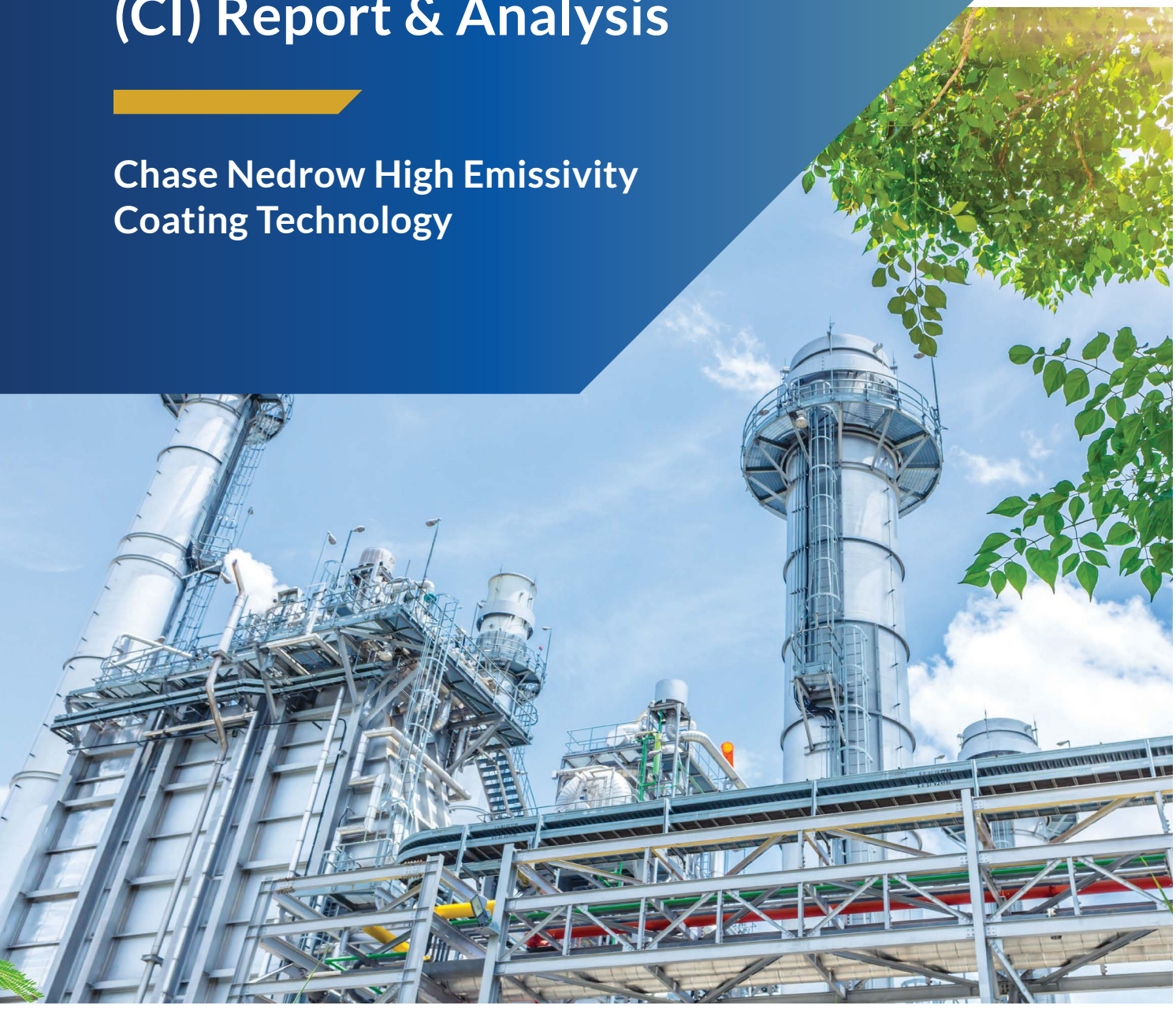
OCTOBER 2022

PROtect℠

# Carbon Intensity (CI) Report & Analysis

## Chase Nedrow High Emissivity Coating Technology



# 1 Background

As more low carbon fuel programs are developed to incentivize the production of renewable fuels, more producers are implementing carbon reduction strategies to capitalize on these programs and associated incentives. Competition drives producers to obtain the lowest carbon score possible. Understanding the impact and potential reduction of certain technologies on a producer's carbon score is integral in project planning.

To aid in the decision-making process for capital project implementation, Chase Nedrow Industries, Inc. has retained PROtect, LLC to determine the potential reduction of a High Emissivity Coating Technology (HECT). For this case study a sample facility has been modeled using currently available carbon calculators. Additional operating scenarios were then calculated based on the integration of the high emissivity coating (HEC) on various units. This report identifies the reduction impacts through the use of the HECT.

For this analysis, PROtect, LLC has used the State of California's Low Carbon Fuel Standard (LCFS) Tier 1 Simplified Carbon Intensity (CI) Calculator for Starch and Fiber Ethanol (LCFS Tier 1) to which it used by fuel producers to calculate the carbon intensity of a producer's fuel.

# 2 Chase Nedrow Coating Technology Description

In 2015, Chase Nedrow Industries, Inc. partnered with Emisshield®, Inc., the industry's leader in High Emissivity Coatings. Emisshield® is a NASA licensed, high emissivity coating technology that increases heat transfer and saves energy while increasing production in nearly all heat driven industrial applications. Emisshield® Systems are ceramic nanoparticle materials with high emissivity and heat re-radiation capabilities extending over a wide temperature range of up to 3100°F. Emisshield® increases the emissivity of a surface, which can absorb and re-radiate more energy efficiently which reduces the amount of energy that penetrates the substrate, keeping the shell cooler and the Unit running at maximum efficiency. Additionally, these coatings provide incredible bonding strength which allows it to withstand the intense environment of boilers, thermal oxidizers, dryers, and most thermal processes.

Emisshield® coatings are applied directly to the existing ceramic fiber. Not only does this coating demonstrate thermal stability at high temperatures, but it is also resistant to thermal shock at temperatures between -392°F to 2732°F. Emisshield® increases the abrasion resistance of the ceramic

fiber refractory decreasing maintenance costs and downtime. It has been shown to last over 5 years in boiler applications.

Beyond decreasing maintenance costs, Emisshield® also provides energy savings and decreased emissions. Emisshield® can be applied to thermal oxidizers (TOs), regenerative thermal oxidizers (RTOs), boilers, and dryers. Application in any of this equipment will result in a decrease of natural gas consumption, decrease NOx emissions, decreased ramp up and cool down time, minimization of hot spots, and a significant decrease in inlet temperature. In dryer applications, uniformity in the dryer system has also been observed.

## 2 Chase Nedrow Industries, Inc. Carbon Intensity Standard Factors and Description

***For each operational scenario the CARB Tier I calculator was used. In an effort to create uniformity and consistency in baseline analysis, some standard factors were used. These factors are considered representative of a typical plant. The following standard factors that were applied to each scenario are as follows:***

| Factor Description: | Standard Selection |
|---|---|
| Electricity Mix Region for Feedstock | 1-U.S. Ave Mix |
| Electricity Region Used for Fuel | 14-RFCM Mix |
| Distance Final Product is shipped by rail* | 2,300 miles |
| Standard corn transport distance: | 40 miles |

**It is assumed for the sake of the calculator that no rail shipment is greater than 2,300 miles.*

In all cases, it is assumed that the final product of the plant (fuel-grade ethanol) is shipped by rail from the facility for further distribution. Other baseline factors are determined as follows:

- The sample facility's yield is calculated based on grain usage and 200 proof ethanol production (prior to the denaturant addition).
- The electricity usage is calculated based on electricity invoices from the sample facility.
- The natural gas usage is based on natural gas bills from the sample facility.

A summary of the site-specific factors is found below. It should be noted that the sample facility data is considered representative, however, variability in the site-specific data could vary from plant to plant based on numerous considerations.

# 4 CI Calculator Scenario Description and Inputs

In addition to the CI reduction benefits, there has been energy improvements after the application of Emisshield®. As detailed below, the electricity usage is compared across four scenarios. Electricity yield comparison shows a usage reduction from 0.61 to 0.60 kilowatt hours (kWh) across the different scenarios. Likewise, the natural gas yield decreases from 26,736 British Thermal Units (BTUs)) per gallon (BTU/gal) to 25,244 BTU/gal.

## BASELINE

Baseline data was collected for the 24-month period before Emisshield® was applied to the sample facility's Thermal Oxidizer (TO) and DDGS Dryers. The baseline data represents normal operations before the changes and serves as a comparison point for determining efficiency gains from the Emisshield® coating. The baseline carbon intensity was 72.70 gCO2e/MJ.

## SCENARIO 1

Emisshield® was applied to the TO in September 2019. While corn-grind and ethanol production were lower due to a shortened reporting period, the ethanol yield (gal/bushel) and natural gas yield (btu/gal) reflect the improvement to efficiency per gallon of ethanol produced. The ethanol yield improved by 0.05 gallons per bushel and the natural gas yield decreased by 961.14 btu. While the gains in ethanol yield were marginal, the decrease in natural gas usage is reflective of the increased heat retention and lower gas demands to maintain the process. This improved the carbon intensity by 0.52 grams to 72.18 gCO2e/MJ.

It should be noted that the reporting period for Scenario One was shortened to 18 months to focus on timeframe Emisshield® was applied to just the TO, prior to the installation on Dryer A.

## SCENARIO 2 AND 2A

Emisshield® was applied to Dryer A in April 2021. Two (2) scenarios were modeled to capture the carbon impacts of the addition of Emisshield® to multiple units. Scenario 2 is a 23-month reporting period that reflects the cumulative impact of Emisshield® being applied to both the TO and Dryer A. This scenario accounts for the TO being the only unit with Emisshield® from October 2019 through March 2021 and both the TO and Dryer A having Emisshield® from April 2021 to August 2021. Scenario 2 shows a 0.05 gal/bushel improvement to ethanol yield as well as demonstrating that the natural gas yield continued to improve with the additional coating. Scenario 2 showed a 1288.72 btu/gal decrease in natural gas usage from the baseline figures and an additional 327.58 btu/gal reduction from Scenario 1. As with Scenario 1, the efficiency gains are the direct result of increased heat retention and therefore lower heat/gas demand. Scenario 2 resulted in a decrease of 0.75 gCO2e/MJ from the baseline and a reduction of 0.23 gCO2e/MJ from Scenario 1.

Because Scenario 2 includes a longer reporting period with the cumulative impacts of a staged installation (TO only and then TO and Dryer A), Scenario 2a is being provided to focus on the period of operation where Emisshield® was applied to both the TO and Dryer A (April 2021 to August 2021), prior to application in Dryer B. Scenario 2a yielded a 0.01 gal/bushel increase to ethanol yield over Scenario 2 and a 1,079.55 btu/gal improvement to natural gas yield. Scenario 2a resulted in a decrease of 1.54 gCO2e/MJ from the baseline and a reduction of 1.02 gCO2e/MJ from Scenario 1. Due to the short dataset for Scenario 2a, Scenario 2 is considered more representative of carbon impacts.

## SCENARIO 2 AND 2A

Emisshield® was applied to Dryer B in September 2021. Similar to Scenario 2 and 2a, two (2) scenarios were modeled to capture the carbon impacts of the addition of Emisshield® to multiple units. Scenario 3 includes a full 24-month reporting period that reflects the cumulative impacts of Emisshield® being applied to the TO and both Dryers. This scenario accounts for Emisshield® only being applied to the TO from October 2020 to March 2021, Emisshield® being applied to the TO and Dryer A from April 2021 to August 2021, and Emisshield® being applied to the TO, Dryer A, and Dryer B from September 2021 to June 2022. The results in similar efficiency gains as Scenario 2. Scenario 3 resulted in an increase in ethanol yield in gal/bushel, from the baseline 2.82 to 2.90 gal/bushel of ethanol produced. Furthermore, Scenario 3 displayed a natural gas yield similar to Scenario 2; a reduction of 1491.82 btu/gal from baseline. The carbon intensity decreased by 1.13 grams from the baseline and showed a decrease of 0.38 gCO2e/MJ from Scenario 2.

Scenario 3a is being provided, similar to Scenario 2a, due to the various stages of implementation of Emisshield® being accounted for in Scenario 3. Where the reporting period for Scenario 3 includes a period of time when Emisshield® was applied to the TO, a time where it was applied to the TO and Dryer A and a time period where it was applied to the TO, Dryer A and Dryer B, Scenario 3a accounts for the period after installation had occurred on all three units (September 2021 – June 2022). This scenario yielded an improvement of 0.04 gal/bushel as well as a 648.92 btu/gal improvement to natural gas yield over Scenario 2. Scenario 3a resulted in a decrease of 6.40 gCO2e/MJ from the baseline and a reduction of 5.88 gCO2e/MJ from Scenario 1. Due to the short dataset for Scenario 3a, it does not account for variation in temperature caused by summer heat nor operational variability. Because of these shortcomings in

Scenario 3a, Scenario 3 is considered more representative of carbon impacts.

| | Baseline | Scenario 1 - Applied to TO | Scenario 2 -Applied to Dryer A |
|---|---|---|---|
| **Reporting Period[1]:** | 10/2017 – 9/2019 | 10/2019 – 3/2021 | 10/2019 – 8/2021 |
| **Months in Dataset:** | 24 | 18 | 23 |
| **Corn use, bushels:** | 39,038,371.00 | 27,878,342.00 | 36,306,692.00 |
| **Undenatured ethanol produced, gal:** | 110,269,320.00 | 79,922,597.00 | 104,174,314.00 |
| **Ethanol Yield, gal/bushels:** | 2.82 | 2.87 | 2.87 |
| **DDGS Produced, tons:** | 294,885.00 | 200,426.00 | 259,339.00 |
| **Wet DGS Produced, tons:** | 1,908.00 | 1,096.00 | 1,359.00 |
| **Corn Oil Produced, tons:** | 13,653.40 | 10,665.20 | 14,267.64 |
| **Natural Gas, MMBtu:** | 2,948,147.25 | 2,059,984.08 | 2,650,940.48 |
| **Natural Gas Yield, btu/gal:** | 26,735.88 | 25,774.74 | 25,447.16 |
| **Electricity Usage, kWh:** | 67,152,102.44 | 48,441,678.82 | 63,028,540.82 |
| **Electricity Yield, kWh/gal:** | 0.61 | 0.61 | 0.61 |
| **CARBON INTENSITY SCORES (gCO2e/MJ)** | | | |
| **Land Use Change** | 19.80 | 19.80 | 19.80 |
| **Facility Product Carbon Footprint** | 52.90 | 52.38 | 52.15 |
| **Total Product Carbon Footprint** | **72.70** | **72.18** | **71.95** |

[1] *For information on the timeline for Emisshield® installation, refer to the above scenario narratives.*

| Scenario 2a - Applied to Dryer A | Scenario 3 - Applied to Dryer B | Scenario 3a -Applied to Dryer B |
|---|---|---|
| 4/2021 – 8/2021 | 7/2020 – 6/2022 | 9/2021 – 6/2022 |
| 5 | 24 | 10 |
| 8,428,350.00 | 39,520,212.00 | 16,137,893.00 |
| 24,251,717.00 | 114,683,836.00 | 47,431,021.00 |
| 2.88 | 2.90 | 2.94 |
| 58,913.00 | 280,356.00 | 113,661.00 |
| 263.00 | 1,597.00 | 647.00 |
| 3,602.44 | 16,439.38 | 6,718.17 |
| 590,956.40 | 2,895,085.86 | 1,228,130.39 |
| 24,367.61 | 25,244.06 | 25,892.98 |
| 14,586,862.00 | 68,330,861.94 | 28,107,516.32 |
| 0.60 | 0.60 | 0.59 |
| | | |
| 19.80 | 19.80 | 19.80 |
| 51.36 | 51.77 | 46.50 |
| **71.16** | **71.57** | **66.30** |

# 5 Monetary Assessment

To calculate the monetary benefit of the carbon reductions for each scenario, a comparison has been made from the ethanol settlement of the Baseline against the three scenarios, as captured in the table below. The ethanol settlement for each scenario is compared to a yield of 110,000,000 gallons, with a baseline of $793,100 to $896,203 from Baseline through Scenario 3.

The ethanol yield across the scenarios started at 2.82 gallons per bushel at Baseline and increased to 2.90 gallons per bushel by Scenario 3.

The Carbon Intensity (CI) for each Scenario from Baseline decreases from 72.70 gCO2e/MJ to 71.57 gCO2e/M in Scenario 3, a reduction of 0.63 gCO2e/MJ, as detailed in the table below. Scenario 2a and 3a are not included as Scenarios 2 and 3 were considered more representative.

| | Baseline | Scenario 1 - Applied to TO | Scenario 2 - Applied to Dryer A | Scenario 3 - Applied to Dryer B |
|---|---|---|---|---|
| **CI, gCO2e/MJ** | 72.70 | 72.18 | 71.95 | 71.57 |
| **Difference from baseline (CI):** | – | -0.52 | -0.75 | -1.13 |
| **Ethanol Settlement:** | $0.00721 | $0.004 | $0.005 | $0.008 |
| **110,000,000 gallons** | – | $412,412.00 | $594,825.00 | $896,203.00 |

***Chase Nedrow's CARB Tier 1 Calculator output summary sheets is attached in Appendix B.***

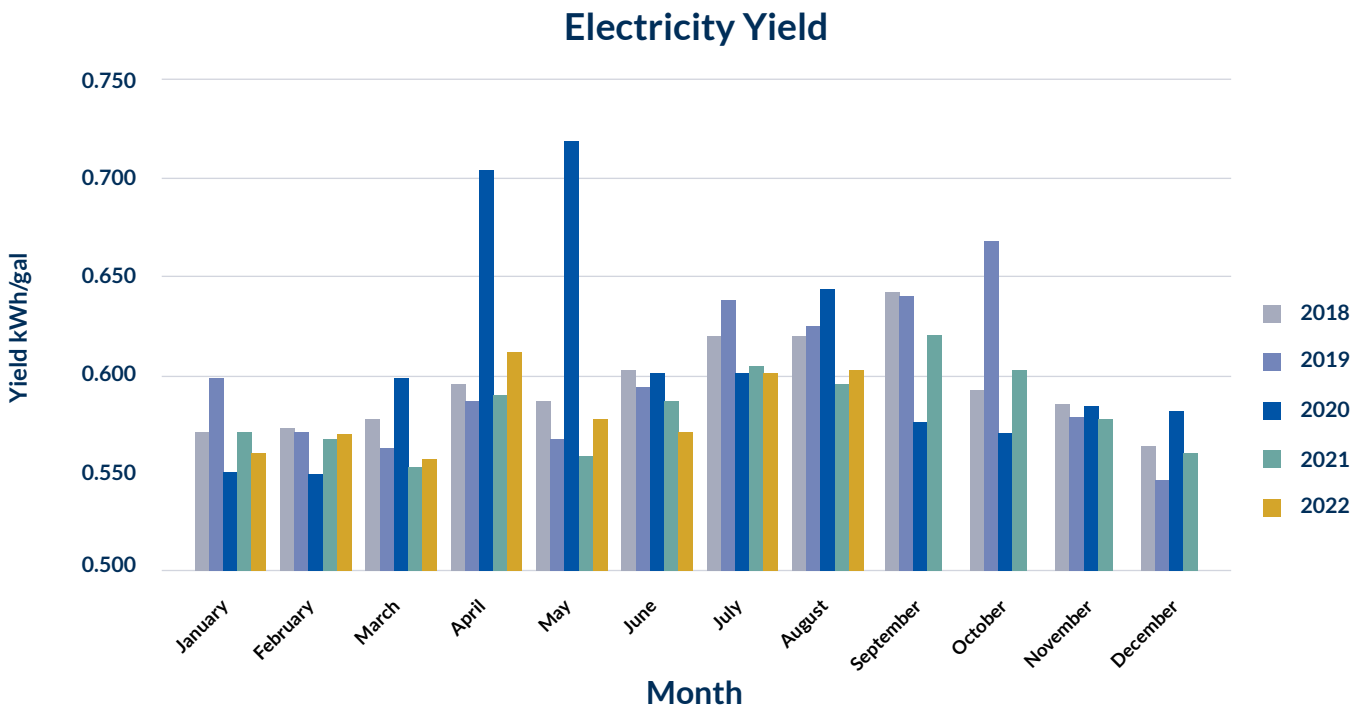
It should be noted that the Ethanol Settlement values represent a value for the CARB market in dollars per Carbon Intensity point. These values represent the value as of August 22, 2022.

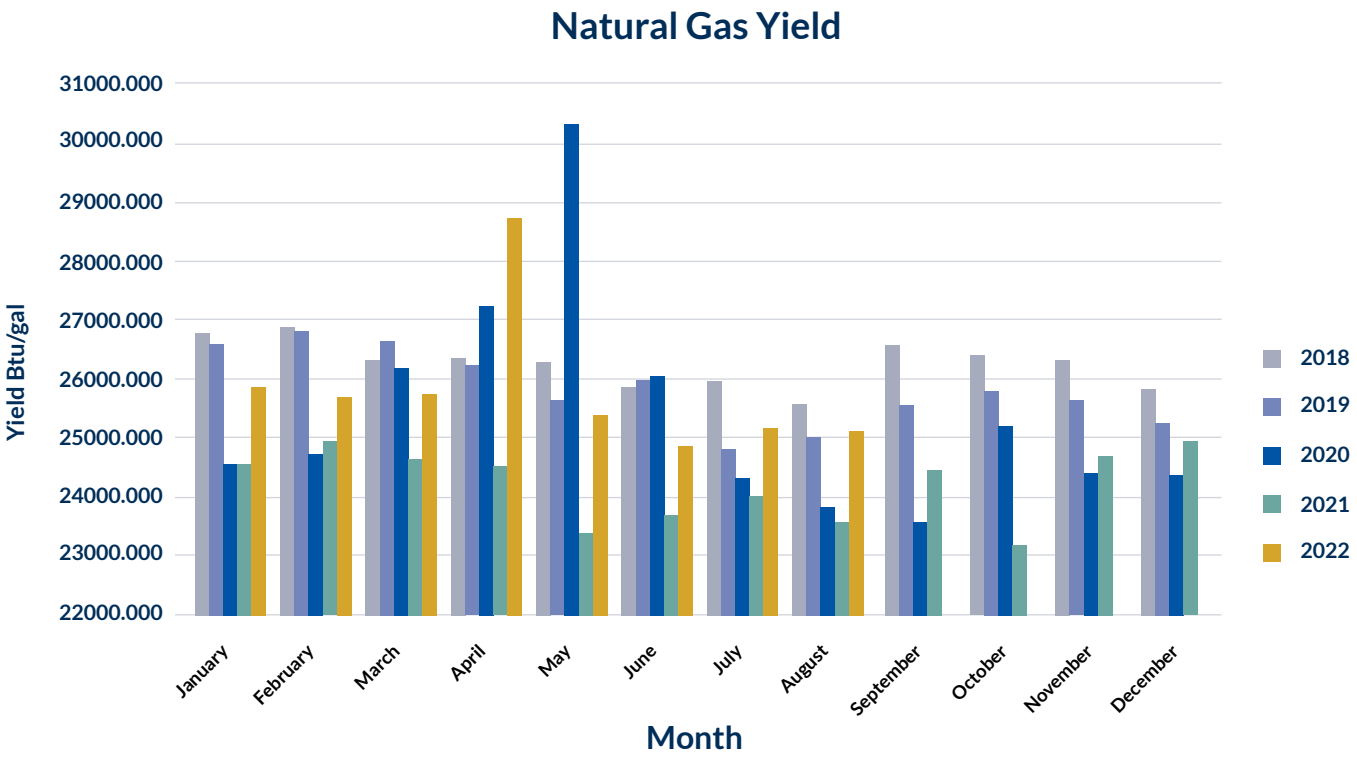
# 6 Conclusion and Recommendation

Based on the data compiled and assessment of the results of the CARB LCFS calculator, it is reasonable to anticipate a carbon intensity reduction ranging between 0.5 through 1.15 gCO2e/MJ due to the application of Chase Nedrow's installation of the Emisshield® coating. Carbon reduction will depend on technology to which the coating is applied, and the units coated. Again, each facility has varying operational factors and as such, different carbon impacts. Therefore, each site should be analyzed individually for a more definitive site-specific determination.

# Appendix A

## Chase Nedrow Industries, Inc. Electricity and Natural Gas Table



# Appendix B

## CARB Tier 1 Calculator Output Tables

### BASELINE

| Parameters | gCO2e/MJ |
|---|---|
| Corn Farming, Fertilizers and Ag Chemicals, N2O in Soil | 28.32 |
| Corn Transport | 1.48 |
| Co-product Credit | -10.96 |
| Natural Gas Usage | 22.01 |
| Electricity Usage | 5.94 |
| Chemicals Usage (Standard) | 2.02 |
| Ethanol Transport Rail | 2.57 |
| Ethanol Distribution | 0.46 |
| Denaturant CI | 0.95 |
| Non-Combustion CI | 0.09 |
| Indirect Land Use | 19.80 |

### SCENARIO 1

| Parameters | gCO2e/MJ |
|---|---|
| Corn Farming, Fertilizers and Ag Chemicals, N2O in Soil | 27.90 |
| Corn Transport | 1.43 |
| Co-product Credit | -10.33 |
| Natural Gas Usage | 21.22 |
| Electricity Usage | 5.92 |
| Chemicals Usage (Standard) | 2.02 |
| Ethanol Transport Rail | 2.57 |
| Ethanol Distribution | 0.46 |
| Denaturant CI | 1.09 |
| Non-Combustion CI | 0.09 |
| Indirect Land Use | 19.80 |

# Appendix B CONTINUED

## CARB Tier 1 Calculator Output Tables

### SCENARIO 2

| Parameters | gCO2e/MJ |
|---|---|
| Corn Farming, Fertilizers and Ag Chemicals, N2O in Soil | 27.88 |
| Corn Transport | 1.42 |
| Co-product Credit | -10.27 |
| Natural Gas Usage | 20.95 |
| Electricity Usage | 5.90 |
| Chemicals Usage (Standard) | 2.02 |
| Ethanol Transport Rail | 2.57 |
| Ethanol Distribution | 0.46 |
| Denaturant CI | 1.10 |
| Non-Combustion CI | 0.09 |
| Indirect Land Use | 19.80 |

### SCENARIO 3

| Parameters | gCO2e/MJ |
|---|---|
| Corn Farming, Fertilizers and Ag Chemicals, N2O in Soil | 27.57 |
| Corn Transport | 1.49 |
| Co-product Credit | -10.15 |
| Natural Gas Usage | 20.78 |
| Electricity Usage | 5.81 |
| Chemicals Usage (Standard) | 2.02 |
| Ethanol Transport Rail | 2.57 |
| Ethanol Distribution | 0.46 |
| Denaturant CI | 1.10 |
| Non-Combustion CI | 0.09 |
| Indirect Land Use | 19.80 |