Occidental Chemical Corporation – Ingleside Ethylene Plant
Average Cost Effectiveness Calculations
9/18/13

Thermal Oxidizers CCS Average Cost Effectiveness

Capital Cost

Pipeline	$167,000,000	
Pipeline Pumps	$62,500,000	
Amine Contactor, Amine Stripper, Reclaimer, Boiler	$100,000,000	
Stack Blowers	$20,500,000	
Total	$350,000,000	

Annual Costs

Pipeline pumps electricity	$6,000,000	$0.07/kw and 75% efficiency
Pipeline operating expense	$9,200,000	4% of installation costs
Fuel for CCS	$5,000,000	
Straight Line Annualized Capital Cost for 25 Years	$14,000,000	
Estimated Annual Revenue	-$3,843,729	(107,879 tons/yr X $35.63/ton)
Annual Cost	$30,356,271	

CO2 Emissions Reduction from Thermal Oxidizers (100% Load)	107,879
CO2 Emission Increase from boilers for Regenerator	96,012
Net CO2 Emissions Reduction tons/yr	11,867
Average Cost Effectiveness $/ton	**$2,558**

Emissions Assuming Natural Gas Fired Boilers for new Amine Regenerator

Assume maximum firing for maximum CO2 capture		
Max CO2 emissions from Thermal Oxidizers (100% load)	12,315	lb/hr per themal oxidizer
CO2 Capture (assuming 100% recovery) - 2 Thermal Oxidizers	107,879	ton/year
Total CO2 capture	24,630	lb/hr
Use gas processing data on amine absorber-strippers from Campbell Gas Processing Books		
From J.M. Campbell & Co Gas Processing Handbook (Table 4.10))		
Energy Required per lb of CO2 for Regeneration	72000	Btu/hr per gpm of DEA
Solvent SG	1.1	
Factor per lb Solvent	130.8	Btu/lb of solvent
Solvent Concentration (Aqueous DEA)	25%	
Factor per lb of DEA	523	Btu/lb of DEA
Moles CO2/Mole DEA	0.2	
Energy Required per lb of CO2 absorbed	6242.9	Btu/lb CO2
Additional Steam Energy Required for Amine Regenerator	153.8	MMBtu/hr
Boiler Efficiency	0.82	
Fuel Required	187.5	MMBtu/hr
CO2 Factor	116.9	lb/Mmbtu/hr
CO2 Produced	21,921	lb/hr
CO2 Produced from boilers for regenerator	96,012	ton/year

Furnaces CCS Average Cost Effectiveness

Capital Cost

Pipeline	$167,000,000	
Pipeline Pumps	$62,500,000	
Amine Contactor, Amine Stripper, Reclaimer, Boiler	$200,000,000	
Stack Blowers	$20,500,000	
Total	$450,000,000	

Annual Costs

Pipeline pumps electricity	$6,000,000	$0.07/kw and 75% efficiency
Pipeline operating expense	$9,200,000	4% of installation costs
Fuel for CCS	$15,000,000	
Straight Line Annualized Capital Cost for 25 Years	$18,000,000	
Estimated Annual Revenue	-$10,396,513	(291,791 tons/yr X $35.63/ton)
Annual Cost	$37,803,487	

CO2 Emissions Reduction from Furnaces (100% Load)	291,791
CO2 Emission Increase from boilers for Regenerator	-259,692
Net CO2 Emissions Reduction tons/yr	32,099
Average Cost Effectiveness $/ton	**$1,178**

Emissions Assuming Natural Gas Fired Boilers for new Amine Regenerator

Assume maximum firing for maximum CO2 capture		
Max CO2 emissions from Furnaces (100% load)	13,324	lb/hr per furnace
CO2 Capture (assuming 100% recovery) - 5 furnaces	291,791	ton/year
Total CO2 capture	66,619	lb/hr
Use gas processing data on amine absorber-strippers from Campbell Gas Processing Books		
From J.M. Campbell & Co Gas Processing Handbook (Table 4.10))		
Energy Required per lb of CO2 for Regeneration	72000	Btu/hr per gpm of DEA
Solvent SG	1.1	
Factor per lb Solvent	130.8	Btu/lb of solvent
Solvent Concentration (Aqueous DEA)	25%	
factor per lb of DEA	523	Btu/lb of DEA
Moles CO2/Mole DEA	0.2	
Energy Required per lb of CO2 absorbed	6242.9	Btu/lb CO2
Additional Steam Energy Required for Amine Regenerator	415.9	MMBtu/hr
Boiler Efficiency	0.82	
Fuel Required	507.2	MMBtu/hr
CO2 Factor	116.9	lb/Mmbtu/hr
CO2 Produced	59,290	lb/hr
CO2 Produced from boilers for regenerator	259,692	ton/year