CO_2 Capture and Utilization: Not so easy

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2010 E S &T paper*
(Algenol-GaTech) had boundary at Algenol battery limits with "unburdened" pure CO_2 available at that point.

90% Heat Exchange Efficiency

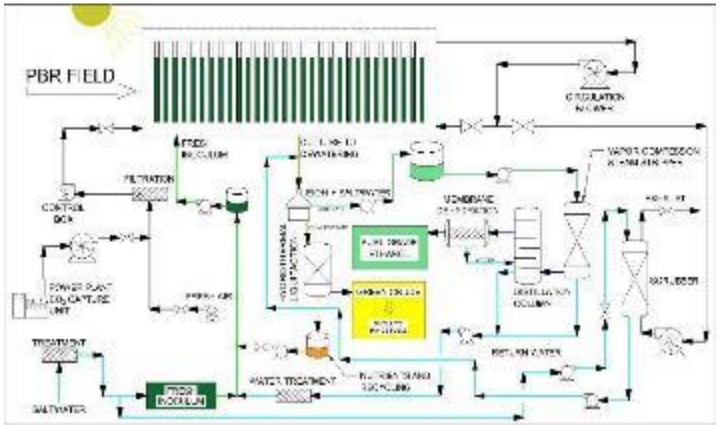
1 wt % EtOH Feed

Algenol Process Pathway

GHGe: 15.6 g CO_2e/MJ_{EtOH} *

83% GHGe Reduction vs. Gasoline

On-site CHP Unit



Extend the boundary

Coal Case

CO_2 capture emission**

Adds 33 gCO2e/MJ-EtOH

Natural Gas Case

CO_2 capture emission**

Adds 20 gCO2e/MJ-EtOH

CO_2 Supply from Coal Power Plant

Same Algenol Process Pathway

Total GHGe: 48.6 g CO_2e/MJ_{EtOH}

48% GHGe Reduction vs. Gasoline

Only meets lowest RFS credits

CO_2 Supply from Natural Gas Power Plant

Same Algenol Process Pathway

Total GHGe: 35.6 g CO_2e/MJ_{EtOH}

62% GHGe Reduction vs. Gasoline

Advanced Biofuel: Close to EPA Pathway estimate

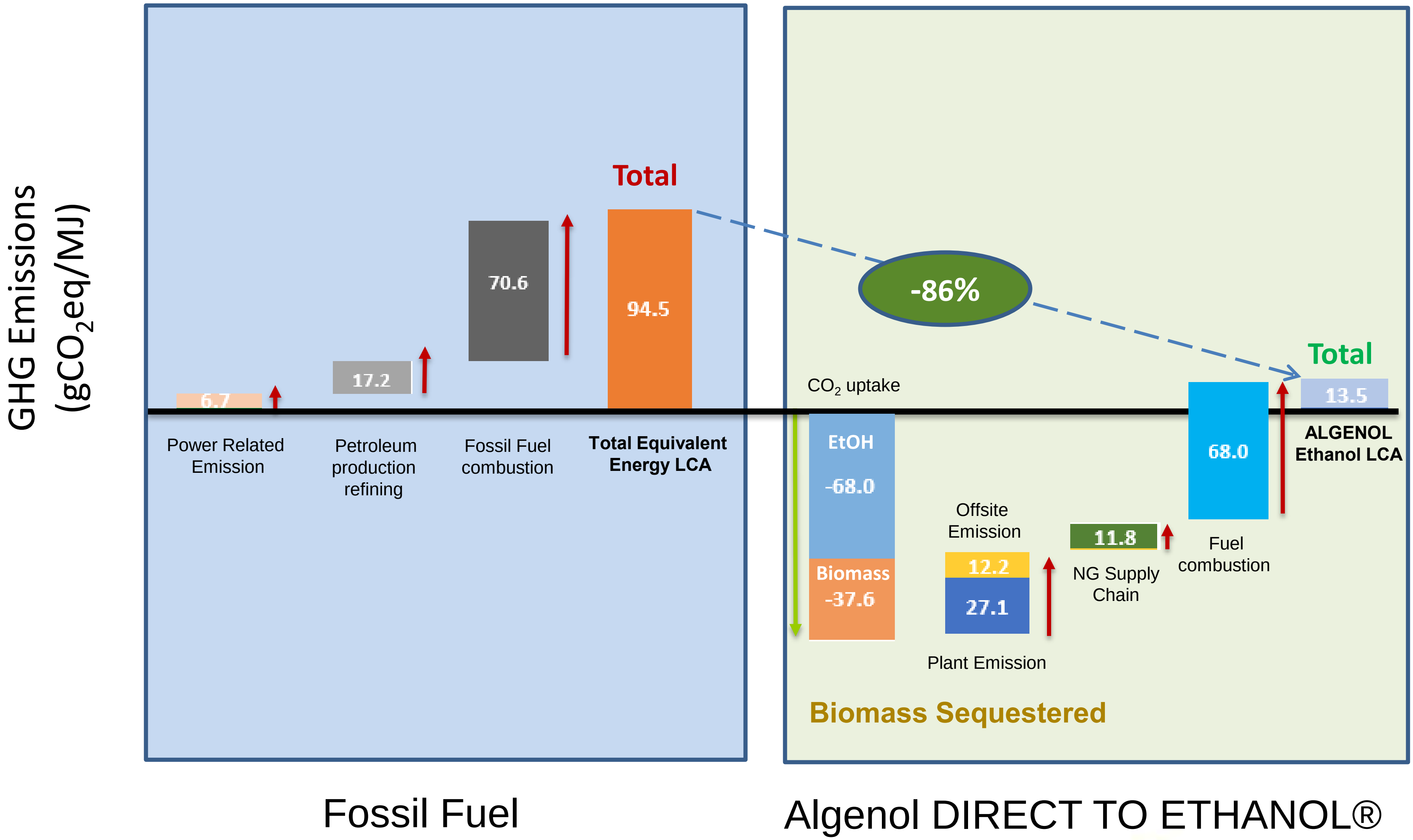
*D Luo, et al, Env. Sci. & Tech. **44**, 8670 (2010).

** R. Lively, et al, *Biofuels, Bioprod. Bioref.* **9**, 72 (2015)

Life Cycle Benefits

Coal Flue Gas Transport with Power Generation

This scenario yields a GHG emissions of 86% compared to fossil fuel



CO_2 Delivery Systems – Life Cycle and Techno-Economic Analyses

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Case #	CO_2 Delivery System Description	GHG reduction (fossil fuel reference)*	Equivalent CO_2 Cost \$/tonne CO_2**	
1	Coal Flue Gas Transport and no Power Generation	24%	45	
2	Coal Flue Gas Transport with Power Generation	86%	50	*Example*
3	Coal Flue Gas with CC and no Power Generation	27%	60	
4	NGCC Flue Gas with CC and No Power Generation	73%	70	
5	CHP unit for CO_2 no Refrigeration	74%	96	
6	CHP unit for CO_2 with Refrigeration	85%	50	
7	NGCC Flue Gas with CC and Power Generation	88%	70	
8	CHP System with CC and refrigeration vent absorber exhaust	82%	35	
9	Pure CO_2 (no burden) + NG Power generation**	83%	0	*Reference***
10	Pure CO_2 (from Coal plant CC) + NG Power generation	48%	55	
11	Pure CO_2 (from NG plant CC) + NG Power generation	62%	65	
12	Biomass (wood chips) CHP System and CO_2 capture	113%	46	
13	Biomass (wood chips) CHP System flue gas	106%	38	

Stand Alone Units

**GHG reduction includes total energy produced with a 1 MJ reference to fossil fuel (gasoline plus surplus electricity supplied to natural gas power plant).*
***Techno-Economic Analyses (TEA) quoted as effective cost of CO_2 with respect to a reference Algenol plant with a 10% IRR and zero CO_2 cost (Case 9).*

Note: For all these cases, spent biomass injected (sequestered).