CPChem Completeness Determination Response

Gleason, Cynthia L to: Aimee Wilson 03/19/2012 01:37 PM

History: This message has been replied to.

1 attachment

Revised GHG BACT Response 03 19 12.pdf

Aimee: Thanks for catching the error. Attached is a corrected version.

Cindy Gleason

From: Gleason, Cynthia L
Sent: Thursday, March 08, 2012 5:26 PM
To: 'Aimee Wilson'
Cc: 'Sharon P. Jones'
Subject: Completeness Determination Response

Aimee: Attached is Chevron Phillips response to the information requested in your Feb. 28 letter. The updated BACT analysis (Section 6) includes three items you requested as additional information:

- Estimated cost of carbon capture and storage,
- Estimated cost of LDAR on fuel gas lines (references Table A-8A – second attachment) and BACT determination,
- Proposed parameters to monitor for the furnaces and boiler to demonstrate energy efficient operation.

I will call you next week after you've had a chance to review and we can discuss if this is sufficient to consider the application complete. I won't send you a hard copy unless you request it. You've also received the approval of the Archeological Assessment by the Texas Historical Society. Let me know if you have any questions on this also.

Thanks,
Cindy Gleason
Chevron Phillips Chemical Company LP
USGC Petrochemicals Project
713-280-0869 (office)

From: Aimee Wilson [mailto:Wilson.Aimee@epamail.epa.gov]
Sent: Tuesday, February 28, 2012 9:20 AM
To: Gleason, Cynthia L
Subject: Completeness Determination

Cindy,

Please find the attached completeness determination. A hard copy will be mailed out today.

Please let me know if you have any questions.

Thanks,

Aimee Wilson
Air Permits Section (6PD-R)
U.S. Environmental Protection Agency
1445 Ross Avenue
Dallas, TX 75202
(214) 665-7596

6.0 BEST AVAILABLE CONTROL TECHNOLOGY ANALYSIS

As required by 40 CFR §52.21(j),best available control technology (BACT) must be demonstrated for new and modified emissions sources in a PSD permit application for which a significant net emissions increase will occur. In this application, the only applicable pollutants are the GHGs CO_2, CH_4, N_2O, and CO2e. For these pollutants, the following emissions sources propose significant net GHG emissions increases as defined by §52.21(b)(23)(ii) and §52.21(b)(49)(v):

- Cracking furnaces,
- VHP boiler,
- Vapor destruction unit,
- Low profile flare,
- Routine emergency generator testing, and
- Fugitive emissions from piping components in GHG service.

In its October 1990 draft guidance document entitled *New Source Review Workshop Manual (Draft)*, EPA established a five-step process for conducting a top-down BACT review for PSD permitting. In its March 2011 guidance document for GHG *permitting, PSD and Title V Permitting Guidance for Greenhouse Gases* (EPA 457/B-11-001), EPA reaffirmed that this five-step top-down BACT analysis should also be used for GHG PSD permit application BACT demonstrations. Therefore, the five steps used in this BACT analysis are:

1. Identification of available control technologies;
2. Eliminate technically infeasible alternatives from further consideration;
3. Rank remaining technologies according to control effectiveness;
4. Evaluate the most effective controls from the standpoint of cost-effectiveness, energy impacts, and environmental effects, continuing with the next most effective technology if unreasonable adverse impacts are identified for the more effective option(s); and
5. Select BACT.

As shown in Table A-1, over 99.5% of the CO2e emissions proposed for the new cracker unit are CO_2. With the exception of piping fugitives, CH_4 and N_2O contribute insignificantly to the overall GHG emissions potential, and even piping fugitives of CH4 contribute only 0.02% of the GHG mass emissions total and 0.4% of the CO2e total. Therefore, Chevron Phillips searched the EPA RACT/BACT/LAER Clearinghouse (RBLC) database only for applicable CO_2 BACT determinations to assist in identifying potential GHG control technologies relevant to the proposed emissions sources. Appendix B of this application includes the corresponding RBLC search results.

6.1. Steam Cracking Furnaces

6.1.1. Step 1 – Identify Potential Control Technologies

For furnaces and boilers, the RBLC database identified only proper combustion operation and maintenance as BACT controls. Add-on controls and other potential technologies have not been designated in the RBLC database as applicable GHG controls to date. Nonetheless, Chevron Phillips considered the following technologies as potential GHG control measures for the cracking furnaces in the new ethylene Unit 1594:

- Carbon capture and storage (CCS),
- Energy efficient design,
- Low-carbon fuel(s), and
- Good combustion practices and maintenance.

6.1.1.1. Carbon Capture and Storage

CCS requires separation of CO_2 from flue gases, compression of the isolated CO_2, transportation to a suitable injection/storage location, and long-term storage in appropriate geologic formations. Although several technologies are available for segregating CO_2 from moderate to high- CO_2 purity flue gases, many of these are still being used on a pilot or laboratory scale and are not yet proven for use in large-scale industrial applications except oil and gas production. Once segregated, the CO_2 must be compressed and transported, requiring additional energy to accomplish. Geologic storage must consider the acidic nature of CO_2 gases, especially in formations such as limestone that are susceptible to acidic erosion.

6.1.1.2. Energy Efficient Design

Energy efficiency considers integration of heat and energy balances throughout a facility, not just for one piece of equipment. Therefore, energy efficiency is an integrated design and operational solution to plant-wide energy optimization.

Chevron Phillips proposes to use a proprietary furnace and integrated cold system design developed by its vendor to result in a lower carbon footprint than typical ethylene cracking process units. For example, the proprietary design recovers refrigeration capacity from incoming ethane feed to reduce demand for refrigeration compression power downstream of the furnaces, resulting in reduced high-pressure steam demand and thus reducing the required fuel combustion (and related CO_2 generation) for steam generation. Lower pressure separation of ethylene and ethane likewise reduces compression and resulting steam demand and CO_2 generation from combustion. The vendor also incorporates an optimized distillation tower design, resulting in minimization of reboiler and reflux demand, as well as proprietary optimized cooling water system design that balances heat exchange temperatures with compression and circulation requirements. Further, excess high-pressure steam is anticipated from incorporation of these energy efficiency measures. Thus, Chevron Phillips proposes to export this steam to other existing process units onsite, replacing and/or supplementing steam demand from older, less energy-efficient existing steam generation units.

6.1.1.3. Low-Carbon Fuel

Use of fuels containing lower concentrations of carbon generate less CO_2 than other higher-carbon fuels. Typically, gaseous fuels such as natural gas or high-hydrogen plant tail gas contain less carbon, and thus lower CO_2 potential, than liquid or solid fuels such as diesel or coal.

Chevron Phillips proposes to use high-hydrogen plant tail gas as the primary fuel for the cracking furnaces. When this tail gas may be unavailable, the alternate fuel will be natural gas.

6.1.1.4. Good Combustion Practice

Good combustion practices include appropriate maintenance of equipment (such as periodic burner tune-ups) and operating within the recommended combustion air and fuel ranges of the equipment as specified by its design, with the assistance of oxygen trim control. Although good combustion practices do not themselves necessarily directly reduce GHG emissions, using good combustion practices results in longer life of the equipment and more efficient operation. Therefore, such practices indirectly reduce GHG emissions by supporting operation as designed and with consideration of other energy optimization practices incorporated into the integrated plant.

Chevron Phillips will incorporate such combustion practices as recommended by its vendor and based on its extensive operating experience with steam cracking furnaces.

6.1.2. Step 2 – Eliminate Technically Infeasible Options

6.1.2.1. Carbon Capture and Storage

As indicated in its March 2011 PSD permitting guidance for GHGs, the EPA notes[1]:

> For the purposes of a BACT analysis for GHGs, EPA classifies CCS as an add-on pollution control technology that is “available” for facilities emitting CO_2 in large amounts, including fossil fuel-fired power plants, and for industrial facilities with high-purity CO_2 streams (e.g., hydrogen production, ammonia production, natural gas processing, ethanol production, ethylene oxide production, cement production, and iron and steel manufacturing). For these types of facilities, CCS should be listed in Step 1 of a top-down BACT analysis for GHGs.

The new ethylene unit does not incorporate hydrogen recovery from the plant fuel gas, although the plant fuel gas is high in hydrogen content. However, rather than purify this

---

[1] U.S. EPA, Office of Air Quality Planning and Standards, *PSD and Title V Permitting Guidance for Greenhouse Gases,* March 2011, p. 32.

hydrogen stream for sale, Chevron Phillips instead uses the high-hydrogen/lower-carbon tail gas stream as primary fuel for the furnaces, reducing the CO_2 emissions from these large combustion units significantly from that which would be experienced if the hydrogen were recovered and sold and higher-GHG fuels were used as primary furnace fuel year-round.

Further, the furnace exhaust streams are not high-purity streams, as recommended in EPA's guidance. Instead, the furnace exhausts contain approximately 5% or less CO_2 in the stack gas on an average annual basis. Therefore, the recovery and purification of CO_2 from the stack gases would necessitate significant additional processing, including energy, and environmental/air quality penalties, to achieve the necessary CO_2 concentration for effective sequestration.

Finally, even if the CO_2 could be segregated efficiently from the furnace exhausts, the availability of appropriate sites for geologic sequestration in proximity to the facility does not exist. There are salt dome caverns within 10 to 15 miles of the site; however, these limestone formations have not been demonstrated to safely store acid gases such as CO_2, nor is there adequate availability of space. Instead, these domes are used for cyclical storage of liquefied petroleum gases (LPGs) for use in the Gulf Coast as well as for shipment throughout the United States via pipeline. To replace this critical active storage with long-term CO_2 sequestration would necessarily jeopardize energy supplies locally and nationally. Other potential sequestration sites that are presently commercially viable, such as the SACROC enhanced oil recovery (EOR) unit in the Permian Basin, are more than 400 to 500 miles from the proposed project site. Developing CO_2 EOR projects in the Hastings and Conroe fields, each within 50 miles of the Cedar Bayou facility are not yet proven and thus cannot be relied upon as the only point for project CO_2 management.

Further, as stated in the August 2010 *Report of the Interagency Task on Carbon Capture and Storage*[2]:

> Current technologies could be used to capture CO_2 from new and existing fossil energy power plants; however, they are not ready for widespread implementation primarily because they have not been demonstrated at the scale necessary to establish confidence for power plant application. Since the CO_2 capture capacities used in current industrial processes are generally much smaller than the capacity required for the purposes of GHG emissions mitigation at a typical power plant, there is considerable uncertainty associated with capacities at volumes necessary for commercial deployment.

Therefore, because there is not a demonstrated commercial implementation of CCS for non-power plant industrial applications, since the furnace stack gases are not high-purity CO_2 streams, and because there is not a proven geologic sequestration site available in the project

---

[2] President Obama's Interagency Task Force on Carbon Capture and Storage, *Report of the Interagency Task Force on Carbon Capture and Storage,* August 2010, p. 50.

area for long-term CO_2 storage, Chevron Phillips considers CCS a technically infeasible control option for the proposed new cracking unit at Chevron Phillips' Cedar Bayou plant. However, Chevron Phillips retains CCS for consideration in this BACT analysis and will evaluate environmental and economic considerations in Step Four.

6.1.2.2. Energy Efficient Design

Use of certain energy efficient design measures is considered technically feasible.

6.1.2.3. Low-Carbon Fuel

Use of low-carbon fuel is considered technically feasible.

6.1.2.4. Good Combustion Practice

Use of good combustion practices is considered technically feasible.

6.1.3. Step 3 – Rank According to Effectiveness

6.1.3.1. Carbon Capture and Storage

CCS has the theoretical ability to capture and control up to 90 percent of CO_2 generated in the furnaces[3,4].

6.1.3.2. Energy Efficient Design

Chevron Phillips selected an energy efficient proprietary design for its integrated cracking furnaces and boiler, to optimize steam, fuel, and overall energy balances *across the site*, not just for a single furnace or boiler. Therefore, because the energy efficiency is "designed-in" rather than added on after the fact, it is difficult to quantify the overall effectiveness of such a design basis. Chevron Phillips believes that the selection of the a base energy efficient design, coupled with additional optional incremental energy conservation features selected for implementation, is the most effective measure for minimizing fuel consumption and thus direct GHG emissions associated with combustion.

Because energy and mass is integrated across the entire existing and proposed process units, establishment of a GHG emission limit considering only the production and/or fuel use associated the proposed cracker project is not practical. Steam and energy balances across the site, which produces olefins, polyolefins, and other derivative products, area not always linearly coupled with production rates. Certain equipment must be maintained on hot standby as primary or back-up control devices (e.g. VHP boiler and VDU) and for safe operating conditions (e.g. flare). Further, furnace decoke operations – which are required to maintain the furnaces

---

[3] *Developments and Innovation in Carbon Dioxide (CO_2) Capture and Storage Technology, Volume 1: Carbon Dioxide (CO_2) Capture, Transport and Industrial Applications,* Woodhead Publishing, 2010, p. 9.

[4] President Obama's Interagency Task Force on Carbon Capture and Storage, *Report of the Interagency Task Force on Carbon Capture and Storage,* August 2010, p. 23.

at efficient product conversion and fuel consumption rates – operate less thermally efficient than during normal operation. As such, a GHG limit for energy efficiency in terms of lb GHG/MMlbs of product or lb GHG/MMBtu consumed is impractical for an energy-integrated site such as Cedar Bayou. Instead, furnace energy efficiency is more appropriately illustrated by managing stack temperature (an indication of maximization of recovered heat/energy value) below a practical maximum. Chevron Phillips consulted with its design licensor and reviewed its own extensive experience with olefin furnace operation to establish a practical stack gas temperature indicative of energy efficient operation. Based on this research, Chevron Phillips proposes to monitor the cracking furnaces' stack temperatures and control to a maximum stack exit temperature of 350°F, to verify energy efficient operation during normal operation.

6.1.3.3. Low-Carbon Fuel

Material balance principles dictate that the lower the quantity of carbon in the fuel, the lower the resulting CO_2 emissions will be in the combustion stack gases. Therefore, use of low-carbon fuels when they are available is the next most effective control measure behind energy efficient design. By using high-hydrogen plant tail gas in lieu of liquid or solid fuels such as diesel or coal, or even substituting plant tail gas (when available) over natural gas, which is over 95% methane, combustion CO_2 emissions are reduced linearly with the mass of carbon in the fuel. Using plant tail gas preferentially over pipeline natural gas provides at least a 40% reduction in combustion $CO_{2;}$ tail gas is even more effective at controlling combustion GHG emissions when considered against higher-carbon liquid or solid fuels.

High-hydrogen tail gas availability is directly related to steady-state operation of the olefins unit. Without ethylene cracking activities, tail gas is not produced. Thus, although Chevron Phillips will use tail gas in lieu of natural gas as furnace fuel whenever possible, natural gas must be used during start-up activities as well as during certain periods of potential production curtailments. In these instances, Chevron Phillips will use pipeline natural gas. Chevron Phillips will not use liquid or solid fuels in the furnaces.

6.1.3.4. Good Combustion Practice

The use of good combustion practices includes periodic combustion tune-ups and maintaining the recommended combustion air and fuel ranges of the equipment as specified by its design, with the assistance of oxygen trim control. Although good combustion practices do not themselves necessarily directly reduce GHG emissions, using good combustion practices results in longer life of the equipment and more efficient operation. The effectiveness of proper maintenance and combustion control cannot be directly quantified and is anticipated to have a less direct effect on overall GHG emissions reduction than either energy efficient design or use of low-carbon fuels. Thus, although a specific efficiency rating is not quantifiable, good combustion practice is qualitatively ranked as the least effective of the remaining control measures.

Because good combustion practices effectively support the energy efficient design discussed in Section 6.1.3.2, additional monitoring of combustion practices is not warranted. By conducting proper maintenance and maintaining appropriate combustion air and fuel ratios, Chevron Phillips will support the inherent design of the furnaces. Thus, monitoring stack gas temperature and ensuring it remains below 350°F satisfies the demonstration of not only energy efficient design but also good combustion practices.

6.1.4. Step 4 – Evaluate the Most Effective Controls

6.1.4.1. Carbon Capture and Storage

As discussed in Section 6.1.1, Chevron Phillips considers CCS to be technically infeasible for the proposed Cracker project, based in part on U.S. EPA and Department of Energy (DOE) Interagency Task Force data and guidance. However, Chevron Phillips is providing additional data illustrating that this technology is also economically and environmentally impractical for the proposed project.

CCS can be an effective method to reduce CO_2 emissions from certain industrial sources. However, in large gas-fired applications, the dilute flue gas CO_2 concentrations coupled with large flue gas volumes creates both economic and environmental challenges, which can offset the benefit of implementing CCS as a control measure. These considerations are discussed in the following sections.

6.1.4.1.1 Economic Considerations

Carbon capture and storage is comprised of three major components: capture and compression, transport, and injection and storage. Of these three, capture and compression comprises approximately 70-90 percent of the total cost[5]. Although most cost estimates for CO_2 capture and compression technologies have been developed for power plant applications, the integration of steam and compression power for the proposed Cracker project closely approximates the operation of a natural gas-fired combined cycle (NGCC) power generation facility. Thus, the costs estimated by the Interagency Task Force for capture and compression of CO2 in flue gases from an NGCC facility are comparable to what would be anticipated for the proposed furnaces and boiler. These costs are estimated at \$95 to \$114/tonne CO_2 (\$104 to \$126/ton)[6], in 2010 dollars.

Remaining CCS costs include pipeline transportation[7] (\$1 to \$3/tonne or \$1.10 to \$3.30/ton) and long-term storage[8] (\$6 to \$20/tonne or \$7 to \$22/ton). Aggregating these costs and using the lower estimates for capture/ compression and storage, the overall cost for CCS for the proposed Cracker project is approximately \$104 + \$2 + \$7 = \$113/ton CO_2 controlled.

---

[5] Ibid, p. 27.
[6] Ibid, pp. 33-34.
[7] Ibid, p. 37.
[8] Ibid, p 44.

Assuming 90 percent of the proposed CO_2 emissions from the proposed combustion devices – furnaces, VHP boiler, VDU, and emergency generators – would be captured and controlled by CCS, this annualized cost equates to:

$$\$113/\text{ton } CO_2 * (90\% * 1{,}573{,}374 \text{ ton } CO_2/\text{yr}) = \$160{,}012{,}136/\text{yr}$$

An annual cost of approximately $160 million/yr eliminates CCS as an economically feasible option for controlling CO_2 from the combustion devices associated with the cracker project.

6.1.4.1.2 Environmental Considerations

Economic infeasibility notwithstanding, Chevron Phillips asserts that CCS can have detrimental effects on the environment. Specifically, carbon capture and compression results in an energy penalty of approximately 30 percent[9]. For the cracker project, this energy penalty would result in generation of not only 30% more GHGs to generate the required steam energy to operate the plant, but also would increase emissions of NO_x, CO, VOC, PM_{10}, SO_2, and ammonia by an equivalent percentage. Considering that the plant is in an ozone nonattainment area, generation of 30 percent more NO_x and VOC is environmentally detrimental. Further, adding 30 percent more steam generation capacity to the project necessitates construction of a second VHP boiler, thus requiring a larger footprint and more construction disturbance to the soil.

Additionally, carbon capture and compression increases the water demand for the proposed project. Due to cooling water requirements for CO_2 capture and compression, as well as a 30 percent increase in steam/boiler feedwater demand, water consumption for the project could be increased by 80 percent or more[10]. With water as a scarce resource, as evidenced by recent drought conditions, this impact of CCS is likewise environmentally detrimental.

Based on the economic impracticability and environmental detriment that would be experienced by incorporating CCS into the Cracker project, Chevron Phillips believes CCS is an infeasible option that does not qualify as BACT.

6.1.4.2. Energy Efficient Design

The use of an energy efficient furnace and unit design is economically and environmentally practical for the proposed project. By optimizing energy efficiency, the project requires less fuel than comparable less-efficient operations, resulting in cost savings. Further, reduction in fuel consumption corresponding to energy efficient design reduces emissions of other combustion products such as NO_x, CO, VOC, PM_{10}, and SO_2, providing environmental benefits as well. Therefore, energy efficient design remains as a viable control technology option.

---

[9] Ibid, p. 30.
[10] Ibid, p. 35.

6.1.4.3. Low-Carbon Fuel

The use of low-carbon fuel is economically and environmentally practical for the proposed project. By using plant tail gas in the furnaces, the project requires less purchased natural gas, resulting in cost savings. Further, combustion of high-hydrogen fuel in lieu of higher carbon-based fuels such as diesel, coal, or even natural gas reduces emissions of other combustion products such as NO_x, CO, VOC, PM_{10}, and SO_2, providing environmental benefits as well. Therefore, low-carbon fuel remains as a viable control technology option.

6.1.4.4. Good Combustion Practice

Good combustion practice effectively supports the energy efficient design. Thus, the economic and environmental practicability discussed in Section 6.1.4.2 related to energy efficient design also applies to the use of good combustion practices. Therefore, good combustion practice also remains as a viable control technology option.

6.1.5. Step 5 – Select BACT

Chevron Phillips proposes to incorporate all of the remaining CO_2 control technologies (energy efficient design, low-carbon fuels, and good combustion practices) discussed in Section 6.1.1 as BACT for controlling CO_2 emissions from furnace combustion and its corresponding steam supply/demand as integrated with the process unit's equipment downstream of the furnace.

To verify the furnaces meet these control technology requirements, Chevron Phillips proposes to monitor furnace stack gas exit temperatures to demonstrate that it remains at or below 350°F during normal operation and to maximize the use of high-hydrogen tail gas as fuel to the furnaces, supplementing with natural gas as required. Note that the stack temperature proposed is for normal operations and does not include commissioning, startup, shutdown, and decoke operations.

6.2. Decoking Activities

Ethane cracking furnaces require periodic decoking to remove coke deposits from the furnace tubes. Coke buildup is unavoidable in olefin production in cracking furnaces, and removal of coke at optimal periods maintains the furnace at efficient ethane-to-ethylene conversion rates without increasing energy (fuel) demand. Decoking too early is unnecessary and results in excess shutdown/start-up cycles; decoking too late results in fouled furnace tubes that reduce conversion rates and increases heat demand.

6.2.1. Step 1 – Identify Potential Control Technologies

Decoking is the process of removing the coke carbon on the furnace tubes through the use of steam and air. Review of the RBLC database identified no specific BACT controls for GHG emissions from decoking operations. Decoking produces carbon particles, CO and CO_2 emissions. Limiting air in the decoking process would tend to drive the conversion of coke to CO rather than CO_2. Additionally, proper design and operation of the furnaces in accordance with manufacturer's recommendations is important in managing the formation of coke in furnace tubes.

6.2.2. Step 2 – Eliminate Technically Infeasible Options

Although limiting air in the decoke process could reduce CO_2 emissions, the result would be an increase in the CO emissions from this process. Since CO is likewise a criteria pollutant, controlling one pollutant category, GHGs, to the detriment of another, CO, is considered not beneficial and therefore is eliminated as technically infeasible.

6.2.3. Step 3 – Rank According to Effectiveness

The single option remaining for control of CO_2 from decoking operations is to follow the design and operational parameters integrated into the furnace to limit the need for decoking and thus the corresponding CO_2 emissions generated from the same. Therefore, ranking according to effectiveness relative to other available options is not possible.

6.2.4. Step 4 – Evaluate the Most Effective Controls

The single option remaining for control of CO_2 from decoking operations is to follow the design and operational parameters integrated into the furnace to limit the need for decoking and thus the corresponding CO_2 emissions generated from the same. This option is integrated into the design and is therefore economically viable and does not incorporate incremental adverse environmental effects as compared to limiting air in the decoke process. Thus, following design and operational parameters integrated into the furnace remains as the viable GHG control method for furnace decoke operations.

6.2.5. Step 5 – Select BACT

Chevron Phillips proposes to incorporate a combination of design and recommended operation to limit coke formation in the tubes to the extent practicable considering ethane as a raw material. Managing coke buildup through such methods will result in limited CO_2 formation from annual decoking operations.

6.3. VHP Boiler

The VHP boiler is integrated in the energy balance of the entire new cracker plant and cannot be considered a stand-along device from the standpoint of GHG control methods. This boiler is integral to the overall energy efficiency of the plant as discussed in Section 6.1. Further, the boiler serves not only to generate very high pressure steam, but also as the primary control device for low-pressure process vents, obviating the need for a secondary combustion device such as the vapor destruction unit, which serves only the control function, to operate full-time.

6.3.1. Step 1 – Identify Potential Control Technologies

As with the cracking furnaces, the RBLC database identified only proper combustion operation and maintenance as BACT control for the VHP boiler or similar combustion devices. Add-on controls and other potential technologies have not been designated in the RBLC database as applicable GHG controls to date. Nonetheless, Chevron Phillips considered the following technologies as potential GHG control measures for the VHP boiler in the new ethylene Unit 1594:

- Carbon capture and storage (CCS),
- Energy efficiencies,
- Low-carbon fuel(s), and
- Good combustion practices and maintenance.

Each of these technologies is discussed in detail in Section 6.1.1 and therefore is not repeated here. The energy efficiency measures integrated into the cracking plant as described for the furnaces also applies generally to the boiler, since it likewise is a contributor to the overall steam balance of the plant and must be considered as integrated in the overall plant energy efficient design. The boiler will use low-carbon natural gas as the primary fuel, with high-hydrogen plant tail gas available as a second low-carbon fuel, if needed. Finally, Chevron Phillips will operate the boiler in accordance with the vendor's recommendations and Chevron Phillips' experience for good combustion and maintenance practices.

6.3.2. Step 2 – Eliminate Technically Infeasible Options

6.3.2.1. Carbon Capture and Storage

For the reasons discussed in Section 6.1.2.1, Chevron Phillips does not consider CCS as a technically feasible option for GHG emissions control from the VHP boiler. Likewise, based on the economic infeasibility and environmental detriment issues discussed in Section 6.1.4.1, CCS is not feasible for GHG control for the VHP boiler and therefore will not be considered further in this analysis.

6.3.2.2. Energy Efficient Design

Use of certain energy efficiency measures is considered technically feasible.

6.3.2.3. Low-Carbon Fuel

Use of low-carbon fuel is considered technically feasible.

6.3.2.4. Good Combustion Practice

Use of good combustion practices is considered technically feasible.

6.3.3. Step 3 – Rank According to Effectiveness

6.3.3.1. Energy Efficient Design

As discussed in Section 6.1.3.1, Chevron Phillips selected an energy efficient proprietary design for its integrated cracking furnaces and boiler, to optimize steam, fuel, and overall energy balances *across the site*, not just for a single furnace or boiler.

The VHP boiler will incorporate vendor design features that are not yet defined. The boiler will operate at less than design maximum rates under normal operation to control process vents, but may operate at higher rates when additional steam demand is experienced for the cracker unit and/or other process areas onsite. Due to the expected fluctuation in operational rates due to multiple purposes for the boiler, and the fact that process vents may provide variable heating value, boiler vendors recommend that the appropriate parameter to monitor for energy efficiency will be the excess air to the boiler. At both normal steam production and maximum design steam rates, vendors suggest that excess air is expected to not exceed 20%, for energy efficient operation. Therefore, Chevron Phillips recommends monitoring excess air in the boiler, with an average annual limit of 20%.

6.3.3.2. Low-Carbon Fuel

Material balance principles dictate that the lower the quantity of carbon in the fuel, the lower the resulting CO_2 emissions will be in the combustion stack gases. Therefore, use of low-carbon fuels when the same are available is the next most effective control measure behind energy efficient design. The boiler will operate primarily on pipeline natural gas unless supplemental tail gas is available (furnaces have primacy over tail gas use). By using gaseous fuels in lieu of liquid or solid carbon fuels (e.g. diesel or coal), combustion CO_2 emissions are reduced significantly, since the mass of carbon in natural gas and plant tail gas are substantially lower than in liquid and solid fuels. Chevron Phillips will not use liquid or solid fuels in the VHP boiler.

6.3.3.3. Good Combustion Practice

The use of good combustion practices includes periodic tune-ups and maintaining the recommended combustion air and fuel ranges of the equipment as specified by its design, with the assistance of oxygen trim control. Although good combustion practices do not themselves necessarily directly reduce GHG emissions, using good combustion practices results in longer life of the equipment and more efficient operation. The effectiveness of proper maintenance and combustion control cannot be directly quantified and is anticipated to have a less direct effect on overall GHG emissions reduction than either energy efficient design or use of low-carbon fuels. Thus, although a specific efficiency rating is not quantifiable, good combustion practice is qualitatively ranked as the least effective of the remaining control measures.

Because good combustion practices effectively support the energy efficient design discussed in Section 6.3.3.1, additional monitoring of combustion practices is not warranted. By conducting proper maintenance and maintaining appropriate combustion air and fuel ratios, Chevron

Phillips will support the inherent design of the boiler. Thus, monitoring excess air to the boiler as described in Section 6.3.3.1 satisfies the demonstration of not only energy efficient design but also good combustion practices.

6.3.4. Step 4 – Evaluate the Most Effective Controls

6.3.4.1. Energy Efficient Design

The use of an energy efficient boiler design is economically and environmentally practical for the proposed project. By optimizing energy efficiency, the project requires less fuel than comparable less-efficient operations, resulting in cost savings. Further, reduction in fuel consumption corresponding to energy efficient design reduces emissions of other combustion products such as NO_x, CO, VOC, PM_{10}, and SO_2, providing environmental benefits as well. Therefore, energy efficient design remains as a viable control technology option.

6.3.4.2. Low-Carbon Fuel

The use of low-carbon fuel is economically and environmentally practical for the proposed project. Combustion of gaseous fuel in lieu of higher carbon-based fuels such as diesel or coal reduces emissions of other combustion products such as NO_x, CO, VOC, PM_{10}, and SO_2, providing environmental benefits. Therefore, low-carbon fuel remains as a viable control technology option.

6.3.4.3. Good Combustion Practice

Good combustion practice effectively supports the energy efficient design. Thus, the economic and environmental practicability discussed in Section 6.3.4.1 related to energy efficient design also applies to the use of good combustion practices. Therefore, good combustion practice also remains as a viable control technology option.

6.3.5. Step 5 – Select BACT

Chevron Phillips proposes to incorporate, energy efficient design, low-carbon fuels, and good combustion practices discussed in Section 6.3.1 as BACT for controlling CO_2 emissions from boiler combustion and its corresponding steam supply/demand as integrated with the process unit's equipment downstream of the boiler.

To verify the VHP boiler meets these control technology requirements, Chevron Phillips proposes to monitor excess combustion air to the boiler to demonstrate the same remains at an average annual optimum level of 20% and to use only gaseous fuels in the boiler.

6.4. Vapor Destruction Unit

The VDU serves as a standby vent control system, which is not anticipated to operate (except in hot stand-by/pilot-only mode) more than the equivalent of four weeks each year, when the primary control device, the VHP boiler, may not be operational due to maintenance or inspection. The VDU is fueled by low-carbon pipeline natural gas.

6.4.1. Step 1 – Identify Potential Control Technologies

The RBLC database did not identify any GHG control technologies for control devices such as the VDU, particularly since the VDU is itself an add-on control unit. Nonetheless, Chevron Phillips considered the following technologies as potential GHG control measures for VDU in the new ethylene Unit 1594:

- Carbon capture and storage (CCS),
- Low-carbon fuel, and
- Good combustion practices and maintenance.

6.4.1.1. Carbon Capture and Storage

As discussed in Section 6.1.1.1, CCS requires separation of CO_2 from flue gases, compression of the isolated CO_2, transportation to a suitable injection/storage location, and long-term storage in appropriate geologic formations.

6.4.1.2. Low-Carbon Fuel

Use of fuels containing lower concentrations of carbon generate less CO_2 than other higher-carbon fuels. Typically, gaseous fuels such as natural gas or high-hydrogen plant tail gas contain less carbon, and thus lower CO_2 potential, than liquid or solid fuels such as diesel or coal.

Chevron Phillips proposes to use natural gas for the pilot gas during hot stand-by mode and as supplemental fuel when the VDU controls low pressure vent streams. Liquid and solid fossil fuels are not proposed for use in the VDU.

6.4.1.3. Good Combustion Practice

Good combustion practices include appropriate maintenance of equipment (such as periodic burner tune-ups) and operating within the recommended combustion air and fuel ranges of the equipment as specified by its design, with the assistance of oxygen trim control. Although good combustion practices do not themselves necessarily directly reduce GHG emissions, using good combustion practices results in longer life of the equipment and more efficient operation. Therefore, such practices indirectly reduce GHG emissions by supporting operation as designed and with consideration of other energy optimization practices incorporated into the integrated plant.

Chevron Phillips will incorporate such combustion practices as recommended by the VDU manufacturer.

6.4.2. Step 2 – Eliminate Technically Infeasible Options

6.4.2.1. Carbon Capture and Storage

As discussed in Section 6.1.2.1, CCS is technically impracticable in situations where stack gases have low concentrations and/or mass flow rates of CO_2. Since the VDU's typical hot standby stack gas flow rate is less than 700 scf/hr at a CO_2 concentration of 10% by volume (or less), carbon capture from this stream is technically impracticable. Additionally, based on the economic infeasibility issues discussed in Section 6.1.4.1.1, CCS is not feasible for GHG control for the proposed combustion devices, including the VDU, and therefore will not be considered further in this analysis.

6.4.2.2. Low-Carbon Fuel

Use of low-carbon fuel is considered technically feasible.

6.4.2.3. Good Combustion Practice

Use of good combustion practices is considered technically feasible.

6.4.3. Step 3 – Rank According to Effectiveness

6.4.3.1. Low-Carbon Fuel

Material balance principles dictate that the lower the quantity of carbon in the fuel, the lower the resulting CO_2 emissions will be in the combustion stack gases. Therefore, use of low-carbon fuels when the same are available is the next most effective control measure behind energy efficient design. The VDU will combust pipeline natural gas in the pilots when in hot standby mode, and when controlling gaseous vent streams, natural gas will be used as supplemental fuel, if needed, to maintain combustion temperatures. Chevron Phillips will not use liquid or solid fuels in the VDU.

6.4.3.2. Good Combustion Practice

The use of good combustion practices includes periodic burner tune-ups and maintaining the recommended combustion air and fuel ranges of the equipment as specified by its design, with the assistance of oxygen trim control. Although good combustion practices do not themselves necessarily directly reduce GHG emissions, using good combustion practices results in longer life of the equipment and more efficient operation. The effectiveness of proper maintenance and combustion control cannot be directly quantified and is anticipated to have a less direct effect on overall GHG emissions reduction than either energy efficient design or use of low-carbon fuels. Thus, although a specific efficiency rating is not quantifiable, good combustion practice is qualitatively ranked as the least effective of the remaining control measures.

Chevron Phillips will maintain records of burner maintenance and operate the VDU within the prescribed air-to-fuel ratios, except when not in hot standby mode burning pilots only.

6.4.4. Step 4 – Evaluate the Most Effective Controls

Since Chevron Phillips proposes to incorporate the remaining control measures identified in Section 6.4.1, an evaluation of the energy, environmental, and economic impacts of the proposed measures is not necessary for this application.

6.4.4.1. Low-Carbon Fuel

The use of low-carbon fuel is economically and environmentally practical for the proposed project. Combustion of gaseous fuel in lieu of higher carbon-based fuels such as diesel or coal reduces emissions of other combustion products such as NO_x, CO, VOC, PM_{10}, and SO_2, providing environmental benefits. Therefore, low-carbon fuel remains as a viable control technology option.

6.4.4.2. Good Combustion Practice

Good combustion practice effectively supports the proper operation of the VDU as a standby control device. Therefore, good combustion practice also remains as a viable control technology option.

6.4.5. Step 5 – Select BACT

Chevron Phillips proposes to incorporate low-carbon fuel and good combustion practices discussed in Section 6.4.1 as BACT for controlling CO_2 emissions from the VDU.

6.5. Low Profile Flare

The low profile flare serves as a safety device designed to provide safe control of gases from the ethylene cracker and support units during periods of high pressure discharges during start-up and shutdown, emergency situations, and other large volume maintenance clearing. Additionally, the flare may control some low-pressure vent streams, such as “leak by” from safety relief and pressure control valves, sweep gas, and small volume maintenance activities. Similar to the VDU, the flare’s pilots are fueled by low-carbon pipeline natural gas.

6.5.1. Step 1 – Identify Potential Control Technologies

Similar to the VDU, the RBLC database did not identify any GHG control technologies for control devices such as the flare, particularly since the flare is itself an add-on control unit. Nonetheless, Chevron Phillips considered the following technologies as potential GHG control measures for the low profile flare in the new ethylene Unit 1594:

- Carbon capture and storage (CCS),
- Low-carbon fuel, and

- Good combustion practices and maintenance.

6.5.1.1. Carbon Capture and Storage

As discussed in Section 6.1.1.1, CCS requires separation of CO_2 from flue gases, compression of the isolated CO_2, transportation to a suitable injection/storage location, and long-term storage in appropriate geologic formations.

6.5.1.2. Low-Carbon Fuel

Use of fuels containing lower concentrations of carbon generate less CO_2 than other higher-carbon fuels. Typically, gaseous fuels such as natural gas or high-hydrogen plant tail gas contain less carbon, and thus lower CO_2 potential, than liquid or solid fuels such as diesel or coal. Likewise, although flaring carbon-containing vent streams (such as those in the ethylene unit that may contain methane) will necessarily result in CO_2 formation, methane has a global warming potential 21 times higher than that of CO_2. Therefore, control of such streams via flare to reduce methane emissions at the expense of CO_2 generation results in lower overall CO2e emissions than leaving such streams uncontrolled.

Chevron Phillips proposes to use natural gas for the flare's pilot gas and as supplemental fuel, if needed, to maintain appropriate vent stream heating value as required by applicable air quality regulations. Liquid and solid fossil fuels are not proposed for use with the flare.

6.5.1.3. Good Combustion Practice

Good combustion practices for flares include appropriate maintenance of equipment (such as periodic flare tip maintenance) and operating within the recommended heating value and flare tip velocity as specified by its design. Although good combustion practices do not themselves necessarily directly reduce GHG emissions, using good combustion practices results in longer life of the equipment and more efficient operation. Therefore, such practices indirectly reduce GHG emissions by supporting operation as designed and with consideration of other energy optimization practices incorporated into the integrated plant.

Chevron Phillips will incorporate such combustion practices as recommended by the flare manufacturer.

6.5.2. Step 2 – Eliminate Technically Infeasible Options

6.5.2.1. Carbon Capture and Storage

Flare exhaust, by design, cannot be captured for CO_2 separation unless the flare is enclosed, which is a safety hazard for a large capacity flare required in an ethylene unit for safe handling of high pressure emergency, startup and shutdown vent streams. Therefore, since flare exhaust cannot be captured, CCS is considered a technically infeasible control option for the proposed low profile flare at Chevron Phillips' Cedar Bayou plant and is not considered further in this analysis.

6.5.2.2. *Low-Carbon Fuel*

Use of low-carbon fuel is considered technically feasible.

6.5.2.3. *Good Combustion Practice*

Use of good combustion practices is considered technically feasible.

6.5.3. Step 3 – Rank According to Effectiveness

6.5.3.1. *Low-Carbon Fuel*

Material balance principles dictate that the lower the quantity of carbon in the fuel, the lower the resulting CO_2 emissions will be in the combustion stack gases. Therefore, use of low-carbon fuels when the same are available is the next most effective control measure behind energy efficient design. The flare will combust pipeline natural gas in the pilots when in hot standby mode, and when controlling gaseous vent streams, natural gas will be used as supplemental fuel, if needed, to maintain combustion temperatures. Chevron Phillips will not use liquid or solid fuels in the flare.

6.5.3.2. *Good Combustion Practice*

The use of good combustion practices include appropriate maintenance of equipment and operating within the recommended heating value and flare tip velocity as specified by its design. Although good combustion practices do not themselves necessarily directly reduce GHG emissions, using good combustion practices results in longer life of the equipment and more efficient operation. Therefore, such practices indirectly reduce GHG emissions by supporting operation as designed and with consideration of other energy optimization practices incorporated into the integrated plant.

Chevron Phillips will maintain records of flare tip maintenance and operate the flare within the prescribed heating value and tip velocity ranges.

6.5.4. Step 4 – Evaluate the Most Effective Controls

6.5.4.1. *Low-Carbon Fuel*

The use of low-carbon fuel is economically and environmentally practical for the proposed project. Combustion of gaseous fuel in lieu of higher carbon-based fuels such as diesel or coal reduces emissions of other combustion products such as NO_x, CO, VOC, PM_{10}, and SO_2, providing environmental benefits. Therefore, low-carbon fuel remains as a viable control technology option.

6.5.4.2. Good Combustion Practice

Good combustion practice effectively supports the proper operation of the flare as a control and safety device. Therefore, good combustion practice also remains as a viable control technology option

6.5.5. Step 5 – Select BACT

Chevron Phillips proposes to incorporate low-carbon fuel and good combustion practices discussed in Section 6.5.1 as BACT for controlling CO_2 emissions from the low profile flare.

6.6. Emergency Generators

The three emergency generator engines proposed for use in Unit 1594 normally will operate at a low annual capacity factor – only one hour per week (approximately 52 hrs/yr) – in non-emergency use. The engines are designed to use diesel fuel, stored in onsite tanks, so that emergency power is available for safe shutdown of the facility in the event of a power outage that may also include natural gas supply curtailments.

6.6.1. Step 1 – Identify Potential Control Technologies

Similar to other equipment previously discussed, the RBLC database did not identify any add-on GHG control technologies emergency generator engines; only good combustion practices were identified in the RBLC as BACT for emergency generators. Nonetheless, Chevron Phillips considered the following technologies as potential GHG control measures for the emergency generators in the new ethylene Unit 1594:

- Carbon capture and storage (CCS),
- Low-carbon fuel, and
- Good combustion practices and maintenance.

6.6.1.1. Carbon Capture and Storage

As discussed in Section 6.1.1.1, CCS requires separation of CO_2 from flue gases, compression of the isolated CO_2, transportation to a suitable injection/storage location, and long-term storage in appropriate geologic formations.

6.6.1.2. Low-Carbon Fuel

Use of fuels containing lower concentrations of carbon generate less CO_2 than other higher-carbon fuels. Typically, gaseous fuels such as natural gas or high-hydrogen plant tail gas contain less carbon, and thus lower CO_2 potential, than liquid or solid fuels such as diesel or coal.

Chevron Phillips proposes to use diesel fuel for the emergency generators, since non-volatile fuel must be used for emergency operations.

6.6.1.3. Good Combustion Practice

Good combustion practices for compression ignition engines include appropriate maintenance of equipment (such as periodic testing as will be conducted weekly) and operating within the recommended air to fuel ratio recommended by the manufacturer. Although good combustion practices do not themselves necessarily directly reduce GHG emissions, using good combustion practices results in longer life of the equipment and more efficient operation. Therefore, such practices indirectly reduce GHG emissions by supporting operation as designed and with consideration of other energy optimization practices incorporated into the integrated plant.

Chevron Phillips will incorporate such combustion practices as recommended by the generator manufacturer.

6.6.2. Step 2 – Eliminate Technically Infeasible Options

6.6.2.1. Carbon Capture and Storage

Because the emergency generators will operate 52 hours per year or less in non-emergency service and because their stack gases are low in volume and CO_2 mass rate, capture and segregation of CO_2 for sequestration has not been demonstrated. Additionally, based on the economic infeasibility issues discussed in Section 6.1.4.1.1, CCS is not feasible for GHG control for the proposed combustion devices, including the emergency generators, and therefore will not be considered further in this analysis.

6.6.2.2. Low-Carbon Fuel

Because the generators are intended for emergency use, these engines must be designed to use non-volatile fuel such as diesel. Use of volatile (low-carbon) natural gas or plant fuel gas in an emergency situation could exacerbate a potentially volatile environment that may be present under certain conditions, resulting in unsafe operation. Therefore, non-volatile fuel is appropriate and necessary for emergency equipment. As a result, Chevron Phillips proposes diesel fuel for use in the emergency engines. The use of low-carbon fuel is considered technically infeasible for emergency generator operation and is not considered further in this analysis.

6.6.2.3. Good Combustion Practice

Use of good combustion practices is considered technically feasible.

6.6.3. Step 3 – Rank According to Effectiveness

Since the remaining control measure identified in Section 6.6.1 –good combustion practices – is being proposed for this project, a ranking of the control technology relative to other available options is not possible.

6.6.4. Step 4 – Evaluate the Most Effective Controls

The use of diesel fuel in these generators is economically viable. Although diesel is less environmentally beneficial than gaseous fuels, diesel must be used for these emergency engines due to safety considerations of incorporating gaseous/volatile fuels in emergency situations. Therefore, use of diesel fuel with good combustion practice is considered environmentally appropriate.

6.6.5. Step 5 – Select BACT

Chevron Phillips proposes to incorporate good combustion practices discussed in Section 6.6.1 as BACT for controlling CO_2 emissions from the low profile flare. Further, these new engines will be subject to the federal New Source Performance Standard (NSPS) for Stationary Compression Ignition Internal Combustion Engines (40 CFR Part 60, Subpart IIII), such that specific emissions standards for various pollutants must be met during normal operation, such that the engines will meet or exceed BACT.

6.7. Piping Fugitives from Fuel Lines

GHGs from piping fugitives within the cracker unit are generated primarily from plant fuel gas and natural gas lines. Other process lines in VOC service contain a minimal quantity of GHGs. Additionally, process lines in VOC service are proposed in the Nonattainment New Source Review (NNSR) application under review at Texas Commission on Environmental Quality (TCEQ) to incorporate the 28LAER leak detection and repair program for fugitive emissions control. Therefore, since process lines contribute insignificant quantities of GHGs and since they are proposed in the governing permit for lowest achievable emission rate controls, process lines in VOC service in the proposed cracker unit are not considered further in this evaluation. Lines containing nitrogen, instrument air, and other non-fuel/non-VOC fluids do not include GHGs and likewise are not evaluated further in this analysis.

6.7.1. Step 1 – Identify Potential Control Technologies

Piping fugitives in fuel gas service may be controlled by various techniques, including:

- Use of leakless and/or sealless technology to eliminate fugitive emissions sources;
- Implementation of instrument leak detection and repair (LDAR) programs as prescribed by various federal and state regulations and permit conditions;
- Remote sensing using infrared cameras as an alternative to instrument LDAR programs; and
- Implementation of audio/visual/olfactory (AVO) leak detection methods.

6.7.2. Step 2 – Eliminate Technically Infeasible Options

6.7.2.1. Leakless/Sealless Technology

Leakless technology valves may be incorporated in situations where highly toxic or otherwise hazardous materials are present. Likewise, some technologies, such as bellows valves, cannot be repaired without a unit shutdown. Because plant tail gas and natural gas are not considered highly toxic nor hazardous materials, these fluids do not warrant the risk of unit shutdown for repair and therefore leakless valve technology for fuel lines is considered technically impracticable.

Sealless pumps and compressors, or seal systems venting to a control device such as the VDU or flare, are technically feasible for fuel gas service. However, since the fuel gas-specific piping lines systems in the proposed cracker plant do not include pumps or compressors, this technology is irrelevant and therefore considered technically impracticable.

6.7.2.2. Instrument LDAR Programs

Use of instrument LDAR is considered technically feasible.

6.7.2.3. Remote Sensing

Use of remote sensing measures is considered technically feasible.

6.7.2.4. AVO Monitoring

Use of as-observed AVO monitoring is considered technically feasible. Use of scheduled AVO, such as that used for highly odorous compounds detectable by AVO methods in lower concentrations than would be detected by instrument LDAR and/or remote sensing, such as for high concentration mercaptan streams or those in hydrogen halide and/or halide service (e.g. H_2S, chlorine) are not technically feasible for plant fuel gas or natural gas service.

6.7.3. Step 3 – Rank According to Effectiveness

Instrument LDAR programs and the alternative work practice of remote sensing using an infrared camera have been determined by EPA to be equivalent methods of piping fugitive controls.[11] The most stringent LDAR program, 28LAER, provides for 97% control credit for valves, flanges and connectors.

As-observed AVO methods are generally somewhat less effective than instrument LDAR and remote sensing, since they are not conducted at specified intervals. However, since pipeline natural gas is odorized with very small quantities of mercaptan, as-observed olfactory observation is a very effective method for identifying and correcting leaks in natural gas systems. Due to the pressure and other physical properties of plant fuel gas, as-observed audio and visual observations of potential fugitive leaks are likewise moderately effective.

---

[11] 73 *FedReg* 78199-78219, December 22, 2008.

6.7.4. Step 4 – Evaluate the Most Effective Controls

Although instrument LDAR and/or remote sensing of piping fugitive emissions in fuel gas and/or natural gas service may be somewhat more effective than as-observed AVO methods, these methods are not economically practical for GHG control from components in fuel gas service. As shown in Table A-8a, the incremental GHGs controlled by implementation of the 28LAER or a comparable remote sensing program is only 4,000 ton CO2e/yr, or less than 0.3% of the total project's proposed CO2e emissions. At a cost of nearly $44/ton CO2e, instrument LDAR programs or their equivalent alternative method, remote sensing, are not economically practicable controlling the piping fugitive GHGs emissions for this project, which constitute less than 0.3% of the total project's GHGs.

As-observed AVO is economically and environmentally practicable for this project.

6.7.5. Step 5 – Select BACT

Based on the economic impracticability of instrument monitoring and remote sensing for fuel gas piping components, Chevron Phillips proposes to incorporate as-observed AVO as BACT for the piping components in the new cracker plant in fuel gas and natural gas service.