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# APPENDIX C

## Cost Information

## Cost Information for Proposed New Regulation 13: Climate Pollutants, Rule 5: Industrial Hydrogen Plants

This appendix to the Rule 13-5 Staff Report lists various costs petroleum refinery hydrogen plant operators may incur to comply with Rule 13-5 emission requirements for total organic compounds and costs to comply with monitoring in Section 400 of Rule 13-5.

## Costs to Comply with Emission Limits

Hydrogen plants at two petroleum refineries, Valero and PBF Energy, are the only industrial hydrogen plants that do not presently comply with the total organic compound emission limits in Rule 13-5-301. All other hydrogen producers, including the Chevron, Marathon and P66 refineries, as well as Air Liquide, a third-party hydrogen supplier to the P66 Refinery, currently comply with the emission limits in Rule 13-5-301. The Air Products hydrogen plant associated with the Marathon refinery will also be in compliance with Rule 13-5-301 when it goes into effect whereas the Air Products hydrogen plant associated with the PBF refinery does not comply with Rule 13-5-301 limits. As stated in the Staff Report, representatives from the PBF refinery have confirmed with Air District staff they will cover the costs for the Air Products' hydrogen plants to comply with Rule 13-5.

The following is a list of cost estimates for each facility to comply Rule 13-5-301 total organic compound emission limits:

1. Valero
    a. Staff estimates the cost for Valero to purchase and install a flare system to be approximately $30,000,000.[1]
    b. Staff estimates the cost for Valero to install a hydrogen plant flare gas recovery system , an alternative control, to range between approximately $40,000,000 to $45,000,000. **Error! Bookmark not defined.**
    c. Staff estimates the cost for Valero to install a pressure swing adsorption (PSA) system is $177,666,667. The PSA system cost was estimated by scaling the maximum hydrogen production rate of the hydrogen plan to the cost estimate provided by PBF as shown below:
    Maximum Hydrogen Production Rate for Valero = 164 MMscf/day
    Maximum Hydrogen Production Rate for PBF for HP-1 and HP-2 = 120 MMscf/day
    Total PBF PSA Cost for HP-1 and HP-2 = $130,000,000
    Valero PSA Cost = ($130,000,000)(164 MMscf/day / 120 MMscf/day)) = $177,666,667
2. PBF Energy
    a. Staff estimates the cost for PBF Energy to purchase and install a flare system to be approximately $40,000,000. [2]
    b. Staff estimates the cost for PBF Energy to install a hydrogen plant flare gas recovery system, an alternative control, to range between approximately $50,000,000 to $55,000,000.[3]

[1] The cost estimate provided in this section was submitted to the Air District by Valero.
[2] The cost estimate provided in this section was submitted to the Air District by PBF Energy.
[3] The cost estimate provided in this section was submitted to the Air District by PBF Energy.

c. Staff estimates the cost for PBF Energy to install a pressure swing adsorption system is $130,000,000.[3]

Annualized Cost for Flare

Table 1 – Total Annualized Cost for Flare - PBF

| | | | |
|---|---|---|---|
| Total Capital Cost for a Flare | | $ | 40,000,000 |
| | Factors used | | |
| Amortization/Capital Recovery | 0.087 [4] | $ | 3,487,382 |
| Tax | 0.01 [5] | $ | 400,000 |
| Insurance | 0.01 [5] | $ | 400,000 |
| G&A (General & Administrative) | 0.02 [5] | $ | 800,000 |
| O&M (Operating and Maintenance) | *Specific costs used* | $ | 195,261 [6] |
| **Total annual cost (amortized capital + operating)** | | **$** | **5,282,643** |

Table 2 – Total Annualized Cost for Flare - Valero

| | | | |
|---|---|---|---|
| Total Capital Cost for a Flare | | $ | 30,000,000 |
| | Factors used | | |
| Amortization/Capital Recovery | 0.087 [4] | $ | 2,615,537 |
| Tax | 0.01[5] | $ | 300,000 |
| Insurance | 0.01[5] | $ | 300,000 |
| G&A (General & Administrative) | 0.02 [5] | $ | 600,000 |
| O&M (Operating and Maintenance) | *Specific costs used* | $ | 197,257 [6] |
| **Total annual cost (amortized capital + operating)** | | **$** | **4,012,793** |

Due to confidentiality requirements of the refineries, staff cannot itemize all of the costs listed above in great detail. However, some of major costs are referenced in general figures as follows:

[4] Capital recovery factor based on lifetime of 20 years, interest rate of 6%.
[5] Default factor per Cost Effectiveness BACT Policy and Implementation Procedure.
[6] Operating and maintenance cost calculated based on EPA Control Cost Manual.

- Total Capital Investment — $20,000,000 to $25,000,000 [7]
  - Flare ($3,500,000 to $5,000,000)
  - Knockout Drum ($450,000 to $600,000 per drum)
  - Gas Transport Piping including insulation and support structures (at a cost of $2500 to $3000 per linear foot for several thousand feet)
  - Monitoring Equipment ($450,000 to $600,000)
  - Instrumentation, Sales Tax & Freight ($950,000 to $1,400,000)

- Direct Installation — $2,750,000 to $3,850,000 [7]
  - Foundations/Supports & Handling/Erection ($2,500,000 to 3,500,000)
  - Electrical, Insulation and Painting ($250,000 to 350,000)

- Indirect Installation: [7]
  - Engineering/Construction/Contractor Fees ($2,500,000 to $3,500,000)
  - Startup/Performance Testing/Continency Fee ($2,500,000 to $3,000,000)

Annualized Cost for PSA System

Table 3 - Total Annualized Cost for PSA System - Valero

| | | | |
|---|---|---|---|
| Total Capital Cost for a PSA | | $ | 130,000,000 |
| | Factors used | | |
| Amortization/Capital Recovery | 0.087 [7] | $ | 11,333,992 |
| Tax | 0.01 [8] | $ | 1,300,000 |
| Insurance | 0.01 [8] | $ | 1,300,000 |
| G&A (General & Administrative) | 0.02 [8] | $ | 2,600,000 |
| O&M (Operating and Maintenance) | *0.05* [8] | $ | 6,500,000 |
| **Total annual cost (amortized capital + operating)** | | **$** | **23,033,992** |

[7] The cost estimate provided in this section was submitted to the Air District by Valero and PBF Energy.

Table 4 - Total Annualized Cost for PSA System - PBF

| | | | |
|---|---|---|---|
| Total Capital Cost for a PSA | | $ | 177,666,667 |
| | Factors used | | |
| Amortization/Capital Recovery | 0.087 [8] | $ | 15,489,790 |
| Tax | 0.01 [9] | $ | 1,776,667 |
| Insurance | 0.01 [8] | $ | 1,776,667 |
| G&A (General & Administrative) | 0.02 [8] | $ | 3,553,333 |
| O&M (Operating and Maintenance) | *0.05* [8] | $ | 8,883,333 |
| **Total annual cost (amortized capital + operating)** | | **$** | **31,479,790** |

**Costs to Comply with Emission Monitoring Requirements**

To help determine the costs to comply with monitoring requirements, staff has listed the number of vents for the different types of hydrogen plan vents in Table 1 below. The cost to comply with each specific vent monitoring requirement is multiplied by the number of vents.

**TABLE 5 – Vent Count at Each Facility**

| Facility | Number of Deaerator Vents | Number of $CO_2$ Scrubbing Vents | Total Number of Atmospheric Vents |
|---|---|---|---|
| Valero | 2 | 2 | 9 |
| PBF / Air Products | 4 | 2 | 9 |
| Marathon | 2 | 2 | 0 |
| P66 | 1 | 0 | 0 |
| Chevron | 2 | 0 | 0 |
| Air Liquide | 1 | 0 | 0 |

Based on multiple sources of information, including a 2017 EPA Flare Cost Manual, discussions with two separate flare system vendors and discussions with refinery representatives, the following price information was used estimate hydrogen plant operator costs to comply with monitoring requirements in Section 500 of Rule 13-15: [10] [11] [12] [13]

Capital Cost

[8] Capital recovery factor based on lifetime of 20 years, interest rate of 6%.
[9] Default factor per Cost Effectiveness BACT Policy and Implementation Procedure.
[10] https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-reports-and-guidance-air-pollution (see flare calculation tab)
[11] Discussions with Zeeco Inc., a vendor of flare systems
[12] Discussions with John Zink, Hamworthy-Combustion, a vendor of flare systems
[13] Discussions with Marathon Refinery representative

- Cost to purchase and install a flowrate meter – $100,000 to $110,000 per flowmeter
  Total # of flowmeters required = (# of Deaerator Vent + # of $CO_2$ Scrubbing Vent + # of Atmospheric Vent)
  Valero -Total # of flowmeter = 2+2+9 = 13
  -Flowmeter Cost = $1,300,000 to $1,430,000
  PBF/Air Products -Total # of flowmeter = 4+2+9 = 15
  -Flowmeter Cost = $1,500,000 to $1,650,000
  Marathon -Total # of flowmeter = 2+2 = 4
  -Flowmeter Cost = $400,000 to $440,000
  P66 -Total # of flowmeter = 1 = 1
  -Flowmeter Cost = $100,000 to $110,000
  Chevron -Total # of flowmeter = 2 = 2
  -Flowmeter Cost = $200,000 to $220,000
  Air Liquide -Total # of flowmeter = 1 = 1
  -Flowmeter Cost = $100,000 to $110,000

- Cost to purchase and install a sampling port – $4,000 to $6,000 per sampling port
  Total # of sampling port required = (# of Deaerator Vent + # of $CO_2$ Scrubbing Vent + # of Atmospheric Vent)
  Valero -Total # of flowmeter = 2+2+9 = 13
  -Sampling Port Cost = $52,000 to $78,000
  PBF/Air Products -Total # of flowmeter = 4+2+9 = 15
  - Sampling Port Cost = $60,000 to $90,000
  Marathon -Total # of flowmeter = 2+2 = 4
  - Sampling Port Cost = $16,000 to $24,000
  P66 -Total # of flowmeter = 1 = 1
  - Sampling Port Cost = $4,000 to $6,000
  Chevron -Total # of flowmeter = 2 = 2
  - Sampling Port Cost = $8,000 to $12,000
  Air Liquide -Total # of flowmeter = 1 = 1
  - Sampling Port Cost = $4,000 to $6,000

- Total Capital Cost for Monitoring
  Valero – $1,352,000 to $1,508,000
  PBF/Air Products – $1,560,000 to $1,740,000
  Marathon – $416,000 to $464,000
  P66 – $104,000 to $116,000
  Chevron – $208,000 to $232,000
  Air Liquide – $104,000 to $116,000

- Total Capital Cost for Monitoring – Amortized using capital recovery factor based on lifetime of 20 years, interest rate of 6%.

Table 5 – Annualized Monitoring Equipment Cost with Capital Recovery Factor based on Lifetime of 20 years and Interest rate of 6%.

| Facility | Total Flowmeter Cost - Amortized ($/year) | | Total Sampling Port Cost - Amortized ($/year) | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| Valero | $ 230,100 | $ 253,110 | $ 9,204 | $ 13,806 |
| PBF / Air Products | $ 265,500 | $ 292,050 | $ 10,620 | $ 15,930 |
| Marathon | $ 70,800 | $ 77,880 | $ 2,832 | $ 4,248 |
| P66 | $ 17,700 | $ 19,470 | $ 708 | $ 1,062 |
| Chevron | $ 35,400 | $ 38,940 | $ 1,416 | $ 2,124 |
| Air Liquide | $ 17,700 | $ 19,470 | $ 708 | $ 1,062 |
| Total | $ 637,200 | $ 700,920 | $ 25,488 | $ 38,232 |

Annual Costs

- For quarterly monitoring and composition monitoring via manual sample, there are no capital costs associated with these monitoring items other than the installation of sampling port which has been calculated and included as presented above.

- Cost to perform quarterly monitoring – $28,000 to $80,000 per year-vent (if scaffolding required)
  Total # of vents require quarterly monitoring
  = (# of Deaerator Vent + # of $CO_2$ Scrubbing Vent)
  Valero -Total # of vents = 2+2 = 4
  -Quarterly Monitoring Cost = $112,000 to $320,000 per year
  PBF/Air Products -Total # of vents = 4+2 = 6
  -Quarterly Monitoring Cost = $168,000 to $480,000 per year
  Marathon -Total # of vents = 2+2 = 4
  -Quarterly Monitoring Cost = $112,000 to $320,000 per year
  P66 -Total # of vents = 1 = 1
  -Quarterly Monitoring Cost = $28,000 to $80,000 per year
  Chevron -Total # of vents = 2 = 2
  -Quarterly Monitoring Cost = $56,000 to $160,000 per year
  Air Liquide -Total # of vents = 1 = 1
  -Quarterly Monitoring Cost = $28,000 to $80,000 per year

- Cost to perform gas composition monitoring via manual sample - $134,886 to $171,386 per year-vent
  Total # of vents require composition monitoring = (# of Deaerator Vent + # of $CO_2$ Scrubbing Vent + # of Atmospheric Vent)

  Valero -Total # of vents = 2+2+9 = 13
  - Gas Composition Monitoring Cost = $1,753,515 to $2,228,015 per year
  PBF/Air Products -Total # of vents = 4+2+9 = 15
  - Gas Composition Monitoring Cost = $2,023,286 to $2,570,786 per year
  Marathon -Total # of vents = 2+2 = 4
  - Gas Composition Monitoring Cost = $539,543 to $685,543 per year

P66 -Total # of vents = 1 = 1

- Gas Composition Monitoring Cost = $134,886 to $171,386 per year

Chevron -Total # of vents = 2 = 2

- Gas Composition Monitoring Cost = $269,772 to $342,772 per year

Air Liquide -Total # of vents = 1 = 1

-Composition Monitoring Cost = $134,886 to $171,386 per year

Table 2 below lists a range of costs to comply with each monitoring requirement.

Table 6 – Total Annualized Cost for the Emissions and Monitoring Requirement

| Facility | Capital Cost to Comply with Section 13-5-301 | Annualized Cost to Install Flowmeter | Annualized Cost for Quarterly Monitoring at Deaerator/$CO_2$ Vents | Annualized Cost to Install Sampling Port at Deaerator/$CO_2$ Vents | Annualized Cost to Monitor Gas Composition |
|---|---|---|---|---|---|
| Valero | $30,000,000 ($4,020,114 annualized) | $230,100 to $253,110 - annualized | $112,000 to $320,000 - annualized | $9,204 to $13,806 - annualized | $1,753,515 to $2,228,015 - annualized |
| PBF Energy | $40,000,000 ($5,284,833 annualized) | $265,500 to $292,050 - annualized | $168,000 to $480,000 - annualized | $10,620 to $15,930 - annualized | $2,023,286 to $2,570,786 - annualized |
| Marathon | N/A – therefore no cost | $70,800 to $77,880 - annualized | $112,000 to $320,000 - annualized | $2,832 to $4,248 - annualized | $539,543 to $685,543 - annualized |
| Phillips 66 | N/A – therefore no cost | $17,700 to $19,470 - annualized | $28,000 to $80,000 - annualized | $708 to $1,062 - annualized | $134,886 to $171,386 - annualized |
| Chevron | N/A – therefore no cost | $35,400 to $38,940 - annualized | $56,000 to $160,000 - annualized | $1,416 to $2,124 - annualized | $269,772 to $342,772 - annualized |
| Air Liquide | N/A – therefore no cost | $17,700 to $19,470 - annualized | $28,000 to $80,000 - annualized | $708 to $1,062 - annualized | $134,886 to $171,386 - annualized |
| Total | $70,000,000 ( $8,040,227 annualized ) | $637,200 to $700,920 - annualized | $504,000 to $1,440,000 - annualized | $25,488 to $38,232 - annualized | $4,855,887 to $6,169,887 - annualized |

Total Annualized Cost = (Annualized Cost to Comply with Section 13-5-301) + (Annualized Cost to Install Flowmeter) + (Annualized Cost to for Quarterly Monitoring) + (Annualized Cost to Install Sampling Port) + (Annualized Cost to Monitor Gas Composition)

Table 7 – Total Annualized Cost for Each Facility

| Facility | Total Annualized Cost - Minimum ($/year) | Total Annualized Cost - Maximum ($/year) |
|---|---|---|
| Valero | $6,124,932 | $6,835,044 |
| PBF Energy | $7,752,240 | $8,643,600 |
| Marathon | $725,175 | $1,087,671 |
| Phillips 66 | $181,294 | $271,918 |
| Chevron | $362,588 | $543,836 |
| Air Liquide | $181,294 | $271,918 |
| Total | $15,327,522 | $17,653,986 |

Annualized potential cost for all hydrogen plants to comply with emissions standards and monitoring requirements of Rule 13-5 is estimated from approximately $15,327,522 to $17,653,986. It should be noted that estimated costs in Table 7 above represent the upper end of potential costs for each facility to comply with the requirement of the Rule, since the most facilities likely already collect the data required to comply with the monitoring requirement of this Rule. It should also be noted that the cost to install atmospheric monitoring equipment can be avoided if a facility can demonstrate that atmospheric vents can no longer vent to atmosphere after the vent control technology is installed and operational. Therefore, staff anticipates the cost to comply with monitoring requirements to be less than the figures in Table 7.

**Costs for the Alternative Reduction Measures proposed by Valero and PBF**

Due to confidentiality requirements of the refineries, staff cannot itemize all of the costs listed above in detail.

The cost for the alternative reduction measures proposed by Valero is estimated to be $6,000,000.[14] This includes the cost of equipment, piping, painting, insulation, foundation, instrumentation, electrical, scaffolding, engineering, permitting, tax, freight, project contingency, infrastructure, and operation costs.

The cost for the alternative reduction measures proposed by PBF is estimated to range from $5,000,000 to $10,000,000. The [15]cost includes computer control, equipment, existing equipment upgrade, and engineering costs.

[14] The cost estimate provided in this section was submitted to the Air District by the Valero.
[15] The cost estimate provided in this section was submitted to the Air District by the PBF Energy.