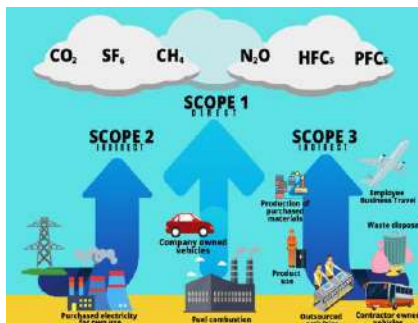


CARBON FOOTPRINT REPORT

FOR

M/s BASE METAL CHEMICALS
1089/B Plot No 2, Lamdapura Road, Taluka Savli,
Dist. Vadodara, Gujarat



Environmental Engineering Services
Consulting & Projects

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1 INTRODUCTION

1.1 Background

Base Metal was established by Mr. Bipin Ramani in 1986 with its first unit at Nandesari Industrial Park (declared chemical zone near Baroda) Gujarat. India has become a major global player in specialty, fine, and commodity chemical manufacturing, driven by globalization. This growth is evident in the 300% increase in aluminium chloride exports over the past decade.

Responding to this booming demand, Base Metal significantly expanded its operations. In 1991, the company established a manufacturing unit in Lamdapura Village, Manjusar, Savli, about 20 km from Baroda. This facility has a capacity of an annual production capacity of 24,000 MT of Anhydrous Aluminium Chloride and also produces 12,000 MT of Aluminium Chloride Hexa hydrate.

Base Metal's commitment to quality and operational excellence is demonstrated by its certifications. The company first achieved **ISO 9002 accreditation on August 13, 1999**. Through continuous improvement and strong teamwork, Base Metal has since been awarded **ISO 9001:2015, ISO 14001:2015, and OHSAS 18001:2007 certifications from United Registrar of Systems (URS) as of August 2017**.

1.2 Product Details and Production Capacities

The present products being manufactured at Base Metal Chemicals site at Savli is presented in **Table 1-1**.

Table 1-1: Product Details and Production Capacity

Name of Product	As per CCA (MT/Month)
Aluminium Chloride Anhydrous	2000
Aluminium Chloride Hexa Hydrate	100

1.3 Purpose of Report

A carbon footprint study is crucial for understanding and mitigating the impact of human activities on climate change. It quantifies the total greenhouse gas emissions associated with a product, service, organization, or individual, allowing for informed decisions about emission reduction strategies and sustainable practices. Base Metal Chemicals intends to undertake a carbon footprint study for their unit at Manjusar with an aim to move forward to Carbon Emission Control and reduction of carbon emissions.

1.4 Carbon Footprint

Carbon footprint is the total greenhouse gas (GHG) emissions caused by an individual, event, organization, service, place or product, expressed as carbon dioxide equivalent (CO₂e). Greenhouse gases, including the carbon-containing gases carbon dioxide and methane, can be emitted through the burning of fossil fuels, land clearance, and the production and consumption of food, manufactured goods, materials, wood, roads, buildings, transportation and other services.

Over the last few years, the importance of sustainability has considerably grown and it is now being considered a key issue for every company's performance.

Carbon footprint describes the environmental impact of a product or service over its entire life cycle (International Standards Office, 2013).

Carbon footprint analysis is a Life Cycle Assessment (LCA) impact category focused exclusively on Global Warming Potential (GWP). It measures the climate change potential of GHG emissions in units of CO₂ equivalent. Carbon footprint refers to the spent natural resources and produced GHG emissions over the life cycle of the commodity. It is based on extensive factors ranging from source and supply chain of raw materials to disposal of the waste materials and the disposal of product itself and owing to this. In this regard, Carbon Footprint study has become one of the most relevant methodologies to help organizations know their environmental impact. As a result of availability of such impacts data, companies are increasingly being asked to perform their activities in the most environmentally friendly way, not only about internal processes but also in relation to their customers and suppliers, throughout their value chain.

A carbon footprint is usually expressed as a measure of weight, as in tons of CO₂ or CO₂e per year. The secondary carbon footprint reflects the carbon emissions associated with the consumption of goods and services.

1.5 Scope of GHG Emissions

Calculating the carbon footprint is fundamental to understand how various activities impact environment and global sustainability. For this purpose, the carbon footprints (CF) of all activities have been calculated considering below listed scopes:

❖ **Scope - 1: Direct emissions from activities owned or controlled by the organization**

Direct GHG emissions which occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment. Direct CO₂ emissions from the combustion of biomass will not be included in scope - 1 but reported separately. GHG emissions not covered by the Kyoto Protocol, e.g. CFCs, NO_x, etc. shall not be included in scope - 1 but may be reported separately.

❖ **Scope - 2: Indirect emissions associated with purchased electricity**

Scope - 2 accounts for GHG emissions from the generation of purchased electricity consumed by a company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. Scope - 2 emissions physically occur at the facility where electricity is generated.

❖ **Scope - 3: Indirect emissions from activities that occur at sources outside its control and are not classified as scope 2**

Scope - 3 is an optional reporting category that allows for the treatment of all other indirect emissions. Scope - 3 emissions are a consequence of the activities of the company, but occur from sources not owned or controlled by the company. Some examples of scope - 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of products and services.

1.6 Global Warming Potential

Climate change can be defined as the change in global temperature caused by the greenhouse effect that the release of "greenhouse gases" by human activity. There is now scientific consensus that the increase

in these emissions is having a noticeable effect on climate. This rise of global temperature is expected to cause climatic disturbance, desertification, rising sea levels and spread of disease.

Climate change is one of the major environmental effects of economic activity, and one of the most difficult to handle because of its broad scale.

The Carbon Profiles characterization model is based on factors developed by the UN's Intergovernmental Panel on Climate Change (IPCC). Factors are expressed as Global Warming Potential over the time horizon of different years, being the most common 100 years (GWP100), measured in the reference unit, kg CO₂ equivalent.

1.7 Objective of Study

The overall carbon emission study would have broad objectives as under:

1. Identification & Quantification of emissions

Identification of emission sources: By analyzing the lifecycle of a product, service, or activity, the study helps pinpoint the main sources of emissions, such as energy use, transportation, or manufacturing.

2. Measure greenhouse gas emissions

A carbon footprint study aims to accurately measure the amount of greenhouse gas emissions (expressed as CO₂ equivalents) generated directly or indirectly by a particular activity. It helps in decision making and actions to be taken.

3. Set reduction goals

Understanding the carbon footprint provides a basis for setting realistic and ambitious goals for reducing emissions.

4. Target Mitigation Measures

The identified emission sources can be used to develop and implement specific strategies to reduce them, such as switching to renewable energy, improving energy efficiency, or optimizing transportation routes. Regular carbon footprint assessments allow for monitoring progress towards emission reduction goals and adapting strategies as needed.

5. Sustainability and Compliances

- Carbon footprint assessments will help in compliance with existing and upcoming regulations related to greenhouse gas emissions.
- Enhance Reputation and Competitive Advantage
- Demonstrating a commitment to reducing emissions can improve the industrial unit reputation and attract customers and investors.
- Raise Awareness and Promote Sustainability - Carbon footprint assessments can raise awareness about the environmental impact of activities and promote more sustainable practices.

Specific objectives of study:

- Compute Scope 1, Scope 2 and Scope 3 Carbon Footprint for all activities operating from the Base Metal Chemical Industry for financial year 2024-25.
- Compute the various components in each of the categories. The estimation of carbon footprint this year as base year would be a benchmark to evaluation any change in the same for next year.
- Identify opportunities for Improvement to further enhance Base Metal Chemicals performance on their sustainability journey
- Present a factual status of the overall performance through the assessment year on all the three scopes of emissions, to facilitate the leadership team to take internal decisions to drive the overall sustainability program.

The study is being conducted for the first time, Year 2024-25, being close to normal operations, is considered as the base year to undertake analysis as baseline year.

1.8 Scope of Services

The scope of services for undertaking the carbon foot print study was as under:

- Collection of Baseline information related to Scope 1 and 2 of the Carbon foot print calculations.
- Checklist sending to client for Scope 1 and 2 data collection related to Raw materials, energy carriers, products, solid waste, emissions to air and water, outside electricity, transportation etc.
- Site visit and review of present plant operations and understanding of data of checklist.
- Carbon Foot Print Inventory Analysis - Identify and quantify energy, water, materials as inputs as well as environmental releases as outputs, Fuel combustion, company vehicles, fugitive emissions, purchased electricity, heat and steam, cooling etc.
- Use of data base wherever data / standard emission potentials are not available.
- Calculation of Global Warming Potential for each of the scope 1 and 2, 3 to a possible extent.
- Review of present practices followed in industry for carbon sequestration.
- Identify needs for carbon sequestration based on discussion with clients.
- Calculation of carbon sequestration / mitigation measured to sequest carbon emission by implementation of carbon reduction methods and systems
- Preparation of Draft Report on Carbon Foot Print study and submission to clients
- Addressing comments and submission of final report to clients

1.9 Work Executed

Works executed as part of scope of services is as under:

- Sending of questionnaire / data checklist for data collection of last one Calendar Year 2024-25.
- Understanding of project, processes and manufactured products
- Site Visit undertaken on 24/5/2025 for review of the process and verification of data related to industry
- Carbon Foot print inventory analysis based on available information.
- Calculations of carbon emissions for Scope 1 and 2 emissions.
- Review of the carbon sequestration measures undertaken by industry.
- Overall carbon foot print estimation and carbon sequestration already done.
- Future goals of achieving carbon sequestration based on discussion with clients.

2 CARBON FOOT PRINT METHODOLOGY

2.1 Overall Framework

To obtain the objective of the study, the methodology framework is based on the Carbon Footprint framework and approaches. This framework starts by data collection, data analysis, results interpretation and dissemination.

2.2 System Boundary & Methodology

System boundaries are a set of criteria that define the scope of the analysis. These boundaries specify the unit processes to be included in the study. Accurate description of the system and its boundaries has strong implications for the results of the assessment and must be clearly stated. Accordingly, the study considers scope - 1, scope - 2 and scope – 3 of Carbon Footprint analysis.

The scope - 1 emissions arise from direct emissions from activities owned or controlled by the organization such as all production processes and operation of utilities. Secondly, scope - 2 emissions are calculated based on the purchased power for all operations.

Finally, scope - 3 emissions encompass indirect emissions from activities that occur at sources outside its control and are not classified as scope - 2. This study sets the boundary so that scope - 3 emissions are attributed to upstream and downstream transportation, consequently avoiding overlap of upstream and downstream emissions with other organizations. Thus, the unit process, products and activities included in this study are as follows:

A) Scope – 1:

I) Fuel Consumption

- 1) Boiler
- 2) DG Set
- 3) Onsite vehicles – Forklifts & Commuting Vehicles

B) Scope – 2:

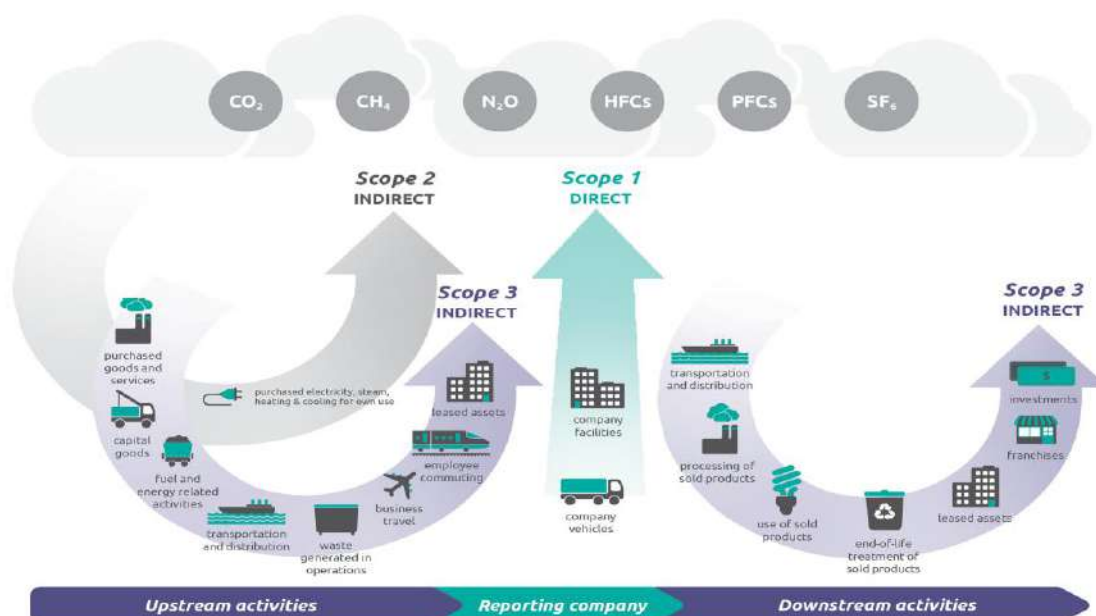
Purchased Electricity

C) Scope – 3:

I) Manufacturing of raw materials

II) Transportation

- Upstream Transportation or Transportation of raw materials
- Downstream Transportation or Transportation of products
- Transportation and disposal of Hazardous Wastes from site



Functional Unit

One of the primary purposes of a functional unit (FU) is to provide a reference to the input and output data (in a mathematical sense). In this study, we have considered 1 MT of a product as a functional unit.

Carbon footprint analysis is an impact category focused exclusively on Global Warming Potential (GWP). It measures the climate change potential of GHG emissions in units of CO₂ equivalent. The standard emission rates as published are used to find the impact and results of Carbon Footprint of production / process activities.

2.3 Data Collection and Sources

Data was collected from primary source of Industry. Inventory of actual data and analysis for year 2024-25 was considered for analysis of carbon foot print and calculations for Cradle to Gate scenario. Primary data are directly accessible, plant-specific, measured & accurate data generated from the factual information.

Data categories for which inventory data were collected, including material requirement from the production team and energy inputs from the engineering team; and wastes and product outputs from production planning team. In general, inventory data are normalized to either the mass of an input or output per functional unit, or energy input (e.g., kWh) per functional unit. Data were also collected on the final deposition of emissions outputs, such as whether outputs are recycled, treated, and/or disposed. This information was used to help determine which impacts are calculated for inventory item.

The GHG emission factors have been taken from standard sources of national and International organizations for carbon emissions.

3 DATA COLLECTION

Industry related information for analysis of carbon foot print was collected for the following:

3.1 Production Data

The total production for the two products for the year 2024-25 is presented in **Table 1-1** & **Table 3-2** as below:

Table 3-1: Month wise production data of Anhydrous Aluminium Chloride for 2024-25

Month	Production in MT
Apr-24	904.817
May-24	913.800
Jun-24	905.423
Jul-24	929.201
Aug-24	938.208
Sep-24	894.220
Oct-24	922.821
Nov-24	911.491
Dec-24	918.519
Jan-25	872.272
Feb-25	847.387
Mar-25	927.902
Total	10886 MTPA

Table 3-2: Month wise production data of Aluminium Hexa Hydrate for 2024-25

Month	Production in MT
Apr-24	19.781
May-24	14.650
Jun-24	30.100
Jul-24	9.700
Aug-24	10.250
Sep-24	5.000
Oct-24	11.150
Nov-24	21.570
Dec-24	39.500
Jan-25	23.908
Feb-25	28.350
Mar-25	33.475
Total	247 MTPA

The production is a continuous process 365 days a year.

3.2 Process Description & Material Balance

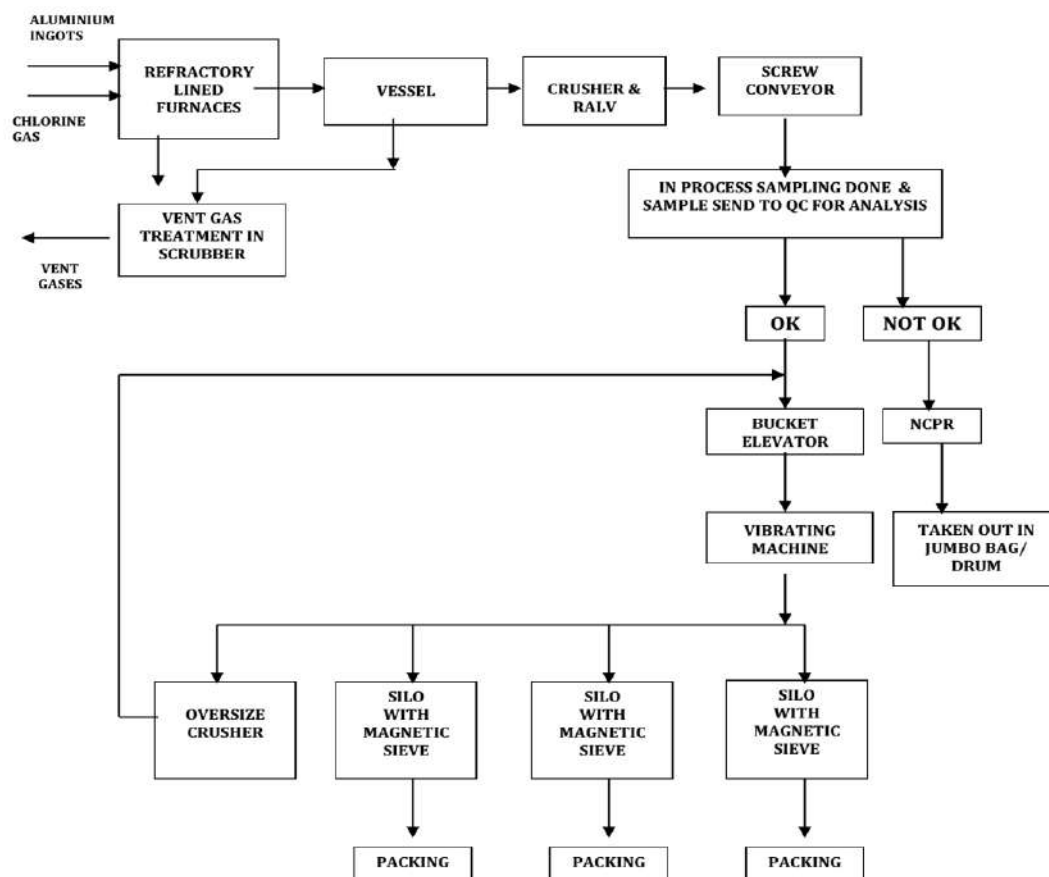
Anhydrous Aluminium Chloride (AlCl_3)

Aluminium Chloride Anhydrous is produced from the reaction of pure gaseous chlorine with high purity molten Aluminium.

Aluminium ingots are raw materials which are melted in a furnace and then reacted with chlorine gas through purging to produce aluminium chloride. The Aluminum metal is reacted with chlorine gas directly, usually at temperatures between 650°C and 750°C.

Raw Materials Used: Aluminium ingots, Chlorine gas through tonners.

A process flow diagram is presented as below:



In the process vent gas emissions are passed through scrubber and then vented to atmosphere. The material balance of the production process for anhydrous aluminium chloride is as under:

S. No.	Input/MT of Product					
	Raw Materials			Quantity (MT/MT)		
1	Aluminium			0.208		
2	Cl_2			0.820		
	Total			1.028		
S. No.	Output/MT of Product					Remark
	Product	Liquid Effluent	Air Emission	Recovery / Product	Solid Waste	
1	Anhydrous AlCl_3	-	-	1	-	Product
2			0.028			Treated in scrubber and recovered and further off gases vented to atmosphere

Aluminium Chloride Hexa Hydrate

Aluminum Chloride Hexa hydrate is a chemical compound with the formula $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$. It is a hydrate of aluminum chloride, meaning it contains water molecules within its crystal structure.

3.3 Power Utilization

The total power utilized from external electricity source in the industry is presented in **Table 3-3** as below:

Table 3-3: Month wise Electricity / Power Consumption Data for 2024-25

Month	Electricity Consumption in KWH
Apr-24	44744
May-24	46881
Jun-24	44334
Jul-24	43153
Aug-24	35524
Sep-24	33607
Oct-24	44648
Nov-24	44992
Dec-24	47236
Jan-25	41836
Feb-25	38436
Mar-25	41973
Total	507364

3.4 Standby Power Utilization

As standby power DG Sets are installed in factory premises of 200 KVA. The DG Sets are operated on HSD. The data of running of DG Sets during power failure for entire year is presented in **Table 3-4** as below:

Table 3-4: Month wise Standby DG Running Hours and its HSD Consumption for 2024-25

Sr No	Month	DG Running hours	Diesel Consumption in Litres per hr
1	Apr-24	33	40
2	May-24	25	40
3	Jun-24	44	40
4	Jul-24	24	40
5	Aug-24	133	40
6	Sep-24	81	40
7	Oct-24	14	40
8	Nov-24	37	40
9	Dec-24	19	40
10	Jan-25	32	40
11	Feb-25	26	40
12	Mar-25	212	40
13	TOTAL	680	

3.5 Utility

As part of utility, there is boiler available on site of 200 Kgs per hr running on agro wastes. The data on agro waste consumption per month for entire year is presented in **Table 3-5** as below:

Table 3-5: Month wise data on agro waste consumption in Boiler for 2024-25

Sr No	Month	Agro Waste Consumption (in Kgs per month)	Agro Waste Consumption (in MTPM)
1	Apr-24	66860	66.86
2	May-24	64862	64.862
3	Jun-24	64214	64.214
4	Jul-24	47883	47.883
5	Aug-24	51590	51.59
6	Sep-24	43540	43.54
7	Oct-24	59762	59.762
8	Nov-24	64922	64.922
9	Dec-24	81320	81.32
10	Jan-25	57670	57.67
11	Feb-25	60350	60.35
12	Mar-25	64240	64.24
13	TOTAL	727213	727.213

3.6 Raw Material Input

Aluminium ingots and Gaseous Chlorine tonners are basic two input raw materials for the production. The data on raw material input of Aluminium and Chlorine tonners, truck trips and km travelled per month for entire year is presented in **Table 3-6** and **Table 3-7** is as below:

Table 3-6: Month wise data on raw material (Aluminium) input, trucks & km travelled for 2024-25

Month	No of Vehicles / Trucks	Total Qty (in Kgs)	Qty per Truck (in Kgs)	Km travelled
Apr-24	10	281502	28150	7700
May-24	6	135256	22542	4942
Jun-24	8	149950	18743	6995
Jul-24	9	206293	22921	9713
Aug-24	6	167933	27988	4905
Sep-24	10	228867	22886	6285
Oct-24	6	148608	24768	6220
Nov-24	4	108621	27155	4780
Dec-24	7	132211	18887	4166
Jan-25	7	164131	23447	7009
Feb-25	4	95946	23986	4167
Mar-25	7	170063	24294	6702
TOTAL	84	1989381		73584
		1989.38 Tonnes		

Table 3-7: Month wise data on raw material (Chlorine Tonners) input, trucks & km travelled for 2024-25

Month	No of Vehicles / Trucks	Total Qty (in Kgs)	Qty per Truck (in Kgs)	Km travelled
Apr-24	44	715500	16261	5223
May-24	44	712800	16200	4878
Jun-24	41	702000	17122	5042
Jul-24	50	816300	16326	6275
Aug-24	47	719100	15300	5634
Sep-24	46	738900	16063	5382
Oct-24	50	764100	15282	5700
Nov-24	57	735300	12900	1599
Dec-24	46	743400	16161	5037
Jan-25	44	715500	16261	5568
Feb-25	41	680400	16595	5272
Mar-25	43	751500	17477	5891
TOTAL	553	8794800		61501
		8794.8 Tonnes		

3.7 Product Material Input

Anhydrous Aluminium Chloride and Aluminium Chloride Hexa Hydrate are basic two output products from the production. The data on product output, truck trips and km travelled per month for entire year is presented in **Table 3-8** as below:

Table 3-8: Month wise data on raw material (ALCL₃ Anhydrous and Hexa Hydrate) input, trucks & km travelled for 2024-25

Month	No of Vehicles / Trucks	Total Qty (in Kgs)	Qty per Truck (in Kgs)	Km travelled
Apr-24	128	1122.298	18263.163	49810
May-24	133	1090.286	16936.245	39527
Jun-24	127	847.722	14872.642	34914
Jul-24	116	711.976	14884.634	35590
Aug-24	102	642.933	15029.040	31446
Sep-24	83	559.545	17763.228	24761
Oct-24	95	575.646	12273.540	39206
Nov-24	65	445.27	12737.833	19031
Dec-24	92	812.613	25815.632	27016
Jan-25	102	746.025	18037.069	31924
Feb-25	69	487.866	17177.474	21046
Mar-25	85	634.525	17733.667	27096
TOTAL	1197	8676.705		381367

3.8 General Transportation to & within the site

The employee transportation to the site on daily basis will also contribute to the carbon emissions and thereby are considered as part of calculations. The data on daily commuting of officials to the site is presented in **Table 3-9** as below:

Table 3-9: Month wise data travel by vehicles for staff, vehicles & km travelled for 2024-25

No. of Employee	No. of Days	Travel (Km per month)	Vehicle Type
10	26	1196	Diesel (Tavera)
2	26	1196	Disel (Innova)
54	30	11700	CNG (VAN)
40	26	780	Petrol (BIKE)

The internal material handling is carried out by Forklifts; operated on HSD, and hence will also contribute to the carbon emissions. Hence they are also considered as part of calculations. The data on operational of Forklift within the site is presented in **Table 3-10** as below:

Table 3-10: Month wise data on operation of forklifts within the site for 2024-25

Month	Diesel Consumption (in Litres)
Apr-24	220
May-24	230
Jun-24	240
Jul-24	230
Aug-24	140
Sep-24	160
Oct-24	130
Nov-24	150
Dec-24	230
Jan-25	150
Feb-25	170
Mar-25	130

Based on the above baseline information the carbon foot print analysis and calculations (GWP Potential) are further carried out and presented in next chapter.

4 CARBON FOOTPRINT ANALYSIS

Inventory analysis involves calculation procedures to quantify relevant inputs and outputs of the product system, processes or activity. Data collection is the identification and quantification of relevant inputs and outputs for each unit processes of a specific product system, process or activity. Data for each unit process within the systems boundary often includes energy, raw material, products, co-products, and waste and emissions to air, water, and solid waste.

All product systems, processes or activities are identified to belong to Scope - 1, Scope - 2 and scope - 3 as stated in **Scope of GHG Emissions** and the Environmental Assessment is considered of **Cradle to Gate**.

Each of the products systems, processes or activities are then further substantiated by collection of data.

Data was collected from both primary and secondary sources. Primary data is directly accessible, plant-specific, measured, estimated data generated for the site. Secondary data is from literature sources, verified databases. Typically, data for each unit process in a product system is either provided directly from industry or using an LCI database, such as *ecoinvent*[®]. Databases such as *ecoinvent*[®] provide industrial data on chemicals, unit processes and unit reactions that allow for the development of complex product systems. The estimation is based on primary data collected from Industry.

In general, inventory data is normalized to either the mass of an input or output per functional unit, or energy input (e.g., KWH) per functional unit. Data is also collected on the final deposition of emissions outputs, such as whether outputs are recycled, treated, and/or disposed. This information is used to help determine which impacts are calculated for inventory item.

4.1 Scope 1 GHG Emissions

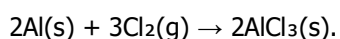
These are direct emissions from activities owned or controlled by the organization. Direct GHG emissions which occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment.

Following direct emissions are covered based on available baseline data:

- Fuel Consumption – Boilers and DG Sets required for the process.
- Operation of Forklifts

1. Manufacturing Process

Anhydrous aluminum chloride (AlCl₃) is produced by the exothermic reaction between aluminum ingots and dry chlorine gas at high temperatures, with the balanced chemical equation being:



Production Process:

Reaction: Aluminum metal reacts directly with dry chlorine gas.

Temperature Control: The reaction is typically conducted at around 800°C.

Product Collection: The gaseous anhydrous aluminum chloride product is cooled to approximately 400°C for natural condensation and crystallization, yielding solid anhydrous aluminum chloride.

The entire reaction is closed loop system and hence no emissions are estimated from the process. The scope – 1 estimation is based on the fuel consumption in utilities required for process operations.

2. Fuel Consumption

In Boilers:

One Boiler of 600 Kgs per hr capacity have been provided at the plant and which run on Agro waste as feed stock. The inventory and inputs considered for the GHG emissions due to fuel consumption for the operation of Boilers is presented in **Table 4-1**

Table 4-1: Global warming potential for emissions from operation of boiler using HSD as fuel - 2024-25

Sr No	Month	Agro Waste Consumption (in Kgs per month)	Agro Waste Consumption (in MTPM)	NCV of Agro Waste (Rice Husk)	Total Energy	Emission factor (Indian Context) - t/TJ (As per Indian Institute of Science)				Emission Calculation				Global Warming Potential
				TJ/kt	TJPM	CO ₂	CH ₄	N ₂ O	Unit	CO ₂	CH ₄	N ₂ O	Unit	tCO ₂ e, GWP100
1	Apr-24	66860	66.86	14.5	0.97	57.6	0.007	0.002	t/TJ	55.84	0.01	0.00	t	55.85
2	May-24	64862	64.862	14.5	0.94	57.6	0.007	0.002	t/TJ	54.17	0.01	0.00	t	54.18
3	Jun-24	64214	64.214	14.5	0.93	57.6	0.007	0.002	t/TJ	53.63	0.01	0.00	t	53.64
4	Jul-24	47883	47.883	14.5	0.69	57.6	0.007	0.002	t/TJ	39.99	0.00	0.00	t	40.00
5	Aug-24	51590	51.59	14.5	0.75	57.6	0.007	0.002	t/TJ	43.09	0.01	0.00	t	43.09
6	Sep-24	43540	43.54	14.5	0.63	57.6	0.007	0.002	t/TJ	36.36	0.00	0.00	t	36.37
7	Oct-24	59762	59.762	14.5	0.87	57.6	0.007	0.002	t/TJ	49.91	0.01	0.00	t	49.92
8	Nov-24	64922	64.922	14.5	0.94	57.6	0.007	0.002	t/TJ	54.22	0.01	0.00	t	54.23
9	Dec-24	81320	81.32	14.5	1.18	57.6	0.007	0.002	t/TJ	67.92	0.01	0.00	t	67.93
10	Jan-25	57670	57.67	14.5	0.84	57.6	0.007	0.002	t/TJ	48.17	0.01	0.00	t	48.17
11	Feb-25	60350	60.35	14.5	0.88	57.6	0.007	0.002	t/TJ	50.40	0.01	0.00	t	50.41
12	Mar-25	64240	64.24	14.5	0.93	57.6	0.007	0.002	t/TJ	53.65	0.01	0.00	t	53.66
13	TOTAL	727213	727.213		11									607

The Global Warming Potential (GWP) calculated for emissions due to consumption of HSD for operation of boilers will be ~ **607 tCO₂e per annum**.

In DG Sets:

DG Set of 200 KVA is provided and operated at the plant. The inventory and inputs considered for the GHG emissions due to fuel consumption for the operation of DG Set is presented in **Table 4-2** as below:

Table 4-2: Global warming potential for emissions from operation of DG Sets using HSD as fuel - 2024-25

Sr No	Month	DG Running hours	Diesel Consumption in Litres per hr	Total Diesel Consumption per month (Litres)	Density of Diesel (1 Litre = 0.84 Kg)	Total Diesel consumed in MTPM)	NCV of Diesel	Energy	Emission factor (Indian Context) - t/TJ (As per Indian Institute of Science)				Emission Calculation				Global Warming Potential
							TJ/kt	TJ	CO ₂	CH ₄	N ₂ O	Unit	CO ₂	CH ₄	N ₂ O	Unit	tCO ₂ e, GWP100
1	Apr-24	33	40	1320	0.84	1.1	45	0.0	74.1	0.007	0.002	t/TJ	3.70	0.00	0.00	t	3.70
2	May-24	25	40	1000	0.84	0.8	45	0.0	74.1	0.007	0.002	t/TJ	2.80	0.00	0.00	t	2.80
3	Jun-24	44	40	1760	0.84	1.5	45	0.1	74.1	0.007	0.002	t/TJ	4.93	0.00	0.00	t	4.93
4	Jul-24	24	40	960	0.84	0.8	45	0.0	74.1	0.007	0.002	t/TJ	2.69	0.00	0.00	t	2.69
5	Aug-24	133	40	5320	0.84	4.5	45	0.2	74.1	0.007	0.002	t/TJ	14.90	0.00	0.00	t	14.90
6	Sep-24	81	40	3240	0.84	2.7	45	0.1	74.1	0.007	0.002	t/TJ	9.08	0.00	0.00	t	9.08
7	Oct-24	14	40	560	0.84	0.5	45	0.0	74.1	0.007	0.002	t/TJ	1.57	0.00	0.00	t	1.57
8	Nov-24	37	40	1480	0.84	1.2	45	0.1	74.1	0.007	0.002	t/TJ	4.15	0.00	0.00	t	4.15
9	Dec-24	19	40	760	0.84	0.6	45	0.0	74.1	0.007	0.002	t/TJ	2.13	0.00	0.00	t	2.13
10	Jan-25	32	40	1280	0.84	1.1	45	0.0	74.1	0.007	0.002	t/TJ	3.59	0.00	0.00	t	3.59
11	Feb-25	26	40	1040	0.84	0.9	45	0.0	74.1	0.007	0.002	t/TJ	2.91	0.00	0.00	t	2.91
12	Mar-25	212	40	8480	0.84	7.1	45	0.3	74.1	0.007	0.002	t/TJ	23.75	0.00	0.00	t	23.76
13	TOTAL	680		27200	0.84	23		1									76.20

The Global Warming Potential (GWP) calculated for emissions due to consumption of HSD for operation of DG Sets will be ~ **76.2 tCO₂e per annum.**

Operation of Forklifts inside site premises:

Forklifts are operated within the site running of fuel as HSD inside the plant. The inventory and inputs considered for the GHG emissions due to fuel consumption for the operation of Forklifts is presented in **Table 4-3** as below:

Table 4-3: Global warming potential for emissions from operation of forklifts using HSD as fuel - 2024-25

Sr No	Month	Total Diesel Consumption per month for 2 Nos of Forklifts (Litres)	Density of Diesel (1 Litre = 0.84 Kg)	Total Diesel consumed in MTPM)	NCV of Diesel	Energy	Emission factor (Indian Context) - t/TJ (As per Indian Institute of Science)				Emission Calculation				Global Warming Potential
					TJ/kt	TJ	CO ₂	CH ₄	N ₂ O	Unit	CO ₂	CH ₄	N ₂ O	Unit	tCO ₂ e, GWP100
1	Apr-24	220	0.84	0.185	45	0.0	74.1	0.007	0.002	t/TJ	0.62	0.00	0.00	t	0.62
2	May-24	230	0.84	0.193	45	0.0	74.1	0.007	0.002	t/TJ	0.64	0.00	0.00	t	0.64
3	Jun-24	240	0.84	0.202	45	0.0	74.1	0.007	0.002	t/TJ	0.67	0.00	0.00	t	0.67
4	Jul-24	230	0.84	0.193	45	0.0	74.1	0.007	0.002	t/TJ	0.64	0.00	0.00	t	0.64
5	Aug-24	140	0.84	0.118	45	0.0	74.1	0.007	0.002	t/TJ	0.39	0.00	0.00	t	0.39
6	Sep-24	160	0.84	0.134	45	0.0	74.1	0.007	0.002	t/TJ	0.45	0.00	0.00	t	0.45
7	Oct-24	130	0.84	0.109	45	0.0	74.1	0.007	0.002	t/TJ	0.36	0.00	0.00	t	0.36
8	Nov-24	150	0.84	0.126	45	0.0	74.1	0.007	0.002	t/TJ	0.42	0.00	0.00	t	0.42
9	Dec-24	230	0.84	0.193	45	0.0	74.1	0.007	0.002	t/TJ	0.64	0.00	0.00	t	0.64
10	Jan-25	150	0.84	0.126	45	0.0	74.1	0.007	0.002	t/TJ	0.42	0.00	0.00	t	0.42
11	Feb-25	170	0.84	0.143	45	0.0	74.1	0.007	0.002	t/TJ	0.48	0.00	0.00	t	0.48
12	Mar-25	130	0.84	0.109	45	0.0	74.1	0.007	0.002	t/TJ	0.36	0.00	0.00	t	0.36
13	TOTAL	2180	0.84	1.83		0									6.11

The Global Warming Potential (GWP) calculated for emissions due to consumption of HSD for operation of Forklifts will be ~ **6.1 tCO₂e per annum**.

In Commuting Vehicles running on Diesel and Petrol:

The site has commuting vehicles for their officers and staff being operated on petrol, diesel and CNG. The inventory and inputs considered for the GHG emissions due to fuel consumption for the operation of commuting vehicles is presented in **Table 4-4** as below:

Table 4-4: Global warming potential for emissions from operation of commuting vehicles using HSD as fuel - 2024-25

Type of Vehicle	Fuel Used	Distance Travelled in Km per year	Emission factor kg CO ₂ e per Km				Emission Calculation				Global Warming Potential per year
			CO ₂	CH ₄	N ₂ O	Unit	CO ₂	CH ₄	N ₂ O	Unit	tCO ₂ e, GWP100
Tavera / Innova	Diesel	28704	0.17142	0.0000046	0.00167	Kg	4.92	0.0001	0.05	t	4.97
CNG Van	CNG	140400	0.03718	0.0015	0.00012	Kg	5.22	0.2088	0.02	t	5.45
Bike	Petrol	9360	0.19143	0.0003584	0.00032	Kg	1.79	0.0034	0.00	t	1.80
TOTAL		178464									12.21

Note: 1 kg of CH₄ is roughly equivalent to 25 kg of CO₂e, 1 kg of N₂O is roughly equivalent to 298 kg of CO₂e. The emission factor for CNG vehicles is typically around 0.03718 kg CO₂e/km, or 0.00003718 t CO₂e/km.

The Global Warming Potential (GWP) calculated for emissions due to consumption of Petrol, Diesel and CNG for operation of commuting vehicles will be ~ **12.21 tCO₂e per annum**.

4.2 Scope 2 GHG Emissions

Scope - 2 emissions are the indirect emissions associated with purchased electricity; physically occur at the facility where electricity or energy is generated. They account for GHG emissions from the generation of purchased electricity or energy consumed by company. Purchased electricity/energy is defined as electricity or other utilities that are acquired or otherwise brought into the organizational boundary of the company. Actual power (purchased electricity) of the site from the Dakshin Gujarat Vij Company Limited (DGVCL) is used for estimating the indirect emissions as under:

Table 4-5: Global warming potential based on inputs considered for purchased electricity - 2024-25

Sr No	MONTH	Electrical Consumption KWH	Electrical Consumption MWH	Emission Factor tCO ₂ e/MWh	Global Warming Potential
					tCO ₂ e, GWP100
1	Apr-24	44744	44.74	0.727	32.53
2	May-24	46881	46.88	0.727	34.08
3	Jun-24	44334	44.33	0.727	32.23
4	Jul-24	43153	43.15	0.727	31.37
5	Aug-24	35524	35.52	0.727	25.83
6	Sep-24	33607	33.61	0.727	24.43
7	Oct-24	44648	44.65	0.727	32.46
8	Nov-24	44992	44.99	0.727	32.71
9	Dec-24	47236	47.24	0.727	34.34
10	Jan-25	41836	41.84	0.727	30.41
11	Feb-25	38436	38.44	0.727	27.94
12	Mar-25	41973	41.97	0.727	30.51
13	TOTAL	507364	507.36		368.85
Hrs of operation					24.00
Total tCO₂e, GWP100 per annum					8852.49

Note: The Central Electricity Authority (CEA) in India has established a weighted average CO₂ emission factor of 0.727 tCO₂/MWh for the Indian grid in the fiscal year 2023-24.

The Global Warming Potential (GWP) calculated for purchased electricity will be ~ **8852.89 tCO₂e per annum**.

4.3 Scope 3 GHG Emissions

Scope - 3 emissions are indirect emissions from activities that occur at sources outside its control and are not classified as scope - 2. Scope - 3 emissions are a consequence of the activities of the company, but occur from sources not owned or controlled by the company.

This study delineates the scope boundary so that scope - 3 emissions are attributed to upstream and downstream transportation for input of raw material from source and transportation of products to potential product buyers.

Raw Material Transportation:

The GPW Potential for Inventory and inputs for raw materials transportation of Aluminium is presented in **Table 4-6** as below:

Table 4-6: Global warming potential based on Inventory and inputs for raw material transportation (Aluminium) - 2024-25

Sr No	Month	No of Vehicles	Quantity in MT	Avg Qty	Km	CO2 Emission Kg / Km	Global Warming Potential
							tCO _{2e} , GWP100
1	Apr-24	10	281502	28150	7700	0.8	6.16
2	May-24	6	135256	22542	4942	0.8	3.95
3	Jun-24	8	149950	18743	6995	0.8	5.60
4	Jul-24	9	206293	22921	9713	0.8	7.77
5	Aug-24	6	167933	27988	4905	0.8	3.92
6	Sep-24	10	228867	22886	6285	0.8	5.03
7	Oct-24	6	148608	24768	6220	0.8	4.98
8	Nov-24	4	108621	27155	4780	0.8	3.82
9	Dec-24	7	132211	18887	4166	0.8	3.33
10	Jan-25	7	164131	23447	7009	0.8	5.61
11	Feb-25	4	95946	23986	4167	0.8	3.33
12	Mar-25	7	170063	24294	6702	0.8	5.36
13	TOTAL	84	1989381		73584		58.9

Note: A study by the International Council on Clean Transportation found that average CO2 emissions for heavy-duty vehicles (HDVs) range from 600-1200 g CO2/km, considered average of 800 g CO2 per km.

The Global Warming Potential (GWP) calculated for raw material transportation of Aluminium will be ~ **58.9 tCO_{2e} per annum.**

The GPW Potential for Inventory and inputs for raw materials transportation of Chlorine Gas is presented in **Table 4-7** as below:

Table 4-7: Global warming potential based on Inventory and inputs for raw material transportation (Chlorine Gas) - 2024-25

Sr No	Month	No of Vehicles	Quantity in MT	Avg Qty	Km	CO2 Emission Kgs / Km	Global Warming Potential
							tCO _{2e} , GWP100
1	Apr-24	44	715500	16261	5223	0.8	4.18
2	May-24	44	712800	16200	4878	0.8	3.90
3	Jun-24	41	702000	17122	5042	0.8	4.03
4	Jul-24	50	816300	16326	6275	0.8	5.02
5	Aug-24	47	719100	15300	5634	0.8	4.51
6	Sep-24	46	738900	16063	5382	0.8	4.31
7	Oct-24	50	764100	15282	5700	0.8	4.56
8	Nov-24	57	735300	12900	1599	0.8	1.28
9	Dec-24	46	743400	16161	5037	0.8	4.03
10	Jan-25	44	715500	16261	5568	0.8	4.45
11	Feb-25	41	680400	16595	5272	0.8	4.22
12	Mar-25	43	751500	17477	5891	0.8	4.71
13	TOTAL	553	8794800		61501		49.20

Note: A study by the International Council on Clean Transportation found that average CO₂ emissions for heavy-duty vehicles (HDVs) range from 600-1200 g CO₂/km, considered average of 800 g CO₂ per km.

The Global Warming Potential (GWP) calculated for raw material transportation of Chlorine will be **~ 49.2 tCO_{2e} per annum**

Raw Materials Manufacturing:

The Global Warming Potential (GWP) calculated for raw material manufacturing of Chlorine and Aluminium is as under:

Chlorine manufacturing – It is observed that GHG Emission for chlorine production is 2.1 tonnes of CO₂ emissions per tonne of chlorine produced. For Total chlorine input in factory the GWP Potential is estimated to $8794.8 \times 2.1 = \mathbf{18469.08 \text{ tCO}_2\text{e per annum}}$

Aluminium manufacturing – It is observed that GHG Emission for Aluminium production is 14.8 tonnes of CO₂ emissions per tonne of Aluminium produced. For Total chlorine input in factory the GWP Potential is estimated to $1989.381 \times 14.8 = \mathbf{29442.84 \text{ tCO}_2\text{e per annum.}}$

Products Transportation:

The GPW Potential for Inventory and inputs for products transportation is presented in **Table 4-8** as below:

Table 4-8: Global warming potential based on Inventory and inputs for product transportation (AlCl₃ and hydrate) - 2024-25

Sr No	Month	No of Vehicles	Quantity in MT	Avg Qty	Km	CO2 Emission Kgs / Km	Global Warming Potential
							tCO _{2e} , GWP100
1	Apr-24	128	1122	18263	49810	0.8	39.85
2	May-24	133	1090	16936	39527	0.8	31.62
3	Jun-24	127	848	14873	34914	0.8	27.93
4	Jul-24	116	712	14885	35590	0.8	28.47
5	Aug-24	102	643	15029	31446	0.8	25.16
6	Sep-24	83	560	17763	24761	0.8	19.81
7	Oct-24	95	576	12274	39206	0.8	31.36
8	Nov-24	65	445	12738	19031	0.8	15.22
9	Dec-24	92	813	25816	27016	0.8	21.61
10	Jan-25	102	746	18037	31924	0.8	25.54
11	Feb-25	69	488	17177	21046	0.8	16.84
12	Mar-25	85	635	17734	27096	0.8	21.68
13	TOTAL	1197	8676.705		381367		305.09

The Global Warming Potential (GWP) calculated for product transportation will be ~ **305.9 tCO_{2e} per annum**

Hazardous Waste Transportation and Disposal:

The hazardous Waste generation storage and transportation to the site of disposal and ultimate disposal of the same also is calculated in Scope 3 emissions related to the industry. These emissions are calculated as presented **Table 4-9** and **Table 4-10** as below:

Table 4-9: Global warming potential based on Inventory of Hazardous Waste Transportation - 2024-25

Sr No	Annual	No of Vehicles	Quantity in MT	Avg Qty	Km	CO2 Emission Kgs / Km	Global Warming Potential
							tCO _{2e} , GWP100
1	Annual Data	12	120	120	528	0.8	0.42

Table 4-10: Global warming potential based on Inventory of Hazardous Waste Disposal at the landfill site - 2024-25

Sr No	Annual	No of Vehicles	Quantity in MT	Quantity in MT	Km	CO2 Emission per tonne of waste disposed	Global Warming Potential
							tCO _{2e} , GWP100
1	Annual Data	12	120	120	528	1	120

4.4 Summary of all Scope 1, 2 and 3 GHG Emissions

A Summary of all Carbon Foot print / GWP Potential as evaluated for Scope 1, 2 and 3 emissions is presented in **Table 4-11** as below:

Table 4-11: Summary of Scope 1, 2 and 3 GHG Emissions for 2024-25

Sr No	Description of GHG Emissions	Global Warming Potential per year in tCO ₂ e, GWP100
	Scope 1	
1	Operation of Boilers	607
2	Operation of DG Sets	76.20
3	Forklift Operations Emissions	6.11
4	Vehicular transport - Passenger Emissions	12.21
	Total of Scope 1	701.98
	Scope 2	
1	Purchased Electricity	8852.49
	Scope 3	
1	Raw Material Production - Aluminium	29442.84
2	Raw Material Production - Chlorine Gas	18469.08
3	Raw Material Transportation - Aluminium	58.87
4	Raw Material Transportation - Chlorine	49.20
5	Product Transportation	305.09
6	Transportation of Hazardous Waste	0.42
7	Disposal of Hazardous Waste	120.00
	Total of Scope 3	48445.5
1	Total of Scope 1, 2 and 3 (tCO₂e, GWP100)	57999.97
2	Total Production per year (MTPA) - 2024-25	11133
3	Carbon Foot Print per Tonne of product (T CO₂ Eq.)	5.21
		52.1E-01

The overall GWP Potential (Carbon foot print) of current manufacturing facilities in the site of Base Metal Chemicals at Savli plant is estimated to ~ **57999.97 tCO₂e per annum which is 5.21 (52.1E-01) tCO₂e per Tonne of product.**

5 CARBON SEQUESTRATION

5.1 Carbon Sequestration Estimation

Understanding of Carbon footprint refers to the spent natural resources and produced GHG emissions over the life cycle of the product. Carbon footprint analysis focuses exclusively on Global Warming Potential (GWP) and measures the climate change potential of GHG emissions in units of CO₂ equivalent. In order to mitigate the carbon emissions, the company has already established carbon sink measures to sequest carbon as under:

1. Solar Power

A solar plant is established of 48 KW is established on site at Base metal.

To estimate the annual CO₂ savings, firstly determination of annual electricity generated by the 48 kW solar plant is to be estimated. Considering an electricity generation capacity of 4 kWh per day per kW, then 48 kW x 4 kWh/day x 365 days/year = 70,080 kWh/year.

The saved carbon thus can be worked out as 70,080 kWh/year x 0.82 kgCO₂/kWh = 57,465.6 kg of CO₂ which is ~ **57.5 tons of CO₂ annually**.

2. Green Belt Plantation

Greenbelt design and development has been attributed a great importance and became an essential element of carbon sequestration. A total of 200 trees are planted in and around the site periphery area. Global warming emission factor for *Annual Carbon Sequestration Potential* from *Assessment of Status and Carbon Sequestration Potential of Green Cover in the Major Urban Development Authorities of Gujarat* is considered to calculate the GWP reduced due to the activity as presented in **Table 5-1** as below:

Table 5-1: Global warming impact reduced using greenbelt plantation

Number of trees	Emission factor	GWP offset
	kgCO ₂ per tree per annum	tCO ₂ e, GWP 100
180	12.91	2.324

Thus, ~**2.324 tCO₂e per annum** are offset using greenbelt plantation.

Reduction of global warming impact due to mitigation measures

The aforementioned mitigation measures already taken on site would reduce global warming impact or emissions and mitigate the overall carbon footprint of the facility as presented in **Table 5-2** as below:

Table 5-2: Total Global Warming Impact Reduction – Carbon Sequestration

S. No.	Mitigation Measure	Global warming Potential offset
		tCO ₂ e per annum
1	Solar Power	57.5
2	Greenbelt Plantation	2.324
Total		59.734

Total carbon sequestration measures only contribute to 0.1 % of emissions of carbon annually.

5.2 Mitigation Measures

The reduction of carbon emissions need to be aimed at around 20% by the industry and adopt the following mitigation measures:

- Running of Forklifts on Battery instead of Diesel.
- Taking Electricity from Solar Grid.
- Reduced Transportation carbon foot print for raw materials and products.
- Increased Green Belt area and plantation of trees as part of CER.

6 SUMMARY & CONCLUSIONS

All emissions have been categorized as direct and indirect emissions. Direct emissions are identified from sources that are owned and controlled by the company. These emissions are considered scope-1. Indirect emissions are emissions that are a consequence of the activities of the reporting company, but occur at sources owned or controlled by another company. These include scope-2 and scope 3 emissions. Scope-2 includes emissions from energy purchased or acquired and consumed by the reporting company, while scope-3 emissions include upstream and downstream value chain emissions.

The scope-1 emissions, considering manufacturing processes as well as fuel consumption as contributing activities for the year 2024-25 are **~ 701.98 tCO₂e per annum** and constitute **~1.21%** of the carbon footprint.

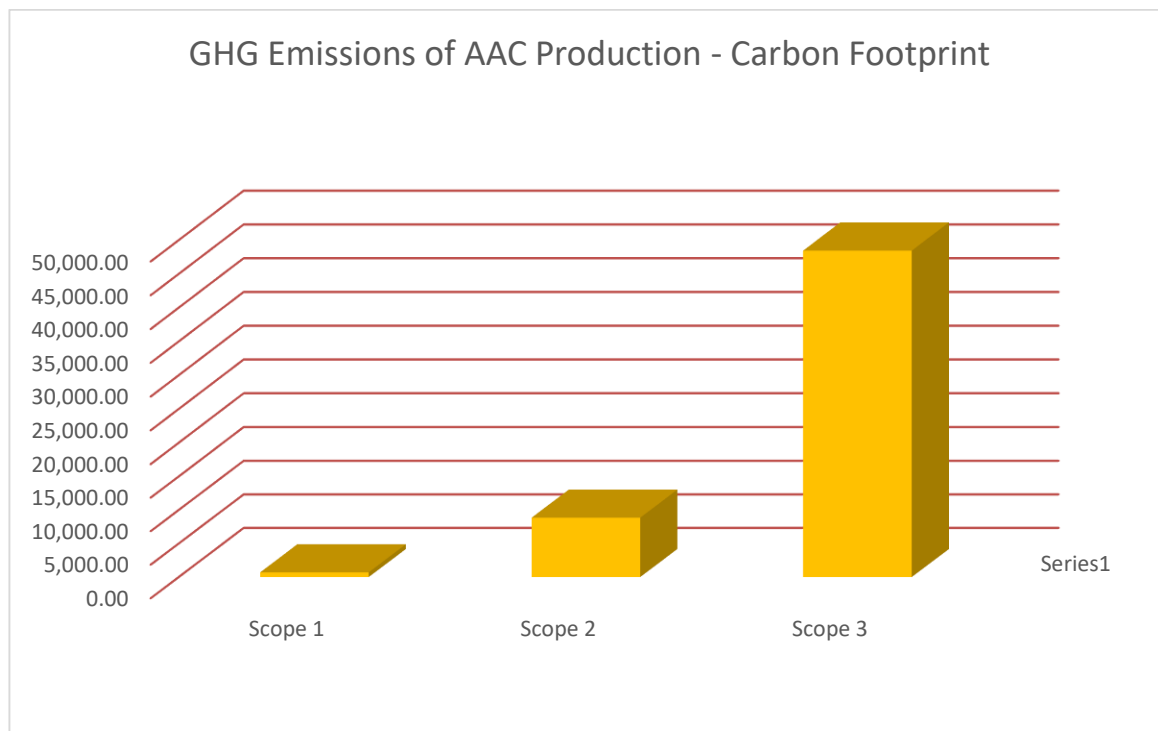
Secondly, scope - 2 emissions are the indirect emissions associated with purchased electricity.

The purchased electricity as a contributor is **~ 8852.5 tCO₂e per annum** and constitute **~15.3%** of the carbon footprint.

Lastly, scope - 3 emissions are indirect emissions from activities that occur at sources outside its control and are not classified as scope-2. Scope-3 emissions are a consequence of the activities of the company, but occur from sources not owned or controlled by the company. The scope-3 emissions put together are **~ 48445.5 tCO₂e per annum** for transportation of products, raw materials and transportation & disposal of hazardous waste. This constitute **~ 83.49%** of the carbon footprint.

The overall GWP Potential (Carbon foot print) of current manufacturing facilities in the site of Base Metal Chemicals at Savli plant is estimated to **~ 57999.97 tCO₂e per annum which is 5.21 tCO₂e per Tonne of product (52.1E-01).**

Graphical representation of the Carbon Foot print for Scope 1, 2 and 3 is as under:



Overall Summary of GHG Emissions

Description	Upstream activities (Scope 3 (indirect))	Core Project (Scope 1 (direct) & Scope 2 (indirect))	Downstream activities (Scope 3 (indirect))	Total GHG Emissions
Emissions in tCO ₂ e, GWP100	48019.99	9554.47	425.52	57999.98
Emissions in tCO ₂ e, GWP100 per Ton of AAC	4.31	0.86	0.04	5.21
	43.10E-01	8.6E-01	4E-01	52.1E-01

Mitigation Measures

The overall impact and global warming potential (GWP) is sequestered by Solar Power and green belt development in and around the site to the tune of **59.734 tCO₂e per annum**.

The company need to aim at reducing (sequestering) the carbon foot print to a level of around 20% of generation level in the coming years.

Following are the suggested mitigation measures:

- Running of Forklifts on Battery instead of Diesel.
- Taking Electricity from Solar Grid.
- Increased Solar Power generation within the site as per feasibility of area
- Reduced Transportation carbon foot print for raw materials and products
- Increased Green Belt area and plantation of trees as part of CER.