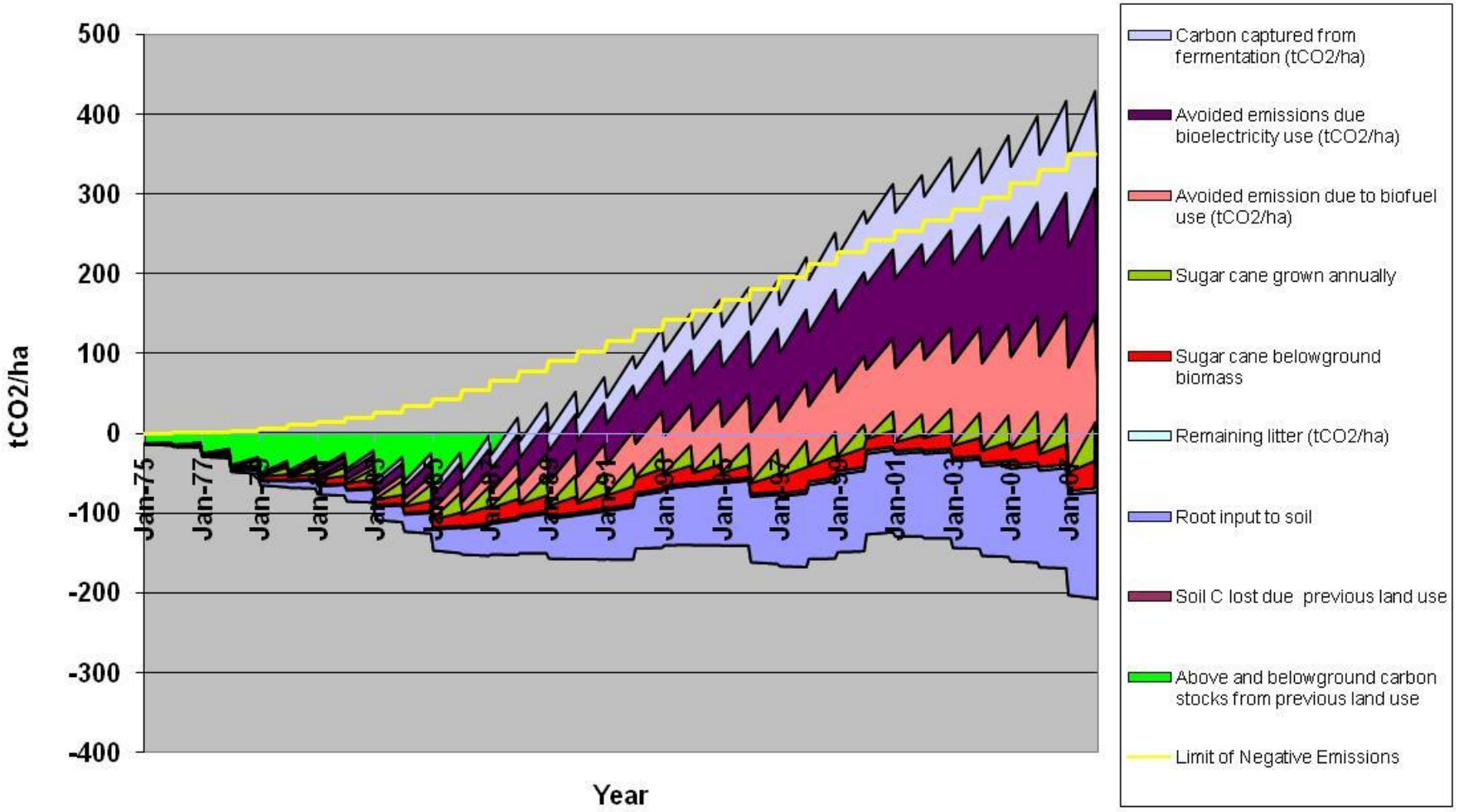


TABLE 1: SUMMARY OF COSTS AT THE TIME OF THE DECISION TO START CO_2 INJECTION, FOR SLEIPNER AND WEYBURN

Historic Costs	SLEIPNER		WEYBURN	
	USD (1996)	%	USD (2000) per tonne	%
- Preparation - Compressors - Injection well	2 million 79 - -"- - 15 - -"- -	2 82 16		
Investments	96 - -"- -	100	10.19	51
Operations - per year - per tonne	7 - -"- - 7		9.85	49
TOTAL	- - -		20.04	100

(Exchange rate 1 USD = 8 NOK)

Source: Torp and Brown, 2004

BECCS FROM SUGAR FERMENTATION CONCLUSIONS

- Feasible simple technology
- Investment cost for pilot project – HIGH
- Levellized annual cost for pilot project - MEDIUM
- Uncertain return on BECCS investment and on operational cost
- Competition for money between advanced greenfield bioenergy plants and BECCS

1. Advanced greenfield project provides assured return and very low GHG emission
2. Advanced greenfield projects may provide negative emission if degraded soil is used.

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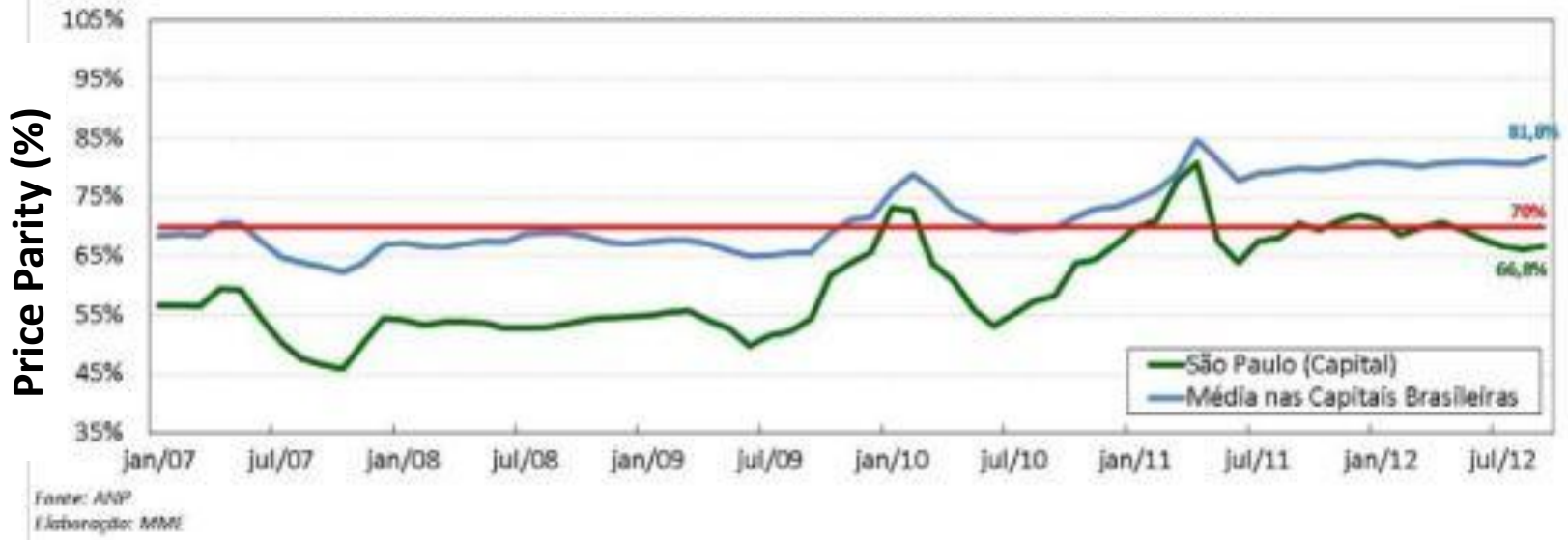
TABLE 37: COMPARING AVERAGE EU BIOFUELS (WHOLESALE PRICES) TO FOSSIL-FUEL PRICES (UNTAXED)

AVERAGE EU PRICES PER LITRE, EUROS (2011)			
[1] Ethanol (EUR cents)	€ 0.63	[5] Biodiesel (EUR cents)	€ 0.90
[2] Ethanol adjusted for energy content (EUR cents)	€ 0.85	[6] Biodiesel adjusted for energy content (EUR cents)	€ 0.99
[3] Gasoline (EUR cents)	€ 0.72	[7] Diesel (EUR cents)	€ 0.77
[4] Difference per litre - energy adjusted (EUR cents)	€ 0.13	[8] Difference per litre - energy adjusted (EUR cents)	€ 0.22

Final Consumer Price Parity – Hydrated ethanol/Gasoline



Fonte: ANP
Elaboração: MME

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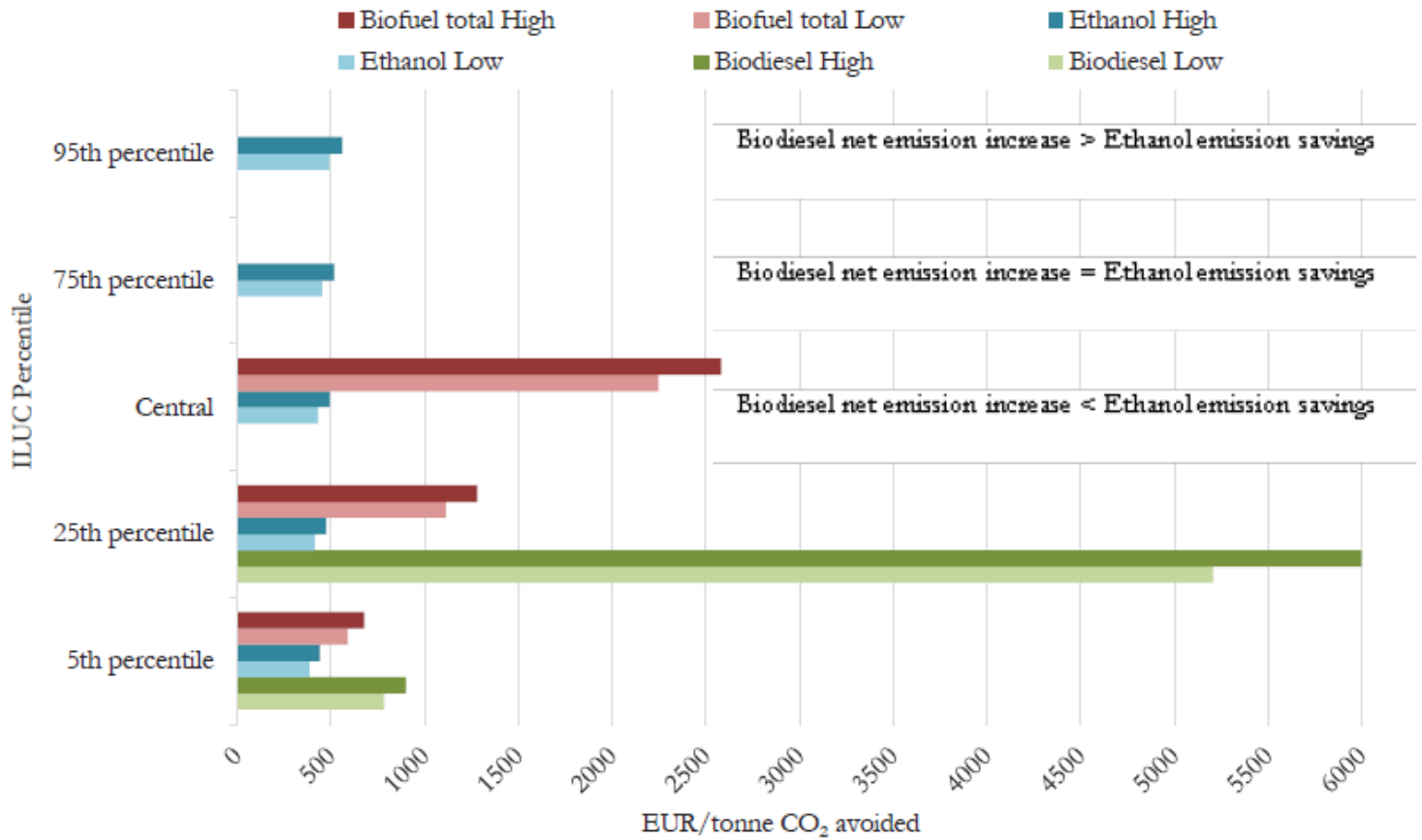

FIGURE 27: BIOFUEL ABATEMENT COSTS FOR DIFFERENT ILUC FACTORS.

Source: Author calculations.

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TABLE 36: COMPARISON OF ABATEMENT COSTS FOR BIOFUELS AND EMISSION STANDARDS FOR PASSENGER VEHICLES

	A	B	C	D
1	**Biofuels**	**Costs[1] (EUR thousand)**	**Emission savings[4] (million tonnes CO_2 eq)**	**Abatement Cost[6] (EUR/tonne CO_2 eq)**
2	Biofuel (aggregated ethanol and biodiesel)	9,271 - 10,652	4.12	2,248 - 2,583
3	Ethanol only	2,954 - 3,372	6.84	432 - 493
4	Biodiesel only	6,317 - 7,280	-2.71	N.A.*
5	**Vehicle emission standard (95 gCO_2/km)**	**Costs (EUR)**	**Emissions savings[5] (tonne CO_2 eq)**	**Abatement Cost (EUR/tonne CO_2 eq)**
6	[2] Investment in technology costs (per vehicle)	1,000	7.5	133
7	Investment in technology costs + fuel savings (per vehicle)	-3,255	7.5	-434
8	[3] Investment in technology costs (per vehicle)	1,750	7.5	233
9	Investment in technology costs + fuel savings (per vehicle)	-2,505	7.5	-334

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Renewable volume obligations (—RVOs||) under the RFS ensure that all renewable fuels produced up to annually prescribed volumes will have a market.

To accommodate uncertainty in the timeline of deployment for cellulosic biofuels, the RFS provided obligated parties with flexibility in complying with cellulosic volume requirements. To satisfy their compliance obligations, obligated parties can either buy a gallon of cellulosic biofuel or purchase some combination of fuels—including advanced biofuels— and EPA waiver credits.

This paper finds the RFS to be an effective mechanism in providing market motivation for investment in advanced and cellulosic biofuels.

Source: **The Value Proposition for Cellulosic and Advanced Biofuels Under the Federal Renewable Fuel Standard, BIO – Biotchenology Industry Organization, 2013**

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Figure 2 – Eligible Biofuels for RFS2

RFS2 designation	GHG reduction	Qualifying renewable fuel
Advanced	50%	Any renewable biofuel, other than corn starch ethanol, that meets 50% GHG reduction (includes sugarcane-based ethanol)
Cellulosic	60%	Biofuel, including diesel, derived from cellulosic biomass
Biomass-based Diesel	50%	Fatty methyl ester or hydrogenated biodiesel from any fat or oil, including algal oils
Conventional	20%*	Corn starch based ethanol

*Facilities where construction began before Dec. 2007 and is completed by June 2011 do not have to meet this GHG reduction threshold.

Source: **The Value Proposition for Cellulosic and Advanced Biofuels Under the Federal Renewable Fuel Standard, BIO – Biotchenology Industry Organization, 2013**

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- EPA is unlikely to waive the advanced or total RFS2 requirements for at least the next few years. Sufficient biodiesel, sugarcane ethanol and other advanced biofuels are likely to remain available to satisfy the advanced volumes in the RFS2 schedule for the next several years given existing capacity in those industries. EPA has demonstrated in its 2010 and 2011 rulemakings that it is committed to enforcing these volumes. This means the total and advanced EISA volumetric requirements are likely to be maintained at congressionally directed levels. **Under this scenario, waived cellulosic volumes are re-designated into the "other advanced" category, expanding the requirement and opportunity for "other advanced" biofuels.**

Source: **The Value Proposition for Cellulosic and Advanced Biofuels Under the Federal Renewable Fuel Standard, BIO – Biotchenology Industry Organization, 2013**

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Ethanol can currently be utilized in vehicles in either a 10 percent blend in regular vehicles ("E10"), 15 percent blend in newer vehicles ("E15")[4], or up to an 85 percent blend ("E85") in flex fuel vehicles ("FFVs"). At E10 and E15, there is effectively no distinguishable mileage loss (compared to using 100 percent gasoline) and no corresponding impact on price. However E85 blends suffer a 25 percent mileage loss in the final blended fuel in typical flex fuel vehicles available today.[5] *An outlook on the prevailing blend of ethanol is important in determining the GBV*. Other biofuels, such as butanol, can be blended at higher percentages without a mileage loss.

Source: **The Value Proposition for Cellulosic and Advanced Biofuels Under the Federal Renewable Fuel Standard, BIO – Biotchenology Industry Organization, 2013**

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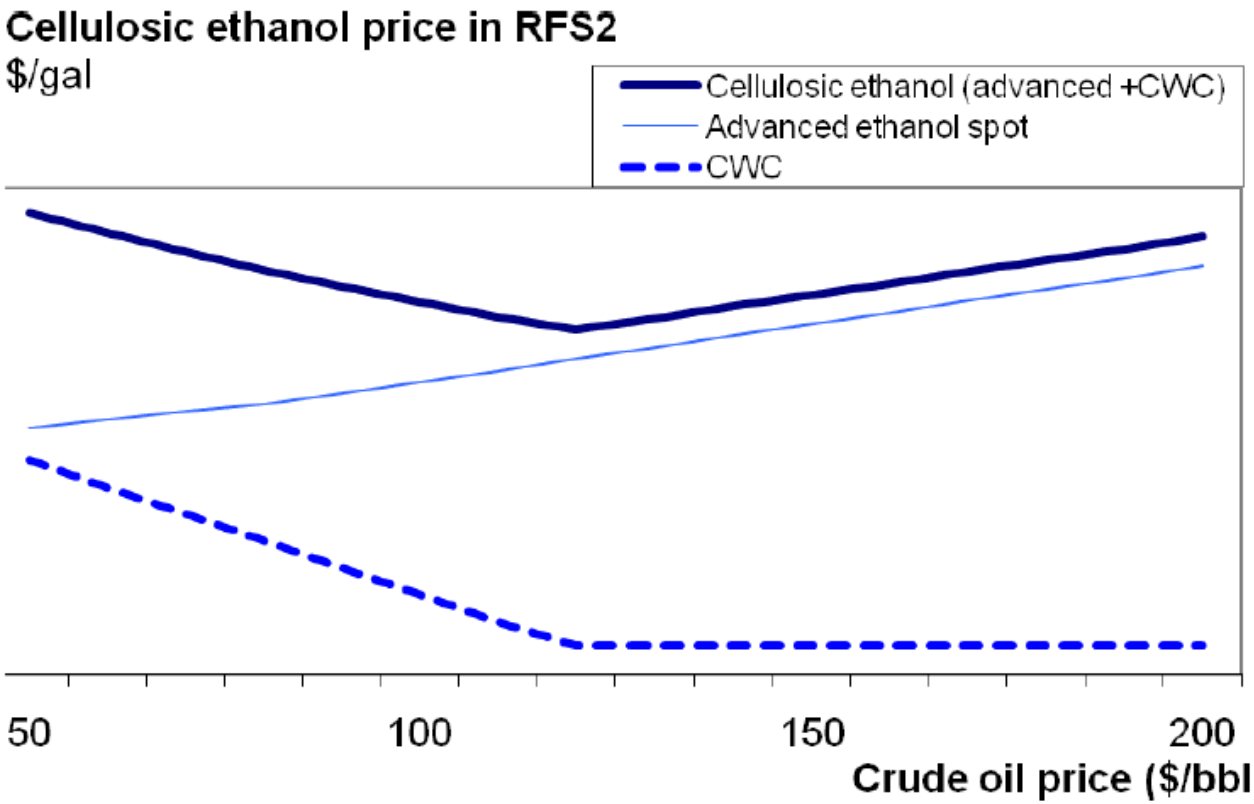
Figure 5 - Cellulosic Ethanol and Crude Oil Prices



* Assumes 16 percent gasoline refining margin, A-RIN and blenders credit of $0.50/gal, a $0.54/gal tariff and 20% blender margin capture

Source: **The Value Proposition for Cellulosic and Advanced Biofuels Under the Federal Renewable Fuel Standard, BIO – Biotchenology Industry Organization, 2013**

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INTERNAL MARKET FOR BECCCS

Inclusion of BECCS from ethanol fermentation in the ethanol final consumer price

1. Typical `new car has annual consumption of 2,250 liters of ethanol/yr
2. Assuming BECCS cost of US$ 20/tCO2, this means that while producing 1775 kg of ethanol it is possible to capture and store 1,775 tCO2, with a CCS cost of US$35.50/yr.
3. Thus, ethanol with BECCS must be sold at US$0.016/liter above regular ethanol price; **this is a price increase of 2.6%.**
4. Probably, the government can help with tax reduction and the extra cost can be reduced to **2% for the final user**.

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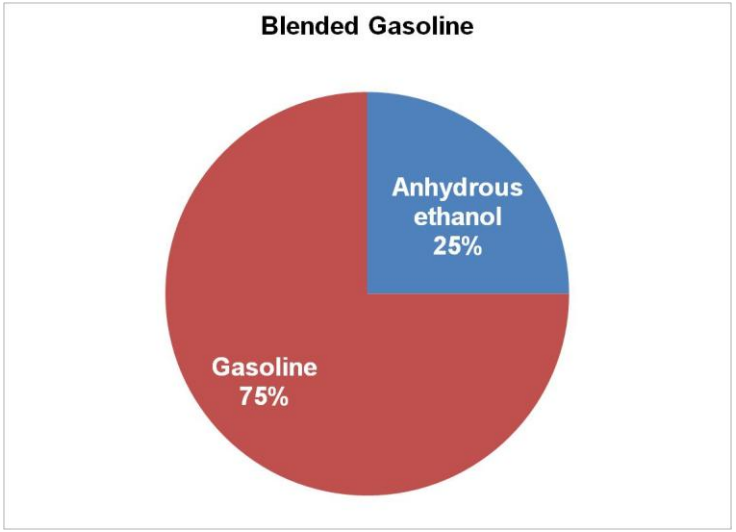
5. Another option would be to charge an added value to the gasoline blend, instead of to ethanol. Blended gasoline is 1 part of ethanol 3 parts of gasoline; **if consumers overpay US$ 0.5 cents per liter**, and this money is used to compensate the BECCS ethanol producer, he will receive a **value of US$ 2 cents per liter produced**, probably high enough to remunerate the investment in BECCS.



5. An increase of 0.5 cents/ liter represents 0.8% increase in blended gasoline price and its impact almost undetected by consumers due the regular price spread practicezed by the service stations.

CONCLUSION

Nevertheless, what will be the motivation for the client to acquire this more expensive fuel?