

March 9, 2014

Ms. Aimee Wilson  
United States Environmental Protection Agency, Region 6  
Air Permits Section (6PD-R)  
1445 Ross Avenue, Suite 1200  
Dallas, TX 75202-2733

Re: Conceptual Carbon Capture Sequestration Cost Estimate for FGE Power, LLC  
Greenhouse Gas Prevention of Significant Deterioration Permit  
FGE Texas Project: Westbrook, Mitchell County, Texas

Dear Ms. Wilson,

This letter is in response to your requesting for additional information with regards to the cost of carbon capture and sequestration (CCS) in support of the Greenhouse Gas (GHG) Prevention of Significant Deterioration (PSD) permit application and Statement of Basis for the FGE Texas Project (FGETP) located in Westbrook, Mitchell County, Texas.

FGE has provided the following additional technical and economic details for the FGETP and its potential for installing a CCS system for recovering CO<sub>2</sub> for both EOR and non-EOR geologic sequestration. FGE conducted an analysis of the capital cost impact of CCS capture and compression equipment on the FGETP using project specific data along with the methodology provided by the U.S. Department of Energy's *Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous and Natural Gas to Electricity*, DOE/2010/1397 (Revision 2, November 2010). These cost have been prepared based upon project specific criteria and have been updated to calendar year 2014 dollars. These updated costs are provided in Attachment 1.

The total estimated capital cost for CCS is \$1,508 million, which is greater than 100% total capital cost of the proposed project. The total estimated capital cost includes the capital cost for pipeline to convey the CO<sub>2</sub> estimated to be \$83 million for a 100 mile long 10-inch diameter pipeline.

Including the costs of capture and long-term geologic storage (non-EOR), FGE estimates an annualized cost of \$352 million (\$90/ton of CO<sub>2</sub>); while the cost of capture and EOR has been estimated at \$322 million (\$82/ton of CO<sub>2</sub>) assuming that 50 percent of the captured and compressed CO<sub>2</sub> could be sold for 9.09/ton.

FGE Power has prepared this response so that it does not contain Confidential Business Information (CBI). If you have any questions or concerns with the information provided, please contact Brad Sohm with SWCA at (602) 274-3831 or [bsohm@swca.com](mailto:bsohm@swca.com) or myself at (281) 362-2830 or [efarrell@fgpower.com](mailto:efarrell@fgpower.com).

Sincerely,



Emerson G. Farrell  
CEO & President

Enclosure

Cc: Scott Deatherage, Gardere Wynne Sewell LLP  
Brad Sohm, SWCA Environmental Consultants  
Bill Jamieson, SWCA Environmental Consultants

**Attachment 1 –  
Updated Conceptual CCS Cost Estimate**

**FGE Texas Project  
GHG BACT Analysis  
Conceptual Carbon Capture and Sequestration Cost Estimate (Updated: 3-9-14)**

Post-Combustion CO <sub>2</sub> Capture and Compression Equipment		
Plant Output (kW) <sup>1</sup> =		1,621,462
Total Heat Input, HHV (mmBtu/hr) <sup>1</sup> =		10,786
CO <sub>2</sub> Captured <sup>2</sup>		3,919,629
<i>Capture and Compression Cost Breakdown</i>		
Capital <sup>3</sup>	\$878.84/kW	\$1,425,005,664
Annual O&M (Fixed) <sup>3</sup>	\$22.61/kW	\$36,661,256
Annual O&M (Variable) <sup>3</sup>	\$0.0014/kWh	\$18,160,374
Total Annual O&M Costs	Fixed + Variable	\$54,821,630
Annual Fuel <sup>4</sup>	14.7% fuel use at \$2.77/mmBtu	\$38,473,494

  

CO <sub>2</sub> Transport - Pipeline Cost Breakdown <sup>5</sup>		
L, Pipeline Length (miles) =		100
D, Pipeline Diameter (inches) =		10
<i>Pipeline Costs</i>		
Materials	\$70,350 + \$2.01 x L x (330.5 x D <sup>2</sup> + 686.7 x D + 26,960)	\$13,512,627
Labor	\$371,850 + \$2.01 x L x (343.2 x D <sup>2</sup> + 2,074 x D + 170,013)	\$45,611,523
Miscellaneous	\$147,250 + \$1.55 x L x (8,417 x D + 7,234)	\$14,314,870
Right of Way	\$51,200 + \$1.28 x L x (577 x D + 29,788)	\$4,602,624
<i>Other Capital</i>		
CO <sub>2</sub> Surge Tank	\$1,244,724	\$1,244,724
Pipeline Control System	\$111,907	\$111,907
Total Pipeline Capital Cost <sup>6</sup>		\$82,574,206
<i>O&amp;M</i>		
Fixed O&M (\$/year)	\$8454 x L	\$879,216

  

CO <sub>2</sub> Transport - Compression Cost Breakdown		
CO <sub>2</sub> Transport (\$/year) <sup>7</sup>	\$3.32 x ton CO <sub>2</sub> captured/year	\$13,533,694

  

EOR Revenue		
EOR Revenue (\$/year) <sup>8</sup>	\$9.09 x ton CO <sub>2</sub> captured/year	\$17,814,713

  

Non-EOR/Geologic Storage Costs		
CO <sub>2</sub> Storage (\$/year) <sup>7</sup>	\$6.06 x ton CO <sub>2</sub> captured/year	\$24,703,069

  

Capital Recovery Factor		
% of Project Funded by Equity (%)		49
% of Project Funded by Debt (%)		51
Cost of Equity (%)		20
Cost of Debt (%)		7
Weighted Cost of Capital (%) <sup>9</sup>		13.37
Equipment Lifetime (years)		20
Capital Recovery Factor <sup>10</sup>		0.1455

  

Annualized Cost Estimate		
Total Capital Cost (\$)		\$1,507,579,870
Annualized Capital Cost (\$) <sup>11</sup>		\$219,398,315
Total Annualized Cost - non EOR (\$)		\$351,809,418
Total Annualized Cost - EOR (\$)		\$321,643,171
CO <sub>2</sub> Cost Effectiveness - non EOR (\$/ton)		90
CO <sub>2</sub> Cost Effectiveness (\$/ton) - EOR (\$/ton)		82

<sup>1</sup> Alstom turbine performance data represents the maximum value from all normal and LLOC operating scenarios.

<sup>2</sup> For the purposes of the conceptual cost estimate, the tons of CO<sub>2</sub> captured is based on the average CO<sub>2</sub> emission rate represented by the Alstom turbine performance data during base load conditions (100% Load) operating 8,000 hours with an assumed CO<sub>2</sub> capture rate of 85%.

<sup>3</sup> Adapted from *Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous and Natural Gas to Electricity*, DOE/2010/1397 (Revision 2, November 2010). The difference in the plant (\$779/kW) and O&M (fixed = \$20.039/kW and variable = \$0.00124/kWh) costs between Case 14 (NGCC w/ CCS) and Case 13 (NGCC w/o CCS) was used to estimate the capital cost of the CCS capture and compression equipment for the FGE Texas Project. Capital costs adjusted using the U.S. BLS CPI Inflation Calculator from 2007 (\$779/kW) to 2014 dollars (\$878.84/kW) ([http://www.bls.gov/data/inflation\\_calculator.htm](http://www.bls.gov/data/inflation_calculator.htm)). O&M costs adjusted using the U.S. BLS CPI Inflation Calculator from 2007 (\$20.039/kW and \$0.00124/kWh) to 2014 dollars (\$22.61/kW and \$0.0014/kWh).

<sup>4</sup> Fuel costs represent the additional fuel necessary to compensate for parasitic load caused by the addition of CCS. Based on review of the plant heat rates used in Case 13 and 14 presented in *Cost and Performance Baseline For Fossil Energy Plants, Volume 1: Bituminous and Natural Gas to Electricity*, DOE/2010/1397 (Revision 2, November 2010), CCS imposes a 14.7% increase in the plant heat rate. Therefore, 14.7% more fuel would be necessary to meet the plant output.

<sup>5</sup> Pipeline capital cost and O&M costs based on equations from DOE NETL analysis *CO<sub>2</sub> Transport, Storage & Monitoring Costs Quality Guidelines for Energy Systems Studies*, DOE/NETL-2013/1614 (March 2013) utilizing pipeline length and diameter values. Capital and O&M costs multiplied by 1.04 to convert from 2011 to 2014 dollars ([http://www.bls.gov/data/inflation\\_calculator.htm](http://www.bls.gov/data/inflation_calculator.htm)).

<sup>6</sup> Sum of materials, labor, miscellaneous, right of way, CO<sub>2</sub> surge tank, and pipeline control system capital costs, multiplied by 1.04 to convert from 2011 to 2014 dollars ([http://www.bls.gov/data/inflation\\_calculator.htm](http://www.bls.gov/data/inflation_calculator.htm)).

<sup>7</sup> CO<sub>2</sub> transport and storage costs from DOE NETL analysis *CO<sub>2</sub> Transport, Storage & Monitoring Costs Quality Guidelines for Energy Systems Studies*, DOE/NETL-2013/1614 (March 2013) using the Texas location, East Texas basin as representative of transport and storage costs. Transport cost for East Texas basin were listed as \$3.65/tonne (\$3.32/ton) in 2011 and storage cost for the East Texas basin were listed as \$6.06/tonne (\$5.51/ton) in 2011. Capital costs multiplied by 1.04 to convert from 2011 to 2014 dollars ([http://www.bls.gov/data/inflation\\_calculator.htm](http://www.bls.gov/data/inflation_calculator.htm)).

<sup>8</sup> US price from sale of CO<sub>2</sub> for Enhanced Oil Recovery (EOR) is \$10-40/tonne (\$9.09/ton-\$36.36/ton) obtained from Global CCS Institute's report, *The Global Status of CCS, Chapter 9 – CO<sub>2</sub> Enhanced Oil Recovery as CCS, Section 9.2 – Potential role of CO<sub>2</sub> EOR in CCS*, page 146 (2012). Once the captured CO<sub>2</sub> in the pipeline reaches the oil producers in the nearest EOR markets (100 miles to the west); FGE is uncertain of the ability for existing EOR markets and the availability of other existing pipelines to accept the volume of CO<sub>2</sub> produced by the FGE project. Therefore, it has been assumed for the purposes of this calculation that FGE would be able to sell 50% of its captured CO<sub>2</sub>. <http://cdn.globalccsinstitute.com/sites/default/files/publications/47936/global-status-ccs-2012.pdf>

<sup>9</sup> Weighted cost of capital calculated by summing the products of the weighted averages of the different financing components with the cost of the particular financing component.

<sup>10</sup> Capital recovery factor calculated via the following equation:

$$CRF = \frac{i [(1+i)^n] \cdot n}{[(1+i)^n] \cdot n - 1}$$

with:

CRF = capital recovery factor

i = weighted cost of capital (interest rate)

n = number of years over which project is annualized

<sup>11</sup> Annualized capital cost calculated by multiplying the total capital cost by the capital recovery factor.