# Assessment on Carbon Footprint of Products Report

**Jubilant Ingrevia Limited**

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# 1. Introduction

## 1.1 About Jubilant Ingrevia Limited

Jubilant Ingrevia is a global integrated Life Science products and Innovative Solutions provider. We tread across Pharmaceutical, Nutrition, Agrochemical, Consumer, and Industrial sectors. We specialize in customized products and solutions that are innovative, cost-effective, and conforming to excellent quality standards.

Jubilant Ingrevia Limited offers a broad portfolio of high-quality ingredients that find application in a wide range of industries. Jubilant Ingrevia's business portfolio includes specialty chemicals, nutrition & heath solutions, and chemical intermediates.

## 1.2 Corporate Sustainability

Sustainability is at the core of our business. We have taken various sustainability initiatives to enhance socio-economic value for all our stakeholders while minimizing the environmental footprint of our operations. The company strive to follow latest available global sustainable business model while doing business and monitor its sustainability performance to benchmark against publicly available global best practices. Every year the Company prepare its sustainability report in accordance with GRI Standards: Comprehensive option and publish the report post third party assurance & GRI content index service check. To benchmark its performance, the Company also participate in Dow Jones sustainability index, EcoVadis CSA assessment & TfS (together for sustainability) audit. During last EcoVadis assessment, the Company has scored 68 out of 100 & 93rd percentile and achieved 'Gold' category. In DJSI (Dow Jones Sustainability Indices) 2022 the Company scored 66 (Total) and 95 (Percentile) in Chemicals (CHM) sector.

The Company is signatory to UNGC (United Nations Global Compact) and majority of its manufacturing sites are ISO 14001 and ISO 45001 certified. The company has also implemented responsible care management system and certified under RC 14001.

At Jubilant Ingrevia Limited, we aim to manufacture products for our customers through optimized utilization of resources to minimize the effect on the environment. We strive to reduce our carbon footprint through several energy efficiency initiatives and by using different renewable energy sources.

There is dedicated business excellence team across corporate office & manufacturing sites. They follow lean six-sigma approach and every year identify and implement list of resource efficiency projects, including energy efficiency projects and monitor the savings accrued both in monetary and absolute terms. The company regularly monitor its energy consumption and GHG emission (scope 1, scope 2 & scope 3) and publish its performance every year in its sustainability report post third party assurance. Every year the Company also participates in CDP climate change program and CDP water security Program. During last CDP assessment in 2022, the Company has scored 'B' under both climate change & water security program and 'A-' in Supplier Engagement Rating (SER). Some of its plants are also certified under ISO 50001 based energy management system. Recently the Company is working on net zero carbon strategy following SBTi Corporate Net-Zero standard and working towards implementation of the same once the road map is ready.

To remain cost-competitive, we always practice efficient use of quality material in our processes. Our Company uses molasses as its key raw material (a by-product from the sugar industries). This is first time the company is going for PCF assurance. However, in the past the Company has twice conducted carbon footprint study of 15 products with help from external consultant.

### 1.3. Project Context & Objective:

Given the influence of industry to GHG emissions, there is an urgent need to increase the pace and scope of the clean energy activities of Indian corporates to support India in achieving climate change commitments.[1] Below figure illustrates key actions and options being taken by businesses to accelerate climate action in India.

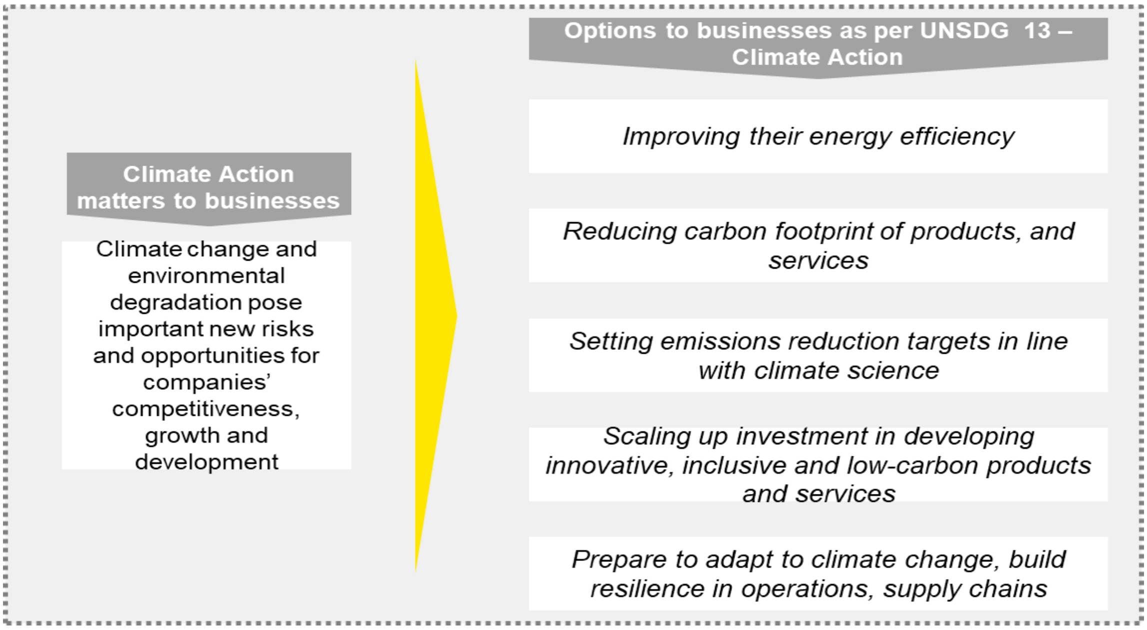


Figure 1: Options to businesses for accelerating climate action

[1] *Prakash Javadekar Urges Corporates To Invest In Innovation And Technology,* https://allindiaroundup.com/news/prakash-javadekar-urges-corporates-to-invest-in-innovation-and-technology/

This inspired **Jubilant Ingrevia Limited** to develop a Carbon footprint of products for the below listed 30 chemicals manufactured at Gajraula, Bharuch, Nira and Savli, locations.

**Gajraula, Uttar Pradesh**

1. ZPT–50 (Zinc Pyrithione–50)
2. Ethyl Acetate
3. Acetic Anhydride
4. Acetaldehyde
5. Pyridine
6. Beta Picoline
7. 3-Cyanopyridine
8. 2-Amino Pyridine
9. Gamma Picoline
10. Alpha Picoline
11. 2-Amino 4-Methyl pyridine
12. 4-Cyanopyridine
13. 4DMAP (4-(Diethylamino) Pyridine)
14. CPC (Cetyl Peridinium Chloride)
15. Pyridine 2 Aldehyde_Crude
16. 2-Amino 5-Methyl pyridine
17. Azacyclonol
18. 2,4,6 - Collidine
19. 2-Amino 5-Chloro Pyridine
20. 4-Amino Pyridine
21. Ethanol
22. 3,5 Lutidine
23. Propionic anhydride
24. Bio Acetic acid

**Bharuch, Gujarat**

1. Acetic Anhydride
2. 3-Cyanopyridine
3. 2-Chloropyridine
4. Pyridine 2 ethanol
5. Niacinamide
6. 2,3,5-Collidine
7. 2-Chloro-6-Trichloro-methyl pyridine

**NIRA, Maharashtra**

1. Acetic Anhydride
2. Ethyl Acetate
3. Ethanol

**Savli, Gujarat**

1. Anichol 60 (Choline Chloride, Dry 60%)

This study will help us to identify the emission hotspots and devise a reduction plan in the product's cradle to gate value chain. This study will also help the company to develop its net zero strategy and TCFD report. We want to embark on a journey to be a sustainable, environment-friendly, and transparent organization. This study also presents the results of reduction in carbon footprint by using bioethanol based raw materials in place of conventional petro based chemicals.

This study has been conducted as per the ISO 14067:2018 Standards requirements and has been externally reviewed by third-party auditors as per international standards on assurance engagements 3000 (ISAE 3000).

The key stakeholders for this CFP assessment outcome will be customers, investors, regulatory bodies, and our employees.

Summary of carbon footprint of products for selected chemicals under the study are provided in the table below:

Table 1: Summary - carbon footprint of products

| Site | Products | Fossil GHG Emission Intensity (Kg $CO_2e$/Kg of Product) | Biogenic Emission Intensity ( Kg $CO_2e$ /Kg of Product) | Biogenic Removal Intensity ( Kg $CO_2e$ /Kg of Product) | Stored Biogenic Carbon Intensity ( Kg $CO_2e$ /Kg of Product) |
|---|---|---|---|---|---|
| Bharuch, Gujarat | Acetic Anhydride | 3.46 | 0.0029 | -0.01 | -0.0059 |
| | 3-Cyanopyridine | 19.71 | 1.84 | -4.19 | -2.79 |
| | 2-Cyanopyridine | 23.73 | 1.45 | -3.30 | -2.20 |
| | Pyridine 2 ethanol | 44.59 | 4.99 | -13.03 | -8.69 |
| | Niacinamide | 19.50 | 1.64 | -3.66 | -2.44 |
| | 2,3,5-Collidine | 21.72 | - | - | - |
| | 2-Chloro 6 Trichloro methyl pyridine | 43.47 | 2.24 | -5.84 | -3.89 |
| Gajraula,Uttar Pradesh | ZPT-50 (Zinc Pyrithione–50) | 9.42 | - | - | 0 |
| | Ethyl Acetate | 3.48 | 0.6614 | -1.98 | -1.32 |
| | Acetic Anhydride | 3.34 | 0.004 | -0.01 | -0.01 |
| | Ethanol | 1.07 | 0.69 | -2.87 | -1.91 |
| | Acetaldehyde | 2.54 | 1.06 | -3.19 | -2.13 |
| | Pyridine | 11.39 | 1.70 | -3.87 | -2.58 |
| | Beta Picoline | 11.37 | 1.76 | -3.99 | -2.66 |
| | Pyridine\|PP2 | 12.22 | 1.64 | -3.80 | -2.53 |
| | Beta Picoline\|PP2 | 12.23 | 1.77 | -4.11 | -2.74 |
| | Pyridine\|PP1 | 10.81 | 1.75 | -3.92 | -2.61 |
| | Beta Picoline\|PP1 | 10.82 | 1.75 | -3.92 | -2.61 |
| | 3-Cyanopyridine | 23.10 | 2.30 | -4.44 | -2.96 |
| | 2-Amino Pyridine | 20.38 | 4.99 | -3.77 | -2.52 |
| | Gamma Picoline | 19.84 | 3.59 | -9.36 | -6.24 |
| | Alpha Picoline | 19.84 | 3.59 | -9.36 | -6.24 |
| | 2-Amino 4-Methyl pyridine | 33.94 | 8.39 | -10.65 | -7.10 |
| | 4-Cyanopyridine | 42.20 | 5.00 | -12.08 | -8.06 |
| | 4DMAP [4-(Dimethylamino) Pyridine] | 44.39 | 4.74 | -4.23 | -2.82 |
| | CPC (Cetyl peridinium chloride) | 27.98 | 1.86 | -2.59 | -1.73 |
| | Pyridine 2 Aldehyde_Crude | 41.78 | 1.79 | - | - |
| | 2-Amino 5-Methyl pyridine | 70.96 | 7.12 | -6.94 | -4.63 |
| | Azacyclonol_Crude | 63.49 | 0.30 | - | - |
| | 2,4,6 -Collidine_Crude | 49.02 | 13.10 | - | - |
| | 2-Amino 5-Chloro Pyridine | 105.26 | 12.04 | -6.53 | -4.35 |
| | 4-Amino Pyridine_Crude | 114.71 | 10.64 | -24.54 | -16.36 |
| | Propionic Anhydride | 19.18 | 0.00 | -0.01 | -0.01 |
| | 3,5 Lutidine | 9.27 | 15.57 | - | - |
| | Bio Acetic acid | 2.79 | 0.85 | -2.54 | -1.69 |
| Nira, Maharashtra | Ethanol | 2.67 | 0.91 | -2.87 | -1.91 |
| | Acetic Anhydride | 3.52 | 0.20 | -0.01 | -0.01 |
| | Ethyl Acetate | 3.67 | 0.52 | -1.56 | -1.04 |

| | | | | | |
|---|---|---|---|---|---|
| Savli, Gujarat | Anichol 60 (Choline Chloride, Dry 60%) | 1.74 | 0.23 | - | - |

Note: +ve sign indicates emissions & -ve sign indicates carbon uptake & storage

## 2. Scope of the Study

### 2.1. Functional Unit

The functional unit selected for this study is 1 Kg of Product manufactured. Carbon footprint will be communicated in both absolute (Tonnes $CO_2e$) and Intensity terms (Kg $CO_2e$/kg of product manufactured) for the selected period of study.

The functional unit is also consistent with the earlier CFP (Carbon footprint of products) studies as well and 3rd party databases which will assist in interpreting and comparing the results.

### 2.2. Boundary

The system boundary considered for this study is Cradle to Gate for selected products from four manufacturing facilities of Jubilant Ingrevia Limited (Gajraula, , Bharuch, Nira and Savli,) as listed in the previous chapter.

Cradle-to-gate is an assessment of a partial product life cycle from resource extraction (cradle) to the factory gate (i.e., before it is transported to the consumer). Most of the impacts are attributable to the life cycle stages defined in the cradle to gate system boundary for B2B business.

The illustration below outlines the different activities in the Cradle to gate boundary that is considered for computation of product carbon footprint.

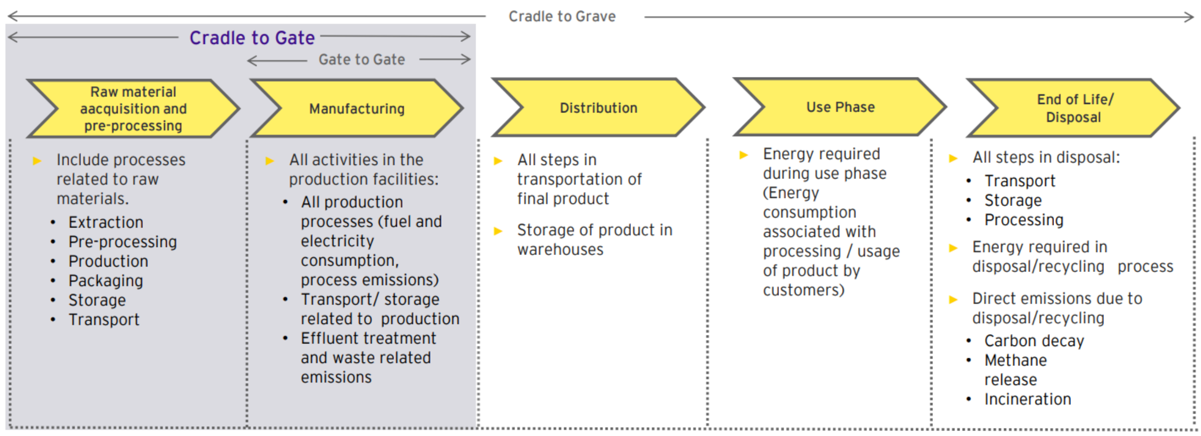


Figure 2: System Boundary for Product Carbon Footprint

Excluded activities include:

- Manufacturing of production equipment, buildings, and other capital infrastructure.
- Business travel of personnel.
- Travel to and from work by personnel.
- Research and development activities.
- Energy use (heating and electricity) of office spaces.

- Fugitive emissions from air conditioning and refrigeration equipment

It is estimated that impacts from excluded activities would be negligible compared to impacts associated with Cradle to gate activities.

### 2.3 Time Boundary

The period for computation of carbon footprint for all chemical products (except propionic anhydride & bio acetic acid) in this study is from Calendar year 2020 (January 2020 to December 2020).

- Due to non-availability of calendar 2020 activity data for propionic anhydride, calendar year 2021 data has been considered.
- At present bio acetic acid is not being produced in the facility. To estimate the potential carbon footprint for the same, data based on stoichiometric equations has been considered.

Primary data related to energy consumption, material consumption, and production for established time boundary was collected for all the products under the scope of work.

### 2.4. GHG's & Characterization Factors Considered

Except SF6, HFC's & PFC's from organizational boundary, all other greenhouse gases covered under Kyoto protocol has been considered for the study. IPCC 2013 life cycle impact assessment method and respective characterization factors have been considered for assessing the global warming impacts associated with product life cycle from cradle to gate.

Removals of CO2 into biomass have been characterized in the impact assessment as −1 kg $CO_2e$ /kg CO2 in the calculation of the CFP when entering the product system. Emissions of biogenic CO2 have been characterized as +1 kg $CO_2e$/kg CO2 of biogenic carbon in the calculation of the CFP.

### 2.5. Data and Data Quality Requirements

Site-specific data for the unit manufacturing processes was calculated. Data points included but were not limited to:

- Energy and Raw Material Consumption Data
- Background processes data e.g., DM water Units, Waste Treatment Units, Captive Power, and Steam Generation Plants
- Raw Material and Fuel Upstream Supply Chain Transportation Data
- Packaging Material Consumption

According to ISO 14067, secondary data may be considered when the collection of site-specific (primary) data is not possible or practicable. Secondary data from various sources like Eco invent, IPCC, and other peer-reviewed studies were used for computing the upstream emissions of Raw Materials, Waste Treatment impacts, and Fuel Emission Factors.

Data quality requirements as mentioned below by ISO 14067 were appropriately considered while collecting data for specific unit processes and development of emission factor databases.

- **Time and Geography-related coverage:** Time coverage of site-specific data is specified in the respective section. All primary and secondary data were collected specifically for Indian geography. In case of non-availability, proxy data, developed for other regions/ rest of the world averages were used.

- **Technology Coverage:** Majority of the primary data was collected from data collection systems updated monthly from production sites. Secondary data was sourced from external databases. Primary and secondary data were specific to the technology deployed. In case technology-specific data was not available, proxy data has been used for production through alternate technology routes.

### 2.6. Allocation procedures

In this study both mass based, and economic based allocation has been considered wherever applicable. Emission Allocation is done only among products and co-product excluding waste products.

Table 2: List of products considered for allocation

| Site | Product | Allocation Method |
|---|---|---|
| **Gajraula, Uttar Pradesh** | Pyridine and Beta Picoline | Mass Based Allocation |
| **Bharuch, Gajurat** | 2- Chloro 6 - Trichloro methyl Pyridine and Hypochlorite | Economic Value Based Allocation |
| **Gajraula, Uttar Pradesh** | Alpha & Gamma Picoline | Mass Based allocation |

### 2.7. Cut off Criteria

For this study, we haven't defined any cut-off criterion for the processes. All processes and flows attributable to the analyzed product system as defined by ISO 14067:2018 were included in the system boundary. Available elementary flows to the production processes were included and analyzed for carbon footprint calculations. The impacts of waste treatment units were evaluated based on site-specific energy and chemical consumption data.

For raw material source to gate transportation data, we have accounted for 95% of the material by mass from the overall input quantity. Few catalysts and special chemicals, whose emission factors are not available and whose mass share in overall inventory is very minimal has been excluded.

### 2.8. Limitations

Apart from inherent benefits from product carbon foot printing, there are also few limitations. Two major limitations of this study are as follows.

- This study focuses on single environmental issue (Climate change) and doesn't cover other impacts associated with air, water, soil and other eco systems.
- Life cycle emission factors for majority of the raw materials has been considered from rest of the world data bases due to non-availability of geographic specific factors. This constraint can have an influence on the outcome of calculations.

## 3. Life Cycle Inventory Development

While computing the carbon footprint of our products, we followed ISO 14067:2018 standards. We took the following steps to develop the life cycle inventory.

### 3.1. Data Collection & Validation

Primary data was collected using customized data templates developed for each product and site. These templates were based on the input and output information gathered from the black box type process flow map. A sample map for the product acetic anhydride is shown below.

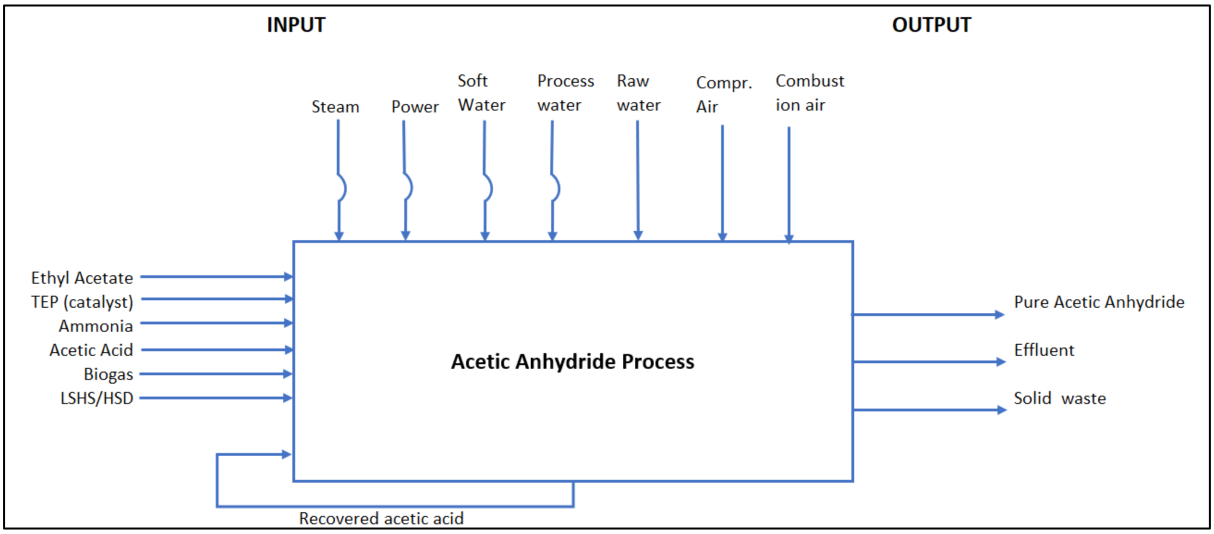


Figure 3:Acetic Anhydride Process Map – Gajraula, Uttar Pradesh Facility

### List of Major Unit Processes:

Few major unit processes considered in the study are combined heat and power generation, steam generation in boiler, effluent treatment, water demineralisation, multi effect evaporation, incineration, and distillery treatment.

Site-level data was also collected to perform validation checks and develop site-level emission factors for captive electricity, steam, effluent, and waste treatment.

Post receipt of the site and product-level data from the internal stakeholders' appropriate checks were done for completeness and mass and energy balances. If any gaps or outliers/anomaly occurred, they were informed to data providers and were corrected.

In the sub-sections below, phase-wise (Raw material extraction, pre-processing, transportation, product manufacturing and packaging) carbon footprint results for all the products under the scope is provided.

### 3.2. Raw Material acquisition and pre-processing

This phase of the life cycle includes all upstream emissions involved in the production of raw materials and fuels used in various processes including waste treatment, power & steam generation, effluent treatment, and water treatment. Jubilant Ingrevia Limited sources raw materials both from domestic and international markets. Since the emission footprint of these raw materials is not available from the manufacturer (primary data), the same has been taken from secondary data sources like Eco invent, IPCC, and other peer-reviewed sources. Raw material data is presented in Appendix A along with the conversion factors.

### 3.3. Raw Material Transportation

The carbon footprint due to transportation of raw materials from the origin to the Jubilant Ingrevia Limited manufacturing location is considered under the study. The primary data is collected from the Jubilant Ingrevia Limited logistics team. Site-wise carbon emissions due to transportation of raw materials are calculated. Emissions values are based on two parameters – transportation distance and quantity transported. India-specific emission factors from India GHG Program for freight transport have been considered for Road and Air transport whereas eco invent emission factor has been considered for sea and train transport.

### 3.4. Product Manufacturing

This stage of the life cycle accounts for the emissions arising out of energy use for various mainline processes, utilities, effluent, and waste treatment. Primary data from Jubilant Ingrevia Limited manufacturing facilities were used for calculating all energy inputs. At the Gajraula, Uttar Pradesh facility where the combined heat and power plant (CHP) is catering the process heat and electricity requirements, emission factors for the unit of steam and electricity generated from CHP have been derived using the efficiency method. Detailed calculations on the same have been provided in Annexure B. For other facilities where electricity is procured from grid, respective grid emission factor which accounts all upstream emissions in delivering 1 unit of electricity at manufacturing facilities incomer have been considered.

### 3.5. Packaging

Jubilant Ingrevia Limited is dispatching the chemicals produced mainly through HDPE drums and tankers. Under this section, only emissions concerning packaging through HDPE drums have been considered as no major packaging material is being used while dispatching through tankers within the factory gate. Data on the type of packing material, its weight per unit of tare, and its weight-carrying capacity per unit has been gathered. Based on this data, an estimate has been made of the total amount of packing material required to pack all the produced material, along with the weight of the packing material used. This estimation was necessary as obtaining precise information about the actual packing material used is challenging.

### 3.6. Cradle to Gate fossil carbon footprint

Aggregated fossil emission intensity from the cradle to the gate has been computed for each of the products under the current scope. Since there are no fossil carbon removals like carbon capture and storage, net fossil emissions will be equal to fossil carbon emissions. Site wise computed cradle to gate fossil carbon footprint of all the products is reported below

Table 3:Gajraula, Uttar Pradesh - Cradle to Gate Phase Wise Fossil Carbon Footprint

| Products | Raw Material Extraction & Pre-Processing | Raw Material Transportation | Product Manufacturing | Packaging | Total Cradle to Gate (CFP) |
|---|---|---|---|---|---|
| Pyridine – Average | 5.68 | 0.02 | 5.55 | 0.13 | 11.39 |
| Pyridine - PP 1 | 5.59 | 0.02 | 5.06 | 0.13 | 10.81 |
| Pyridine - PP 2 | 5.82 | 0.02 | 6.24 | 0.13 | 12.22 |
| Beta Picoline – Average | 5.68 | 0.02 | 5.52 | 0.14 | 11.36 |
| Beta Picoline - PP 1 | 5.59 | 0.02 | 5.06 | 0.13 | 10.81 |
| Beta Picoline - PP 2 | 5.82 | 0.02 | 6.24 | 0.14 | 12.23 |
| 3 – Cyanopyridine | 14.08 | 0.03 | 8.81 | 0.18 | 23.10 |
| 4-Cyanopyridine | 27.20 | 0.04 | 14.78 | 0.18 | 42.20 |
| Alpha Picoline | 9.31 | 0.04 | 10.34 | 0.14 | 19.84 |
| Gamma Picoline | 9.31 | 0.04 | 10.34 | 0.14 | 19.84 |
| Acetaldehyde | 1.59 | 0.38 | 0.57 | 0.00 | 2.54 |
| 2-Amino pyridine | 13.28 | 0.042 | 6.77 | 0.28 | 20.38 |
| CPC (Cetyl peridinium chloride) | 11.22 | 0.05 | 16.45 | 0.26 | 27.98 |
| 4-DMAP [4-(Dimethylamino) Pyridine] | 23.91 | 0.21 | 20.00 | 0.27 | 44.39 |
| 2-Amino 5-Methyl Pyridine | 35.10 | 0.04 | 35.56 | 0.27 | 70.96 |
| 2-Amino-4-methyl pyridine | 25.19 | 0.05 | 8.42 | 0.28 | 33.94 |
| 4-Amino Pyridine_Crude | 91.02 | 0.64 | 22.77 | 0.28 | 114.71 |
| 2,4,6,- Collidine | 34.91 | 0.69 | 13.17 | 0.25 | 49.02 |
| 2-amino – 5- chloro pyridine | 77.00 | 0.02 | 27.97 | 0.27 | 105.26 |
| Azacyclonol_Crude | 32.80 | 0.34 | 30.08 | 0.27 | 63.49 |
| Pyridine – 2- aldehyde | 11.05 | 0.02 | 30.44 | 0.28 | 41.78 |
| ZPT-50 (Zinc Pyrithione–50) | 8.56 | 0.00 | 0.75 | 0.11 | 9.42 |
| Acetic Anhydride | 2.04 | 0.12 | 1.18 | 0.00 | 3.34 |
| Ethyl Acetate | 2.13 | 0.30 | 0.95 | 0.09 | 3.48 |
| Ethanol | 0.00 | 0.01 | 1.05 | 0.00 | 1.07 |
| Propionic Anhydride | 6.28 | 7.01 | 5.78 | 0.09 | 19.18 |
| 3,5 Lutidine | 0.007 | 0.00 | 9.26 | 0.00 | 9.27 |
| Bio acetic acid | 2.03 | 0.00 | 0.76 | 0.00 | 2.79 |

Table 4: Bharuch, Gujarat - Cradle to Gate Phase Wise Fossil Carbon Footprint

| Products | Raw Material Extraction & Pre-Processing | Raw Material Transportation | Product Manufacturing | Packaging | Total Cradle to Gate (CFP) |
|---|---|---|---|---|---|
| 3 – Cyanopyridine | 13.23 | 0.06 | 6.42 | 0.00 | 19.71 |
| Niacinamide | 17.40 | 0.00 | 2.07 | 0.03 | 19.50 |
| Pyridine -2- ethanol | 28.12 | 0.00 | 16.35 | 0.12 | 44.59 |
| 2 – Chloropyridine | 11.86 | 0.05 | 11.69 | 0.13 | 23.73 |
| 2- Chloro 6 - Trichloro methyl Pyridine | 15.97 | 0.01 | 26.82 | 0.66 | 43.47 |
| 2,3,5 Collidine | 11.07 | 0.02 | 10.54 | 0.10 | 21.72 |
| Acetic Anhydride | 2.15 | 0.08 | 1.23 | 0.00 | 3.46 |

Table 5: Nira, Maharashtra - Cradle to Gate Phase Wise Fossil Carbon Footprint

| Products | Raw Material Extraction & Pre-Processing | Raw Material Transportation | Product Manufacturing | Packaging | Total Cradle to Gate (CFP) |
|---|---|---|---|---|---|
| Acetic Anhydride | 1.95 | 0.07 | 1.39 | 0.11 | 3.52 |
| Ethyl Acetate | 1.91 | 0.30 | 1.37 | 0.09 | 3.67 |
| Ethanol | 0.02 | 0.02 | 2.63 | 0.00 | 2.67 |

Table 6: Savli, Gujarat - Cradle to Gate phase wise Fossil Carbon Footprint

| Products | Raw Material Extraction & Pre-Processing | Raw Material Transportation | Product Manufacturing | Packaging | Total Cradle to Gate (CFP) |
|---|---|---|---|---|---|
| Anichol 60 (Choline Chloride, Dry 60%) | 1.606 | 0.000 | 0.131 | 0.000 | 1.74 |

## Absolute Emissions – Cradle to Gate (Fossil)

Absolute net fossil emissions of all the products under the scope are computed site wise and tabulated below:

Table 7: Absolute emissions - Cradle to gate (Fossil)

| Site | Products | Fossil GHG Emissions (tonnes $CO_2e$) |
|---|---|---|
| Bharuch, Gujarat | Acetic Anhydride | 1,48,347 |
| | 3-Cyanopyridine | 1,62,057 |
| | 2-Cyanopyridine | 82,254 |
| | Pyridine 2 ethanol | 2,609 |
| | NIACINAMIDE | 1,84,092 |
| | 2,3,5-Collidine | 4,081 |
| | 2-Chloro 6 Trichloro methyl pyridine | 19,853 |
| Gajraula, Uttar Pradesh | ZPT-50 (Zinc Pyrithione–50) | 911 |
| | Ethyl Acetate | 73,118 |
| | Acetic Anhydride | 27,154 |
| | Ethanol | 26,557 |
| | Acetaldehyde | 1,15,093 |
| | Pyridine | 1,75,923 |
| | Beta Picoline | 1,43,750 |
| | Pyridine\|PP2 | 74,304 |
| | Beta Picoline\|PP2 | 58,898 |
| | Pyridine\|PP1 | 1,01,619 |
| | Beta Picoline\|PP1 | 84,852 |
| | 3-Cyanopyridine | 48,369 |
| | 2-Amino Pyridine | 10,839 |
| | Gamma Picoline | 1,068 |
| | Alpha Picoline | 1,068 |
| | 2-Amino 4-Methyl pyridine | 5,105 |
| | 4-Cyanopyridine | 12,444 |
| | 4DMAP [4-(Dimethylamino) Pyridine] | 15,070 |
| | CPC (Cetyl peridinium chloride) | 5,343 |

| | | |
|---|---|---|
| | Pyridine 2 Aldehyde_Crude | 1,098 |
| | 2-Amino 5-Methyl pyridine | 5,460 |
| | Azacyclonol_Crude | 12,413 |
| | 2,4,6 - Collidine_Crude | 1,097 |
| | 2-Amino 5-Chloro Pyridine | 335 |
| | 4-Amino Pyridine_Crude | 352 |
| | Propionic Anhydride | 16,376 |
| | 3,5 Lutidine | 4,679 |
| | Bio acetic acid | 2.79 |
| Nira, Maharashtra | Ethanol | 22,322 |
| | Acetic Anhydride | 1,94,537 |
| | Ethyl Acetate | 3,19,447 |
| Savli, Gujarat | Anichol 60 (Choline Chloride, Dry 60%) | 19,875 |

### 3.7. Biogenic carbon emissions

Biogenic carbon is derived from material of biological origins such as organic material (both living and dead), e.g., trees, crops, grasses, tree litter, algae, and animal manure excluding material embedded in geological formations and material transformed into fossilized material. Biomass sequesters carbon from the atmosphere while growing and release the same back into the atmosphere while oxidized (combusted) or fermented resulting in net-zero carbon emissions.

Jubilant Ingrevia Limited is manufacturing bioethanol by fermenting sugar cane molasses. This process results in CO2 emissions which are biogenic in nature. Apart from this, there are biogenic emissions resulting primarily from the combustion of biogas in furnaces for process heating. All these biogenic emissions are occurring under manufacturing phase of cradle to gate life cycle. Biogenic carbon emissions have been computed site-wise for relevant products under the scope and presented in the table below.

Table 8: Biogenic Emissions

| Site | Products | Biogenic Emission Intensity ( Kg $CO_2e$ /Kg of Product) | Absolute Biogenic Emissions ( tonnes $CO_2e$ ) |
|---|---|---|---|
| Bharuch, Gujarat | Acetic Anhydride | 0.0029 | 126 |
| | 3-Cyanopyridine | 1.84 | 15,151 |
| | 2-Cyanopyridine | 1.45 | 5,032 |
| | Pyridine 2 ethanol | 4.99 | 292 |
| | NIACINAMIDE | 1.64 | 15,467 |
| | 2,3,5-Collidine | - | - |
| | 2-Chloro 6 Trichloro methyl pyridine | 2.24 | 1,020 |
| Gajraula, Uttar Pradesh | ZPT-50 (Zinc Pyrithione–50) | - | - |
| | Ethyl Acetate | 0.6614 | 13,893 |
| | Acetic Anhydride | 0.004 | 35 |
| | Ethanol | 0.69 | 17,192 |
| | Acetaldehyde | 1.06 | 48,164 |
| | Pyridine | 1.70 | 27,054 |
| | Beta Picoline | 1.76 | 22,823 |
| | Pyridine\|PP2 | 1.64 | 10,431 |
| | Beta Picoline\|PP2 | 1.77 | 8,943 |

| | | | |
|---|---|---|---|
| | Pyridine\|PP1 | 1.75 | 16,623 |
| | Beta Picoline\|PP1 | 1.75 | 13,880 |
| | 3-Cyanopyridine | 2.30 | 4,815 |
| | 2-Amino Pyridine | 4.99 | 2,653 |
| | Gamma Picoline | 3.59 | 2,753 |
| | Alpha Picoline | 3.59 | 3,829 |
| | 2-Amino 4-Methyl pyridine | 8.39 | 1,261 |
| | 4-Cyanopyridine | 5.00 | 1,473 |
| | 4DMAP [4-(Dimethylamino) Pyridine] | 4.74 | 1,609 |
| | CPC (Cetyl peridinium chloride) | 1.86 | 355 |
| | Pyridine 2 Aldehyde_Crude | 1.79 | 47 |
| | 2-Amino 5-Methyl pyridine | 7.12 | 548 |
| | Azacyclonol_Crude | 0.30 | 59 |
| | 2,4,6 - Collidine_Crude | 13.10 | 293 |
| | 2-Amino 5-Chloro Pyridine | 12.04 | 38 |
| | 4-Amino Pyridine_Crude | 10.64 | 33 |
| | Propionic Anhydride | 0.00 | 4 |
| | 3,5 Lutidine | 15.57 | 7,865 |
| | Bio acetic acid | 0.85 | 0.85 |
| Nira, Maharashtra | Ethanol | 0.91 | 7,621 |
| | Acetic Anhydride | 0.20 | 11,020 |
| | Ethyl Acetate | 0.52 | 45,440 |
| Savli, Gujarat | Anichol 60 (Choline Chloride, Dry 60%) | 0.23 | 2,678 |

### 3.8. Biogenic Carbon Removals

In the case of products containing biomass, the biogenic carbon content is nearly equal to the carbon removal during plant growth through photosynthesis. These carbon removals have been computed site-wise for relevant products under the scope and presented in the table below.

Table 9: Biogenic Carbon Removals

| Site | Products | Biogenic Removal Intensity ( Kg $CO_2e$ /Kg of Product) | Absolute Biogenic Removals ( tonnes $CO_2e$ ) |
|---|---|---|---|
| Bharuch, Gujarat | Acetic Anhydride | -0.01 | -379 |
| | 3-Cyanopyridine | -4.19 | -34,428 |
| | 2-Cyanopyridine | -3.30 | -11,435 |
| | Pyridine 2 ethanol | -13.03 | -763 |
| | NIACINAMIDE | -3.66 | -34,528 |
| | 2,3,5-Collidine | - | - |

| | | | |
|---|---|---|---|
| | 2-Chloro 6 Trichloro methyl pyridine | -5.84 | -2,664 |
| Gajraula, Uttar Pradesh | ZPT-50 (Zinc Pyrithione–50) | - | - |
| | Ethyl Acetate | -1.98 | -41,679 |
| | Acetic Anhydride | -0.01 | -106 |
| | Ethanol | -2.87 | -71,473 |
| | Acetaldehyde | -3.19 | -1,44,492 |
| | Pyridine | -3.87 | -61,461 |
| | Beta Picoline | -3.99 | -51,860 |
| | Pyridine\|PP2 | -3.80 | -24,197 |
| | Beta Picoline\|PP2 | -4.11 | -20,745 |
| | Pyridine\|PP1 | -3.92 | -37,264 |
| | Beta Picoline\|PP1 | -3.92 | -31,115 |
| | 3-Cyanopyridine | -4.44 | -9,299 |
| | 2-Amino Pyridine | -3.77 | -2,007 |
| | Gamma Picoline | -9.36 | -7,191 |
| | Alpha Picoline | -9.36 | -9,999 |
| | 2-Amino 4-Methyl pyridine | -10.65 | -1,601 |
| | 4-Cyanopyridine | -12.08 | -3,563 |
| | 4DMAP [4-(Dimethylamino) Pyridine] | -4.23 | -1,437 |
| | CPC (Cetyl peridinium chloride) | -2.59 | -495 |
| | Pyridine 2 Aldehyde_Crude | - | - |
| | 2-Amino 5-Methyl pyridine | -6.94 | -534 |
| | Azacyclonol_Crude | - | - |
| | 2,4,6 - Collidine_Crude | - | - |
| | 2-Amino 5-Chloro Pyridine | -6.53 | -21 |
| | 4-Amino Pyridine_Crude | -24.54 | -75 |
| | Propionic Anhydride | -0.01 | -12 |
| | 3,5 Lutidine | - | - |
| | Bio Acetic acid | -2.54 | -2.54 |
| Nira, Maharashtra | Ethanol | -2.87 | -23,991 |
| | Acetic Anhydride | -0.01 | -596 |
| | Ethyl Acetate | -1.56 | -1,35,770 |
| Savli, Gujarat | Anichol 60 (Choline Chloride, Dry 60%) | - | - |

### 3.9. Biogenic Carbon Stored

Biogenic carbon up taken during plant growth can be released in the use phase or end-of-life treatment phase of a product. Since the boundary of this study is limited to the factory gate, we haven't computed use phase and end-of-life biogenic CO2 emissions. Instead, the amount of biogenic carbon stored in the products have been calculated separately and presented in the table below.

Table 10: Stored Biogenic Carbon in Products

| Site | Products | Biogenic Stored Carbon Intensity ( Kg $CO_2e$ /Kg of Product) | Absolute Biogenic Carbon Stored ( tonnes $CO_2e$ ) |
|---|---|---|---|
| Bharuch, Gujarat | Acetic Anhydride | -0.0059 | -253 |
| | 3-Cyanopyridine | -2.79 | -22,952 |
| | 2-Cyanopyridine | -2.20 | -7,624 |
| | Pyridine 2 ethanol | -8.69 | -509 |
| | NIACINAMIDE | -2.44 | -23,019 |
| | 2,3,5-Collidine | - | - |
| | 2-Chloro 6 Trichloro methyl pyridine | -3.89 | -1,776 |
| Gajraula, Uttar Pradesh | ZPT-50 (Zinc Pyrithione–50) | 0 | - |
| | Ethyl Acetate | -1.32 | -27,786 |
| | Acetic Anhydride | -0.01 | -71 |
| | Ethanol | -1.91 | -47,648 |
| | Acetaldehyde | -2.13 | -96,328 |
| | Pyridine | -2.58 | -40,974 |
| | Beta Picoline | -2.66 | -34,574 |
| | Pyridine\|PP2 | -2.53 | -16,131 |
| | Beta Picoline\|PP2 | -2.74 | -13,830 |
| | Pyridine\|PP1 | -2.61 | -24,843 |
| | Beta Picoline\|PP1 | -2.61 | -20,744 |
| | 3-Cyanopyridine | -2.96 | -6,199 |
| | 2-Amino Pyridine | -2.52 | -1,338 |
| | Gamma Picoline | -6.24 | -4,794 |
| | Alpha Picoline | -6.24 | -6,666 |
| | 2-Amino 4-Methyl pyridine | -7.10 | -1,068 |
| | 4-Cyanopyridine | -8.06 | -2,376 |
| | 4DMAP [4-(Dimethylamino) Pyridine] | -2.82 | -958 |
| | CPC (Cetyl peridinium chloride) | -1.73 | -330 |
| | Pyridine 2 Aldehyde_Crude | - | - |
| | 2-Amino 5-Methyl pyridine | -4.63 | -356 |
| | Azacyclonol_Crude | - | - |
| | 2,4,6 - Collidine_Crude | - | - |
| | 2-Amino 5-Chloro Pyridine | -4.35 | -14 |
| | 4-Amino Pyridine_Crude | -16.36 | -50 |
| | Propionic Anhydride | -0.01 | -8 |
| | 3,5 Lutidine | - | - |
| | Bio acetic acid | -1.69 | -1.69 |
| Nira, Maharashtra | Ethanol | -1.91 | -15,994 |
| | Acetic Anhydride | -0.01 | -397 |
| | Ethyl Acetate | -1.04 | -90,514 |
| Savli, Gujarat | Anichol 60 (Choline Chloride, Dry 60%) | - | - |

## 4. Sensitivity Analysis

Apart from Gajraula, all other facilities under the boundary are using electricity from the grid in the manufacturing process. Market for electricity-western grid from ecoinvent database have been considered as an emission factor in calculating the emissions associated with electricity. Even though this is the closest data set available for grid electricity emission calculation, still there will be a variation on actual emission factor due to the following reason.

- Eco invent data set value is the extrapolated value from 2015 to 2021 considering some uncertainty on power mix, transmission losses and distribution losses which may vary with actual power mix and line efficiency values particular to Bharuch, Nira, and Savli, Gujarat locations.

Since energy related emissions are one of the major contributors in product carbon footprint, sensitivity analysis has been done with grid electricity factor to account for the variations and the results are tabulated below:

Table 11: Sensitivity with Grid Electricity Emission Factor

| Site | Product | Fossil GHG Emission Intensity (Kg $CO_2e$ /Kg of Product) | | |
|---|---|---|---|---|
| | | Grid EF Variation (-10%) | Grid EF Variation (No Variation) | Grid EF Variation (+10%) |
| Bharuch, Gujarat | 3 – Cyanopyridine | 19.48 | 19.71 | 19.94 |
| | Niacinamide | 19.22 | 19.50 | 19.77 |
| | Pyridine -2- ethanol | 43.74 | 44.59 | 45.43 |
| | 2 – Chloropyridine | 23.53 | 23.73 | 23.92 |
| | 2- Chloro 6 - Trichloro methyl Pyridine | 42.34 | 43.47 | 44.59 |
| | 2,3,5 Collidine | 21.25 | 21.72 | 22.2 |
| | Acetic Anhydride | 3.42 | 3.46 | 3.49 |
| Nira, Maharashtra | Acetic Anhydride | 3.49 | 3.52 | 3.55 |
| | Ethyl Acetate | 3.65 | 3.67 | 3.69 |
| | Ethanol | 2.60 | 2.67 | 2.74 |
| Savli, Gujarat | Anichol 60 (Choline Chloride, Dry 60%) | 1.73 | 1.74 | 1.75 |

## 5. Petro vs Bioethanol Route

Chemicals such as Acetaldehyde, acetic anhydride, and ethyl acetate are commercially manufactured through the Petro route using ethanol as feedstock (Produced from Naphtha). Alternatively, these chemicals can also be derived through the bioethanol route where biomaterial like molasses, corn, corn stover etc., can be used as feedstock.

At present, in Jubilant Ingrevia Limited, we are using the bioethanol route for manufacturing of majority of products. With certain set of assumptions*, we have modelled a theoretical case for 8 products of Gajraula, Uttar Pradesh, where feedstock was derived from petro route and computed the carbon footprint accordingly to evaluate the benefit of using bio-based raw material. It is observed that products obtained through bioethanol route have a superior net GHG emission (Fossil +biogenic) intensity compared to those produced through the petro route. This is due to the biogenic CO2 uptake that occurs during the growth stage of the raw materials used in the bioethanol route, providing a beneficial impact on the net GHG emissions. Results for the same have been populated in following table.

Table 12: Carbon Footprint Comparison - Petro vs Bioethanol

| | | Bioethanol Route | | | Petro Route |
|---|---|---|---|---|---|
| **Site** | **Products** | **Fossil GHG Emission Intensity (Kg $CO_2e$ /Kg of Product)** | **Biogenic Emission Intensity ( Kg $CO_2e$ /Kg of Product)** | **Biogenic Removal Intensity ( Kg $CO_2e$ /Kg of Product)** | **GHG Emission Intensity -Fossil + Biogenic ( Kg $CO_2e$ /Kg of Product)** |
| Gajraula, Uttar Pradesh | Ethyl Acetate | 3.48 | 0.6614 | -1.98 | 3.55 |
| | Acetic Anhydride | 3.34 | 0.004 | -0.01 | 3.34 |
| | Acetaldehyde | 2.54 | 1.06 | -3.19 | 2.66 |
| | Pyridine | 11.39 | 1.70 | -3.87 | 11.94 |
| | Alpha picoline | 19.84 | 3.59 | -9.36 | 20.58 |
| | 3 - Cyanopyridine | 23.10 | 2.30 | -4.44 | 23.57 |
| | CPC (Cetyl peridinium chloride) | 27.98 | 1.86 | -2.59 | 28.84 |
| Bharuch, Gujarat | Niacinamide | 19.50 | 1.64 | -3.66 | 19.61 |

Note: For Petroleum based manufacturing route, norms for input energy and material consumption are assumed as that of bioethanol-based production. since the petro based manufacturing case is theoretical, and the point of material dispatch is unknown, market-based emission value was considered for petroleum based raw materials from life cycle data bases.

## 6. Interpretation of Results - Conclusions & Recommendations

The results of present carbon footprint study provide valuable insights in identifying major emission hotspots and can accelerate the actions towards implementation of available low carbon technologies and processes. Below are few conclusions and recommendations from this study.

### Conclusions:

- Major emission share is from raw material extraction and pre-processing followed by energy use and waste treatment
- Products manufactured at Gajraula, facility have relatively lesser footprint compared to similar products manufactured at other facilities, due to availability of low carbon energy from combined heat and power plant.

### Recommendations:

- Corn based ethanol can be substituted with relatively lower carbon footprint ethanol manufactured from cane molasses or corn stover.

| Ethanol Source | Corn | Corn stover | Sugar cane molasses |
|---|---|---|---|
| GHG fossil footprint in $kgCO_2e$/ kg | 1.43 | 0.24 | 0.69 |

Source: National ethanol conference presentation by US DOE laboratory. Analysis is specific to USA

- Acetic acid is the most used raw material after ethanol and hence procuring bio-based acetic acid can reduce raw material related emissions.
- Biomass briquette combustion in boilers can be explored for steam generation.
- Heat pumps can be deployed for preheating applications which have higher COP compared to fuel based or electrical heating systems.
- Grid electricity can be substituted by improving renewable energy quotient in power mix. For facilities, where enough space is available, setting up a solar power plant under OPEX model can be explored. For NIRA manufacturing facility, green power can be procured from the grid by paying additional green tariff to DISCOM.
- SOFC integration in CHP can be explored as a long-term option

# Annexures

## 7. Appendix

### Appendix A: List of Raw Material Emission Factors

This section provides the list of raw material emission factors utilized in calculating the carbon footprint of various products under the scope. Most of the emission factors are sourced from Eco Invent Library and cover the cradle to gate (Manufacturing Entry) related GHG impacts. This section also covers the list of emission factors for raw materials used in utilities and packaging.

| Raw Materials used in product manufacturing stage | Unit | Emission Factor | Source |
|---|---|---|---|
| 1 2 4 Trichlorobenzene | Kg CO2e/kg | 2.50 | Eco Invent v3.8 |
| 2 CP - N- oxide | Kg CO2e/kg | 5.56 | External Proxy Data |
| 2 Hydroxy Methyl pyridine | Kg CO2e/kg | 4.65 | Eco Invent v3.8 |
| ACETIC ACID | Kg CO2e/kg | 1.65 | Eco Invent v3.8 |
| Acetone | Kg CO2e/kg | 3.05 | Eco Invent v3.8 |
| ACTIVATED CARBON | Kg CO2e/kg | 8.45 | Eco Invent v3.8 |
| ALPHA PICOLINE | Kg CO2e/kg | 19.83 | Eco Invent v3.8 |
| Ammonia | Kg CO2e/kg | 2.52 | Eco Invent v3.8 |
| AMMONIUM SULPHATE | Kg CO2e/kg | 1.51 | Eco Invent v3.8 |
| ANHYDROUS LIQUID AMMO | Kg CO2e/kg | 2.52 | Eco Invent v3.8 |
| BENZENE | Kg CO2e/kg | 1.86 | Eco Invent v3.8 |
| CAUSTIC FLAKES | Kg CO2e/kg | 1.45 | Eco Invent v3.8 |
| CETYL CHLORIDE | Kg CO2e/kg | 7.10 | Eco Invent v3.8 |
| CHLORINE | Kg CO2e/kg | 1.01 | Eco Invent v3.8 |
| Choline chloride | Kg CO2e/kg | 1.89 | External Proxy Data |
| Corn cob powder | Kg CO2e/kg | 0.24 | Eco Invent v3.8 |
| DIMETHYL FORMAMIDE | Kg CO2e/kg | 2.97 | Eco Invent v3.8 |
| DRY YEAST | Kg CO2e/kg | 2.94 | Eco Invent v3.8 |
| EDTA | Kg CO2e/kg | 4.32 | Eco Invent v3.8 |
| Ethanol - Petro Route | Kg CO2e/kg | 1.87 | Eco Invent v3.8 |
| Ethanol from Corn | Kg CO2e/kg | 1.43 | External Proxy Data |
| Ethylene | Kg CO2e/kg | 1.45 | Eco Invent v3.8 |
| ETHYLENE DICHLORIDE (EDC) | Kg CO2e/kg | 1.33 | Eco Invent v3.8 |
| FORMALDEHYDE | Kg CO2e/kg | 0.37 | Internally derived |
| Formalin | Kg CO2e/kg | 0.37 | Internally Derived |
| HCL ACID | Kg CO2e/kg | 0.89 | Eco Invent v3.8 |
| HEPTANE | Kg CO2e/kg | 0.62 | Eco Invent v3.8 |
| HYDROGEN PEROXIDE SOL | Kg CO2e/kg | 1.45 | Eco Invent v3.8 |
| Hydrogen Sulfide | Kg CO2e/kg | 0.64 | Eco Invent v3.8 |
| HYDROQUINONE | Kg CO2e/kg | 3.79 | Eco Invent v3.8 |
| IODINE CRYSTAL | Kg CO2e/kg | 5.53 | Eco Invent v3.8 |
| KOH | Kg CO2e/kg | 2.68 | Eco Invent v3.8 |
| LIQUID CHLORINE | Kg CO2e/kg | 1.01 | Eco Invent v3.8 |
| MAGNESIUM TURNNING | Kg CO2e/kg | 16.70 | Eco Invent v3.8 |
| METHANOL | Kg CO2e/kg | 0.62 | Eco Invent v3.8 |
| Methanol | Kg CO2e/kg | 0.62 | Eco Invent v3.8 |
| Mono Chloro Benzene | Kg CO2e/kg | 2.75 | Eco Invent v3.8 |
| N-BUTANOL | Kg CO2e/kg | 3.05 | Eco Invent v3.8 |
| N-Hexane | Kg CO2e/kg | 0.54 | Eco Invent v3.8 |
| NITROGEN FILLED CYLIN | Kg CO2e/kg | 0.43 | Eco Invent v3.8 |
| PARA TOLUENE SUL ACID | Kg CO2e/kg | 0.10 | Eco Invent v3.8 |
| PROPIONALDEHYDE | Kg CO2e/kg | 4.55 | Eco Invent v3.8 |

| | | | |
|---|---|---|---|
| Propionic acid | Kg CO2e/kg | 2.10 | Eco Invent v3.8 |
| Purified Water | Kg CO2e/kg | 0.01 | Eco Invent v3.8 |
| Raw Water | Kg CO2e/kg | 0.00 | Eco Invent v3.8 |
| Sawdust | Kg CO2e/kg | 0.01 | Eco Invent v3.8 |
| SELENIUM DI OXIDE | Kg CO2e/kg | 3.39 | Eco Invent v3.8 |
| Silica (Sipernat 22 S) | Kg CO2e/kg | 0.04 | Eco Invent v3.8 |
| SODIUM AMIDE | Kg CO2e/kg | 3.34 | Eco Invent v3.8 |
| Sodium Bi Carbonate | Kg CO2e/kg | 1.30 | Eco Invent v3.8 |
| SODIUM CARBONATE(SODA) | Kg CO2e/kg | 0.45 | Eco Invent v3.8 |
| SODIUM SULPHITE (COMM) | Kg CO2e/kg | 1.60 | Eco Invent v3.8 |
| SULPHURIC ACID | Kg CO2e/kg | 0.16 | Eco Invent v3.8 |
| TETRA HYDROFURAN | Kg CO2e/kg | 6.02 | Eco Invent v3.8 |
| THIONYL CHLORIDE | Kg CO2e/kg | 0.91 | Eco Invent v3.8 |
| TOLUENE | Kg CO2e/kg | 1.56 | Eco Invent v3.8 |
| UREA | Kg CO2e/kg | 1.66 | Eco Invent v3.8 |
| XYLENE | Kg CO2e/kg | 1.70 | Eco Invent v3.8 |

| Utility Chemicals (ETP,DM, RO, MEE, Incineration) | | | Source |
|---|---|---|---|
| Raw Material | Unit | Emission Factor | |
| Gajraula, Uttar Pradesh | | | |
| ALUM | kg CO2-Eq | 0.63 | Eco Invent v3.8 |
| AMMONIUM CHLORIDE | kg CO2-Eq | 2.30 | Eco Invent v3.8 |
| AMMONIUM SULPHATE | kg CO2-Eq | 1.51 | Eco Invent v3.8 |
| ANTIFOAMING AGENT (CAS) | kg CO2-Eq | 4.37 | Eco Invent v3.8 |
| CAUSTIC FLAKES | kg CO2-Eq | 1.45 | Eco Invent v3.8 |
| FERRIC CHLORIDE ANHYDR | kg CO2-Eq | 0.41 | Eco Invent v3.8 |
| HCL ACID | kg CO2-Eq | 0.89 | Eco Invent v3.8 |
| MAGNESIUM OXIDE | kg CO2-Eq | 1.12 | Eco Invent v3.8 |
| SODIUM CARBONATE(SODA) | kg CO2-Eq | 1.30 | Eco Invent v3.8 |
| SODIUM HYPO CHLORITE S | kg CO2-Eq | 2.53 | Eco Invent v3.8 |
| Bharuch, Gujarat | | | |
| HCl 30% | kg CO2-Eq | 0.89 | Eco Invent v3.8 |
| NaOH 48% | kg CO2-Eq | 1.45 | Eco Invent v3.8 |
| HCL (31%) | kg CO2-Eq | 0.89 | Eco Invent v3.8 |
| LIQUID POLYMER | kg CO2-Eq | 4.37 | Eco Invent v3.8 |
| SODIUM HYPO CHLORITE | kg CO2-Eq | 2.53 | Eco Invent v3.8 |
| PAS /Liquid Coagulant/PAC | kg CO2-Eq | 1.71 | Eco Invent v3.8 |
| NIRA, MAHARASHTRA | | | |
| Defoamer | kg CO2-Eq | 4.37 | Eco Invent v3.8 |
| Di-ammonium Phosphate | kg CO2-Eq | 1.64 | Eco Invent v3.8 |
| Urea | kg CO2-Eq | 1.66 | Eco Invent v3.8 |
| Caustic Flakes | kg CO2-Eq | 1.45 | Eco Invent v3.8 |
| Ferric Chloride | kg CO2-Eq | 0.41 | Eco Invent v3.8 |
| PAC Powder | kg CO2-Eq | 1.71 | Eco Invent v3.8 |
| Common Salt | kg CO2-Eq | 0.23 | Eco Invent v3.8 |
| Hydrochloric Acid | kg CO2-Eq | 0.89 | Eco Invent v3.8 |
| Sodium Hypochloride | kg CO2-Eq | 2.53 | Eco Invent v3.8 |

| Raw Material - Packaging Material | | | |
|---|---|---|---|
| Raw Material | Unit | Emission Factor | Source |
| LDPE Liner | kg CO2-Eq | 3.08 | Eco Invent v3.8 |
| HDPE Granulate | kg CO2-Eq | 2.31 | Eco Invent v3.8 |
| Fibre board, Hard | kg CO2-Eq | 1.13 | Eco Invent v3.8 |
| Hot Rolled Steel | kg CO2-Eq | 1.89 | External proxy data |
| Galvanized Steel | kg CO2-Eq | 1.42 | External proxy data |

| | | | |
|---|---|---|---|
| Aluminium foil | kg CO2-Eq | 3.10 | External proxy data |
| Corrugated paper | kg CO2-Eq | 0.53 | External proxy data |

## Appendix B: Emission Allocation Calculation between steam and electricity at Gajraula, Combined Heat & Power Plant

Gajraula manufacturing facility has a combined heat and power unit which caters to the process steam and electricity requirements of the facility. There is an AFBC boiler that runs on coal along with other heat recovery boilers. Apart from CHP, there is a backup power generator set that runs on HSD. Emission factors for a kg of steam and kWh of electricity have been derived specifically for the Gajraula with the help of available primary data. The efficiency method prescribed by the GHG protocol has been used.

| Fuel Consumption | Unit | Quantity | Emission Factor (Kg $CO_2e$/unit) | Emission (tonne CO2e) |
|---|---|---|---|---|
| **AFBC Boiler Fuel Consumption** | | | | |
| Domestic Coal - Type 1 | Kg | 263059000 | 1.92 | 506171 |
| LSHS (Low Sulphur Heavy Stock) | Kg | 926010 | 3.61 | 3339 |
| Domestic Coal Transportation Emissions | Tonnes | 263059 | 35.82 | 9424 |
| **Emission Allocation to Steam and Electricity** | | | | |
| | **Unit** | **Value** | **Comment** | |
| **Total Steam Production** | Tonnes | 1194884 | | |
| AFBC Boiler Steam | Tonnes | 1096785 | | |
| Slop Boiler Steam | Tonnes | 27860 | Utilized in Process heating | |
| Jubilant Ingrevia Limited Steam | Tonnes | 62766 | Utilized in Process heating | |
| Thermal Oxidizer Steam | Tonnes | 7473 | Utilized in Process heating | |
| **Steam in STG Turbine for Electricity production from AFBC Boiler** | Tonnes | 324857 | Utilized for Electricity Production | |
| **Steam turbine Electricity Production** | Kwh | 138807479 | | |
| | GJ | 499707 | | |
| **Total Process Steam consumption from AFBC** | Tonne | 927187 | | |
| Extracted Steam - Process Steam post STG | Tonne | 155259 | | |
| Direct Process Steam from AFBC Boiler | Tonne | 771928 | | |
| **Steam Enthalpy @ 515 Degree Celsius Temperature and 87 Bar Pressure** | MJ/Kg | 3.43 | Steam Tables Calculator (steamtablesonline.com) | |
| **Energy Input - Process Steam from AFBC** | GJ | 3178826 | AFBC & Extracted Steam for process | |
| **Energy Input Including Boiler Efficiency-Process Steam from AFBC** | GJ | 3973532 | | |
| **Equivalent Energy Input - Electricity – AFBC** | GJ | 1427734 | | |
| **Total Energy Input** | GJ | 5401266 | | |
| **Total Emissions from Fuel Consumption in boiler and thermal oxidizer** | tonnes CO2e | 515595 | Inclusive of fuel upstream transportation emissions | |
| AFBC Boiler | tonnes CO2e | 515595 | | |
| Slop Boiler | tonnes CO2e | 0 | | |
| Jubilant Ingrevia Limited | tonnes CO2e | 0 | | |
| Thermal Oxidizer | tonnes CO2e | 0 | | |
| **Emission Allocated to Steam from AFBC** | tonnes CO2e | 379306 | | |
| **Emission Allocated to Electricity from AFBC** | tonnes CO2e | 136289 | | |
| **Steam Emission Factor for AFBC** | Kg CO2e/kg of steam | 0.41 | | |
| **Electricity Emission Factor for AFBC** | Kg CO2e/kWh | 0.98 | | |
| **AFBC Efficiency Values** | | | | |
| | **Unit** | **Value** | **Comment** | |
| Electricity Production | % | 35% | | |
| Steam Production | % | 80% | | |
| **DG Set Electricity Emission Factor Calculations** | | | | |
| | **Unit** | **Value** | **Comment** | |

| | | | |
|---|---|---|---|
| Electricity Production from DG | KWh | 4684206 | |
| Emissions from Fuel consumption in DG Set | tonne CO2e | 3339.28 | |
| DG Set Electricity Emission Factor | Kg CO2e/KWh | 0.71 | |
| **Average Emission Factor for Electricity and Steam Considering AFBC, DG Sets, Slop Boiler, Thermal Oxidizer, and Jubilant Ingrevia Limited** | | | |
| | **Unit** | **Value** | **Comment** |
| Average Emission factor for Electricity from AFBC and DG Sets | Kg CO2e/KWh | 0.97 | Weighted Average of Emission factors of DG set and AFBC Boiler for electricity production |
| Average Emission for Steam from AFBC, Slop, Jubilant Ingrevia Limited, and Thermal Oxidizer | Kg CO2e/Kg of steam | 0.37 | Weighted average emission factor based on total steam production from the Gajraula, Uttar Pradesh facility |

## Appendix C: Assumptions

Due to the non-availability of certain primary data, following few assumptions have been made while computing the carbon footprint of products

- Acetic acid is one of the major raw materials used in the manufacturing of a few products. Acetic acid can be chemically synthesized majorly in three different routes namely, Oxidation of butane, Acetaldehyde oxidation & Methanol carbonylation. Each route will have a different GHG footprint and since the actual information about the production route is not available, the weighted average footprint of the three routes as per global production has been considered.
- Molasses is considered as a burden free raw material since it is obtained from sugar mills where it is a waste. However, emissions associated in transporting molasses from sugar mills to factory gate have been included.
- Densities of various fuels used is mentioned below

| Density | Unit | Value | Source |
|---|---|---|---|
| **Diesel Oil** | kg/litre | 0.85 | IPCC 2006 Guidelines |
| **Natural Gas** | Kg/m3 | 0.7 | IPCC 2006 Guidelines |
| **Petrol/Gasoline** | kg/litre | 0.74 | IPCC 2006 Guidelines |
| **Furnace Oil** | Kg/litre | 0.94 | IPCC 2006 Guidelines |
| **Biogas** | Kg/m3 | 1.15 | DEFRA 2021 |

- Few raw materials holding less than 5% share of a product’s input inventory by mass, for which emission factors were not available have been excluded. (For e.g., catalysts)
- For products derived from Petro route, ethanol from ethylene is the raw material and market-based value for the same has been considered as the original supplier is unknown.
- 2-mercaptopyridine-n-oxide is one of the raw materials used in manufacturing of ZPT-50. Due to non-availability of respective cradle to gate emission factor in LCA datasets, assumption based on molar weights from external proxy data set has been considered.
- Cetyl chloride is one of the major raw materials used in production of CPC (CETYL PERIDINIUM CHLORIDE). Due to non-availability of cradle to gate emission factor in LCA datasets, the same has been derived using externally available mass balance data.

This factor considers only raw material related emissions and excludes all energy related emissions due to non-availability.

- Propylene glycol is considered as anti-foaming agent in utility treatment
- At present bio acetic acid is not manufactured in the facility. To understand the potential of carbon footprint for the same, theoretical analysis has been done based on stoichiometric equations.

# Assurance Statement

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## Independent Assurance Statement

The Management and Board of Directors
Jubilant Ingrevia Limited
Plot No. 1 A, Sector 16 A, NOIDA – 201301
Uttar Pradesh, India

### Scope

We have been engaged by Jubilant Ingrevia Limited to perform a 'limited assurance', as defined by International Standards on Assurance Engagements 3000 (Revised), hereafter referred to as the 'engagement', to report on Jubilant Ingrevia Limited's (the "Company's") product carbon footprint as per annexure 1 (the "subject matter") as contained in Jubilant Ingrevia Limited's "Assessment on Carbon Footprint of Products Report" for the period 1 January 2020 to 31 December 2020 ("the Report").

Other than as described in the preceding paragraph, which sets out the scope of our engagement, we did not perform assurance procedures on the remaining information included in the Report, and accordingly, we do not express a conclusion on this information.

### Criteria applied by Jubilant Ingrevia Limited

In preparing the product carbon footprint for Calendar Year 2020, Jubilant Ingrevia Limited applied the International Organization for Standardization (ISO) 14067:2018 standard (Criteria). As a result, the subject matter information may not be suitable for another purpose.

### Jubilant Ingrevia Limited's responsibilities

Jubilant Ingrevia Limited's management is responsible for selecting the Criteria, and for presenting the product carbon footprint as part of the "Assessment of the Carbon Footprint of Products Report" (the "Report") for calendar year 2020 in accordance with that Criteria, in all material respects. This responsibility includes establishing and maintaining internal controls, maintaining adequate records, and making estimates that are relevant to the preparation of the subject matter, such that it is free from material misstatement, whether due to fraud or error.

### EY's responsibilities

Our responsibility is to express a conclusion on the presentation of the Subject Matter based on the evidence we have obtained.

We conducted our engagement in accordance with the International Standard for Assurance Engagements ('ISAE 3000 (Revised)'), and the terms of reference for this engagement as agreed with Jubilant Ingrevia Limited on 03 June 2021 and subsequently, as per the amended agreement on 28 September 2022. Those standards require that we plan and perform our engagement to express a conclusion on whether we are aware of any material modifications that need to be made to the Subject Matter in order for it to be in accordance with the Criteria, and to issue a report. The nature, timing, and extent of the procedures selected depend on our judgment, including an assessment of the risk of material misstatement, whether due to fraud or error.

We believe that the evidence obtained is sufficient and appropriate to provide a basis for our limited assurance conclusion.

**Our Independence and Quality Management**

We have maintained our independence and confirm that we have met the requirements of the Code of Ethics for Professional Accountants issued by the International Ethics Standards Board for Accountants and have the required competencies and experience to conduct this assurance engagement.

EY also applies International Standard on Quality Management 1, Quality Management for Firms that Perform Audits and Reviews of Financial Statements, and Other Assurance and Related Services Engagements, and accordingly maintains a comprehensive system of quality management including documented policies and procedures regarding compliance with ethical requirements, professional standards, and applicable legal and regulatory requirements.

**Description of procedures performed**

Procedures performed in a limited assurance engagement vary in nature and timing from and are less in extent than for a reasonable assurance engagement. Consequently, the level of assurance obtained in a limited assurance engagement is substantially lower than the assurance that would have been obtained had a reasonable assurance engagement been performed. Our procedures were designed to obtain a limited level of assurance on which to base our conclusion and do not provide all the evidence that would be required to provide a reasonable level of assurance.

Although we considered the effectiveness of management's internal controls when determining the nature and extent of our procedures, our assurance engagement was not designed to provide assurance on internal controls. Our procedures did not include testing controls or performing procedures relating to checking aggregation or calculation of data within IT systems.

A limited assurance engagement consists of making enquiries, primarily of persons responsible for preparing the subject matter and related information and applying analytical and other appropriate procedures.

**Our procedures included:**

The Product Carbon Footprint quantification process is subject to scientific uncertainty, which arises because of incomplete scientific knowledge about the measurement of GHGs. Additionally, GHG procedures are subject to estimation (or measurement) uncertainty resulting from the measurement and calculation processes used to quantify emissions within the bounds of existing scientific knowledge.

- Conducted interviews with select personnel and corporate teams to understand the process for collecting, collating, and reporting the subject matter as per the criteria.
- Tested remotely on a sample basis underlying source information to check the accuracy of the data through consultation with relevant stakeholders.
- Checked that the calculation criteria have been correctly applied by the methodologies outlined in the Criteria.
- Undertook analytical procedures to support the reasonableness of the data, limited to the production process and activities followed in the plant
- Execution of an audit trail of claims and data streams, on a selective test basis, to

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determine the level of accuracy in the collection, transcription, and aggregation processes followed;

We also performed such other procedures as we considered necessary in the circumstances.

The assurance scope excludes:

- Data and information outside the defined reporting period - 1 January 2020 to 31 December 2020;
- Verification of activity-level data/ associated emissions for products and processes outside the defined reporting boundary of the company
- Data and information on the economic and financial performance of the Company
- Data, statements, and claims already available in the public domain through Annual Report,or other sources.
- The Company's statements that describe the expression of opinion, belief, inference, aspiration, expectation, aim, or future intention.
- The Company's compliance with regulations, acts, and guidelines concerning various regulatory agencies and other legal matters

**Conclusion**

Based on our procedures and the evidence obtained, we are not aware of any material modifications that should be made to the subject matter for the period 1 January 2020 to 31 December 2020, in order for it to be in accordance with the Criteria.

**Restricted use**

This report is intended solely for the information and use of Jubilant Ingrevia Limited and is not intended to be and should not be used by anyone other than Jubilant Ingrevia Limited.

**For and on behalf of Ernst & Young Associates LLP.**

Saunak Saha

Saunak Saha
Partner
Dated: 12 September 2023
Place: Gurugram, India

## Annexure 1

| Site | Products |
|---|---|
| Bharuch, Gujarat | Acetic Anhydride |
| | 3-Cyanopyridine |
| | 2-Cyanopyridine |
| | Pyridine 2 ethanol |
| | Niacinamide |
| | 2,3,5-Collidine |
| | 2-Chloro-6-Trichloromethylpyridine |
| Gajraula, Uttar Pradesh | ZPT–50 (Zinc Pyrithione–50) |
| | Ethyl Acetate |
| | Acetic Anhydride |
| | Ethanol |
| | Acetaldehyde |
| | Pyridine |
| | Beta Picoline |
| | Pyridine\|PP2 |
| | Beta Picoline\|PP2 |
| | Pyridine\|PP1 |
| | Beta Picoline\|PP1 |
| | 3-Cyanopyridine |
| | 2-Amino Pyridine |
| | Gamma Picoline |
| | Alpha Picoline |
| | 2-Amino-4-Methyl Pyridine |
| | 4-Cyanopyridine |
| | 4DMAP [4-(Dimethylamino) Pyridine] |
| | CPC (Cetyl Peridinium Chloride) |
| | Pyridine 2 Aldehyde Crude |
| | 2-Amino 5-Methyl pyridine |
| | Azacyclonol Crude |
| | 2,4,6 - Collidine_Crude |
| | 2-Amino 5-Chloro Pyridine |
| | 4-Amino Pyridine Crude |
| | 3,5 Lutidine |
| Nira, Maharashtra | Ethanol |
| | Acetic Anhydride |
| | Ethyl Acetate |
| Savli, Gujarat | Anichol 60 (Choline Chloride, Dry 60%) |