Transforming Chemicals Production in Louisiana

Methodology and Assumptions

Lever Impact Evaluation Methodology

AI-Driven Predictive Maintenance

1. Scope

- **Technology:** Sensors and AI analytics used to identify emerging failures in pumps, compressors, valves, motors, and instrumentation before they cause a unit upset, shutdown, venting, or flaring.
- **Modeled population:** 29 Louisiana primary-chemical facilities producing hydrogen, ammonia, methanol, or olefins. Aromatics are not included in the current Louisiana scaling population.
- **Event dataset:** 162 maintenance-related TCEQ emissions events reported at nine sampled Texas facilities during 2021–2025; chemical-specific annual rates are extrapolated to Louisiana.
- **Boundary:** Includes events whose reported cause appeared fully or partly detectable through equipment monitoring; excludes power outages, weather, operator error, and sudden failures without a detectable precursor.
- **Interpretation:** High-end Louisiana statewide screening estimate based on cross-state extrapolation; not a prediction of deployment or a guarantee that identified events would be prevented.

2. Methodology

Event identification and emissions

- **Addressability review:** Each event received a weight of 1.0 (detectable), 0.5 (partly detectable), or 0 (not detectable) based on the reported failure mechanism. Weighted addressable events totaled 137.5, or 84.9% of the sample.
- **Time basis:** The 2021–2025 event counts and pollutant totals were divided by five to estimate an average annual rate before statewide scaling, ton reporting, and application of predictive-maintenance effectiveness.
- **State scaling:** For each chemical type, annualized weighted events and emissions per sampled Texas facility were multiplied by the corresponding modeled Louisiana facility count.
- **Headline case:** A 60% intervention-effectiveness factor and 100% statewide-representativeness factor were applied to 84.6 modeled addressable events/year, yielding 50.8 potentially avoided events/year (approximately 1.8 per facility).
- **Avoided emissions:** Reported emissions were weighted for addressability, converted to tons, annualized, scaled by chemical type, and multiplied by the headline factors. CO_2 was derived for selected flaring events when not reported, using flare-stream composition and combustion assumptions.
- **Headline results:** Approximately 30,000 tons CO_2/year, 13 tons NO_x/year, 57 tons VOC/year, 2.5 tons benzene/year, and 3 tons 1,3-butadiene/year.

Cost and economic benefits

- **Deployment cost:** Five-year costs include software licensing, connectivity, enterprise support, vendor installation, and internal installation labor. Modeled cost is $0.43–$0.75 million per facility, or $12.5–$21.9 million statewide over five years.
- **Production-benefit method:** Annual avoided events are multiplied by the probability of production interruption, downtime, affected facility production, the unrecoverable share of affected output, and a high-end hourly production-value proxy.
- **Affected versus unrecoverable production:** The assumptions are independent: 40% of full-facility production is affected during an interruption, and 60% of that affected output cannot be made up later. The remaining affected output is assumed recoverable through rescheduling, higher utilization, or inventory management.
- **High-end hourly value:** $400,000 per full-facility hour is retained as a high-end screening proxy. Public condition-monitoring guidance notes that production value at major continuous petrochemical facilities can reach tens to hundreds of thousands of dollars per hour and recommends site-specific accounting. After the 40% affected and 60% unrecoverable factors, the model values permanent loss at $96,000 per downtime hour.
- **Modeled benefits:** Avoided lost production value is $6.34 million/facility/year, or $183.7 million statewide/year. Adding the high-end COBRA health benefit of $0.42 million yields a total modeled annual benefit of about $184.2 million.

3. Key Calculations

- **Addressable share** = Σ event addressability weights ÷ total events = 137.5 ÷ 162 = 84.9%.
- **Annualized statewide addressable events** = Σ[(five-year weighted events ÷ five years ÷ sampled Texas facilities) × modeled Louisiana facilities] = 84.6 events/year.
- **Potentially avoided events** = 84.6 × 60% effectiveness × 100% representativeness = 50.8 events/year.
- **Avoided emissions** (tons) = Σ[(five-year weighted pollutant totals ÷ five years ÷ sampled facilities) × statewide facilities] × effectiveness × representativeness.
- **Five-year deployment cost** = Year 1 cost + 4 × annual year 2–5 cost.
- **Avoided production value/site** = 1.83 events/year × 75% interruption probability × 48 hours × 40% affected production × 60% unrecoverable share × $400,000/full-facility hour = $6.3 million/year.
- **Annual benefit total** = $183.7 million avoided lost production value + $0.42 million monetized health benefits = $184.2 million/year.

4. Key Limitations

- The empirical sample consists of nine Texas facilities and is dominated by olefins events; event rates and severities may not represent all 29 modeled Louisiana facilities.
- Annualization assumes comparable five-year reporting coverage across sampled facilities; incomplete or partial-year reporting would affect annual event and emissions rates.
- Addressability classifications, 60% effectiveness, and 100% representativeness are high-end expert-judgment scenarios, not measured predictive-maintenance performance.
- Cross-state scaling assumes similar event frequency and severity within each chemical type in Texas and Louisiana and does not adjust for site size, age, existing monitoring, or equipment condition.
- TCEQ event reports vary in completeness; CO_2 for some flaring events is estimated, and preventing an upset may shift some emissions to planned maintenance rather than eliminate them.

- Deployment costs are screening estimates and may omit sensor hardware, control-system integration, cybersecurity, data preparation, training, and added staffing.
- The $400,000/hour value is a high-end order-of-magnitude proxy, not a verified statewide average contribution margin. The affected-production and unrecoverable-output shares are separate screening assumptions, and actual losses depend on product margins, inventories, contractual effects, and production recovery.
- The current Louisiana facility population excludes aromatics; results therefore do not represent potential benefits at Louisiana aromatics facilities.
- COBRA is a screening model; results do not monetize direct benzene or 1,3-butadiene exposure, worker impacts, acute peaks, safety benefits, repair costs, or reputational effects.

5. Sources

- TCEQ Reports of Air Emissions Events: 2021–2025 event causes and reported pollutant quantities. Source quantities were converted to tons for reporting. These Texas records provide the empirical event sample used for Louisiana extrapolation.
- EPA COBRA Screening Model: monetized $PM_{2.5}$- and ozone-related health benefits.
- EPA GHG Emission Factors Hub: natural-gas combustion CO_2 factor used in selected derived calculations.
- EPA AP-42, Section 1.4 - Natural Gas Combustion: combustion-emissions reference.
- US Patent US7838712B2: project proxy for steam-cracker product composition used in selected CO_2 calculations.
- Tractian, How to Build the Board-Level Case for Condition Monitoring in Chemical Operations: supports the high-end order of magnitude for hourly production value at major continuous petrochemical facilities; recommends using site-specific production accounting where available.

Low-Leak Natural Gas Procurement

1. Scope

- **Lever:** Procurement of low-methane-intensity natural gas by target Louisiana chemical production facilities.
- **Modeled intervention:** Shift modeled upstream methane intensity from 1.71% to 0.20%, representing an 85.2% reduction in upstream methane loss intensity.
- **Modeled Louisiana gas procurement denominator:** 360.9 million MMBtu/year of natural gas procurement, including fuel and feedstock for target Louisiana chemical production.
- **Included processes:** Steam cracking, non-refinery BTX, hydrogen, methanol, and ammonia.
- **Boundary:** Includes upstream methane leakage associated with natural gas supplied to target chemical production; does not model on-site equipment changes at chemical facilities.
- **Health screening boundary:** Uses associated upstream VOC reductions as a proxy COBRA input; does not value methane directly in COBRA.
- **Interpretation:** Full-procurement screening scenario assuming all modeled Louisiana chemical-sector natural gas procurement transitions to low-leak gas; not an estimate of achievable near-term adoption or physically delivered certified gas.

2. Methodology

Emissions

- **Demand denominator:** Start with annual natural gas procurement for target Louisiana chemical production, including fuel and feedstock.
- **Methane represented by purchased gas:** Convert gas procurement from MMBtu to methane mass using 1,010 Btu/scf methane heat content and 19.23 g CH_4/scf methane mass conversion.
- **Methane-intensity change:** Apply the difference between the baseline methane intensity of 1.71% and the low-leak target of 0.20%.
- **Avoided methane:** The modeled procurement shift avoids approximately 104,000 tons CH_4/year.
- **Climate impact:** Avoided methane is converted to CO_2e using fossil methane GWP20 = 82.5, resulting in approximately 8.6 million tons CO_2e/year avoided.
- **VOC proxy for health screening:** Avoided methane is translated to associated upstream VOC reductions using EPA's rule-wide ratio of 16 million tons VOC / 58 million tons methane, resulting in approximately 29,000 tons VOC/year entered into COBRA.
- **COBRA setup:** COBRA run uses the 2023 baseline, Louisiana as the location, and the closest available upstream oil-and-gas production sector. The resulting monetized health benefit is approximately $22 million/year.

Cost

- **Incremental low-leak procurement cost:** reported cost of $0.01 to $0.12/MMBtu for certified gas.

3. Key Calculations

- Methane represented by purchased gas = gas procurement × 10^6 ÷ methane heat content × methane mass conversion ÷ grams per short ton.
- Methane-intensity difference = baseline methane intensity − low-leak methane intensity.
- Avoided methane = methane represented by purchased gas × methane-intensity difference.
- Avoided CO_2e = avoided methane × fossil methane GWP20.

VOC proxy input = avoided methane × EPA VOC-to-methane reduction ratio.

4. Key Limitations

- This is a procurement screening scenario, not a facility-level engineering retrofit model.
- The gas procurement denominator is a project estimate for target Louisiana chemical production and does not represent measured facility-level purchase contracts.
- The modeled methane benefit depends on the assumed upstream baseline methane intensity of 1.71% and target intensity of 0.20%.
- COBRA does not model methane directly; health benefits reflect associated upstream VOC reductions only.
- COBRA results do not value climate damages, methane-driven global background ozone, or hazardous air pollutants.
- The Louisiana statewide COBRA run is a geographic proxy for upstream supply; actual purchased gas may originate outside Texas.
- Results do not address market complexities such as physical delivery, certificate ownership, chain of custody, double counting, or certification-market availability.

5. Sources

- International Energy Agency Methane Tracker: methane abatement cost stack.
- EPA final oil and natural gas methane rule: methane and VOC co-reduction proxy.

- EPA COBRA Web Edition and COBRA methodology: health benefit screening.
- IPCC AR6 WG1, Chapter 7, Table 7.15: fossil methane GWP20.
- EIA methane heat content value: 1,010 Btu/scf.
- EPA methane unit conversion table: 1 scf methane = 19.23 g methane.
- Manufacturing Energy Consumption Survey, GHGRP, and RMI analysis: gas usage by chemical facilities in project scope.

NO_x Emissions Control Technologies

1. Scope

- Technologies: Low-NO_x burner and combustion-control retrofits (LNBs), selective catalytic reduction (SCR), and a stacked case that applies LNBs before SCR.
- Facility universe: 28 core facilities; 26 were matched to 31 LDEQ emissions records.
- Modeled baseline: 20,000 tons NO_x/year from matched 2025 LDEQ annual certified facility records.
- Eligible emissions: Facility-level NO_x from matched chemical sites. Texas product-specific opportunity rates — derived from boilers, furnaces, and process heaters — are used because the Louisiana inventory does not provide comparable unit-level detail.
- Interpretation: Incremental control-opportunity screen from current reported emissions; not an uncontrolled baseline, total chemical-sector inventory, or unit-level retrofit plan.

2. Methodology
Emissions

- Inventory construction: Audited facilities were mapped to LDEQ Agency Interest records; multiple records for one physical complex were combined, and unmatched sites were not imputed.
- LNB central case: Each Louisiana facility is assigned a product category, and the corresponding Texas unit-screening LNB reduction share is applied to its current facility NO_x. Central product rates range from 0.16% for ammonia to 7.73% for olefins.
- SCR central case: Texas product-specific SCR opportunity shares are applied to Louisiana facility NO_x. Central product rates range from 7.57% for methanol to 13.11% for olefins; these rates reflect the Texas screen for larger eligible combustion sources.
- Stacked case: Product-specific Texas stacked rates apply LNB first and SCR to the remaining emissions from screened candidates. Stand-alone LNB and SCR results should not be added.
- Central results: LNBs reduce 1,300 tons/year; SCR reduces 2,412 tons/year; the stacked case reduces 3,700 tons/year. Olefins account for approximately 96% of LNB, 87% of SCR, and 90% of stacked reductions.

Cost and health benefits

- Average annualized costs: $2.1 million/year for LNBs, $26.6 million/year for SCR, and $28.7 million/year for the stacked case. The stacked cost equals the LNB cost plus SCR cost on the screened portfolio.
- COBRA screen: A 1 ton Louisiana chemical-sector NO_x reduction run produced low and high monetized benefits equivalent to approximately $21,800–$25,000 per ton. Midpoint benefits are $30.1 million/year for LNBs, $56.4 million/year for SCR, and $86.6 million/year for the stacked case.

3. Key Calculations

- Texas product proxy rate = Texas modeled control reduction for a product category ÷ current matched Texas NO_x for that category.
- Louisiana control reduction = current matched LDEQ facility NO_x × the corresponding Texas product-specific LNB, SCR, or stacked proxy rate.
- Stacked reduction applies the Texas product-specific stacked rate, which reflects LNB first and SCR on the post-LNB residual.
- Annualized control cost = modeled reduction × annualized cost-effectiveness input; all cost inputs were converted to dollars per ton for reporting.
- COBRA health benefit = modeled reduction × midpoint monetized benefit per ton.

4. Key Limitations

- LDEQ records used here are facility-level and do not identify which combustion units, source types, emission rates, or controls drive each facility total.
- Louisiana reduction potential relies on Texas product-specific opportunity rates. Differences in equipment mix, existing controls, utilization, and source composition make this the lowest-confidence component of the analysis.
- The baseline covers matched 2025 public records only; two unmatched core facilities are excluded rather than imputed.
- SCR feasibility is not screened for exhaust temperature, catalyst compatibility, ammonia handling, ductwork, space, unit age, remaining life, or outage timing.
- Annualized $/ton ranges are policy-scale screening assumptions, not engineering estimates; they do not provide a capital/O&M split or unit-specific retrofit cost.
- COBRA values are extrapolated from a one-ton screening run. The parish-level scenario input tables should be rerun and imported before final publication; COBRA also does not capture all localized or worker-exposure effects.
- The stacked case represents broad technical opportunity, not an optimized deployment sequence or forecast of achievable adoption.

5. Sources

- LDEQ, Annual Certified Emissions: 2025 facility-level NOx and parish; TCEQ, Point Source Emissions Data: Texas unit/source data used to derive product-category proxy rates.
- US EPA, NOx Emissions from Process Heaters: LNB/SCR performance and cost context.
- US EPA, SCR Cost Manual and Cost Equations: control-cost methodology and future unit-level upgrades.
- US EPA, Non-EGU NOx Control Assessment: control-efficiency and cost ranges.
- US EPA, COBRA Screening Model: monetized $PM_{2.5}$- and ozone-related health benefits.

Thermal Energy Storage (TES) for Industrial Steam

1. **Scope**
    - **Technology:** Electric thermal energy storage (TES) replacing steam supplied by conventional natural gas boilers.
    - **Included processes:** Steam cracking and other olefins, non-refinery BTX, hydrogen, methanol, and ammonia.

- Modeled Louisiana heat demand denominator: 26 million MMBtu/year of natural gas boiler fuel, equivalent to 21 million MMBtu/year of useful steam heat.
- **Boundary:** Includes conventional natural gas boiler steam; excludes feedstock use, CHP/cogeneration, direct-fired process heat, purchased steam, and non-natural-gas boiler fuel.
- **Interpretation:** Gross statewide technical-potential screen assuming full displacement of eligible boiler load; not an estimate of achievable or near-term deployment.

2. **Methodology**

Emissions

- Demand denominator: Start with national natural gas fuel estimates by target process; allocate to Louisiana using production, capacity, facility, and GHGRP-based activity indicators; apply process-specific conventional-boiler shares from EIA 2022 MECS Table 5.2; convert fuel to useful heat at 80% boiler efficiency.
- Natural gas baseline: Boiler fuel × 53.06 kg CO_2/MMBtu = 1.38 million tons CO_2/year.
- TES electricity demand: Useful heat × 293.071 kWh/MMBtu ÷ 98% efficiency = 6.24 TWh/year.
- Current-grid case: Electricity demand × Louisiana 2024 average generation intensity (0.420 kg CO_2/kWh) = 2.6 million tons CO_2/year, or 1.2 million tons above the gas baseline.
- Zero-emissions case: Charging intensity = 0 kg CO_2/kWh; avoided boiler emissions = 1.4 million tons CO_2/year.
- Onsite air pollutants: NO_x, VOC, SO_2, and $PM_{2.5}$ reductions use EPA AP-42 screening factors and do not reflect boiler-specific controls.

Cost

- **Primary comparison:** Energy cost only — natural gas fuel for boiler heat versus electricity for TES heat. TES capital, fixed O&M, interconnection, and installation costs are excluded.
- Average 2025 prices: Gas at $4.49/MCF yields boiler heat at $5.41/MMBtu; electricity at $62.30/MWh yields TES heat at $18.63/MMBtu. Annual energy expenditure rises from $113 million to $389 million, a $276 million premium.
- Favorable energy-price scenario: 2022 gas at $7.18/MCF yields boiler heat at $8.65/MMBtu; TES charging at $30/MWh yields TES heat at $8.97/MMBtu, a 3.7% or $6.6 million annual premium.
- Interpretation: Results are not a levelized cost of heat or full project-cost comparison.

3. **Key Calculations**

- **Eligible useful heat** = state-allocated process fuel × conventional-boiler share × boiler efficiency.
- **Gas heat cost** = gas price ÷ natural gas energy content ÷ boiler efficiency.
- **TES heat energy cost** = electricity price × 0.293071 MWh/MMBtu ÷ TES efficiency.
- **TES electricity demand** = useful heat × 293.071 kWh/MMBtu ÷ TES efficiency.
- **Energy-only abatement cost** = incremental electricity expenditure ÷ operational CO_2 avoided.
- **Illustrative infrastructure requirement:** 11.2 GWh of thermal storage and 2.14 GW of electric charging capacity.

4. **Key Limitations**

- National MECS boiler shares and state activity allocations are screening proxies, not measured facility steam consumption.
- Full displacement does not account for technical suitability, steam conditions, load shape, redundancy, retrofit timing, or site constraints.

- Current-grid emissions use annual-average generation intensity rather than hourly marginal emissions; low-price hours are not assumed to be low-emissions hours.
- The $30/MWh case is an illustrative final all-in price, not an available tariff or market forecast.
- Energy-only economics exclude equipment, O&M, interconnection, electrical upgrades, steam integration, installation, engineering, contingency, and financing.
- Infrastructure sizing assumes a flat average load and an eight-hour daily charging period.

5. **Sources**
   - EIA 2022 Manufacturing Energy Consumption Survey, Table 5.2: Conventional-boiler fuel shares.
   - EIA Natural Gas Navigator: 2022 and 2025 Louisiana industrial natural gas prices.
   - EIA Electric Power Monthly, Table 5.6.B: 2025 Louisiana industrial electricity price.
   - EIA Louisiana State Electricity Profile, 2024: Average grid generation emissions.
   - EPA GHG Emission Factors Hub: Natural gas CO_2 factor.
   - EPA AP-42, Section 1.4: Natural gas boiler air-pollutant factors.

High-Purity CCS for Hydrogen and Related Primary Chemical Production

1. Scope

- **Technology:** Carbon capture and storage applied to high-purity process CO_2 streams associated with hydrogen and related primary chemical production.
- **Included processes in the model:** Hydrogen, ammonia, and methanol.
- **Modeled Louisiana facility count:** 12 hydrogen facilities, 4 ammonia facilities, and 2 methanol facilities.
- **Modeled cases:**
  - **Louisiana + CCS:** CCS deployed using the Louisiana grid emissions factor for added electricity demand.
  - **Louisiana Renewable + CCS:** CCS deployed assuming 100% renewable electricity for added electricity demand.
- **Interpretation:** Statewide screening estimate of emissions-reduction potential from CCS on high-purity process streams. This is not a facility-specific engineering design or a full project-level investment estimate.

2. Methodology

Emissions

- **Baseline emissions intensity:** Start with RMI's internal *Chemistry in Transition* emissions model for baseline emissions intensities by primary chemical.
- **CCS case emissions intensity:** Apply CCS-adjusted emissions intensities for hydrogen, ammonia, and methanol.
- **Statewide reduction:** Multiply the change in emissions intensity by average production volume and the number of facilities in Louisiana.
- **Grid case:** Uses Louisiana grid electricity emissions for added CCS electricity demand.
- **Renewable case:** Assumes added CCS electricity demand is supplied by 100% renewable electricity.

- **GHGs**
    - Percent reduction from Louisiana primary chemicals baseline:
        - Louisiana + CCS: 15.8%.
        - Louisiana Renewable + CCS: 19.1%.
- **Air pollutants**
    - The model estimates changes in VOC, CO, NOx, PM_{10}, $PM_{2.5}$, SOx, and CH_4.
    - In the Louisiana + CCS grid-powered case, several CAPs increase because added CCS energy demand increases upstream or power-sector emissions.
    - Total CAPs reduction in the renewable case is approximately 1.0%.

Cost

- **Estimated statewide capex:** $5.09 billion.
- **Statewide annual cost before 45Q:** $881 million/year.
- **Cost per net ton CO_2e avoided before 45Q:** $122/t$CO_2$e.
- **Statewide annual net cost after $85/ton 45Q:** $267 million/year.
- **Cost per net ton CO_2e avoided after $85/ton 45Q:** $37/t$CO_2$e.
- **Interpretation:** Cost results are screening-level estimates and do not include full project-finance, tax-equity, site-specific engineering, pipeline, storage, or transaction-cost detail beyond what is represented in the model.

3. Key Calculations

- **Louisiana statewide primary chemicals baseline emissions** = baseline emissions intensity × average production volume × number of facilities.
- **CCS case emissions** = CCS-adjusted emissions intensity × average production volume × number of facilities.
- **GHG reduction** = baseline emissions − CCS case emissions.
- **Percent reduction from primary chemicals baseline** = total GHG reduction ÷ Louisiana statewide primary chemicals baseline emissions.
- **Statewide annual cost after 45Q** = annual cost before 45Q − value of 45Q credit.
- **Cost per net ton CO_2e** = annual cost ÷ net CO_2e avoided.

4. Key Limitations

- The model is a statewide screening analysis, not a facility-specific CCS deployment plan.
- Facility production is estimated using average production volumes and facility counts, not measured facility-level production.
- Results depend on RMI's internal *Chemistry in Transition* emissions model and CCS-adjusted emissions intensities.
- The grid-powered CCS case can increase some criteria air pollutants due to added energy demand.
- The renewable case assumes 100% renewable electricity for added CCS load and does not evaluate hourly matching, interconnection, or electricity procurement constraints.

- CAP and CH_4 results are directional screening estimates and should not be interpreted as permit-level emissions estimates.
- Cost results do not include project-specific pipeline distance, storage-site availability, permitting, pore-space access, financing structure, tax-credit monetization, or liability considerations.
- The 45Q sensitivity assumes an $85/ton credit value but does not model eligibility, transfer discounts, tax appetite, transaction costs, or credit sharing.

5. Sources

- RMI internal emissions and cost modeling
- EPA GHGRP / FLIGHT: facility-level greenhouse gas reporting framework.
- DOE/NETL, Cost of Capturing CO_2 from Industrial Sources: capture cost and energy assumptions.
- EPA eGRID: grid emissions factors.
- EPA GHG Emission Factors Hub: natural gas combustion emissions factors.
- IPCC AR6: fossil methane GWP assumptions.
- IRS 45Q guidance: carbon dioxide sequestration credit sensitivity.

COBRA Assumptions & Outputs

AI-Driven Predictive Maintenance

Exhibit 1: COBRA assumptions for AI-driven predictive maintenance

Counties	Ascension, Calcasieu, East Baton Rouge, Iberville, Jefferson, Orleans, Ouachita, St. Charles, St. James, St. John the Baptist
Sector/Subsectors	Chemical & Allied Product > Organic Chemical
Discount rate	2%
$PM_{2.5}$ reduce by (short tons)	0.04
SO_2 reduce by (short tons)	0.04
NO_x reduce by (short tons)	14.65
VOC reduce by (short tons)	62.72

Exhibit 2: COBRA outputs for AI-driven predictive maintenance

Total Annual Health Benefits to Louisiana		
	$374,482	**$422,180**
	Low Value	**High Value**

	Change in Incidence	Monetary Value
Total Mortality	**0.023 / 0.026**	**$328,440 / $376,137**
Mortality, All Cause (PM)	0.002 / 0.006	$35,985 / $83,683
Mortality, O3 Short-term Exposure (O3)	0.001	$12,619
Mortality, O3 Long-term Exposure (O3)	0.019	$279,836
Nonfatal Heart Attacks (PM)	**0.002**	**$137**
Infant Mortality (PM)	**0.000**	**$501**
Total Hospital Admits, All Respiratory	**0.002**	**$46**
Hospital Admits, All Respiratory (PM)	0.000	$7
Hospital Admits, All Respiratory (O3)	0.002	$39
Total Emergency Room Visits, Respiratory	**0.064**	**$103**
Emergency Room Visits, Respiratory (PM)	0.002	$3
Emergency Room Visits, Respiratory (O3)	0.061	$100
Total Asthma Onset	**0.154**	**$11,720**
Asthma Onset (PM)	0.007	$527
Asthma Onset (O3)	0.147	$11,193
Total Asthma Symptoms	**23.622**	**$8,626**
Asthma Symptoms, Albuterol Use (PM)	1.266	$1
Asthma Symptoms, Chest Tightness (O3)	6.159	$2,376
Asthma Symptoms, Cough (O3)	7.266	$2,803
Asthma Symptoms, Shortness of Breath (O3)	3.108	$1,199
Asthma Symptoms, Wheeze (O3)	5.823	$2,247
Emergency Room Visits, Asthma (O3)	**0.000**	**$0**
Lung Cancer (PM)	**0.000**	**$7**
Hospital Admits, Cardio-Cerebro/Peripheral Vascular Disease (PM)	**0.000**	**$10**
Hospital Admits, Alzheimer's Disease (PM)	**0.001**	**$29**
Hospital Admits, Parkinson's Disease (PM)	**0.000**	**$3**
Stroke (PM)	**0.000**	**$9**
Total Hay Fever/Rhinitis	**0.981**	**$1,093**
Hay Fever/Rhinitis (PM)	0.044	$49
Hay Fever/Rhinitis (O3)	0.937	$1,044
Cardiac Arrest, Out of Hospital (PM)	**0.000**	**$2**
Emergency Room Visits, All Cardiac (PM)	**0.001**	**$2**
Minor Restricted Activity Days (PM)	**1.922**	**$242**
School Loss Days (O3)	**13.783**	**$23,409**
Work Loss Days (PM)	**0.326**	**$103**
Total PM Health Effects	**3.573 / 3.577**	**$37,617 / $85,315**
Total O3 Health Effects	**37.308**	**$336,865**

Low-Leak Natural Gas Procurement

Exhibit 3: COBRA assumptions for low-leak gas

Counties	Texas (all)
Sector/Subsectors	Petroleum & Related Industries > Oil and Gas production
Discount rate	2%
VOC reduce by (short tons)	39,100

Exhibit 4: COBRA outputs for low-leak gas

Total Annual Health Benefits to Louisiana		
	$22,014,294	**$22,014,294**
	Low Value	**High Value**
	Change in Incidence	**Monetary Value**
Total Mortality	**1.313 / 1.313**	**$19,170,311 / $19,170,311**
Mortality, All Cause (PM)	0.000 / 0.000	$0 / $0
Mortality, O3 Short-term Exposure (O3)	0.057	$826,975
Mortality, O3 Long-term Exposure (O3)	1.257	$18,343,336
Nonfatal Heart Attacks (PM)	**0.000**	**$0**
Infant Mortality (PM)	**0.000**	**$0**
Total Hospital Admits, All Respiratory	**0.143**	**$2,564**
Hospital Admits, All Respiratory (PM)	0.000	$0
Hospital Admits, All Respiratory (O3)	0.143	$2,564
Total Emergency Room Visits, Respiratory	**3.925**	**$6,376**
Emergency Room Visits, Respiratory (PM)	0.000	$0
Emergency Room Visits, Respiratory (O3)	3.925	$6,376
Total Asthma Onset	**9.352**	**$713,375**
Asthma Onset (PM)	0.000	$0
Asthma Onset (O3)	9.352	$713,375
Total Asthma Symptoms	**1,432.805**	**$552,765**
Asthma Symptoms, Albuterol Use (PM)	0.000	$0
Asthma Symptoms, Chest Tightness (O3)	394.722	$152,281
Asthma Symptoms, Cough (O3)	465.661	$179,648
Asthma Symptoms, Shortness of Breath (O3)	199.223	$76,859
Asthma Symptoms, Wheeze (O3)	373.199	$143,977
Emergency Room Visits, Asthma (O3)	**0.020**	**$17**
Lung Cancer (PM)	**0.000**	**$0**
Hospital Admits, Cardio-Cerebro/Peripheral Vascular Disease (PM)	**0.000**	**$0**
Hospital Admits, Alzheimer's Disease (PM)	**0.000**	**$0**
Hospital Admits, Parkinson's Disease (PM)	**0.000**	**$0**

Stroke (PM)	**0.000**	**$0**
Total Hay Fever/Rhinitis	**60.048**	**$66,906**
Hay Fever/Rhinitis (PM)	0.000	$0
Hay Fever/Rhinitis (O3)	60.048	$66,906
Cardiac Arrest, Out of Hospital (PM)	**0.000**	**$0**
Emergency Room Visits, All Cardiac (PM)	**0.000**	**$0**
Minor Restricted Activity Days (PM)	**0.000**	**$0**
School Loss Days (O3)	**884.395**	**$1,501,981**
Work Loss Days (PM)	**0.000**	**$0**
Total PM Health Effects	**0.000 / 0.000**	**$0 / $0**
Total O3 Health Effects	**2,392.003**	**$22,014,294**

NO_x Controls

Exhibit 5: COBRA assumptions for NO_x controls

Counties	Ascension, Calcasieu, East Baton Rouge, Iberville, Jefferson, Orleans, Ouachita, St. Charles, St. James, St. John the Baptist
Sector/Subsectors	Chemical & Allied Product > Organic Chemical
Discount rate	2%
$PM_{2.5}$ reduce by (short tons)	0
SO_2 reduce by (short tons)	0
NO_x reduce by (short tons)	1.00
VOC reduce by (short tons)	0

Exhibit 6: COBRA outputs for NO_x controls

Total Annual Health Benefits to Louisiana		
	$19,739	**$22,706**
	Low Value	**High Value**
	Change in Incidence	**Monetary Value**
Total Mortality	**0.001 / 0.001**	**$17,357 / $20,323**
Mortality, All Cause (PM)	0.000 / 0.000	$2,239 / $5,206
Mortality, O3 Short-term Exposure (O3)	0.000	$652
Mortality, O3 Long-term Exposure (O3)	0.001	$14,465
Nonfatal Heart Attacks (PM)	**0.000**	**$9**
Infant Mortality (PM)	**0.000**	**$31**
Total Hospital Admits, All Respiratory	**0.000**	**$2**
Hospital Admits, All Respiratory (PM)	0.000	$0

Hospital Admits, All Respiratory (O3)	0.000	$2
Total Emergency Room Visits, Respiratory	**0.003**	**$5**
Emergency Room Visits, Respiratory (PM)	0.000	$0
Emergency Room Visits, Respiratory (O3)	0.003	$5
Total Asthma Onset	**0.008**	**$608**
Asthma Onset (PM)	0.000	$33
Asthma Onset (O3)	0.008	$575
Total Asthma Symptoms	**1.227**	**$443**
Asthma Symptoms, Albuterol Use (PM)	0.079	$0
Asthma Symptoms, Chest Tightness (O3)	0.316	$122
Asthma Symptoms, Cough (O3)	0.373	$144
Asthma Symptoms, Shortness of Breath (O3)	0.160	$62
Asthma Symptoms, Wheeze (O3)	0.299	$115
Emergency Room Visits, Asthma (O3)	**0.000**	**$0**
Lung Cancer (PM)	**0.000**	**$0**
Hospital Admits, Cardio-Cerebro/Peripheral Vascular Disease (PM)	**0.000**	**$1**
Hospital Admits, Alzheimer's Disease (PM)	**0.000**	**$2**
Hospital Admits, Parkinson's Disease (PM)	**0.000**	**$0**
Stroke (PM)	**0.000**	**$1**
Total Hay Fever/Rhinitis	**0.051**	**$57**
Hay Fever/Rhinitis (PM)	0.003	$3
Hay Fever/Rhinitis (O3)	0.048	$54
Cardiac Arrest, Out of Hospital (PM)	**0.000**	**$0**
Emergency Room Visits, All Cardiac (PM)	**0.000**	**$0**
Minor Restricted Activity Days (PM)	**0.119**	**$15**
School Loss Days (O3)	**0.708**	**$1,202**
Work Loss Days (PM)	**0.020**	**$6**
Total PM Health Effects	**0.222 / 0.222**	**$2,340 / $5,307**
Total O3 Health Effects	**1.916**	**$17,399**

Thermal Energy Storage

Exhibit 7: COBRA assumptions for TES with 100% renewable energy

Counties	Ascension, Calcasieu, East Baton Rouge, Iberville, Jefferson, Orleans, Ouachita, St. Charles, St. James, St. John the Baptist
Sector/Subsectors	Chemical > Organic
Discount rate	2%
$PM_{2.5}$ reduce by (short tons)	90.5
SO_2 reduce by (short tons)	7.14
NO_x reduce by (short tons)	1,190.6

VOC reduce by (short tons)	65.5

Exhibit 8: COBRA outputs for TES with 100% renewable energy

Total Annual Health Benefits to Louisiana		
	$30,383,021	**$42,558,234**
	Low Value	**High Value**
	Change in Incidence	**Monetary Value**
Total Mortality	**1.865 / 2.700**	**$27,228,082 / $39,403,285**
Mortality, All Cause (PM)	0.627 / 1.462	$9,158,356 / $21,333,559
Mortality, O3 Short-term Exposure (O3)	0.053	$779,721
Mortality, O3 Long-term Exposure (O3)	1.185	$17,290,006
Nonfatal Heart Attacks (PM)	**0.418**	**$35,151**
Infant Mortality (PM)	**0.009**	**$134,513**
Total Hospital Admits, All Respiratory	**0.192**	**$4,179**
Hospital Admits, All Respiratory (PM)	0.058	$1,778
Hospital Admits, All Respiratory (O3)	0.134	$2,401
Total Emergency Room Visits, Respiratory	**4.320**	**$7,017**
Emergency Room Visits, Respiratory (PM)	0.556	$904
Emergency Room Visits, Respiratory (O3)	3.764	$6,114
Total Asthma Onset	**10.805**	**$824,160**
Asthma Onset (PM)	1.796	$136,968
Asthma Onset (O3)	9.009	$687,193
Total Asthma Symptoms	**1,701.062**	**$529,924**
Asthma Symptoms, Albuterol Use (PM)	328.007	$210
Asthma Symptoms, Chest Tightness (O3)	378.255	$145,928
Asthma Symptoms, Cough (O3)	446.246	$172,158
Asthma Symptoms, Shortness of Breath (O3)	190.917	$73,654
Asthma Symptoms, Wheeze (O3)	357.636	$137,973
Emergency Room Visits, Asthma (O3)	**0.020**	**$16**
Lung Cancer (PM)	**0.042**	**$1,863**
Hospital Admits, Cardio-Cerebro/Peripheral Vascular Disease (PM)	**0.088**	**$2,543**
Hospital Admits, Alzheimer's Disease (PM)	**0.330**	**$7,381**
Hospital Admits, Parkinson's Disease (PM)	**0.034**	**$815**
Stroke (PM)	**0.036**	**$2,298**
Total Hay Fever/Rhinitis	**68.886**	**$76,753**
Hay Fever/Rhinitis (PM)	11.341	$12,636
Hay Fever/Rhinitis (O3)	57.545	$64,117

Cardiac Arrest, Out of Hospital (PM)	**0.009**	**$555**
Emergency Room Visits, All Cardiac (PM)	**0.215**	**$464**
Minor Restricted Activity Days (PM)	**501.954**	**$63,106**
School Loss Days (O3)	**846.294**	**$1,437,273**
Work Loss Days (PM)	**85.162**	**$26,938**
Total PM Health Effects	**930.683 / 931.517**	**$9,586,477 / $21,761,680**
Total O3 Health Effects	**2,291.059**	**$20,796,554**

CCS on Hydrogen

Exhibit 9: COBRA assumptions for CCS with 2024 Louisiana grid mix

Counties	Ascension, Calcasieu, East Baton Rouge, Jefferson, Orleans, Ouachita, St. Charles, St. James, St. John the Baptist
Sector/Subsectors	Fuel combustion: electric utility > All
Discount rate	2%
$PM_{2.5}$ increase by (short tons)	25.3
SO_2 increase by (short tons)	210.7
NO_x increase by (short tons)	477.6
VOC increase by (short tons)	120.0

Exhibit 10: COBRA outputs for CCS with 2024 Louisiana grid mix

Total Annual Health Benefits to Louisiana		
	-$11,607,954	**-$16,350,852**
	Low Value	**High Value**
	Change in Incidence	**Monetary Value**
Total Mortality	**-0.710 / -1.035**	**-$10,361,118 / -$15,104,016**
Mortality, All Cause (PM)	-0.245 / -0.570	-$3,580,471 / -$8,323,368
Mortality, O3 Short-term Exposure (O3)	-0.020	-$292,705
Mortality, O3 Long-term Exposure (O3)	-0.445	-$6,487,943
Nonfatal Heart Attacks (PM)	**-0.162**	**-$13,632**
Infant Mortality (PM)	**-0.003**	**-$45,961**
Total Hospital Admits, All Respiratory	**-0.077**	**-$1,668**
Hospital Admits, All Respiratory (PM)	-0.022	-$679
Hospital Admits, All Respiratory (O3)	-0.055	-$989
Total Emergency Room Visits, Respiratory	**-1.735**	**-$2,819**
Emergency Room Visits, Respiratory (PM)	-0.209	-$340
Emergency Room Visits, Respiratory (O3)	-1.526	-$2,479

Total Asthma Onset	**-4.262**	**-$325,114**
Asthma Onset (PM)	-0.673	-$51,330
Asthma Onset (O3)	-3.589	-$273,784
Total Asthma Symptoms	**-673.364**	**-$212,123**
Asthma Symptoms, Albuterol Use (PM)	-123.732	-$79
Asthma Symptoms, Chest Tightness (O3)	-151.436	-$58,423
Asthma Symptoms, Cough (O3)	-178.618	-$68,909
Asthma Symptoms, Shortness of Breath (O3)	-76.418	-$29,481
Asthma Symptoms, Wheeze (O3)	-143.160	-$55,230
Emergency Room Visits, Asthma (O3)	**-0.008**	**-$7**
Lung Cancer (PM)	**-0.016**	**-$720**
Hospital Admits, Cardio-Cerebro/Peripheral Vascular Disease (PM)	**-0.034**	**-$987**
Hospital Admits, Alzheimer's Disease (PM)	**-0.128**	**-$2,875**
Hospital Admits, Parkinson's Disease (PM)	**-0.013**	**-$316**
Stroke (PM)	**-0.014**	**-$889**
Total Hay Fever/Rhinitis	**-27.276**	**-$30,391**
Hay Fever/Rhinitis (PM)	-4.270	-$4,758
Hay Fever/Rhinitis (O3)	-23.006	-$25,633
Cardiac Arrest, Out of Hospital (PM)	**-0.003**	**-$213**
Emergency Room Visits, All Cardiac (PM)	**-0.083**	**-$178**
Minor Restricted Activity Days (PM)	**-187.763**	**-$23,606**
School Loss Days (O3)	**-338.729**	**-$575,268**
Work Loss Days (PM)	**-31.837**	**-$10,071**
Total PM Health Effects	**-349.210 / -349.535**	**-$3,737,104 / -$8,480,002**
Total O3 Health Effects	**-917.009**	**-$7,870,850**

Exhibit 11: COBRA assumptions for CCS with 100% renewable energy

Counties	Ascension, Calcasieu, East Baton Rouge, Jefforson, Orleans, Ouachita, St. Charles, St. John the Baptist
Sector/Subsectors	Fuel combustion: electric utility > All
Discount rate	2%
$PM_{2.5}$ reduce by (short tons)	5.4
SO_2 reduce by (short tons)	39.3
NO_x reduce by (short tons)	85.9
VOC reduce by (short tons)	19.6

Exhibit 12: COBRA outputs for CCS with 100% renewable energy

Total Annual Health Benefits to Louisiana

	$2,138,915	$3,060,654
	Low Value	**High Value**
	Change in Incidence	**Monetary Value**
Total Mortality	**0.131 / 0.194**	**$1,912,828 / $2,834,567**
Mortality, All Cause (PM)	0.048 / 0.111	$695,821 / $1,617,560
Mortality, O3 Short-term Exposure (O3)	0.004	$52,540
Mortality, O3 Long-term Exposure (O3)	0.080	$1,164,467
Nonfatal Heart Attacks (PM)	**0.032**	**$2,650**
Infant Mortality (PM)	**0.001**	**$8,921**
Total Hospital Admits, All Respiratory	**0.014**	**$310**
Hospital Admits, All Respiratory (PM)	0.004	$132
Hospital Admits, All Respiratory (O3)	0.010	$178
Total Emergency Room Visits, Respiratory	**0.315**	**$511**
Emergency Room Visits, Respiratory (PM)	0.041	$66
Emergency Room Visits, Respiratory (O3)	0.274	$445
Total Asthma Onset	**0.775**	**$59,102**
Asthma Onset (PM)	0.131	$9,975
Asthma Onset (O3)	0.644	$49,127
Total Asthma Symptoms	**122.696**	**$38,073**
Asthma Symptoms, Albuterol Use (PM)	24.047	$15
Asthma Symptoms, Chest Tightness (O3)	27.178	$10,485
Asthma Symptoms, Cough (O3)	32.060	$12,368
Asthma Symptoms, Shortness of Breath (O3)	13.716	$5,292
Asthma Symptoms, Wheeze (O3)	25.695	$9,913
Emergency Room Visits, Asthma (O3)	**0.001**	**$1**
Lung Cancer (PM)	**0.003**	**$140**
Hospital Admits, Cardio-Cerebro/Peripheral Vascular Disease (PM)	**0.007**	**$192**
Hospital Admits, Alzheimer's Disease (PM)	**0.025**	**$559**
Hospital Admits, Parkinson's Disease (PM)	**0.003**	**$61**
Stroke (PM)	**0.003**	**$173**
Total Hay Fever/Rhinitis	**4.959**	**$5,525**
Hay Fever/Rhinitis (PM)	0.830	$925
Hay Fever/Rhinitis (O3)	4.129	$4,601
Cardiac Arrest, Out of Hospital (PM)	**0.001**	**$41**
Emergency Room Visits, All Cardiac (PM)	**0.016**	**$35**
Minor Restricted Activity Days (PM)	**36.504**	**$4,589**
School Loss Days (O3)	**60.793**	**$103,245**
Work Loss Days (PM)	**6.190**	**$1,958**

Total PM Health Effects	**67.883 / 67.946**	**$726,253 / $1,647,992**
Total O3 Health Effects	**164.583**	**$1,412,662**