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Independent Study Report

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Beaver County

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Abstract

Shell plans to build an ethane cracker plant in Beaver County/Pennsylvania. This independent study has recollected the data/information available in regards to this plant such as the plant related impact in the employment/investment in Beaver County, its business outlook (economic data), its production outlook (including an analysis of how many wells will be needed etc.). In addition to that the regulations to which the plant has to comply with are discussed focusing especially on the subject of emission reduction credits.

A forecast of the aspects regarding the emissions of this ethane cracker plant and their potential environmental impact (from the point of view of air quality) are presented. Technology measures and management measures to decrease the negative environmental impact of the plant have been elaborated.

Due to the substantial importance of this subject this independent study shall give a first approach on this important topic, which can be intensified with further future analysis/projects.

1. Introduction

Shell Chemical Appalachia LLC (Shell) has taken the final investment decision to build a major petrochemical complex, comprising an ethylene cracker with polyethylene derivatives unit, near Pittsburgh, Pennsylvania, USA.

The complex will use low-cost ethane from shale gas producers in the Marcellus and Utica basins to produce 1.6 million tons of polyethylene per year.

The facility will be built on the banks of the Ohio River in Potter Township, Beaver County, about 30 miles north-west of Pittsburgh.

The project will bring new growth and jobs to the region, with up to 6,000 construction workers involved in building the new facility, and an expected 600 permanent employees when completed¹.



Figure 1: Plan/Layout of the Cracker Plant¹

This report presents an overview of this new cracker plant related impact in the employment/investment in Beaver County, the business outlook (economic data), the production outlook (how many wells will be needed etc.) and which regulations/permits/emissions credits have been taken into account.

An analysis of the air emissions/air pollution aspects follows the data overview. Based on this a proposal of measures to reduce the impact on air quality is described.

To conclude an outlook and further steps to be taken is given.

¹ <http://www.shell.com/media/news-and-media-releases/2016/shell-final-investment-decision-petrochemicals-complex-pennsylvania.html>

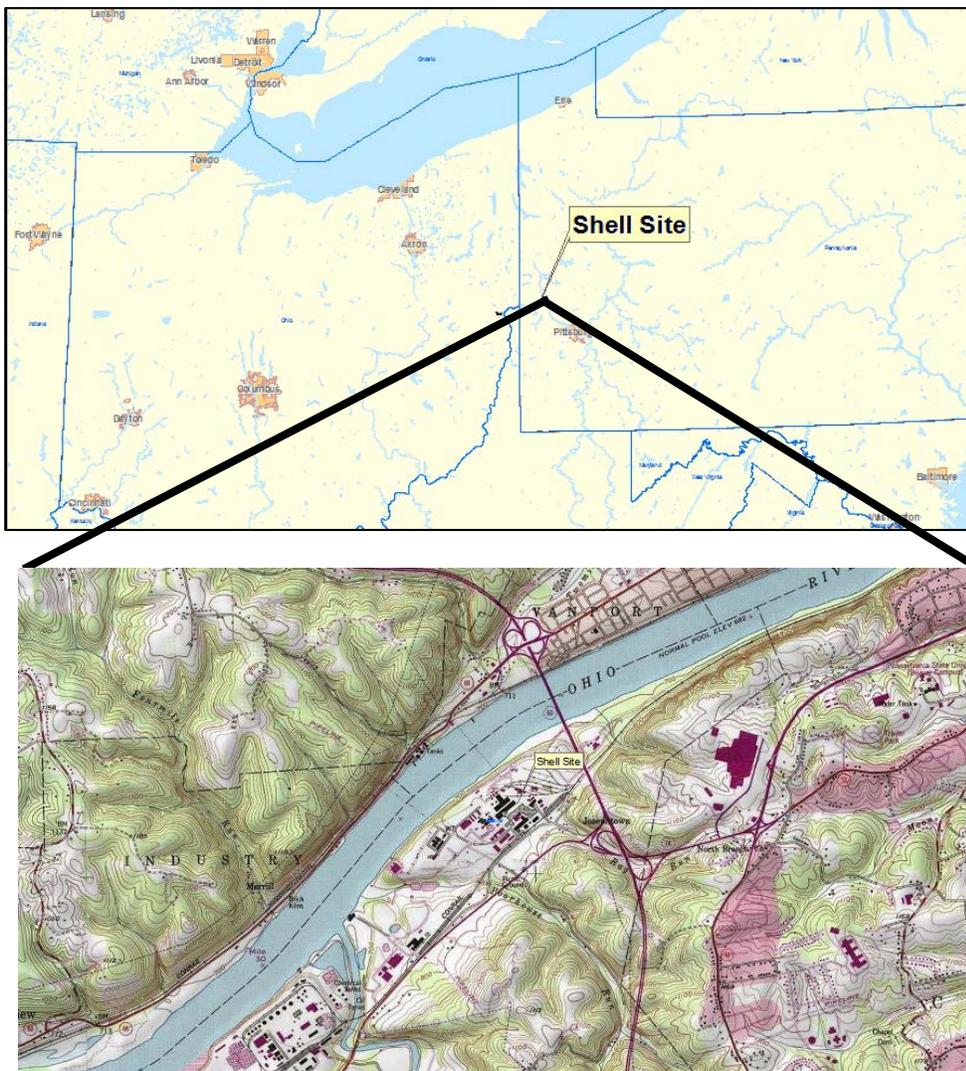
2. Detailed Data Recollection

2.1. Site Description

The Shell facility will occupy approximately 400 acres on the site of the zinc smelter previously owned by the Horsehead Corporation. The site is located adjacent to the Ohio River in Beaver County, Pennsylvania (Figure 2).

Beaver County is located in western Pennsylvania, with its western boundary bordering the Ohio State line.

Figure 2. Location of the Shell Cracker Plant in Beaver County along the Ohio River².



² Air Quality Plan Approval, Application Petrochemicals Complex Shell Chemical Appalachia LLC Beaver County, PA.

2.2. Background Data

The site will house the cracker; three units that will convert ethylene into polyethylene pellets; a natural gas-fired power plant; a loading dock; and a wastewater plant. Main construction will start about end of 2017, with commercial production expected to begin early in the next decade.

Shell has committed \$80 million to deal with environmental contamination inherited from the former owner of the site (Horsehead zinc smelter) and its predecessors; \$60 million to shuffle roadways; and \$69 million for the Center Township Water Authority to relocate its water intake site and build a new water treatment plant³.

Pennsylvania, too, will spend money to bring the cracker to life. In 2012, then-Gov. Corbett pushed through a tax break for Shell that would give the company a \$2.10 credit for every barrel of ethane it buys from Pennsylvania's oil and gas operators. The company also will reap 15 years of tax cuts and exemptions because the site is an expanded Keystone Opportunity Zone³.

³ <http://powersource.post-gazette.com/powersource/companies/2016/06/07/Shell-says-Marcellus-cracker-is-a-go-ethane-beaver-county-pennsylvania-pittsburgh/stories/201606070131>

2.3. Production Outlook

2.3.1 Overview of Process

Ethane, the primary raw material for the proposed Project, is a natural gas liquid, or NGL, that exists in certain natural gas deposits including the Marcellus and Utica Shales. (Propane and butane are examples of other NGLs.) Natural gas companies remove NGLs from natural gas, with the natural gas (mainly methane) to be shipped by pipeline for use as a fuel by residences, power plants, and industry. The NGLs are used for a variety of industrial, residential, and commercial uses. Ethane’s primary use is as a feedstock used to create ethylene (see process flow in Figure 3).

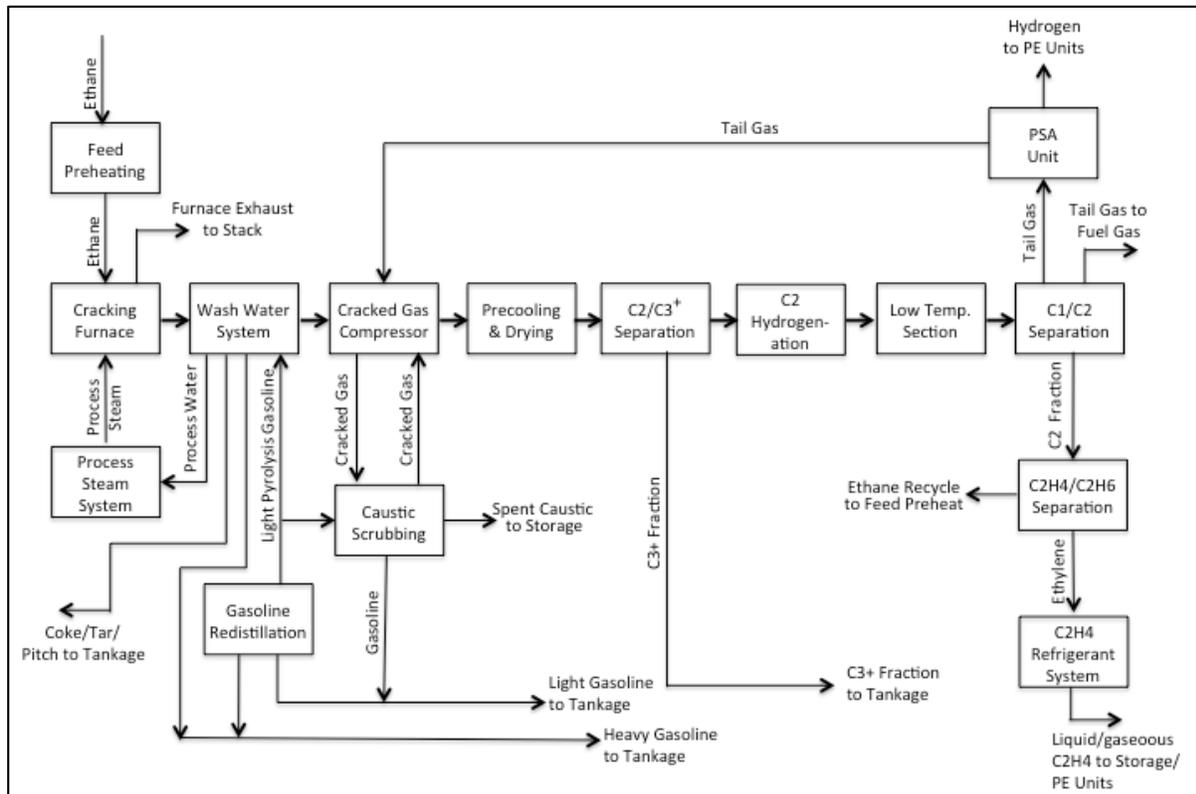


Figure 3: Ethane cracker process flow²

Ethylene is an important first step in creating many of the products in everyday use. This facility will process the ethylene to make different types of polyethylene. Different grades of polyethylene are used to make different types of products:

- low-density polyethylene (LDPE) and linear low density polyethylene (LLDPE) are the raw materials for flexible items like food packaging, film, trash bags, diapers, toys, and housewares
- high density polyethylene (HDPE) is used to create “stiffer” products such as crates, drums, bottles, food containers, and other types of housewares

Details to the Ethylene and Polyethylene manufacturing process can be found in chapter 3 of the Shell Approval Document.

2.3.2 Production Details

The cracker plant will consist of an ethylene manufacturing process, three polyethylene manufacturing units, three Cogen Units, and a variety of ancillary equipment required to support the overall plant operations. The ethylene that is produced will be used to supply feed to three polyethylene manufacturing units with a combined annual production of approximately 1,600,000 metric tons of polyethylene².

The cracker plant will produce up to 1.7 million metric tons of ethylene (2.169 million metric tons of ethane, 1.287 metric ton to produce 1 metric ton of ethylene) each year, and then process that chemical into 1.6 million metric tons of polyethylene.

The cracker plant will consume about 105,000 barrels (4.41 million gallons (1 barrel = 42 gallons), 5,943 metric tons (742 gallons per metric ton)) of ethane per day. Shell said it has signed supply contracts with 10 operators — its anchors are Antero Resources, Ascent Resources Utica, Consol Energy, Eclipse Resources, Hilcorp Energy, Noble Energy and Penn Energy Resources.

This operator will send their raw gas to Mark West Energy <http://www.markwest.com/> to three plants which separates the ethane which will be send to the cracker plant.

Each year, the facility will pump out about 1.6 million tons of polyethylene in small balls or pellets that will be sold to clients to mold into products⁴.

The ethane cracker is intended to capitalize on the historic price spread between more expensive oil and less expensive natural gas, from which ethane molecules are extracted. Both can be “cracked” to produce ethylene — a building block of pharmaceuticals, industrial chemicals and consumer goods.

Production from the Marcellus and Utica shale formations, with their large reserves of natural gas liquids, has driven up supply and plunged the cost of ethane.

According to Ms. Kendal Puig’s estimates (senior analyst at Platts Analytics), there are eight ethane crackers in various stages of construction on the Gulf Coast now, with the first scheduled to come online in 2017. That will boost demand for ethane and raise the price of the ethane feedstock. Shell’s advantage will be its proximity to the so-called wet gas of the Marcellus and Utica shale’s⁴.

⁴ <http://powersource.post-gazette.com/powersource/companies/2016/06/07/Shell-says-Marcellus-cracker-is-a-go-ethane-beaver-county-pennsylvania-pittsburgh/stories/201606070131>

2.3.3 Number of Wells required

Calculation base:

1. To determine the available wells the data from PA DEP for Washington County from 2009 to 2016 has been used⁵.
2. The average number of active wells in the year 2013 compared to the year 2015.

Average active wells in 2013: 635.

Total gas production (365 days) = 256,744,853 Mcf

Average active wells in 2015: 965.

Total gas production (365 days) = 663,151,615 Mcf

3. Gas production per day in the year 2015:
 965 active wells = 1,816,853 Mcf
 (conversion factor 5.8 Mcf per bbl⁶) = **313,216 barrels**
4. Total quantity of ethane produced in 2015:
 Assumption is that 50% of gas is Methane, the double of the total production is the basis for the ethane calculation. Total gas per day = 626,423 barrels
 Scenario 1 - 18% ethane = 112,723 barrels per day
 Scenario 2 - 15% ethane = 93,663 barrels per day (one well = 97.06 barrels per day)
5. Number of wells needed to supply the cracker plant (based on scenario 2 of point 4):
 Required ethane per day = 105,000 barrels
Total wells required to produce this amount of ethane = approx. 1,082 wells

Based on this calculation result, more wells than the active wells in Washington County would be needed to supply the cracker plant with the ethane it requires (and assuming all the wells would only supply the cracker plant). Considering that studies and analysis performed by Duquesne University haven shown, that the average lifetime of a gas producing well is about 5 years (in a conservative view the lifetime would be 10 years), more than 1,000 wells each 5 to 10 years must be drilled, after 50 years of production of the cracker plant approximately 5,000 to 10,000 wells would have been drilled in Washington County.

⁵ Nolan, 2016.

⁶ <http://www.kylesconverter.com/energy,-work,-and-heat/cubic-feet-of-natural-gas-to-barrels-of-oil-equivalent>

2.4. Impact regarding Employment/Investment in the Region

The following estimates on the economic benefits as presented by Dennis Nichols, Commissioner of Beaver County, PA in August 2012 stated:

- \$2 billion investment in the plant
- 10,000 construction jobs
- 450 permanent industrial jobs
- 18,000 ancillary jobs
- \$4-6 billion total investment in the area⁷

According to the latest announcement from Shell, however has stated the following employment/investment impact¹:

- 6,000 construction workers
- 600 industrial workers
- \$2 billion investment in the plant

2.5. Business Outlook

The cracker plant is expected to produce up to 1.6 million metric tons of polyethylene per year².

It will produce low-density polyethylene or LDPE but also linear polyethylene or HDPE.

Based on the current average price for LDPE/HDPE: 1,125 USD/ton⁸ (EUR/USD exchange rate: 1 = 1.12) a total revenue of \$ 1.8 Billion dollar per year is predicted (when the total production volume is reached).

⁷ <http://www.ektinteractive.com/shell-ethane-cracker-beaver-county/>

⁸ http://plasticker.de/preise/preise_ecebd_en.php

2.6. Compliance with Regulations

Shell submitted an Air Quality Plan Approval pursuant to the Pennsylvania Air Pollution Control Act and 25 Pa. Code Ch. 127, Subch. B, to obtain approval for construction of an “air contamination source” and installation of associated air cleaning devices, including review pursuant to the pre-construction permitting requirements under the PSD and NSR programs.

The cracker plant is subject to the Title 25 Code Pennsylvania Chapters 121 through 145, the specific applicability of each of these regulations in Chapters 121 through 145, and how Shell will address these requirements was presented in detail in chapter 4.1 of the Shell Approval Document.

The analysis provided in this application addressed the requirements governing air emissions from the proposed facility including²:

- 1) New Source Performance Standards (“NSPS”)
- 2) National Emission Standards For Hazardous Air Pollutants (“NESHAPS”)
- 3) Prevention Of Significant Deterioration (PSD)/ Best Available Control Technology (BACT) analysis for applicable pollutants for which the Project is classified as a major source located within an attainment area for such pollutant
- 4) Nonattainment New Source Review (NNSR) / Lowest Achievable Emission Rate (LAER) analysis for those applicable pollutants for which the Project is classified as a major source located within a non-attainment area for such pollutant
- 5) Demonstration that the Project will not cause or contribute to an exceedance of an applicable air quality standard or increment
- 6) quantification of the emissions reduction credits (i.e., offsets) required for certain pollutants in accordance with the nonattainment NSR requirements
- 7) demonstration that emissions from the new sources will be the minimum attainable through use of best available technology pursuant to 25 Pa. Code §127.12(a)(5) (“PaBAT”)

Emissions from the cracking furnace stacks will result from combustion of methane, hydrogen, and natural gas during normal operation, startup/shutdown, decoking, and hot standby.

The annual potential emissions of air quality indicators (e.g., CO, CO₂, NO_x, SO_x, PM_{2.5}, PM₁₀, VOC, HAP_{total}) is listed in Table 1².

Table 1. Summary of the Plants Annual Potential to Emit Pollutants (tons) ¹

Pollutant	Cracking Furnaces	PE Units	Cogen Units	Flares & Incinerators	Tanks & Loading	Fugitives	Support Units	Total	Significance Threshold	Subject to NSR/PSD
Carbon Monoxide	670	-	43.5	277	-	-	0.6	991	100	Yes
Nitrogen Oxides	181	-	67.9	74.8	-	-	2.8	327	100/40	Yes
PM	34.1	15.3	16.9	4.6	-	-	8.3	79	25	Yes
PM ₁₀	86.8	4.9	59.8	8.2	-	-	4.7	164	15	Yes
PM _{2.5}	86.8	4.9	59.8	8.2	-	-	0.1	160	100	Yes
Sulfur Dioxide	3.6	-	13.3	5.0	-	-	0.0	22	100	No
VOC	32.4	96.6	31.9	219	14.1	47.5	42.7	484	50	Yes
CO ₂ e	1,048,668	-	1,061,680	147,708	-	138	1,272	2,259,466	100,000	Yes
Sulfuric Acid Mist	0.1	-	0.5	0.2	-	-	0.0	0.9	7.0	No
Total HAP	18.2	0.0	9.3	3.4	1.8	5.4	3.9	41.9	N/A	N/A

Polyethylene (PE) Units: includes emissions from PE processing equipment but not fugitives, flare, and thermal incinerator emissions.

Support Units: includes emissions from firewater pump and emergency generator engines, cooling tower, wastewater treatment and plant roads

1. This Project may also increase emissions of other pollutants, but reported to be in minimal quantities.

Shell received an approval from PA DEP on June 18, 2015, Permit # 04-00740A⁹.

Relevant extracts of the permit:

In accordance with the provisions of the Air Pollution Control Act, the Act of January 8, 1960, P.L. 2119, as amended, and 25 Pa. Code Chapter 127, Shell by the Department of Environmental Protection to construct, install, modify or reactivate the air emission source(s).

Emissions from the Facility shall not equal or exceed the following in any consecutive 12-month period:

Air Contaminant	Emission Rate (tons)
NOx	348
CO	1,012
PM (filterable)	71
PM10	164
PM2.5	159
SOx	21
VOC	522
VOC (ERC)*	620
HAP	30.5
Ammonia	152
CO2e	2,248,293

* This limit is included to ensure that the proper amount of VOC ERCs are secured by the applicant in accordance with the VOC offset ratios for flue and fugitive emissions under 25 Pa. Code §127.210. Compliance with this limit will be determined by actual VOC emissions at the Facility and the following equation:

$$\text{VOC (ERC)} = 1.15 * \text{sum}(\text{flue VOC emissions}) + 1.3 * \text{sum}(\text{fugitive VOC emissions}) \quad (\text{Eq. 1})$$

Where:

Flue VOC emissions are actual emissions from the ethane cracking furnaces, combustion turbines/duct burners, incinerators, flares, engines, miscellaneous storage tanks, and polyethylene pellet residual VOC.

Fugitive VOC emissions are actual emissions from liquid loadout, component leaks, the process cooling tower, and wastewater treatment plant.

Annual emission reporting shall be conducted as follows⁹ (page 20, # 020 [25 Pa. Code §135.3]):

- a. The Owner/Operator shall submit by March 1 of each year, a source report for the preceding calendar year. The report shall include information for all previously reported sources, new sources which were first operated during the preceding calendar year, and sources modified during the same period which were not previously reported.
- b. A person who received initial notification by the Department that a source report is necessary shall submit an initial source report within 60 days after receiving the notification or by March 1 of the year following the year for which the report is required, whichever is later.
- c. A source Owner/Operator may request an extension of time from the Department for the filing of a source report, and the Department may grant the extension for reasonable cause.

⁹ Plan Approval Permit #04-00740A, Shell Chemical Appalachia LLC, Potter Township, Beaver County.

Air contamination sources and air cleaning devices authorized to be installed at the Facility under this Plan Approval are as follows⁹ (page 22, # 028 [25 Pa. Code §127.12b]):

- Seven (7) tail gas- and natural gas-fired ethane cracking furnaces, 620 MMBtu/hr heat input rating each; equipped with low-NOx burners and controlled by selective catalytic reduction (SCR).
- One (1) ethylene manufacturing line, 1,500,000 metric tons/yr; compressor seal vents and startup/shutdown/maintenance/upsets controlled by the high pressure header system (HP System).
- Two (2) gas phase polyethylene manufacturing lines, 550,000 metric tons/yr each; VOC emission points controlled by the low pressure header system (LP System) or HP System, PM emission points controlled by filters.
- One (1) slurry technology polyethylene manufacturing line, 500,000 metric tons/yr; VOC emission points controlled by the LP System or HP System, PM emission points controlled by filters.
- One (1) LP System; routed to the LP incinerator, 10 tons/hr capacity, with backup multipoint ground flare (MPGF), 74 metric tons/hr capacity.
- One (1) HP System; routed to two (2) HP enclosed ground flares 150 tons/hr capacity each, with backup emergency elevated flare, 1,200 tons/hr capacity.
- Three (3) General Electric, Frame 6B, natural gas-fired combustion turbines, 40.6 MW (475 MMBtu/hr heat input rating) each, including natural gas- or tail gas-fired duct burners, 189 MMBtu/hr heat input rating each; controlled by SCR and oxidation catalysts.
- Four (4) diesel-fired emergency generator engines, 5,028 bhp rating each.
- Three (3) diesel-fired fire pump engines, 700 bhp rating each.
- One (1) process cooling tower, 28 cell counter-flow mechanical draft, 18.3 MMgal/hr water flow capacity; controlled by drift eliminators.

One (1) cogen cooling tower, 6 cell counter-flow mechanical draft, 4.44 MMgal/hr water flow capacity; controlled by drift eliminators.

- Polyethylene pellet blending, handling, storage, and loadout; controlled by fabric filters.
- Liquid loadout, coke residue/tar and recovered oil; controlled by vapor capture and routing back to the process or Spent Caustic Vent incinerator, and low-leak couplings.
- Liquid loadout, pyrolysis fuel oil and light gasoline; controlled by vapor capture and routing to the LP System, and low-leak couplings.
- Liquid loadout, C3+; controlled by pressurized transfer with vapor balance and low-leak couplings.
- One (1) recovered oil, one (1) spent caustic, and two (2) equalization wastewater storage tanks, 23,775 to 742,324 gallon capacities; controlled by internal floating roofs (IFR) and vapor capture routed to the Spent Caustic Vent incinerator, 10.7 MMBtu/hr.

- One (1) light gasoline, and two (2) hexene storage tanks; 85,856 and 607,596 gallon capacities; controlled by IFR and vapor capture routed to the LP System.
- Two (2) pyrolysis fuel oil storage tanks; 85,856 gallon capacity; controlled by vapor capture routed to the LP System.
- Miscellaneous storage tanks, diesel fuel, 1,849 to 10,038 gallon capacities; controlled by carbon canisters.
- Miscellaneous components in gas, light liquid, and heavy liquid service; controlled by leak detection and repair (LDAR).
- Wastewater treatment plant (WWTP).
- Plant roadways; controlled by paving and a road dust control plan including sweeping and watering (as necessary).

3. Sustainability Analysis of the Cracker Plant (Air Quality)

3.1. Emission Reduction Credits

3.1.1 Definition

ERCs (Emission Reduction Credits), expressed in tons per year, can be created by a company if its emissions of certain pollutants, including volatile organic compounds and nitrogen oxides, are reduced more than what is necessary to fulfill regulatory requirements. ERCs can be either bought or sold to meet offset requirements for business expansion in areas with air quality problems.

ERCs can be generated by all facilities in reducing emissions in a variety of ways including:

- Shutdown of an existing source or facility
- Permanent curtailment in production, or hours of operation which results in actual emissions reductions
- Use of new technologies, materials, processes or equipment modifications that are not required for compliance
- Installation of improved control measures that decrease actual emissions
- Pollution prevention

Facilities creating ERCs can bank them for use at their own facilities or trade or sell them to other facilities for use.

ERCs can be transferred from a dirtier area to a cleaner area. Credits cannot be transferred from a cleaner area into a dirtier area¹⁰.

3.1.2 Emission Reduction Credits in Pennsylvania

The Clean Air Act (1990) or Clean Air Act amendments of 1990 authorized the use of market-based approaches such as emission trading to assist states in attaining and maintaining air quality for all criteria pollutants. The US Environmental Protection Agency (EPA) subsequent interpretive rulings expressly allow owners of new sources to obtain emission credits from other companies that operate facilities located in the same air quality control region. To implement an emissions offset program, many states have developed regulations allowing sources to register their emissions reduction credits as ERCs that can be sold to companies required to offset emissions from new or modified sources.

Following the ERC process in Pennsylvania is described.

¹⁰ <http://files.dep.state.pa.us/Air/AirQuality/AQPortalFiles/Permits/erc/ercmain.pdf>

Businesses interested in buying or selling emission reduction credits can now get help through the Department of Environmental Protection's Emission Reduction Credit (ERC) Registry System. DEP encourages businesses to take advantage of this registry, for each time ERCs are created and used, there is always a net benefit to the environment and expedited economic growth and expansion.

An Emission Reduction Credit (ERC) Registry Application has to be filled (http://files.dep.state.pa.us/Air/AirQuality/AQPortalFiles/Permits/erc/ERC_app.pdf)

This application includes all the details on the applicants business (e.g. a specific plant).

ERC-Generating Source Information such as Approval Documents, ERC Generation Techniques, Intended use of ERCs (offsetting, banking, trading, selling purposes) must be included.

A baseline emission rate (expressed in lbs/hr or tons/yr) which is based on the lower of actual or allowable emissions calculated over two calendar years immediately preceding the reduction must also be included.

Emission Quantification Methods such as performance test data or equipment vendor emission data and guarantees and Emission Characteristics are required to determine the ambient impact of the emissions reduction.

The complete process is described on the following website:

<http://www.dep.pa.gov/Business/Air/BAQ/Permits/Pages/EmissionCredit.aspx>

3.1.3 Emission Reduction Credits in the European Union

The EU emissions trading system (EU ETS) is a cornerstone of the EU's policy to combat climate change and it's a key tool for reducing greenhouse gas emissions cost-effectively. It is the world's first major carbon market and remains the biggest one¹¹.

The EU ETS works on the 'cap and trade' principle.

A cap is set on the total amount of certain greenhouse gases that can be emitted by installations covered by the system. The cap is reduced over time so that total emissions fall.

Within the cap, companies receive or buy emission allowances which they can trade with one another as needed. They can also buy limited amounts of international credits from emission-saving projects around the world. The limit on the total number of allowances available ensures that they have a value.

After each year a company must surrender enough allowances to cover all its emissions, otherwise heavy fines are imposed. If a company reduces its emissions, it can keep the spare allowances to cover its future needs or else sell them to another company that is short of allowances.

Trading brings flexibility that ensures emissions are cut where it costs least to do so. A robust carbon price also promotes investment in clean, low-carbon technologies.

The system covers the following sectors and gases with the focus on emissions that can be measured, reported and verified with a high level of accuracy:

- carbon dioxide (CO₂) from
- power and heat generation
- energy-intensive industry sectors including oil refineries, steel works and production of iron, aluminum, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals
- commercial aviation
- nitrous oxide (N₂O) from production of nitric, adipic, glyoxal and glyoxalic acids
- perfluorocarbons (PFCs) from aluminum production

Participation in the EU ETS is mandatory for companies in these sectors, but in some sectors only plants above a certain size are included, certain small installations can be excluded if governments put in place fiscal or other measures that will cut their emissions by an equivalent amount in the aviation sector. Until 2016 the EU ETS applies only to flights between airports located in the European Economic Area (EEA)¹¹.

¹¹ http://ec.europa.eu/clima/policies/ets/index_en.htm

3.1.4 Cracker Plant Requirements

According to the approval document from SHELL:

Under non-attainment NSR regulations, the cracker plant emissions of NO_x, PM_{2.5}, and VOC will be subject to the emissions offset requirement at 25 Pa. Code §127.205(3)².

As a result, in accordance with the offset ratios of 1.15, 1.1, and 1.15, respectively, at 25 Pa. Code §127.210(a), Shell will secure the following amounts of emissions reduction credits (ERCs)²:

NO_x: 376 tons = (1.15) x (327 tons)

PM_{2.5}: 176 tons = (1.1) x (160 tons)

VOC: 557 tons = (1.15) x (484 tons)

ERC general requirements (according to section c #34 of the permit)⁹:

SHELL shall secure **391 tons of NO_x, 632 tons of VOC, and 159 tons of PM_{2.5} ERCs.** ERCs shall be properly generated, certified by the Department and processed through the registry in accordance with 25 Pa. Code §127.206(d)(1).

Upon transfer, the Owner/Operator shall provide the Department with documentation clearly specifying the details of the ERC transaction. This facility may not commence operation until the required emissions reductions are certified and registered by the Department.

From where will Shell get the required ERCs?

The 391 tons of NO_x are similar to emissions produced by the Horesehead zinc smelter, thus it is assumed that Shell will buy the ERCs from this no longer active zinc smelter. In general due to the industry already present in Beaver County, the NO_x emitted from the cracker plant will not significantly increase the overall impact (considering the time when the zinc smelter was active)¹².

The 632 tons of VOC emissions are higher than any other source of VOC in Western Pennsylvania. According to available information Shell has bought so far max. 15% of the required ERCs and they may have to acquire the rest of the ERCs in Maryland and/or New York. In this case if the ERCs purchased are so far away from Beaver County, there will be no reduction of the negative impact in the air quality of Beaver County caused by these VOC emissions. In fact, it is predicted that the levels of VOC will exceed 1990s levels¹².

Thus VOC impact is the greatest concern, impacting air quality and health in general.

¹² Personal Meeting with James P. Fabisiak, Pittsburgh. October 11th 2016.

3.2. Forecast of the impact of the plant on air quality

Using emissions data from a similar cracker plant operating in Louisiana and comparing it to the Horsehead smelter, it shows that such a cracker plant would likely release significant amounts of air toxins known as volatile organic compounds as well as nitrogen oxides (see Table 2 and Table 3).

POLLUTANT (measured in tons)	HORSEHEAD SMELTER (amount released)	GEISMAR CRACKER FACILITY (amount released)	PERCENT OF CURRENT EMISSIONS
Lead	5	0.004	0.1%
Nitrogen oxides	1,176	553	47%
Sulfur dioxide	3,320	4.5	0.1%
Carbon monoxide	25,735	800	3.1%
PM ₁₀ primary	334	215	64.4%
PM _{2.5} primary	239	212	88.7%

Table 2: Comparison of the 2008 annual release of NAAQS criteria pollutants at the Horsehead zinc smelter and a surrogate to the ethane cracker plant¹³

POLLUTANT	HORSEHEAD SMELTER (amount released)	GEISMAR CRACKER FACILITY (amount released)	PERCENT OF CURRENT EMISSIONS
Acrolein (lbs.)	91	191	209.9%
Benzene (lbs.)	404	49	12.1%
Ethyl Benzene (lbs.)	37	0.3	0.8%
VOCs (tons)	66	481	728.8%
Xylenes (lbs.)	26	0.02	0.1%

Table 3: Comparison of the 2008 annual release of HAPs between the Horsehead zinc smelter and a surrogate to the ethane cracker plant¹³

These pollutants have adverse effects on their own, but one significant concern is their ability to promote the formation of ozone. Ozone is one of six air pollutants for which the Environmental Protection Agency sets standards because of its ability to exacerbate lung diseases such as asthma. The linkage between ozone and motor-vehicle traffic in many parts of the United States is indisputable. Therefore to portray the cracker’s expected emissions in terms of motor-vehicle traffic would be useful to give a common perspective of its magnitude.

Shell’s own estimate for release of volatile organic compounds by the proposed plant is 484 tons per year. The EPA estimates an average automobile driving 12,000 miles annually emits about 27 pounds. Therefore, the proposed cracker would emit about as much as 35,800 cars. Emissions of nitrogen oxides

¹³ PITTSBURGH REGIONAL ENVIRONMENTAL THREATS ANALYSIS (PRETA) REPORT, P27-28

from the plant also would be about the same as 36,000 cars (the plant would release about 327 tons per year).¹⁴

Southwestern Pennsylvania — especially Allegheny County, which sits downwind of Beaver — already has some of the worst air quality in the nation and often ranks poorly in the daily Air Quality Index due to ozone.

The question then becomes, what would be the impact of putting an additional 36,000 cars on the road in the region?

Operation of the cracker would be similar to increasing existing vehicular traffic in Beaver County by about 25 percent. This alone is likely to make a significant impact, but it portends even larger increases in ozone should the promise of spinoff industrial expansion come true¹⁴.

According to the U.S. Change Research Program, increases in ozone will cause premature deaths, hospital visits, lost school days, and acute respiratory symptoms.¹⁵ Outdoor ground-level ozone and particle pollution can have a range of adverse effects on human health. Current levels of ground-level ozone have been estimated to be responsible for tens of thousands of hospital and emergency room visits, millions of cases of acute respiratory symptoms and school absences, and thousands of premature deaths each year in the United States¹⁵.

3.3. Measures Shell will take to reduce their Impact on Air Quality

Decoking: Furnace decoking is a normal and routine part of the ethylene manufacturing process. High ethane conversion rates (i.e., 72 percent) require more frequent decoking relative to lower ethane conversion rates (i.e., 65 percent). Decoking is accomplished by injecting steam into the radiant coils while progressively raising the concentration of air to achieve controlled combustion of the coke in the furnace tubes. The CO₂ (carbon dioxide) concentration exiting the tubes is used to monitor the decoking process. After passing through a separator to remove large particulate, the decoking vent will be redirected back into the furnace where the CO and remaining particulate in this stream will be combusted².

Furnace Emissions: The nitrogen oxide (NO_x) emissions from the furnaces will be controlled through the use of low NO_x burner technology and selective catalytic reduction (SCR). The carbon monoxide (CO), volatile organic compound (VOC) and hazardous air pollutant emissions from the furnaces will be controlled through the use of low carbon fuel and good combustion control².

¹⁴ <http://www.post-gazette.com/opinion/Op-Ed/2016/07/17/Shell-and-others-shouldn-t-dismiss-community-concerns-about-the-Beaver-County-cracker-plant/stories/201607170023>

¹⁵ <https://health2016.globalchange.gov/air-quality-impacts>

Emissions control of the Gas Phase Technology Process and Slurry Technology (Polyethylene Manufacturing) ²:

All of the vents with VOC containing gases located upstream of and including the Product Purge Bin and upstream of the Degasser will be directed to the VOC Control System. All of the vents with particulate containing gases located upstream of and including the Product Purge Bin and upstream of the Degasser will be directed through filters prior to release to the atmosphere.

Control of VOC emissions resulting from vents located downstream of the Product Purge Bin and upstream of the Degasser will be accomplished by maintaining the residual VOC content in the resin exiting the Product Purge Bin below a level of 50 ppmw. Except for the pellet dryer, particulate filters (i.e., sintered metal, fabric, or HEPA) will be used to control the non-fugitive particulate matter emissions from all vents located downstream of the Product Purge Bin.

4. Measures to reduce Industrial Air Pollution

4.1. Technological Measures

As described in Chapter 3.1.4 and 3.2 the Volatile Organic Compounds (VOCs) are the emissions that arise the most concern in the context of the cracker plant therefore technical measures to reduce VOC emissions will be presented.

VOCs are among the most common air pollutants emitted from chemical, petrochemical, and allied industries. VOCs are one of the main sources of photochemical reaction in the atmosphere leading to various environmental hazards.

VOCs include most solvent thinners, degreasers, cleaners, lubricants, and liquid fuels. A brief list of some common VOCs are methane, ethane, tetrachloroethane, methyl chloride, and various chlorohydrocarbons and perfluorocarbons. VOCs are the common air pollutants emitted by the chemical and petrochemical industries. Emissions of VOCs originate from breathing and loading losses from storage tanks, venting of process vessels, leaks from piping and equipment, wastewater streams and heat exchange systems.

From an environmental point of view, it is necessary to limit and control vapor emissions because they affect the change of climate, the growth and decay of plants, and the health of human beings and all animals.

VOCs react with nitrogen oxides and other airborne chemicals, in the presence of sunlight (photo-chemically), to form ozone, which is a primary component of smog. Reduction of VOCs emissions that exceeds the current national ambient air quality standard for ozone of 0.12 ppm is mandated under Title I of the US Clean Air Act Amendment of 1990.

There are many different techniques available to control VOCs emissions. These techniques are basically classified into two different groups (see Figure 4):

- Process and equipment modification and
- Add-on-control techniques.

In the first group, control of VOCs emissions are achieved by modifying the process equipment, raw material, and/or change of process, while in the other group an additional control method has to be adopted to regulate emissions. Though the former is the most effective and efficient method, its applicability is limited, as usually it is not possible to modify the process and/or the equipment. The techniques in the second group are further classified into two sub-groups, namely the destruction and the recovery of VOCs.

For case of the cracker plant there will be a focus on add-on control techniques.

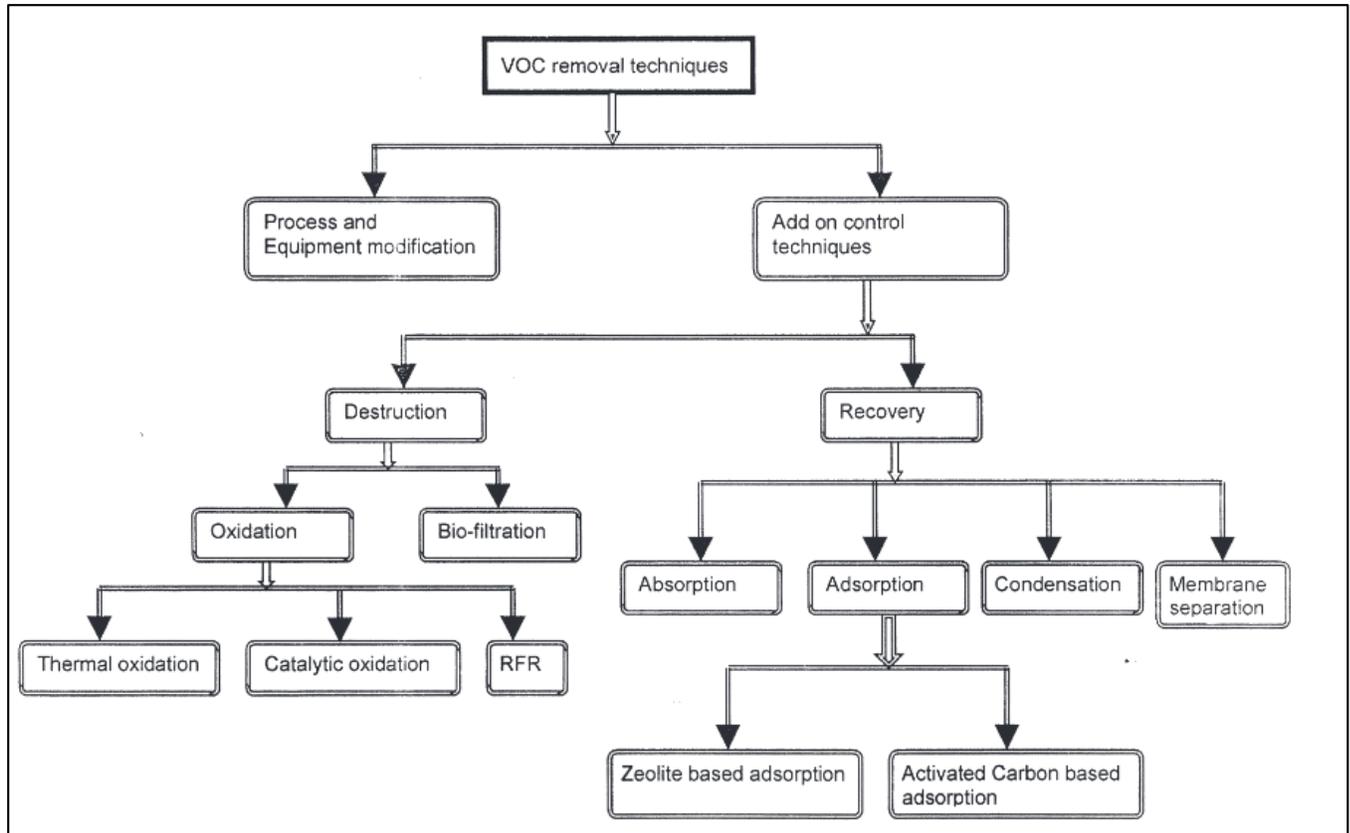


Figure 4: Classification of VOC control techniques¹⁶

As stated above add-on control techniques are broadly classified into two types: destruction and recovery.

4.1.1 Add-on Control Techniques

Destruction of VOCs:

In this step, VOCs are destroyed by different types of oxidation such as thermal and catalytic, and digestion of VOCs under aerobic conditions by microbes (Bio-filtration).

Oxidation of VOCs:

Thermal oxidation

Thermal oxidation systems, also known as fume incinerators, are not simple flares or afterburners. The modern thermal oxidizer is designed to accomplish from 95% to 99% destruction of virtually all VOCs. These systems can be designed to handle a capacity of 1,000 to 500,000 cfm (cubic feet per minute) and VOC concentration ranges from 100 to 2,000 ppm. Nominal residence time ranges from 0.5 to 1.0 s. Available with thermal energy recovery options to reduce operating costs, thermal oxidizers are very popular.

Thermal oxidation systems combust VOCs at temperatures of 1,300–1,800°F. Actual operating temperature is a function of the type and concentration of material in the vent stream and the desired DRE (Destruction and Removal Efficiency).

High DRE requirements will also require higher temperatures and longer retention times. Inlet concentrations in excess of 25% of the LEL (Lower Explosive Limit) are generally avoided by oxidizer manufacturers because of potential explosion hazards.

Two types of thermal energy recovery systems are in common use today, regenerative and recuperative (Figure 5). Both use the heat content of the combustion exhaust stream to heat the incoming gas stream prior to entering the combustion zone.

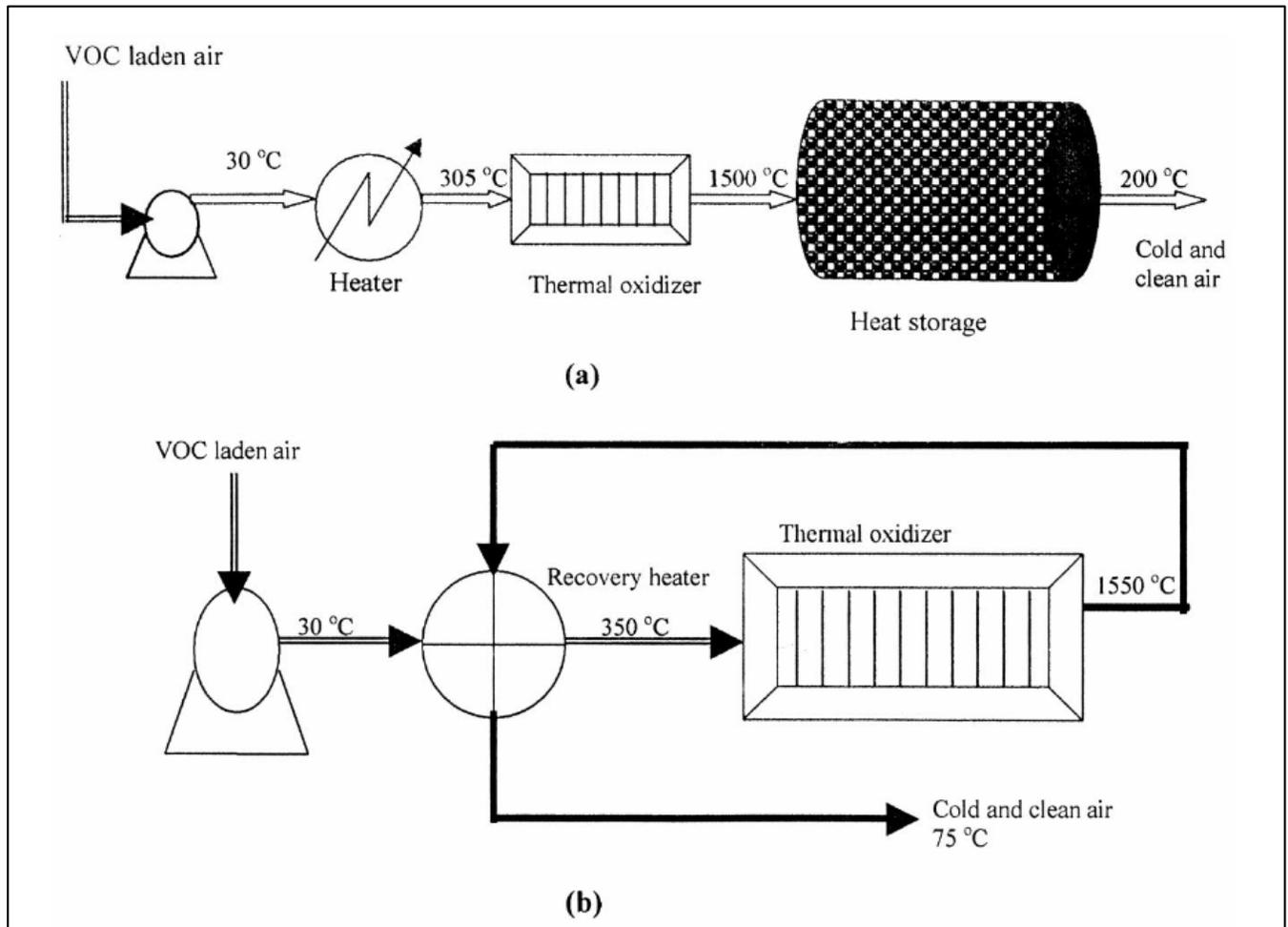


Figure 5: Schemes of thermal oxidation. (a) Regenerative thermal oxidation; (b) recuperative thermal oxidation¹⁶

Regenerative systems use ceramic beds to capture heat from gases exiting the combustion zone. As the bed approaches the combustion zone temperature, heat transfer becomes inefficient and the combustion exhaust gas stream is switched to a lower temperature bed. The incoming gas stream is then passed through the heated bed where it recovers the captured heat prior to entering the combustion zone (Figure 5a). By using multiple beds, regenerative systems have achieved up to 95% recovery of the thermal energy input to the system as fuel and the heat content of the combusted VOCs. Where the incoming gas stream contains sufficient thermal energy potential from VOC combustion, regenerative systems can

operate without external fuel (excluding the need for a pilot light). The efficiency of the thermal recovery system depends on the process operating characteristics. A process where the flow rate and VOC content are relatively constant has a good potential for achieving virtual no-fuel operation. Cyclic processes generally are not as compatible with regenerative oxidation systems. The absorbed heat is lost to the environment during periods of low activity. Operation with insufficient VOC content to supply thermal input requirements necessitates the use of external fuel sources.

Recuperative thermal oxidation systems recapture thermal energy with a simple metallic heat exchanger, typically a shell-and-tube design (Figure 5b). The maximum thermal energy recovery of a recuperative system is around 70% of the fuel and VOC combustion energy input to the system. The advantage over the regenerative system comes from the relatively short period required for the heat exchanger to reach operating conditions.

Catalytic oxidation:

Catalytic oxidation systems directly combust VOCs in a manner similar to thermal oxidizers. The main difference is that the catalytic system operates at a lower temperature—typically about 700–900° F. This is made possible by the use of catalysts that reduce the combustion energy requirements. The incoming gas stream is heated, most often in a recuperative heat exchanger followed by additional input from a burner if needed, and passed through a honeycomb or monolithic support structure coated with catalyst. Catalyst systems can be designed to handle a capacity of 1,000 to 100,000 cfm and VOC concentration ranges from 100 to 2,000 ppm. The catalytic system is well suited to low concentration operations or those that operate in a cyclic manner. They are often used for vent controls where flow rates and VOCs content are variable. Destruction efficiencies in excess of 90% are common with a maximum DRE of 95%

Reverse Flow Reactor (RFR):

A Reverse Flow Reactor (RFR) is an adiabatic packed bed reactor in which the direction of the feed flow is reversed periodically. Thus, the reactor is forced to operate under transient conditions. RFR is becoming a strong alternative for the removal of VOCs from polluted air because unsteady-state reactor operation can be profitable for the chemical process. The RFR, if operated on a large scale, will behave close to adiabatically. For the RFR the dynamics of the system should be well defined and not influenced by its surroundings. This excludes the use of insulation to obtain adiabatic conditions, because for a reasonable resistance against heat losses the amount of insulation needed is very large. The heat capacity of the insulation can easily be larger than that of the packed bed and thus a significant additional heat buffer is created. Also, applying compensation heating has to be voided, because in that case the dynamics of the system are certainly influenced and no more well defined. The best way of achieving adiabatic conditions and minimizing the influence of surroundings is making use of an evacuated jacket with the provision of a radiation shield at higher operating temperatures.

Recovery of VOCs:

Adsorption of VOCs:

The adsorption process is classified into two types, namely, *physical adsorption and chemisorption* based on the interaction between adsorbate and adsorbent. Physical adsorption has been found to be more significant in the case of separation processes.

Physical adsorption is again classified into Thermal Swing Adsorption (TSA) and Pressure Swing Adsorption (PSA), based on the operation of the process. Both the processes have their advantages and disadvantages. Physical adsorption occurs when organic molecules are held on the surface and in the pores of the adsorbent by the weak Van der Waals force of attraction and is generally characterized by low heat of adsorption, and by the fact that the adsorption equilibrium is reversible and rapidly established.

The proper adsorbent choice depends upon the application, but activated carbon and styrene/divinylbenzene macroporous resins are the preferred adsorbents for VOCs recovery.

Analysis of various VOC control techniques					
Techniques	Annual operating cost \$/cfm	Removal efficiency %	Secondary waste generated	Positive remarks	Negative remarks
Thermal oxidation	15–90 for recuperative, 20–150 for regenerative	95–99	Combustion products	Energy recovery is possible (maximum up to 85%)	Halogenated and other compounds may require additional control equipment downstream
Catalytic oxidation	15–90	90–98	Combustion products	Energy recovery is possible (maximum up to 70%)	Efficiency is sensitive to operating conditions. Certain compounds can poison the catalyst. May require additional control equipment downstream
Bio-filtration	15–75	60–95	Biomass	Requires less initial investment, less non-harmful secondary waste, and non-hazardous	Slow, and selective microbes decomposes selective organics, thus requires a mixed culture of microbes (which is difficult). No recovery of material.
Condensation	20–120	70–85	Condensate	Product recovery can offset annual operating costs	Requires rigorous maintenance. Not recommended for the materials having boiling points above 33°C
Absorption	25–120	90–98	Wastewater	Product recovery can offset annual operating costs	Requires rigorous maintenance. May require pretreatment of the VOCs. Design could be difficult due to lack of equilibrium data
Adsorption Activated carbon	10–35	80–90	Spent carbon and collected organics	Recovery of compounds, which may offset annual operating costs	Susceptible to moisture, and some compounds (ketones, aldehydes, and esters) can clog the pores, thus decreasing the efficiency
Zeolite	15–40	90–96	Collected organic, spent zeolite after several cycles	Effective in more than 90% RH, Recovery of compounds offsets annual operating costs	High cost of zeolite, restricted availability.
Membrane separation	15–30	90–99	Exhausted membranes	No further treatment, recovery of solvent may offset the operating costs	Membranes are rare and costly

Table 4: Overview/Analysis of various VOC control techniques¹⁶.

4.1.2 Summary

Catalytic combustion is a good alternative that overcomes some of limitations of Oxidation (the most commonly used technique). However, the Reverse Flow Reactor is the best alternative to oxidation in today's context of energy management.

Bio-filtration is a cheap and effective alternative for VOCs elimination. However, due to selective destruction, sluggishness, the applicability of this process is limited in commercial applications. This technique is in current research and it is possible that in future it would be the most preferred alternative.

Adsorption is the next most favored technique. It has good removal (recovery) efficiency, though it requires higher capital investment and operating costs. Desorption of adsorbent and separation of VOCs from desorbed solution increase the complexity and cost of the process.

If VOCs recovery is important, adsorption is as a good technique to be implemented. There are many solvent recovery units available commercially based on the adsorption principle¹⁶.

4.2. Management Measures

The importance of efficient management of outdoor and indoor air pollution cannot be overemphasized. Air pollution management aims at the elimination or reduction to acceptable levels, of airborne gaseous pollutants, suspended particulate matter and physical and, to a certain extent, biological agents whose presence in the atmosphere can cause adverse effects on human health (e.g., irritation, increase of incidence or prevalence of respiratory diseases, morbidity, cancer, excess mortality) or welfare (e.g., sensory effects, reduction of visibility), deleterious effects on animal or plant life, damage to materials of economic value to society and damage to the environment (e.g., climatic modifications). The serious hazards associated with radioactive pollutants, as well as the special procedures required for their control and disposal, also deserve careful attention.

Beyond considerations of emissions from fixed or mobile sources, air pollution management involves consideration of additional factors (such as topography and meteorology, and community and government participation, among many others) all of which must be integrated into a comprehensive program. For example, meteorological conditions can greatly affect the ground-level concentrations resulting from the same pollutant emission. Air pollution sources may be scattered over a community or a region and their effects may be felt by, or their control may involve, more than one administration. Furthermore, air pollution does not respect any boundaries, and emissions from one region may induce effects in another region by long-distance transport.

The objective of an air pollution management control system is to ensure that excessive concentrations of air pollutants do not reach a susceptible target. Targets could include people, plants, animals and materials. Air pollutants could include gases, vapors, aerosols and, in some cases, biohazards materials. A well designed system will prevent exposure to harmful concentrations of a pollutant.

¹⁶ http://www.chem.uw.edu.pl/people/AMyslinski/nowy/zarzadzanie_01/literature_HWW/02.pdf

Most air pollution control systems involve a combination of several control techniques, usually technological controls and administrative controls, and in larger or more complex sources there may be more than one type of technological control.

Typical measures in air quality management are control measures at the source, for example, enforcement of the use of catalytic converters in vehicles or of emission standards in incinerators, land-use planning and shut-down of factories or reduction of traffic during unfavorable weather conditions. The best air quality management stresses that the air pollutant emissions should be kept to a minimum; this is basically defined through emission standards for single sources of air pollution and could be achieved for industrial sources, for example, through closed systems and high-efficiency collectors.

Control measures for industrial facilities include adequate, well-designed, well-installed, efficiently operated and maintained air cleaning devices, also called separators or collectors. A separator or collector can be defined as an “apparatus for separating any one or more of the following from a gaseous medium in which they are suspended or mixed: solid particles (filter and dust separators), liquid particles (filter and droplet separator) and gases (gas purifier)”¹⁷.

It should be kept in mind that adequate operation and maintenance are indispensable to ensure the expected efficiency from a collector. This should be ensured at the planning stage, both from the know-how and financial points of view. Energy requirements must not be overlooked. Whenever selecting an air cleaning device, not only the initial cost but also operational and maintenance costs should be considered. Whenever dealing with high-toxicity pollutants, high efficiency should be ensured, as well as special procedures for maintenance and disposal of waste materials.

4.2.1 Selection of the Appropriate Control Measures

This selection can be made in the context of the problem to be solved (see also Table 5).

- a. What is emitted, in what concentration?
- b. What are the targets? What is the most susceptible target?
- c. What are acceptable short-term exposure levels?
- d. What are acceptable long-term exposure levels?
- e. What combination of controls must be selected to ensure that the short-term and long-term exposure levels are not exceeded?

Table 5. Steps in selecting pollution controls¹⁷:

Step	Process
Step 1: Define emissions.	The first part is to determine what will be released from the stack. All potentially harmful emissions must be listed. The second part is to estimate how much of each material will be released in order to be able to design a control program.
Step 2: Define target groups.	All susceptible targets should be identified. This includes people, animals, plants and materials. In each case, <u>the most susceptible member of each group must be identified</u> . For example, asthmatics near a plant that emits isocyanides.
Step 3: Determine acceptable exposure levels.*	An acceptable level of exposure for the most sensitive target group must be established. If the pollutant is a material that has cumulative effects, such as a carcinogen, then long-term exposure levels (annual) must be set. If the pollutant has short-term effects, such as an irritant or a sensitizer, a short-term or perhaps peak exposure level must be set.**
Step 4: Select controls.	Step 1 identifies the emissions, and Step 3 determines the acceptable level. In this step, each pollutant is checked to ensure that it does not exceed the acceptable level. If it exceeds the acceptable level, additional controls must be added, and the exposure levels checked again. This process continues until all exposures are at or below the acceptable level. Dispersion modelling can be used to estimate exposures for new plants or to test alternative solutions for existing facilities.

* When setting exposure levels in Step 3, it must be remembered that these exposures are total exposures, not just those from the plant. Once the acceptable level has been established, background levels, and contributions from other plants must be subtracted to determine the maximum amount that the plant can emit without exceeding the acceptable exposure level. If this is not done, and three plants are allowed to emit at the maximum, the target groups will be exposed to three times the acceptable level.

** Some materials such as carcinogens do not have a threshold below which no harmful effects will occur. Therefore, as long as some of the material is allowed to escape to the environment, there will be some risk to the target populations. In this case a no effect level cannot be set (other than zero). Instead, an acceptable level of risk must be established. Usually this is set in the range of 1 adverse outcome in 100,000 to 1,000,000 exposed persons.

4.2.2 The Fundamental Control measures in Industrial Facilities.

Substitution of materials. Examples: substitution of less toxic solvents for highly toxic ones used in certain industrial processes; use of fuels with lower sulfur content (e.g., washed coal), therefore giving rise to less sulfur compounds and so on.

Modification or change of the industrial process or equipment. Examples: in the steel industry, a change from raw ore to pelleted sintered ore (to reduce the dust released during ore handling); use of closed systems instead of open ones; change of fuel heating systems to steam, hot water or electrical systems; use of catalyzers at the exhaust air outlets (combustion processes) and so on.

Modifications in processes, as well as in plant layout, may also facilitate and/or improve the conditions for dispersion and collection of pollutants. For example, a different plant layout may facilitate the installation of a local exhaust system; the performance of a process at a lower rate may allow the use of a certain collector (with volume limitations but otherwise adequate). Process modifications that concentrate different effluent sources are closely related to the volume of effluent handled, and the efficiency of some air-cleaning equipment increases with the concentration of pollutants in the effluent. Both the substitution of materials and the modification of processes may have technical and/or economic limitations, and these should be considered.

The Role of Environmental Impact Assessment:

Environmental impact assessment (EIA) is the process of providing a detailed statement by the responsible agency on the environmental impact of a proposed action significantly affecting the quality of the human environment. EIA is an instrument of prevention aiming at consideration of the human environment at an early stage of the development of a program or project.

EIA is particularly important for countries which develop projects in the framework of economic reorientation and restructuring. EIA has become legislation in many developed countries and is now increasingly applied in developing countries and economies in transition.

EIA is integrative in the sense of comprehensive environmental planning and management considering the interactions between different environmental media. On the other hand, EIA integrates the estimation of environmental consequences into the planning process and thereby becomes an instrument of sustainable development. EIA also combines technical and participative properties as it collects, analyses and applies scientific and technical data with consideration of quality control and quality assurance, and stresses the importance of consultations prior to licensing procedures between environmental agencies and the public which could be affected by particular projects. A clean air implementation plan can be considered as a part of the EIA procedure with reference to the air.

Parameters Influencing Pollutant Dispersion:

Two types of parameters influence pollutant dispersion: source parameters and meteorological parameters. For source parameters, concentrations are proportional to the amount of pollutant which is emitted.

Meteorological parameters which influence pollutant dispersion are wind speed and direction, as well as vertical thermal stratification. The pollutant concentration is proportional to the reciprocal of wind speed. This is mainly due to the accelerated transport. Moreover, turbulent mixing increases with growing wind speed. As so-called inversions (i.e., situations where temperature is increasing with height) hinder turbulent mixing, maximum surface concentrations are observed during highly stable

stratification. On the contrary, convective situations intensify vertical mixing and therefore show the lowest concentration values.

Quality Assurance:

Measurements of ambient air pollutant concentrations can be costly to conduct, and results can affect significant decisions with serious economic or ecological implications. Therefore, quality assurance measures are an integral part of the measurement process. Two areas should be distinguished here.

Procedure-oriented measures:

Every complete measurement procedure consists of several steps: sampling, sample preparation and clean-up; separation, detection (final analytical step); and data collection and assessment. In some cases, especially with continuous measurement of inorganic gases, some steps of the procedure can be left out (e.g., separation). Comprehensive adherence to procedures should be strived for in conducting measurements. Procedures that are standardized and thus comprehensively documented should be followed, in the form of DIN/ISO standards, CEN standards or VDI guidelines.

User-oriented measures:

Using standardized and proven equipment and procedures for ambient air pollutant concentration measurement cannot alone ensure acceptable quality if the user does not employ adequate methods of quality control. The standards series ISO 9000 (Quality Management and Quality Assurance Standards), EN 45000 (which defines the requirements for testing laboratories) and ISO Guide 25 (General Requirements for the Competence of Calibration and Testing Laboratories) are important for user-oriented measures to ensure quality¹⁷.

Final statement based on field experience:

Steve Smith, technical advisor to the industry-funded Houston Regional Monitoring Network, which operates around a dozen air pollution monitoring stations around the city, says the key to keeping emissions low is simple: Keep an eye on it. “If you monitor, it will get better”¹⁸.

¹⁷ <http://www.ilocis.org/documents/chpt55e.htm>

¹⁸ <http://publicsource.org/investigations/houston-cleaning-up-pollution-going-after-ethane-cracker-emissions>

5. Conclusions and Outlook

The new cracker plant will definitely have an impact in Beaver County and even in Western Pennsylvania. There should be positive effects like new employment opportunities and in general a considerable investment in the infrastructure and other areas but there will also be mid and long term negative effect in the environment and also possible negative effect to the health of the population.

The 5,000 to 10,000 wells needed (for a 50 years production period) will require in total about 50,000 to 100,000 acres (approx. 10 acres for the well pad including access roads etc.) which will have a direct impact in the landscape of the area causing deforestation and habitat deprivation among other potential consequences to the environment.

Ethane which is the main source for the cracker plant is a not renewable source. What happens when the ethane is gone? What will happen to all those well pads? What will happen to the cracker plant and to the people working there?

Let's focus next on the direct impact on the air quality of the cracker plant.

The air emissions caused by the cracker plant specially the 632 tons of VOC that will be released to the air per year will have a potential negative impact on the air quality. What should be done is avoid the release of this emissions to the environment using for example the technical and management measures described in chapter 4.

But additional measures have not been required by the PA DEP, instead Shell is required to acquire ERCs, but these ERCs be used for the cracker plant will not counterbalance the impact on the air quality (see details in chapter 3.1.4). If further technical and/or management measures are not feasible (the reason for this unfeasibility should be clarified either by the PA DEP) why not at least improve the ERC system for example the EU emissions trading system requires that each year a company must surrender enough allowances to cover all its emissions, otherwise heavy fines are imposed and it is not possible to use allowances of companies that are not functioning anymore (in contrast to what Shell will possible do for its NO_x emissions).

Beyond all this let's take a step back and ask ourselves, do we need another cracker plant to produce more plastics? Finished products made of plastic are often non-biodegradable, so their disposal creates irreversible environmental damage in land and water. The amount of plastic waste contaminating our planet is staggering: There are 5.25 trillion pieces of plastic debris in the ocean alone. Of that mass, 269,000 tons float on the surface, while there is some four billion plastic microfibers per square kilometer of litter in the deep sea¹⁹.

As seen above there are quite many uncertainties about the sustainability of the cracker plant so why not invest something that has a clear sustainability footprint for example in renewable energy sources. Why not give the planned 15 year Tax cut to industries that will produce renewable energy (like solar panels) and sustainable production?

¹⁹ <http://news.nationalgeographic.com/news/2015/01/150109-oceans-plastic-sea-trash-science-marine-debris/>

Many questions have been stated which this report will and cannot give an answer, but the first steps to give an environmental and sustainability perspective to this very important subject have been taken, more should follow.

Following the outlook of what could be the next steps:

- Illustrate in detail the impact the immense number of wells that will be required to supply the cracker plant will have on the landscape of Western Pennsylvania, as well as Ohio and West Virginia.
- Make an estimation on how long the ethane supply will last and describe in detail what will be the consequences of the unavailability of ethane for the cracker plant and Beaver County/Western PA.
- Compare the impact on the ozone from 3 different sources of VOC to see if they differ, which would mean that buying VOC ERC from other industries does not equalize the impact of VOC output from a certain industry.
- Prepare a detailed proposal for the PA DEP of how the air emission that are supposed to be counterbalanced by the ERCs could be avoided (technical and management measures).
- Prepare a concept of building a plant which will produce renewable energy sources and prepare a comparison to the cracker plant (focusing on the economic and environmental impact).

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