**TECHNO-ECONOMIC FEASIBILITY PROJECT—**

**PVC RESIN MANUFACTURING**

**Submitted By**

**Logo

Description automatically generated**

**MARKET INTELLIGENCE. CONSULTING**

**September 21, 2022**

**Index**

|  |  |  |
| --- | --- | --- |
| **S.No.** | **Contents For Pre-Feasibility Report** | **Page No.** |
| **1** | **Introduction and Background** | **3** |
| **2** | **Demand Supply Gap Analysis Period - April 2020 to March 2040** | **4** |
| **3** | **Basis and Objectives of Pre-Feasibility Study (PFS)** | **23** |
| **4** | **Optimum Case for the PFS** | **26** |
| **5** | **Process Description, Product Slate, Specifications, Applications, and Unit Capacities** | **26** |
| **6** | **Block Flow Diagram and Plot Plan Estimation** | **31** |
| **7** | **Utility Systems** | **46** |
| **8** | **Catalyst and Chemical** | **47** |
| **9** | **Offsite Storage System, Flare System, Effluent Treatment System** | **48** |
| **10** | **Feed, Product and Utility Prices** | **50** |
| **11** | **Regulations** | **54** |
| **12** | **Financial Analysis** | **69** |
| **13** | **Project Schedule and Implementation Strategy** | **85** |
| **14** | **SWOT Analysis** | **86** |
| **15** | **Risk Factors and Mitigation** | **88** |
| **16** | **Technology Licensors** | **88** |
| **17** | **Recommendations** | **90** |

**1. Introduction and Background**

Polyvinyl Chloride (colloquial: polyvinyl, or simply vinyl; abbreviated: PVC) is a versatile thermoplastic. It is stable under normal conditions and shows incompatibility with aromatic or chlorinated hydrocarbons and ketones. It is generally inert but reacts violently with fluorine and is soluble in hydrocarbons, cyclohexanone & certain hydrocarbons.

PVC comes in two primary forms: rigid (sometimes abbreviated as RPVC) and flexible. The rigid form of PVC is used in construction for pipe and profile applications such as doors and windows. It is also used in plastic bottles, non-food packaging, food-covering sheets, and plastic cards (such as bank or membership cards). It can be made softer and more flexible by the addition of plasticizers, the most widely used being phthalates. In this form, it is also used in plumbing, electrical cable insulation, imitation leather, flooring, signage, phonograph records, inflatable products, and many applications where it replaces rubber. With cotton or linen, it is used in the production of canvas.

Pure polyvinyl chloride is a white, brittle solid. It is insoluble in alcohol but slightly soluble in tetrahydrofuran.

The client intended to carry out a detailed Techno-Economic Feasibility Study for PVC Resin manufacturing. New Age TechSci Research Private Limited was awarded to conduct this study as a consultant. Based on TechSci's recommendations, the client would strive to implement the commercial capacity of PVC Resins.

The study broadly covers areas related to

* + Demand Supply Analysis
  + CapEx and OpEx Analysis
  + Detailed Project Cost Estimation
  + Net Realization
  + Profitability Projections
  + Payback
  + SWOT Analysis
  + Process and Licensor Evaluation
  + Project Schedule & Implementation Strategy
  + Regulations
  + Risk Factor & Mitigation

1. **Projected Supply Demand Gap Analysis**
   1. **Global Polyvinyl Chloride (PVC) Capacity and Production, By Volume (000’ Tonnes), 2015-2030F**

*Source: TechSci Research*

The global PVC capacity stood at 54.96960 million thousand tonnes in 2020 and is expected to reach 56.38 million tonnes by 2030. The production in 2020 declined by 5.93% to reach 43.09 million tonnes from 2019. The global production reached 43965 thousand tonnes with a y-o-y growth of 2.03 percent in 2021. The Asia Pacific is the largest demand-generating region and holds around 40% of the global capacity. Shintech, Formosa Plastics, INOVYN, and Occidental Petroleum are the world's largest PVC manufacturing companies. The rising demand for PVC in the construction sector is anticipated to push the global demand for PVC in the forecast period.

* 1. **Global Polyvinyl Chloride (PVC) Demand, By Volume (000’ Tonnes), 2015-2030F**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand** | | | | | | **CAGR 2015-2020** | **CAGR 2021E-2030F** |
| **2015** | **2020** | **2021E** | **2022F** | **2025F** | **2030F** |
| 40,987 | 43,090 | 44,909 | 46,633 | 51,633 | 60,177 | 1.01% | 3.31% |

*Source: TechSci Research*

* 1. **Global Capacity, By Company, By Volume (000’ Tonnes), 2015-2030F**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Company** | **Location** | **2015** | **2020** | **2021E** | **2022F** | **2025F** | **2030F** |
| **Shin-Etsu** | USA | 3,000 | 3,000 | 3,000 | 3,000 | 3,390 | 3,390 |
| Japan | 550 | 550 | 550 | 550 | 550 | 550 |
| Netherlands | 450 | 450 | 450 | 450 | 450 | 450 |
| Portugal | 215 | 215 | 215 | 215 | 215 | 215 |
| **Formosa Plastics** | Taiwan | 1301 | 1301 | 1301 | 1301 | 1301 | 1301 |
| USA | 1160 | 1160 | 1160 | 1160 | 1291 | 1291 |
| **INOVYN** | Belgium | 470 | 470 | 470 | 470 | 470 | 470 |
| Germany | 320 | 320 | 320 | 320 | 320 | 320 |
| France | 320 | 320 | 320 | 320 | 320 | 320 |
| United Kingdom | 290 | 290 | 290 | 290 | 290 | 290 |
| Spain | 240 | 240 | 240 | 240 | 240 | 240 |
| Sweden | 202 | 202 | 202 | 202 | 202 | 202 |
| Norway | 150 | 150 | 150 | 150 | 150 | 150 |
| **Westlake** | USA | 1476 | 1796 | 1796 | 1796 | 1796 | 1796 |
| **Occidental Petroleum** | USA | 1705 | 1705 | 1705 | 1705 | 1705 | 1705 |
| **OxyVinyls** | USA | 1257 | 1257 | 1257 | 1257 | 1257 | 1257 |
| **Georgia Gulf Corp** | USA | 1239 | 1239 | 1239 | 1239 | 1239 | 1239 |
| **Mexichem** | Columbia | 400 | 400 | 400 | 400 | 400 | 400 |
| Mexico | 690 | 690 | 690 | 690 | 690 | 690 |
| **Solvay** | Russia | 330 | 330 | 330 | 330 | 330 | 330 |
| Brazil | 300 | 300 | 300 | 300 | 300 | 300 |
| Argentina | 240 | 240 | 240 | 240 | 240 | 240 |
| **Kem One** | France | 870 | 870 | 870 | 870 | 870 | 870 |
| **VYNOVA** | Germany | 380 | 380 | 380 | 380 | 380 | 380 |
| France | 255 | 255 | 255 | 255 | 255 | 255 |
| Netherlands | 225 | 225 | 225 | 225 | 225 | 225 |
| **LG Chem** | South Korea | 820 | 820 | 820 | 820 | 820 | 820 |
| **Xinjiang Tianye Chemical** | China | 800 | 800 | 800 | 800 | 800 | 800 |
| **Vinnolit** | Germany | 750 | 750 | 750 | 750 | 750 | 750 |
| **Xinjiang Huatai Heavy Chemical** | China | 740 | 740 | 740 | 740 | 740 | 740 |
| **Braskem** | Brazil | 710 | 710 | 710 | 710 | 710 | 710 |
| **Thai Plastic & Chemicals** | Thailand | 620 | 620 | 620 | 620 | 620 | 620 |
| **Sinopec Qilu Petrochemical** | China | 600 | 600 | 600 | 600 | 600 | 600 |
| **Yibin Haifing Herui** | China | 580 | 580 | 580 | 580 | 580 | 580 |
| **Hanwha Chemical** | China | 300 | 300 | 300 | 300 | 300 | 300 |
| South Korea | 560 | 560 | 560 | 560 | 560 | 560 |
| **Taiyo Vinyl** | Japan | 558 | 558 | 558 | 558 | 558 | 558 |
| **Tianjin Dagu Chemical** | China | 540 | 540 | 540 | 540 | 540 | 540 |
| **Unipar Indupa** | Brazil | 300 | 300 | 300 | 300 | 300 | 300 |
| Argentina | 222 | 222 | 222 | 222 | 222 | 222 |
| **Others** | Rest of Global | 27705 | 28505 | 28505 | 29105 | 29415 | 29415 |
| **Total** | | **53840** | **54960** | **54960** | **55560** | **56381** | **56381** |

*Source: TechSci Research*

* 1. **Global Polyvinyl Chloride (PVC) Trade Dynamics, By Value (USD Million) and By Volume (000’ Tonnes), 2018-2020**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Exporter Country** | **2018** | | **2019** | | **2020** | |
| Value | Volume | Value | Volume | Value | Volume |
| **United States of America** | 2590.09 | 2965.49 | 2481.63 | 2989.84 | 2048.57 | 2466.47 |
| **Taiwan** | 1161.3 | 1293.08 | 1143.42 | 1341.04 | 1077.03 | 1243.43 |
| **Germany** | 959.53 | 816.41 | 935.29 | 882.71 | 865.8 | 872.45 |
| **France** | 820.02 | 816.39 | 768.43 | 839.09 | 715.56 | 820.98 |
| **Japan** | 548.68 | 607.1 | 629.6 | 734.7 | 631.06 | 734.43 |
| **Others** | 5765.31 | 5293.87 | 4818.98 | 4880.51 | 4939.69 | 5402.73 |
| **Total** | **11844.93** | **11792.34** | **10777.35** | **11667.89** | **10277.71** | **11540.49** |
| **Importer Country** | 2018 | | 2019 | | 2020 | |
| Value | Volume | Value | Volume | Value | Volume |
| **India** | 1865.06 | 1955.79 | 1932.76 | 2139.33 | 1417.1 | 1617.13 |
| **China** | 807.26 | 838.81 | 681.62 | 751.45 | 899.8 | 1079.92 |
| **Turkey** | 649.51 | 681.16 | 601.85 | 663.37 | 688.91 | 745.3 |
| **Italy** | 696.37 | 648.97 | 611.09 | 634.32 | 552.87 | 619.75 |
| **Germany** | 646.78 | 592.72 | 526.62 | 555.16 | 465.01 | 534.26 |
| **Others** | 7179.95 | 7074.89 | 6423.41 | 6924.26 | 6254.02 | 6944.13 |
| **Total** | 11844.93 | 11792.34 | 10777.35 | 11667.89 | 10277.71 | 11540.49 |

*Source: UN Comtrade*

Major exporter of Polyvinyl Chloride across the globe is the USA, which exported about 2466 thousand tonnes of PVC as of 2020, followed by Taiwan, which exported around 1243 thousand tonnes, followed by Germany- 872 thousand tonnes, France- 820 thousand tonnes and Japan- 734 thousand tonnes, constituting 50% of the total amount exported in 2020. In 2020, the total export from the USA declined by around 18% by volume. However, in 2021, the market sentiments improved, and the export grew by 5%.

The top countries importing Polyvinyl Chloride are India, China, Turkey, Italy, and Germany, with respective imports of 1617 thousand tonnes, 1079 thousand tonnes, 745 thousand tonnes, 619 thousand tonnes, and 534 thousand tonnes in 2020, making 43% of the total amount imported. India is the largest importer of PVC because of the country's high demand and low production. India also overtook China to become the largest PVC importer worldwide. India’s PVC imports for 2020 were close to 1595 thousand tonnes and met the needs of more than half of the total PVC demand. Currently, most of India's PVC is based on imported vinyl chloride monomer or ethylene dichloride (EDC) (VCM). The pattern of imports into India is constantly changing. Taiwan used to be the biggest supplier to the nation, but its share has decreased with the advent of new businesses. Given the promising development prospects for Indian PVC imports, its proportion will decline much further.

* 1. **Demand By End Use**

**Global Polyvinyl Chloride (PVC) Demand, By End Use, By Volume (000’ Tonnes), 2015–2030F**

*Source: TechSci Research*

*Others include Medical & Healthcare, Vinyl Flooring, etc.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Demand By End Use (000’ Tonnes)** | | | | | | |
| **End-Use** | 2015 | 2020 | 2021E | 2022F | 2025F | 2030F |
| Pipe and Fittings | 17342 | 18787 | 19698 | 20578 | 23198 | 27862 |
| Profiles and Tubes | 6230 | 6711 | 7028 | 7334 | 8239 | 9839 |
| Films and Sheets | 7685 | 7711 | 7962 | 8191 | 8818 | 9809 |
| Bottles | 131 | 233 | 269 | 311 | 471 | 927 |
| Wires and Cables | 3054 | 3304 | 3463 | 3617 | 4074 | 4886 |
| Others | 6546 | 6344 | 6488 | 6604 | 6832 | 6854 |
| Total | 40987 | 43090 | 44908 | 46635 | 51632 | 60177 |

*Source: TechSci Research*

*Others include Medical & Healthcare, Vinyl Flooring, etc.*

* 1. **Global Polyvinyl Chloride Demand Supply Gap 2010-2040F (000’ Tonnes)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Parameters | 2010 | 2015 | 2020 | 2021E | 2025F | 2030F | 2040F |
| Capacity | 46604 | 53,840 | 54,960 | 54,960 | 56,381 | 56,381 | 56,381 |
| Production | 33840 | 40,987 | 43,090 | 43,965 | 47,482 | 48,358 | 50,445 |
| Demand | 33840 | 40,987 | 43,090 | 44909 | 51,633 | 60,177 | 80,097 |
| Demand (Y-O-Y, %) | - | - | -5.93% | 4.22% | 3.21% | 3.05% | 2.71% |
| Demand/Supply Gap | - | - | - | -943 | -4,150 | -9,732 | -29,652 |

*Source: TechSci Research*

**Demand By Region**

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Demand by End Use (000’ Tonnes)** | | | | | | |
| **Region** | 2015 | 2020 | 2021E | 2022F | 2025F | 2030F |
| Asia-Pacific | 25715 | 26737 | 28517 | 29715 | 33303 | 39566 |
| North America | 4569 | 4743 | 4956 | 5112 | 5473 | 6091 |
| Europe | 4148 | 4535 | 4735 | 4924 | 5328 | 5843 |
| Middle East & Africa | 3459 | 3714 | 3916 | 4029 | 4502 | 5404 |
| South America | 3095 | 3361 | 2784 | 2854 | 3026 | 3274 |
| Total | 40986 | 43090 | 44908 | 46634 | 51632 | 60178 |

*Source: TechSci Research*

**Asia Pacific**

The growing construction and healthcare sector in the Asia Pacific region is pushing the demand for PVC. Many new initiatives and construction projects are underway in the Asia Pacific region. For instance, the China Belt and Road Initiative, construction of new airports, roads, and other infrastructure projects in the region is anticipated to push the demand for PVC in the region. In India, projects such as Housing for All, Smart Cities Project, construction of new airports, Industrial Corridor Project, and Make in India are pushing the demand for PVC in the country. The growing demand for PVC in the construction sector for the manufacturing of windows, doors, sheets, pipes, etc., coupled with the increasing demand from packaging in labelling, cling films, shrink wrapping, and blister packaging, are driving the market in the Asia Pacific region.

Moreover, the demand for PVC surged due to COVID-19 in 2020 and H1 in 2021. PVC resins are used in the medical field to manufacture blood and urine bags and other medical equipment. Moreover, many companies are moving out of China after the Japanese government asked the parent companies to shift their production base from China to Japan or Southeast Asian Countries to secure supply chains and reduce their dependency on China. The Japanese government has announced to pay around USD536 million to companies for moving out of China. As a result, these companies are relocating to Southeast Asian countries such as India, Taiwan, Thailand, etc., thereby driving the market growth in the Asia Pacific region.

**North America**

The construction activities in North America reduced by around 6%, resulting in the region's declined demand for PVC resins because of the COVID-19 pandemic. The market is estimated to reach approximately 6.1 million tonnes by 2030 with a CAGR of 2.32%. The United States is the largest exporting country of PVC resins globally. In 2020, the total exports from the USA declined by 17.50%. The shifting of manufacturing units back to the USA is anticipated to fuel the industrial construction activities in the region. Furthermore, in 2021, a V-shaped recovery has been observed in the North American market, and construction and commercial activities have gained momentum in the region.

PVC supply from the USA and North America has been tight throughout 2020 and 2021, increasing prices. Hurricanes in Louisiana and a deep freeze in the Gulf Coast in mid-February 2021 were cited as primary reasons for the short supply of PVC in 2021.

Shintech, a subsidiary of Japan's Shin-Etsu Chemical Co., has invested USD1.3 billion to further expand its PVC manufacturing facilities at its Plaquemine, LA site, with an installed capacity of 380 thousand tonnes of PVC and 580 KTPA for the manufacturing of its precursor VCM.

Formosa is scheduled to start a new 130 KTPA PVC production line at its Baton Rouge, LA plant in the 4th quarter of 2022. However, Formosa Plastics' debottlenecking project has been delayed twice from its original start-up date of Q4 2020.

**Europe**

The demand for PVC in Europe declined in 2020 by around 6.25% due to the lockdown imposed in the region. COVID-19 cases in Europe were at par, which resulted in lockdown in significant economies in the region. Germany, the United Kingdom, and Italy were the primarily affected markets. The construction sector was at a halt in Q2 2020 and Q3 2020. However, the demand for PVC has risen on the back of the recovery in the downstream and construction industries. Demand in Northwest Europe was comparatively higher than in Southern Europe because of growth in construction activities and increased demand from the automotive sector.

In 2021, the market sentiments improved compared to 2020, and the demand for PVC in European countries witnessed a sharp growth. In June 2021, the shortage of PVC supply was observed in Germany, which resulted in a rise in PVC prices in the country. The PVC supply chain was disrupted in June and July 2021, hampered the civil engineering segment. The shortage of PVC supply in the country resulted in a shortage of insulation materials, pipes, and profiles. PVC market in Europe is majorly driven by pipes, profiles, insulating materials, etc., and with growing construction activities in Europe, the demand is expected to surpass 5.8 million tonnes of PVC by 2030.

**Rest of the World**

The RoW, including MEA and South America, contributed to around 15% of the global demand for PVC in 2020. The growing demand for PVC applications is generated from pipes and fittings, mainly used for window frames and doors. Demand for PVC from the MEA region is expected to grow on account of multiple large-scale infrastructure projects to be carried out in the region. In addition, UAE is mainly investing in creating a new industrial corridor.

Construction is the primary consumer sector for PVC owing to the increasing usage of PVC pipes, cables, and window profiles in housing, building, and other infrastructural developments. As a result, MEA and South America

will likely grow at a CAGR of 3.64% and 1.82%, respectively, by 2030. Further, heavy investment in the downstream sector in South America is anticipated to fuel the demand for PVC resins in the coming years.

* 1. **Global EDC Demand Supply Scenario (2010-2020) (000’ Tonnes)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Parameters | 2010 | 2015 | 2020 | 2021E | 2025F | 2030F | 2040F |
| Capacity | 61400 | 70550 | 73150 | 77400 | 79500 | 80340 | 80340 |
| Production | 47278 | 57146 | 62324 | 65790 | 65190 | 65879 | 65879 |
| Demand | 47240 | 57300 | 61850 | 65350 | 73008 | 85089 | 113257 |
| Demand/Supply Gap |  |  |  | 440 | -7819 | -19210 | -47378 |

*Source: TechSci Research*

Global demand for Ethylene-dichloride (EDC) stood at 65.35 million tonnes in 2021. Northeast Asia held the largest share in terms of production and consumption of EDC during 2010-2021, while the USA is the second-largest producer and consumer after China due to the availability of inexpensive ethylene.

* 1. **Global Vinyl Chloride Monomer (VCM) Demand Supply Scenario (2010-2020) (000’ Tonnes)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Parameters | 2010 | 2015 | 2020 | 2021E | 2025F | 2030F | 2040F |
| Capacity | 47303 | 54648 | 55784 | 55784 | 57227 | 57227 | 57227 |
| Production | 34178 | 41397 | 43521 | 44405 | 47957 | 48842 | 50949 |
| Demand | 34178 | 41397 | 43521 | 45358 | 52149 | 60778 | 80898 |
| Demand/Supply Gap | - | - | - | -953 | -4192 | -11937 | -29949 |

*Source: TechSci Research*

EDC and VCM market outlook is dependent on the global PVC resin market. The other application segments of VCM include the production of vinylidene chloride and vinyl chloride/vinylidene chloride copolymers, primarily prevalent in the USA, Western Europe, and Japan. Asia Pacific region registered the largest market share, with China emerging as the largest VCM consuming market in 2021, exhibiting 81% of the APAC market share and 43% of the global market share. North America followed APAC with 16% of the worldwide market share. Western Europe was the third-largest market, with a 12% share in the global VCM demand. The growing end-use industries and increasing construction activities in major economies like China and India are anticipated to contribute to the soaring demand for VCM in the Asia Pacific region in the upcoming years.

* 1. **India Polyvinyl Chloride (PVC) Capacity and Production, By Volume (000’ Tonnes), FY2010 - FY2040F**

*Source: TechSci Research*

Five manufacturers share the domestic production of PVC with a combined installed capacity of 1553 thousand tonnes per annum as of FY2021. The largest manufacturer among them is Reliance Industries Ltd, having plants in Hazira, Gandhar and Vadodara in India with a combined capacity of 755 thousand tonnes per annum, which is approximately 51% of the total share of installed capacity. Moreover, Chemplast Sanmar Limited is the second-largest producer of PVC resin, with an installed capacity of 366 thousand tonnes per annum. The total production of PVC as of FY 2021 was 1376 thousand tonnes per annum, and the production is expected to reach 4050 thousand tonnes by FY 2040.

* 1. **India Polyvinyl Chloride (PVC) Capacity, By Company (000’ Tonnes), FY2010 -FY2040F**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Company** | **Location** | **FY2010** | **FY2015** | **FY2021** | **FY2022E** | **FY2030F** | **FY2040F** |
| Reliance Industries Limited | Hazira-Gujarat | 325 | 350 | 350 | 350 | 350 | 350 |
| Reliance Industries Limited | Dahej-Gujarat | 245 | 350 | 350 | 350 | 1350 | 1350 |
| Reliance Industries Limited | Vadodara-Gujarat | 55 | 55 | 55 | 55 | 55 | 55 |
| Finolex Industries Limited | Ratnagiri-Maharashtra | 250 | 250 | 272 | 272 | 272 | 272 |
| Chemplast Sanmar Limited | Cuddalore-Tamil Nadu | 226 | 270 | 300 | 300 | 496\* | 496 |
| Chemplast Sanmar Limited | Mettur-Tamil Nadu | 66 | 66 | 66 | 66 | 106 | 106 |
| DCW Limited | Tuticorin-Tamil Nadu | 90 | 90 | 90 | 90 | 90 | 90 |
| DCM Shriram Limited | Kota-Rajasthan | 70 | 70 | 70 | 70 | 88 | 88 |
| Adani Enterprises Ltd | Mundra, Gujarat | 0 | 0 | 0 | 0 | 1000 | 1000 |
| Total |  | **1327** | **1501** | **1553** | **1553** | **4157** | **4157** |

\**Chemplast Sanmar Ltd has received environment clearance and approval to expand paste PVC capacity by 70 KTPA in two phases.  The company is also planning to add 200 KTPA of suspension PVC resin. The company is in exploratory phase to identify supplier of VCM.*

*Source: TechSci Research*

The suspension resin unit of **Reliance Industries Limited** (RIL)'s PVC Plant was established in December 1990, with a nameplate capacity of 160 thousand tonnes per annum at Hazira. Later, the expansion through debottlenecking and revamping the capacity reached 350 thousand tonnes per annum. RIL uses EDC based process of BF Goodrich, USA (now known as Oxy Vinyl). Apart from this, RIL acquired two PVC units of IPCL, one in Vadodara and another in Gandhar. PVC unit of IPCL was commissioned at Vadodara in 1984, with an annual capacity of 55 thousand tonnes, using BF Goodrich, USA technology.

The second unit at Gandhar was established in December 1997 with a capacity of 150 thousand tonnes per annum based on the same technology. RIL has further expanded its Gandhar Capacity from 150 to 245 thousand tonnes per annum. At present, RIL has 350 thousand tonnes of capacity installed each at their Hazira and Gandhar plant locations, whereas the Vadodara plant has a PVC installed capacity of 55 thousand tonnes per annum as of FY2021. RIL produces suspension grades PVC resins widely used for rigid applications, injection moulding & sheet extrusion, etc. Further, 1000 thousand tonnes of PVC brownfield expansion is expected in FY2026 at the Gandhar plant (Dahej).

**Chemplast Sanmar Ltd** began the production of PVC resin at Mettur Dam, Salem, with an installed capacity of 6 thousand tonnes per annum in FY1967. The capacity was further expanded and now stands at 66 thousand tonnes per annum. This plant has the facility to produce both suspension and emulsion resins in separate batches. The second greenfield unit of 226 thousand tonnes per unit was commissioned at Cuddalore in FY2009. This unit produces suspension-grade PVC resin only. The company has technical contract assistance with BF Goodrich Chemicals Co. of the USA. Currently, Chemplast Sanmar is India's second-largest PVC resin manufacturer, with a total capacity of 300 thousand tonnes per annum. The company has the flexibility of using different feedstocks- EDC and VCM at different points. Chemplast Sanmar Ltd has a PVC Paste resin capacity of 66 thousand tonnes per annum and is planning to expand to 107 thousand tonnes per annum. By the 3rd quarter of FY 2023, Chemplast will enhance the capacity of suspension resin by 10%.

**Chhabria Group set up Finolex Industries Limited** at Ratnagiri, Maharashtra, with a capacity of 130 thousand tonnes per annum. Finolex Industries Limited produces suspension and emulsion grades of PVC resins. The segregation of this capacity was 108 thousand per annum suspension type and 22 thousand tonnes per annum emulsion type with technology from Uhde, based in Germany. In FY2006, PVC capacity was expanded from 130 to 260 thousand tonnes per annum. The company captively consumes around 100 thousand tonnes of its production for manufacturing pipes/fittings and cables. Currently, Finolex Industries Limited has 272 thousand tonnes per annum PVC capacity at their Ratnagiri, Maharashtra plant.

**DCW Ltd**. established the first PVC resin plant near Tuticorin in Tamil Nadu in FY1970. DCW is currently the only Indian producer to handle, and store imported VCM, a volatile gas. It has a 5,600 tonnes storage capacity, including a 5,000 m3 sphere for VCM at Tuticorin port. The company established the polymerization unit itself, although later it entered into a tie-up with Atochem, France, in FY1985. Currently, the company has a production capacity of 90 thousand tonnes per annum. In addition, the company produces suspension-grade PVC resins in the country.

DCM Shriram at Kota manufactures PVC from captive VCM made from Acetylene via captive Calcium Carbide, using Kureha technology. The company also produces PVC Compounds. The company has a PVC installed capacity of 70 thousand tonnes per annum as of FY2021. Moreover, DCM Shriram plans to expand the PVC resin capacity by 18 thousand tonnes by FY2024. DCM Sriram produces only suspension-gradePVC resin in the country.

**Upcoming PVC Plant Details**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Company Name** | **Expected Capacity** | **Type of Process** | **Plant Location** | **Status (November FY2021)** |
| Indian Oil Corporation Limited | 500KTPA | EDC / VCM to PVC | Paradip | Prefeasibility study is going on. The availability of chlorine is a major challenge |
| Adani Enterprises Limited | 1000KTPA | Coal to PVC | Mundra | Submitted the proposal to produce PVC using coal. environmental clearance in the month of April FY2021. |
| Chemplast Sanmar Limited | 236 KTPA (Brownfield Expansion) for Suspension Grade PVC | VCM to PVC | Cuddalore | Received the environmental clearance. The project is in initial phase. |
| Reliance Industries Limited | 1000 KTPA of Brownfield Expansion to produce S-PVC, Emulsion grade and C-PVC | Ethylene to PVC | Dahej Gujarat | Received the environmental clearance. The project is in initial phase and is expected to be commissioned by FY 2026. |

* 1. **India Polyvinyl Chloride (PVC) Demand, By Volume (000’ Tonnes), FY2010-FY2040F**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand (000’ Tonnes)** | | | | | | | | | **CAGR** | | |
| **2010-2021** | **2022E-2030F** | **2031F-2040F** |
| **2010** | **2015** | **2020** | **2021** | **2022E** | **2025F** | **2030F** | **2035F** | **2040F** |
| 1830 | 2622 | 3501 | 2870 | 3121 | 3791 | 5351 | 7655 | 10802 | 4.18% | 6.97% | 7.27% |

*Source: TechSci Research*

The consumption of PVC in India has increased from 1830 thousand tonnes in 2010 to 2870 thousand tonnes in 2021 at an annual compounded growth rate of 4.18 %% per annum. It is expected to reach 5351 thousand tonnes by 2030 with a CAGR of 6.97 %. Moreover, India is a net importer of PVC in the country. Half of India’s demand is met from imports only. Japan, Taiwan, South Korea, and China are the top four importers for India. Additionally, India imported approximately 2055 thousand tonnes in 2020 and 1596 thousand tonnes in 2021.

* 1. **India Polyvinyl Chloride (PVC) Trade Dynamics, By Value (USD Million) and By Volume (000’ Tonnes), FY2019-FY2021**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Importer Country | 2019 | | 2020 | | 2021 | |
| Value | Volume | Value | Volume | Value | Volume |
| Japan | 351.21 | 364.98 | 420.83 | 459.46 | 411.82 | 410.91 |
| Taiwan | 377.49 | 392.83 | 384.36 | 426.73 | 303.44 | 292.52 |
| South Korea | 386.86 | 400.15 | 261.54 | 292.15 | 226.49 | 225.34 |
| China | 107.39 | 114.91 | 58.26 | 62.76 | 106.55 | 91.89 |
| Thailand | 56.56 | 59.13 | 67.52 | 72.49 | 80.88 | 74.64 |
| Others | 622.46 | 674.41 | 636.37 | 741.34 | 454.66 | 499.8 |
| Total | 1901.97 | 2006.41 | 1828.88 | 2054.93 | 1583.84 | 1595.1 |
| Exporter Country | 2019 | | 2020 | | 2021 | |
| Value | Volume | Value | Volume | Value | Volume |
| China | 0 | 0 | 0 | 0 | 43.94 | 73.25 |
| United Arab Emirates | 0.44 | 0.48 | 0.95 | 1.05 | 0.66 | 0.91 |
| Nepal | 0.75 | 0.75 | 0.7 | 0.74 | 0.73 | 0.52 |
| Turkey | 0 | 0 | 0 | 0 | 0.29 | 0.16 |
| Sri Lanka | 0.65 | 0.33 | 0.06 | 0.04 | 0.26 | 0.16 |
| Others | 0.23 | 0.17 | 0.69 | 0.51 | 0.57 | 0.47 |
| Total | 2.07 | 1.73 | 2.4 | 2.34 | 46.45 | 75.47 |

*Source: Ministry of Commerce*

**Anti- Dumping**

Anti-dumping duty is regularly imposed on the import of PVC Resin (Suspension and Emulsion) as a protectionist tariff that a government places on implications thought to be significantly underpriced. There is a continuation of anti-dumping duty levied on exports of PVC paste resin to India from South Korea, Taiwan, China, Malaysia, Thailand, Russia, and the European Union vide notification no. 15/19/2014-DGAD dated April 26, 2016. In July 2019, anti-dumping duties on PVC Resin were extended to the USA and Chinese imports for two and half years. The anti-dumping duty from Oxy Vinyls, USA, was reduced to USD49.1 per ton from USD115 per ton. In 2021, DGTR (Director General of Trade Remedies) decided to terminate a safeguard investigation on imports of PVC Suspension Grade Resin from Japan under the India-Japan Comprehensive Economic Partnership Agreement (CEPA).

For the import of PVC Resin, there have been several trade remedy investigations in India. Directorate General of Trade Remedies had recommended anti-dumping duties against the imports of the subject goods from China PR, Indonesia, Japan, Korea RP, Malaysia, Taiwan, Thailand, and the United States of America in the investigation in 2006. After that, in a separate investigation, anti-dumping duties were also imposed against the imports from European Union and Mexico. However, anti-dumping duties are only assessed on imports from China PR and the United States of America. According to the India-Japan Comprehensive Economic Partnership Agreement, the government resolved to end a safeguard examination on imports of "PVC Suspension Grade Resin" from Japan in July 2021. This resin is widely utilized in the building, construction, automotive, and medical industries (CEPA). One of the biggest suppliers of PVC to India is Japan. According to customs data, India imported about 1.62 million MT PVC in 2020, of which about 411,513 MT, or 25.4%, was from Japan. India levies a 10% customs duty on the import of PVC. However, under the India-Japan Comprehensive Economic Partnership Agreement, PVC imports from Japan are duty-free.

The anti-dumping duty (ADD) imposed on suspension grade polyvinyl chloride (PVC) expired in February 2022 as Reliance Industries Ltd, Chemplast and Finolex Industries Ltd did not file a review petition, and the govt did not issue an extension notification. As a result, nearly eight-year-old ADD on Homopolymer of Vinyl Chloride Monomer (Suspension Grade) has been withdrawn. On June 13, 2014, the ADD was first imposed for five years on homopolymer of vinyl chloride monomer (suspension grade) to protect the interests of local businesses. The ADD was later extended periodically. As a result, the Ministry of Finance assessed ADD ranging from USD29.99 to USD147.96 per tonne of the homopolymer of vinyl chloride monomer (suspension grade), depending on producers in China, Thailand, and the United States.

* 1. **India Polyvinyl Chloride (PVC) Demand Supply Gap, FY2010-FY2040F (000’ Tonnes)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameters** | **2010** | **2015** | **2021** | **2022E** | **2025F** | **2030F** | **2040F** |
| Capacity | 1327 | 1501 | 1553 | 1553 | 1807 | 4157 | 4157 |
| Production | 1191 | 1354 | 1376 | 1388 | 1580 | 4050 | 4050 |
| Import | 659 | 1293 | 1595 | 1786 | - | - | - |
| Export | 0 | 2 | 75 | 27 | - | - | - |
| Inventory | 20 | 23 | 25 | 26 | - | - | - |
| Demand | 1830 | 2622 | 2870 | 3121 | 3791 | 5351 | 10802 |
| Demand (Y-O-Y %) | - | 15.63% | -18.01% | 8.74% | 6.85% | 7.31% | 7.00% |
| **Demand / Supply Gap** | - | - |  | (1733) | (2211) | (1301) | (6752) |

*Source: TechSci Research*

* 1. **Demand By Type**

**India Polyvinyl Chloride (PVC) Demand, By Type, By Volume, FY2010-FY2040F (000’ Tonnes)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Type (000’ Tonnes)** | 2010 | 2015 | 2020 | 2021 | 2022E | 2025F | 2030F | 2040F |
| Suspension Polymerization | 1772 | 2493 | 3349 | 2735 | 2976 | 3620 | 5126 | 10342 |
| Emulsion Polymerization | 58 | 129 | 152 | 135 | 145 | 171 | 225 | 459 |
| Total | 1830 | 2622 | 3501 | 2870 | 3121 | 3791 | 5351 | 10802 |

*Source: TechSci Research*

**Suspension Grade**

**Pipes and Conduits:** Rigid PVC pipes are primarily used in irrigation, chemical, and effluent treatment plants, slurry conveyance, municipal drainage, and sewerage. Compared to traditional galvanized steel pipes, PVC pipes offer a significant cost advantage and have a much longer life as they are non-corrosive. In addition to surface irrigation, PVC pipes are used in tube and deep wells. The size of the PVC pipes ranges from 15 mm to 300 mm, in medium or heavy strength. The K-Value of PVC used in pipes and conduits is 65-67. Fittings & other rare applications like foam-board where K value 57 is used. The consumption of PVC resin in manufacturing PVC pipes and conduits is 73%% of the total consumption in the country and is estimated to be around 2057 thousand tonnes as of 2021. The demand for PVC pipes depends on the monsoon season and government investment in infrastructural activities.

**uPVC SCHEDULE 40 & SCHEDULE 80 INDUSTRIAL PIPES AS PER ASTM D-1785**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PRESSURE RATING @23°C - uPVC SCHEDULE 40 | | | | | | | | |
| Part No. | Nom. Size | | Avg. OD | | Min Wall Thickness | | Max. Work Pre. at 23°C | |
| (in) | (mm) | (in) | (mm) | (in) | (mm) | PSI | (kg/cm2) |
| M061400501 | ½ | 15 | 0.84 | 21.34 | 0.109 | 2.77 | 600 | 42.19 |
| M061400502 | ¾ | 20 | 1.05 | 26.67 | 0.113 | 2.87 | 480 | 33.75 |
| M061400503 | 1 | 25 | 1.315 | 33.4 | 0.133 | 3.38 | 450 | 31.64 |
| M061400504 | 1¼ | 32 | 1.66 | 42.16 | 0.14 | 3.56 | 370 | 26.01 |
| M061400505 | 1½ | 40 | 1.9 | 48.26 | 0.145 | 3.68 | 330 | 23.2 |
| M061400506 | 2 | 50 | 2.375 | 60.32 | 0.154 | 3.91 | 280 | 19.69 |
| M061400507 | 2½ | 65 | 2.875 | 73.02 | 0.203 | 5.16 | 300 | 21.09 |
| M061400508 | 3 | 80 | 3.5 | 88.9 | 0.216 | 5.49 | 260 | 18.28 |
| M061400509 | 4 | 100 | 4.5 | 114.3 | 0.237 | 6.02 | 220 | 15.47 |
| M061400510 | 6 | 150 | 6.625 | 168.28 | 0.28 | 7.11 | 180 | 12.66 |
| M061400511 | 8 | 200 | 8.865 | 219.08 | 0.322 | 8.18 | 160 | 11.25 |
| M061400512 | 10 | 250 | 10.75 | 273.05 | 0.365 | 9.27 | 140 | 9.84 |
| M061400513 | 12 | 300 | 12.75 | 323.85 | 0.406 | 10.31 | 130 | 9.14 |

*Source: Astral Pipes*

MPa = Mega Pascal 1 MPa = 10 kg / cm² 1 kg / cm² = 14.223343 PSI.

|  |  |  |  |
| --- | --- | --- | --- |
| PHYSICAL PROPERTIES OF uPVC MATERIALS | | | |
| Property | Units | PVC | ASTM No. |
| Specific Gravity | g / cc | 1.41 - 1.46 | D792 |
| Tensile Strength (73°F) | PSI | 7,200 | D638 |
| Modulus of Elasticity in Tension (73°F) | PSI | 460,000 | D638 |
| Flexural Strength (73°F) | PSI | 13,200 | D790 |
| Izod Impact (Notched at 73°F) | ft lb/in. | 0.65 | D256 |
| Hardness (Durometer D) | --- | 80 ± 3 | D2240 |
| Hardness (Rockwell R) | --- | 110 - 120 | D785 |
| Compressive Strength (73°F) | PSI | 9,000 | D695 |
| Hydrostatic Design Stress | PSI | 2,000 | D1598 |
| Coefficient of Linear Expansion | in./in./°F | 3.1 x 10-5 | D696 |
| Heat Deflection Temperature at 66 psi | degrees °F | 165 | D648 |
| Coefficient of Thermal Conductivity | BTU/hr/sq. ft/°F/in. | 1.2 | D177 |
| Specific Heat | BTU/F/lb | 0.25 | D2766 |
| Limiting Oxygen Index | % | 43 | D2863 |
| Water Absorption (24 hrs at 73°F) | % Weight gain | 0.05 | D570 |
| Cell Classification-Pipe | --- | 12454-B | D1784 |
| Cell Classification-Fittings | --- | 12454-B | D1784 |

*Source: Astral Pipes*

PVC pipes are predominantly used in plain lands except in uneven/hilly terrain, black alluvial soil, and low-temperature areas, where HDPE is preferred over PVC as PVC is unsuitable. Due to their lower cost, PVC pipes provide a definite advantage over traditional GI pipes. While HDPE is steadily replacing the conventional aluminium and Low Carbon Steel in the main channels of sprinkler systems, LLDPE is the material of choice for 'laterals' in drip irrigation systems. In addition, PVC pipes have critical applications in industrial piping.

**Characteristics of Piping Material Used for Irrigation**

|  |  |  |
| --- | --- | --- |
| **Particulars** | **Weight** | **Coefficient of Flow (C) Value** |
| Galvanised Iron (GI) Pipes | Heavy | 100 |
| Cast Iron (CI) Pipes | Heavy | 100 |
| Asbestos Cement (AC) Pipes | Lighter than CI, heavier than PVC | 140 |
| Rigid PVC Pipes | Light | 150 |

*Source: The European Council of Vinyl Manufacturers*

The demand for uPVC Pipes in the domestic market is estimated to grow at a healthy rate. However, the rising demand for HDPE pipes in different applications may provide competition. The demand for PVC pipes in agriculture and infrastructure development is the key driving factor for PVC pipes in the coming years. Both rigid and flexible pipes are the key market segments for PVC consumption, where the pipe market is likely to grow with a CAGR of more than 4% in the next five years.

Rigid grades of PVC are used for pipe and fittings such as drain-waste-vent (DWV) pipe, sewer, water pipe, conduit, and irrigation pipes. Rigid PVC also caters to the building and housing market for profile applications, including doors, window frames, fencing, etc. PVC can also be applied in flexible applications by adding plasticizers to impart desired flexibility. This versatility, durability, mechanical stability, and ease of processing will keep PVC competitive and attractive polymer in the coming years.

Thermoplastic pipes form a critical part of the construction and agriculture industry. PVC, known for its properties like corrosion resistance, easy installation, and cost-effectiveness, creates an ideal polymer for piping and other allied applications. Furthermore, the construction industry led by infrastructure development and residential building will keep upward pressure on demand fundamentals as the construction industry recovers after stagnation in growth in the last few years caused by the slowdown in the economy, which was further exacerbated by the pandemic. In addition, government schemes like Pradhan Mantri Awas Yojana (PMAY), DDA housing scheme, AMRUT, and others will spur growth from the public sector while increasing urbanization will incentivize the private sectors to build residential buildings and commercial complexes.

**Emulsion Grade**

**Paste Resin:** The paste resin production process involves the polymerization of Vinyl Chloride monomer either by micro-suspension or emulsion. This process consists of adding surfactants and additives, including an initiator, to form PVC slurry. This PVC slurry is spray dried and then milled to obtain fine PVC powder. When PVC resin is mixed with plasticizers, the paste resin disperses readily to form a free-flowing mixture called “plastisols.” These plastisols are spread onto fabric or other substrates or poured on moulds to produce synthetic leather, tarpaulin, flooring, wall covering, conveyor belts, balls, toys, or protective gloves. The K-Value of PVC used in paste resin is 65-67.

**Battery Separator Plate:** The sintered battery separator plate is the traditional PVC paste grade resin application. This grade of PVC is of very fine particle size and is used only for producing these plates. The plates are manufactured through a sintering process, making tiny, porous plates. These plates separate various cells from one another, and only the charge is passed through these plates. The K- Value of PVC used in battery separator plates is 64. Future demand for PVC in this application is likely to be affected by the advent of PE Plates which are cheaper and technically superior, as these are non-conducting.

**Copolymer Resin:** In Copolymer resins, Vinyl Chloride is copolymerized with co-monomers like Vinyl acetate to produce various resins with different properties. PVAc or Polyvinyl Acetate is the most critical copolymer resin with

versatile solubility in different solvents. It makes PVAc the prime choice for Vinyl printing inks and solvent cement. PVAc is also popularly used in floor tiling and is usually the resin of choice for Vinyl Asbestos tiles.

It may, however, be noted that despite substitute products being available in the market, PVC products will continue to be more preferred. Cost is the primary consideration for any product if the two products are technically feasible.

* 1. **Demand By End Use**

**India Polyvinyl Chloride (PVC) Demand, By End Use, By Volume (000’ Tonnes), FY2010–FY2040F**

*Source: TechSci Research*

*Others include Medical & Healthcare, Vinyl Flooring, etc*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by End Use** (**000’ Tonnes)** | 2010 | 2015 | 2020 | 2021 | 2022E | 2025F | 2030F | 2040F |
| Pipes & Fittings | 1283 | 1919 | 2634 | 2106 | 2444 | 2790 | 3955 | 7615 |
| Calendaring (Films & Sheets) | 111 | 164 | 212 | 160 | 188 | 217 | 318 | 706 |
| Profiles | 59 | 88 | 104 | 80 | 95 | 111 | 164 | 364 |
| Wires & Cables | 118 | 177 | 284 | 228 | 270 | 312 | 457 | 987 |
| Footwear | 10 | 13 | 15 | 12 | 14 | 15 | 21 | 40 |
| Others | 249 | 262 | 251 | 283 | 314 | 346 | 436 | 7615 |
| **Total** | 1830 | 2622 | 3501 | 2870 | 3121 | 3791 | 5351 | 10802 |

*Source: TechSci Research*

*Others include Medical & Healthcare, Vinyl Flooring, etc*

|  |  |  |  |
| --- | --- | --- | --- |
| **Demand by End Use** | **CAGR 2010-2021** | **CAGR 2022E-2030F** | **CAGR 2031F-2040F** |
| Pipes & Fittings | 4.61% | 7.06% | 6.72% |
| Calendaring (Films & Sheets) | 3.40% | 7.69% | 8.38% |
| Profiles | 2.83% | 8.02% | 8.31% |
| Wires & Cables | 6.16% | 7.76% | 7.98% |
| Footwear | 2.40% | 4.28% | 4.85% |
| Others s | 1.16% | 4.84% | 10.00% |

*Source: TechSci Research*

*Others include Medical & Healthcare, Vinyl Flooring, etc*

**India PVC Demand by Rigid & Flexible Type, FY2010-FY2040F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by End Use** (**000’ Tonnes)** | 2010 | 2015 | 2020 | 2021 | 2022E | 2025F | 2030F | 2040F |
| Rigid PVC | 1558 | 2249 | 3024 | 2430 | 2644 | 3217 | 4556 | 9137 |
| Flexible PVC | 272 | 373 | 477 | 440 | 478 | 574 | 795 | 1665 |

*Source: TechSci Research*

**Wires & Cables:** Insulation and sheathing of wires and cables is the second most prominent application of plasticized (flexible) suspension resin. Low and High-Tension Line predominantly have PVC and XLPE insulation. The demand for PVC mainly comes from medium and high-tension insulation used in the power grids and new thermal projects. This sector is growing at a healthy rate due to increased spending by the government in the power sector. In low tension, PVC consumption is increasing in line with the GDP growth. However, the consumption of PVC in Wires & Cables was around 228 thousand tonnes in FY 2021, constituting approximately 8% of the total demand.

**Calendering:** Calendering is the process of heating polymer plastics using a series of heated rolls to convert them into thin sheets of films. Calendaring provides smoothness, lustre, and ease of handling. PVC is used in credit cards, footwear, handbags, packaging liquids, tank linings, etc. Calendaring PVC market in India has grown approximately at a CAGR of 6% during the past five years. Moreover, the current consumption of PVC Calendaring in India is 160 thousand tonnes as of 2021.

**Films and Sheets:** The film is a thin sheet of uniform gauge without any underlying support. In this context, the Calendared film is a polymeric material formed into a sheet of consistent gauge passing through a series of rolls. A sheet is a form of plastic in which the thickness is small in proportion to the length and width. PVC films and sheets are of rigid & flexible forms, and both these forms can be manufactured and produced by any of the two processes, i.e., calendaring and extrusion processes. The K-Value of PVC used in films is 67, 57, 71 and 76. K- 57-based suspension grades are used in some footwear applications for shoe making.

**Profiles:** Profiles made of plastics, especially PVC, have great demand in various applications, ranging from architectural products to industrial and commercial structural profiles. It is used in industrial profiles in the automobile, air conditioning, and refrigeration industries. In addition, PVC profiles are used in house doors, windows, panelling and portioning, kitchen cabinet and furniture, and cavity closure insulation (in walls of buildings). The K-Value of PVC used in profiles is 67. The type of PVC used for profiles is entirely suspension type. PVC profiles are widely used in new infrastructural activities initiated by Central and State government agencies. The demand for profiles is mainly emerging from government-supported new construction of buildings and houses.

**Footwear:** PVC is being used in PVC shoes and chappals, insoles for sports shoes, leather shoes, and ladies’ sandals. PVC soles penetrate the traditional leather and leather uppers in leather shoes and chappals. The K- Value of PVC used in footwear is 67. The PVC-based footwear market must compete with EVA-based soles and PU-based soles. Instead of using direct PVC, some footwear companies are using Nitrile blended PVC resins. Demand for PVC resins for the footwear industry is price-conscious; when PVC prices rise, footwear companies cannot pass on the increase in raw material cost to consumers. Recycled PVC resins are also used by small manufacturers, which ultimately affect the demand to a marginal extent.

**Vinyl Flooring:** PVC flooring comes in Marbled Floor Covering (Contract Floorings), Printed PVC Floorings, Anti-static Floorings, Embossed Floorings, ESD Floorings, Anti Acidic Floorings / Tank Lining Material, etc. The K- Value of PVC used in vinyl flooring is 65-67. This is an emerging area having high growth potential in the future. Vinyl Flooring is Paste/Emulsion PVC application. Some low-end product manufacturers blends Paste PVC with S-PVC (K67) in vinyl flooring for retail market sales/export to underdeveloped countries with hefty cost reduction.

The PVC suspension resin is also used in bottles, toys, sports goods, etc. The K- Value of PVC used in bottles is 58-60. However, the demand for PVC in bottles is declining faster and is being replaced by PET or PE bottles. Vinyl boards and soft mould are some applications that require PVC resin of higher K-value up to 88.

**Medical & Healthcare**

The surge in demand for PVC was observed in FY 2021 and FY 2022 because of the increase in COVID-19 cases in the country. PVC has significant applications in the pharmaceutical and medical sector as the material is safe from a toxicological point of view, chemically stable, flexible, durable, and has a low cost. PVC is used in many pharmaceutical applications, including blood and plasma transfusion sets, blood vessels for artificial kidneys, catheters and canulae, blood bags, endotracheal tubing, protective sheeting, tailored covers, etc. PVC gloves also impacted the demand for PVC in FY 2021 & 2022.

**Demand By Region, FY2015-FY2040F**

*Source: TechSci Research*

The demand for PVC in India is growing due to its diversified use in various end-use sectors. However, a large portion of the demand comes from the western part of India, i.e., approximately 42% of the total demand for PVC comes from infrastructure, agriculture, automotive, apparel, etc.

The current demand for PVC in northern and southern India is around 18% and 27%, respectively. On the other hand, the least demand for PVC comes from eastern India, i.e., 12% of the total demand for PVC.

Suspension grade represents the future of PVC, and any new entrant in the market should target this grade due to volumes. Within this grade, the pipes and conduit should be the target market. The copolymer market is also a specialized market that can be targeted.

**Domestic Manufacturer Market Share & Import, Region Wise, FY 2022**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Company** | **West** | **South** | **North** | **East** |
| Reliance Industries Ltd | 380-400 | 130-140 | 145-155 | 20-25 |
| Finolex Industries Ltd | 205 | 20-22 | 0 | 0 |
| Chemplast Sanmar Ltd | 35-40 | 275-300 | 9 | 15 |
| DCW Ltd¹ | 5-10 | 65-75 | 0 | 0 |
| DCM Shriram Limited² | 15-20 | 0 | 50-55 | 0 |

*1.DCW ltd. has a significant sales share in the South with minimal sales in the West region. The company does not sell PVC in the North and East region due to geographical distance from its plant, which increases the freight charges. The company generally sells at a radius of 600 km of its plant due to increased freight charges beyond the distance. DCW has captive consumption of PVC for the manufacturing of CPVC also.*

*2. DCM Shriram Limited sells 80% of its PVC produced in only the North India region. Moreover, the company utilizes approximately 20% to 25% of PVC for captive consumption (inhouse consumption) for unplasticized doors and windows under Fenesta.*

**Market Trends and Opportunities**

Emerging Technology

Smart Cities

Affordable Housing Scheme

* Cost Optimization
* Increased Productivity
* Energy Saving
* Improved Margin
* Demand for Housing
* Better Quality of Living
* Increase in PVC Global Demand (housing, water, and sewerage)

PVC as a preferred material related to:

* Safety (fire)
* Acoustic Comfort
* Thermic Comfort
* Agility in Construction

OPPORTUNITES

OPPORTUNITES

OPPORTUNITES

**2.16 Safety and Health Hazards**

PVC enters through inhalation, ingestion, eye, and absorption through the skin and may cause allergic dermatitis and irritation of the eyes and upper respiratory tract. It does not have explosion sensitivity to static electricity. It emits HCI in fire and is a combustible material but not a hazardous polymerization material nor a flammable and pyrophoric material. PVC does not continue to burn after ignition without an external fire source. However, when forced to burn, the major gaseous products of the combustion of PVC are carbon monoxide, carbon dioxide, and hydrogen chloride, which affect one’s health.

PVC should be stored in a cool, clean, ventilated, fireproof storage area and should be kept away from heat sparks, open flame, and incompatible materials (Strong oxidizing agents). In addition, the PVC containers should be protected against physical damage. The firefighting measures are water fog or dry agent (CO2, dry chemical powder, or halon), self-extinguishing when flames are removed. PVC should be absorbed in sand or earth for disposal, and all ignition sources should be eliminated to minimize dust; vacuum cleaning must be preferred. The spilled material should be collected in an appropriate container for disposal, and releases should be reported, if required, to relevant agencies or authorities.

**Environmental Hazards and Precautions:** PVC is non-biodegradable and will not bioconcentrate. The dioxin, hydrochloric acid, and vinyl chloride are unavoidably created during the production of PVC and may causesevere health problems to workers, fence-line communities, and ultimately the entire community. Theproducts manufactured from PVC will retain their form for decades, and the breakdown that occurs is just granulation.

Animals usually ingest these pieces, and the plastic blocks their digestive tracts. In addition, substances called phthalates are added to PVC to make it flexible, and these chemicals may cause cancer and damage one’s reproductive system.

**Disposal Consideration:** PVC should be disposed of in accordance with State and Local Environmental Control Regulations, and the recycling of PVC should be encouraged wherever possible.

Transport Information PVC is non-hazardous for air, sea, and road movement.

**Packaging of PVC resin:** PVC Resins are majorly supplied in 25 kg commercial bags. However, as per requirement from the end-users, PVC Resins can also be provided in FIBC Jumbo bags with a maximum load of 500kg.

1. **Basis and Objectives of Pre-Feasibility Study (PFS)**

Considering the growing market scenario, the client proposes to enter the PVC resin business. With the increasing demand for PVC (within India and across the globe), there is an urgent need for PVC resin manufacturing units in India. PVC market has gained pace tremendously, and there are more significant opportunities in the indigenous and export markets.

Key Objectivities of Pre- Feasibility Study

* To reduce the dependency on imports in India by adding new green field capacity, which will help tap the growing domestic market.
* Cost Competitiveness: The client has its own Naphtha cracking unit to produce ethylene, which can be further reacted to produce EDC and VCM. Therefore, the cost optimization for producing PVC can add an advantage to the company.
* The proposed project is planned within the existing client’s site, which will integrate with the existing OSBL facilities. It will enhance operational flexibility and synergy and result in a lower manufacturing cost.
* The company is one of the leading suppliers of HDPE, LLPDE, and PP (olefins). If client enters the PVC business, the company will have an entire value chain of commodity polymers.
* Growing construction and agriculture sector are pushing the demand for PVC in the country.
* Better market capitalization and lucrative demand for PVC in pipes and fittings
* “AatmaNirbhar Bharat” and “Make in India” policies push domestic manufacturers to develop green field capacity to promote domestic manufacturing.
* India is the 3rd largest consumer of polymers globally and the 4th largest producer of Chemicals & Petrochemicals in Asia. Thus, dependency on imports for downstream products like polymers and other petrochemicals is pushing domestic manufacturers to enter the market
* In India, there is a shortage of emulsion-grade PVC. Only two companies are producing emulsion grade PVC with a total capacity of 88 thousand tonnes. The rising demand for Emulsion grade PVC in the country is pushing the domestic manufacturer to import the emulsion grade to meet the domestic demand.

The client can help build a nation by supporting the government’s favourable “Swajal Scheme” policy. PVC pipes play a vital role in supplying water across the county.

Strategic location plays a vital role for the client, as the availability of chlorine is a significant challenge for players operating in the market. The client can go for a long-term contract with caustic soda players operating in the region for the availability of chlorine. Gujarat Alkalies and Chemicals Limited, Meghmani Organics Limited, and DCM Shriram Consolidated Limited are the leading caustic soda players in the region, providing an upper edge to client for setting up of PVC Plant.

Proximity to the port is an added advantage for the client. The company can import EDC / VCM to produce PVC. Proximity to the port will help the company reduce lead time and transportation costs, which will further help reduce the operating cost for the company and result in a higher profit margin.

**Atmanirbhar Bharat**

Atmanirbhar Bharat will play a significant role in shaping the industrial sector in India. The initiative of Atmanirbhar Bharat is complimentary to Make-in-India, which aims to integrate local manufacturing and preference in India. As the agriculture sector is considered one of the highest economic sectors in the country, the reforms expected through the agenda of Atmanirbhar Bharat are perceived to play a prominent role in the country’s development.

With an increase in focus on portable water supply, irrigation and drainage systems, the demand for Poly Vinyl Chloride (PVC) polymer will witness a robust surge. GoI schemes such as “Swajal Scheme,” “Jal Jeevan Mission,” etc., are expected to push the demand for PVC pipes in the country. In addition, adopting an Underground Pipeline System (UGPS) is likely to save nearly 30% of the water for irrigation. This system is known to be low maintenance, with the life of pipes extending up to 40 years.

The system uses PVC/ RCC/HDPE pipes with varying diameters to deliver water. It has been revealed that the requirement for digging, repairing, and cleaning water channels decreased significantly with this water system. Demand for PVC pipes will surge from urban and rural household projects. The Ministry of Housing and Urban Affairs aims to provide tap connections to households in 4000 towns.

**India PVC Demand Supply Gap Outlook, FY2022E – FY2030F**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| India PVC Demand Supply (Thousand Tonnes) | | | | | | | | | |
|  | **2022E** | **2023F** | **2024F** | **2025F** | **2026F** | **2027F** | **2028F** | **2029F** | **2030F** |
| Capacity | 1553 | 1553 | 1571 | 1807 | 3157 | 3157 | 3157 | 4157 | 4157 |
| Production | 1388 | 1404 | 1433 | 1580 | 2304 | 2672 | 2844 | 3350 | 4150 |
| Import | 1786 |  | | | | | | | |
| Export | 27 |
| Inventory | 26 |
| Demand | 3121 | 3325 | 3548 | 3791 | 4053 | 4340 | 4651 | 4986 | 5351 |
| Demand (Y-O-Y, %) | 8.74% | 6.52% | 6.72% | 6.85% | 6.90% | 7.10% | 7.15% | 7.22% | 7.31% |
| Demand Supply Gap | -1733 | -1921 | -2115 | -2211 | -1748 | -1668 | -1807 | -936 | -1301 |

*Source: TechSci Research*

In FY 2022, India will have a demand-supply gap of around 1733 thousand tonnes for PVC, which is anticipated to reach approximately 2400 thousand tonnes by FY 2030. The higher demand-supply gap represents the need for setting up manufacturing units as domestic production cannot meet the current demand for PVC in the country. Moreover, no new player has entered the market in the last ten years. In FY 2010, PVC production capacity was 1327 thousand tonnes, reaching 1553 thousand tonnes by FY 2022 (226 thousand tonnes of capacity expansion so far). While the domestic demand for PVC in FY 2010 was 1830 thousand tonnes and is anticipated to reach 3121 thousand tonnes by FY 2022. The demand has grown more than 1.7 times from FY 2010 to 2022. Thus, creating a lucrative opportunity for new players to enter the market.

**Global Chlorine Market Overview**

Global chlorine capacity stood at around 67.5 million tonnes. The demand for chlorine in 2021 was around 54 million tonnes and the market is expected to grow at a CAGR of around 5% by 2030. Global import of chlorine was valued at USD172 million in 2020, with Canada (21.3%) being the leading exporter of chlorine, followed by the United States (10.7%), Japan (7.33%), France (6.53%), and Columbia (3.89%). The United States is the leading importer of chlorine with a value share of 23.8%, followed by Mexico (6.49%), Taiwan (4.14%), and China (4.11%).

Occidental Petroleum Corporation, The Dow Chemical Company, Westlake Chemical Corporation, and Formosa Plastics Corporation are the leading global players in chlorine.

**India** **Chlorine Market Overview**

In India, around 25 caustic soda manufacturers have a total capacity of approximately 5 million tonnes. Chlorine in India is produced alongside Caustic Soda primarily by membrane cell technology. The cost of production of chlorine is majorly dependent on electricity cost as the Electrolysis process takes place to produce chlorine. Due to chlorine's physical and chemical properties, transportation is limited to 10-15 km of range. Therefore, client is suggested to have a long-term strategic partnership with caustic soda manufacturing units located in Dahej, Gujarat, for the availability of chlorine to produce PVC in the long run. The transportation of chlorine is possible by pipeline, adding an added advantage to the client in the long run.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Company** | **Location** | **State** | **2020** | **2021** | **2022** | **2023** | **2024** |
| Gujarat Alkalies and Chemicals Limited | Dahej | Gujarat | 259 | 259 | 259 | 259 | 259 |
| Gujarat-Nalco Alkalies and Chemicals Limited | Dahej | Gujarat | 0 | 0 | 0 | 270 | 270 |
| Meghmani Organics Limited | Dahej | Gujarat | 167 | 294 | 294 | 294 | 400 |

**Chlorine Capacity in Dahej, Gujarat, (000 Tonnes), FY2020-FY2024**

*Source: TechSci Research*

1. **Optimum Case for the Pre- Feasibility Study (PFS)**

The client is planning to enter the PVC market with a capacity of 500 KTPA. Different combinations are evaluated during the prefeasibility study to conclude Optimum case for the PFS.

|  |  |  |  |
| --- | --- | --- | --- |
| **Cases** | **Capacity** | **External Procurement** | **Total PVC Capacity** |
| Case-1 | 350 KTPA of PVC Plant with available ethylene (in-house) | Nil | 350 KTPA |
| Case-2 | 350 KTPA of PVC Plant with available ethylene (in-house) | External procurement of EDC/VCM for 150 KTPA of PVC | 500 KTPA |
| Case-3 | Capacity for 350 KTPA PVC Resin and 200 KTPA Phenol + 120 KTPA Acetone (Propane Furnace: Additional 426 KTPA) | Nil | 350 KTPA (PVC) +200 KTPA Phenol + 120 KTPA Acetone |

.

1. **Process Description, Product Slate, Specifications, Applications and Unit Capacities**

**Product Overview**

Polyvinyl Chloride, also known as PVC, is the third-most widely known and produced synthetic plastic polymer of the thermoplastic family after Polyethylene and Polypropylene, usually supplied in the form of powder. The compounding and additivities are normally done at the customer/processor level, depending on their specific requirements.

PVC is a thermoplastic made up of 57% Chlorine (derived from industrial grade salt) and 43% Carbon (derived predominantly from oil/gas via Ethylene). Unlike other plastics such as Polyethylene, Polypropylene, and Polyethylene Terephthalate, PVC is less dependent on crude oil or natural gas, which are non-renewable resources; therefore, PVC is also considered a natural resource-saving plastic.

PVC is sold in two basic forms - rigid and flexible. The rigid form is used in manufacturing pipes and for doors and windows. Moreover, it is also utilized for bottles, non-food packaging, and plastic cards. Rigid PVC can be made softer and flexible by adding plasticizers (additives that increase the plasticity or fluidity of a material). Flexible PVC is used in plumbing, electrical cable insulation, imitation leather, inflatable products, etc.

**Raw Material**

* Vinyl Chloride Monomer (VCM) is the basic material required to produce PVC. VCM is a gas with a molecular weight of 62.5 and boiling point of -13.9˚C and, thus, has a high vapor pressure at ambient temperature. VCM is always manufactured under strict quality and safety control.
* VCM is derived from Ethylene (obtained from thermal cracking) in two ways: direct chlorination and oxychlorination.
* In the direct chlorination method, Ethylene, and Chlorine, which are obtained from salt electrolysis, react within a catalyst-containing reactor to form the intermediate material EDC (Ethylene Dichloride). In the next step, EDC is thermally cracked to yield VCM at a few hundred degrees Celsius temperature.
* In the oxychlorination method, Hydrogen Chloride is obtained as a by-product. In this method, Hydrogen Chloride, obtained as a by-product, reacts with Ethylene in the presence of catalyst and air (oxygen) to obtain EDC. EDC is further dehydrated and then thermally cracked (together with the EDC obtained from the direct chlorination process), and VCM is obtained.

**Polyvinyl Chloride Production Process (PVC)**

Polyvinyl Chloride is produced by polymerizing Vinyl Chloride Monomer (VCM), where VCM is produced via a reaction between ethylene and Chlor-alkali. It is commonly manufactured using three processes: suspension polymerization, emulsion polymerization, and bulk polymerization.

**Suspension Polymerization Process:** Out of the total production of PVC, about 80% of manufacturers use the suspension polymerization process, making it the most widely used process.

Firstly, the raw material Vinyl Chloride Monomer (VCM) is pressurized, liquefied, and then fed into the polymerization reactor, where suspending agents and water are added to the reactor. Next, high-speed agitation is run inside the reactor to produce tiny droplets of VCM.

In the second step, the initiator for polymerization is fed into the reactor to produce PVC. PVC is produced under a controlled temperature between 40 - 60°C. The produced PVC is obtained in slurry form by suspension polymerization process with particles size ranging between 50~200 μm diameter. In the final step, the slurry discharged from the polymerization reactor is stripped of residual monomer, dehydrated, and dried, and the particle size is controlled through screening to yield Polyvinyl Chloride as a white powder. Further, the un-reacted VCM is completely recovered using the stripping process. Finally, the recovered VCM is purified and recycled for further use as a raw material to feed into the reactor. PVC resin produced via this suspension process is referred to as Suspension Polyvinyl Chloride.

**Emulsion Polymerization Process:** This is a radical polymerization process, which usually starts with the incorporation of an emulsion of water, monomer, and surfactant. The most used process in emulsion polymerization is an oil-in-water emulsion, in which droplets of monomer (oil) are emulsified (with surfactants) in a continuous water phase. Emulsion polymerization produces finer resin grades with much smaller particles, which specific applications require. This resin type is sometimes called paste grade PVC and is abbreviated as P-PVC to distinguish it from S-PVC (Suspension Polyvinyl Chloride).

**Bulk Polymerization Process:** This process requires the polymerization of an undiluted monomer by adding an initiator (Soluble) to a pure monomer in the liquid state. The mixture is agitated for better mixing and simultaneously heated to attain polymerization temperature. During the agitation, the heat evolved in the process is dissipated by using a water jacket. This method is generally used for the polymerization of liquid state monomers.

|  |  |  |
| --- | --- | --- |
| **PVC Physical Properties** | | |
| **Property** | **Suspension Homopolymer Grade (Rigid Application)** | **Suspension Homopolymer Grade (Injection Moulding & Sheet Extrusion)** |
| K-value | 67 | 57 |
| Porosity (DOP) (ml/g) | 0.21 – 0.29 | 0.22–0.34 |
| Inherent Viscosity | 0.92 | 0.68 |
| Apparent Bulk Density (g/ml) | 0.55 | 0.48–0.54 |
| Flowtime (sec) | 25 max | 25 max |
| Heat Loss (% max) | 0.3 | 0.3 |
| Particle Size Distribution |  |  |
| Retention on ASTM 40 mesh (% max) | 0.1 | 0.1 |
| Retention on ASTM 60 mesh (% max) | 5 | 2 |
| Through ASTM 140 mesh (% max) | 25 | 50 |
| Dark Resin count (For 100 g resin) | 10 max | --- |
| Retention on 30 mesh (For 25 kg resin) (% max) | ----- | 0.005 |
| Residual VCM (ppm) | <2 | <2 |

*Source: Reliance Industries Limited*

**PVC Production Process and Technology**

PVC production varies from region to region in terms of raw material used. In the APAC region, primarily in China, Acetylene is heavily used to produce VCM. Coal's easy availability and cost-effectiveness make it an ideal feedstock for manufacturing VCM. Acetylene is produced from coal through the carbide process, where coke from coal is reacted with calcium oxide from limestone to produce calcium carbide. Then calcium carbide is reacted with water to form Acetylene. Finally, Acetylene reacts with Hydrochloric acid (HCl) to form VCM. Above 80% Acetylene based PVC finds application in PVC pipe because it contains a significant amount of Vinyl Chloride residues. However, acetylene-based PVC also results in the high production of waste materials. Therefore, it is considered environmentally degrading and requires high energy input.

In North America and Europe, Ethylene produced from Naphtha cracking is used as primary feedstock and rock salt/brine water to produce PVC. Shintech Inc. uses an integrated PVC production process, where the company first produces chlorine through the electrolysis of brine and then reacts with chlorine and ethylene to produce Ethylene Dichloride (EDC). Two commonly used methods to produce EDC, i.e., direct Chlorination and Oxychlorination. Direct Chlorination involves reacting pure chlorine and ethylene, whereas, in Oxychlorination, ethylene reacts with hydrogen chloride in the presence of oxygen. Now, EDC is converted to VCM by thermal cracking, and HCl is produced as a by-product, which is recycled to an oxychlorination plant to produce more Ethylene Dichloride. VCM, thus made, is polymerized to manufacture PVC.

Many EDC/VCM companies like Shintech Inc, Westlake Chemical Corporation and Formosa Plastics use an integrated chlorination-oxychlorination process to make the process more cost-effective. Traditionally, oxychlorination reaction occurs in a fluid bed reactor or fixed bed, where the former is preferred as it is easier to control the temperature in this process. In addition, the oxychlorination unit uses pure oxygen as it is more eco-friendly and highly efficient.

The advent of new technologies such as ethane-based processes to make VCM has resulted in more innovative production processes. For example, Ineos Vinyls has made several breakthroughs, and its new catalytic process produces VCM directly from ethane.

**Acetylene Carbide Route**

The acetylene carbide route to produce PVC is mainly used in China due to the availability of raw materials and the high cost of ethylene/VCM and EDC. DCM Shriram is the only producer of PVC resins through Acetylene Carbide Route in India.

The primary raw materials required to produce PVC by calcium carbide method are calcium carbide, coal, and crude salt. Apart from this, the Ethylene method is an alternative method to produce PVC. However, the calcium carbide method offers certain advantages over the ethylene method:

1. Cost effective method
2. Enhanced plasticizing property of calcium carbide PVC dry blend

In the preparation of PVC by the calcium carbide method, HCL is required. HCL can be supplied from the caustic soda unit, which DCM Shriram implements, or can be procured directly by the company. First, hydrochloric acid

(HCL) and another monomer, Acetylene gas, are mixed in a predetermined ratio, and then the mixture obtained is fed to the VC reactor to produce a Vinyl Chloride monomer.

A picture containing text

Description automatically generated

The VCM gas is then purified and dehumidified before being subjected to polymerization. Polymerization is a batch process involving converting VCM gas to PVC resin using suitable catalysts and chemicals. The whole process is carried out under controlled conditions.

A picture containing graphical user interface

Description automatically generated

After polymerization, PVC resin is obtained as slurry, i.e., Water + PVC resin. This slurry is then fed into the RVCM tower, where the residual VCM gas is recycled, followed by the separation of water from the slurry by subjecting it to centrifugation. Next, PVC slurry is centrifuged to produce PVC cake, which is then fed through PVC dryers to remove the necessary moisture contents.

**Technology Overview**

PVC was discovered in 1872 by exposing vinyl chloride to sunlight, producing a white solid that resisted an attack by potassium hydroxide or water and melted through degradation. However, the first commercial application came in 1926 when a researcher at Goodrich found that boiling PVC in tricresyl phosphate or dibutyl phthalate made it highly elastic - inventing the first thermoplastic elastomer.

PVC Resin needs to be compounded with additives to impart specific and desirable properties for manufacturing products and ease of processing. Intermediate companies produce compounds from the resin. Some resin manufacturers also have compounding facilities. Companies catering to large markets, like pipes, windows, barriers, packaging film, and wire & cable, can integrate compounding with the manufacturing process.

Vinyl Chloride, the monomer for producing PVC, was first synthesized by Justus von Liebig at the University of Giessen, Germany, in the 1830s, when he reacted dichloroethane with alcoholic potash to make vinyl chloride. However, commercial interest in vinyl chloride developed only after 1926 when the B. F. Goodrich Company found plasticization of PVC. In 1928, Fritz Klatte developed the first practical route to vinyl chloride while looking for the uses of acetylene by reacting hydrogen chloride with acetylene over a mercuric chloride catalyst. It was patented in 1912. However, since no immediate commercial application could be envisaged, the patent was allowed to lapse, though this process eventually formed the basis of the vinyl chloride industry for many years in the 1930s. A balanced process ultimately replaced it from ethylene and chlorine in which vinyl chloride is made by pyrolysis of 1,2-dichloroethane (ethylene dichloride (EDC).

**Margin Analysis from Various PVC Manufacturing Route:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Ethylene Route** | **External EDC-VCM** | **Calcium Carbide** |
| CapEx | Medium to high | Medium to high | Low |
| Opex | Low | Low | High |
| Cost Of Production | Low | Low | High |
| Remarks | Environment friendly process with low cost of production. Mostly preferred by major manufacturers. | Environment friendly process with low cost of production. | Very high energy consuming process per tonne of calcium carbide, which requires about 3000 to 3500 kilowatts energy, and 0.6 tonnes of coke and 0.9 tonnes of limestone. |

**Application:**

|  |  |  |  |
| --- | --- | --- | --- |
| Suspension Grade | Grade | K-Value | Application |
| General Purpose | 57-01 | 57 | Pipe fittings, Foam board, Cooling tower frills |
| 57GMRO1 |
| 57-11 | 57 | Calendared blister film, Bottles |
| 57GERO1 |
| 60-11 | 60 |
| 60GERO1 |
| 67-01 | 67 | Pipes, Rigid films, Doors & Window profiles, Corrugated sheets, Cable channels, Casing & Capping, PVC flooring |
| 67BER01/67GER01 |
| 67-11 | 67 | W&C compounds, Shoe compounds, IV Fluid and Blood bags, Film, Flexible sheets, Tubing. |
| 67GEFO1 |

*Source: Reliance Industries Limited*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Suspension Grade | | Grade | | K-Value | Application |
| General Purpose | | LS070 | | 58 | Rigid Sheet, Film, Fitting, Tile |
| LS080S | | 61 | Rigid Sheet, Film, Fitting, Injection, Bottle, Food Package |
| LS100 | | 66 | Pipe, Wire, Leather, Hose, Rigid & Flexible Sheet, Wrap |
| LS100E | | 67 | Pipe, Profile |
| LS100H | | 67 | Pipe, Profile |
| LS100S | | 66 | Flexible Sheet, Leather Sheet, Wrap |
| LS130S | | 71 | Wire, Film, Leather, Sheet, Hose |
| LS170 | | 76 | Wire, Film, Leather, Sheet |
| LS300 | | 84 | Gasket |
| Speciality | | LC070 | | 58 | Tile Adhesive |
| Emulsion Grade | Grade | | K-Value | | Application |
| Micro Suspension | LP090 | | 64 | | Under Body Coating |
| LP170 | | 74 | | Under Body Coating |
| LP170G | | 76 | | Under Body Coating |
| LK170 | | 75 | | Under Body Coating |
| Micro Seeded | PB900 | | 64 | | Wallpaper (Foaming) |
| PB1120 | | 66 | | Wallpaper (Foaming) |
| PB1200 | | 69 | | Artificial Leather (Foaming) |
| PB1202 | | 67 | | Tarpaulin |
| PE1311 | | 70 | | Foaming |
| PA1302 | | 70 | | Tarpaulin |
| Speciality | LB100M, LB110 | | 64 | | Under Body Coating |

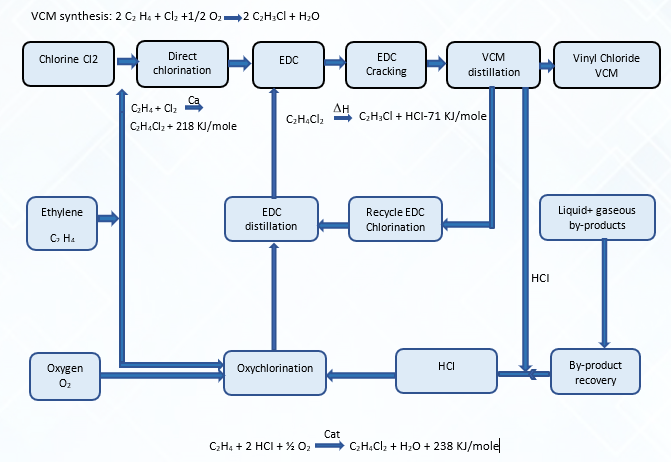
*Source: - LG Chem*

1. **Block Flow Diagram & Plot Plan Estimation**

**The Vinnolit VCM Process**

Vinnolit is one of the leading producers of EDC, VCM and PVC in Europe, with an annual capacity of 780 thousand tonnes per annum for PVC and 665 thousand tonnes of VCM with an upstream chlorine plant. VCM plants are located at Gendorf and Knapsack- Germany. Vinnolit was established in 1993 as a joint venture between Wacker Chemie GmbH and Hoechst AG. In 2000, Vinnolit was acquired by Advent International, one of the largest equity investment firms. In 2014, Vinnolit became a part of Westlake, one of the leading manufacturers and suppliers of polymers, petrochemicals, and PVC products. Further, Uhde is the only engineering partner providing Vinnolit’s VCM, EDC, and PVC processes

**Systemic Diagram of a VCM Plant**



*Source: - Vinnolit GmbH & Co. KG*

**Process Description**

The Vinnolit Process to produce VCM takes place on two different routes. One is direct chlorination of ethylene, and the other is oxychlorination of ethylene. Reactions in both the processes proceed exothermically.

1. **Chlorination of Ethylene**: In the initial phase, Ethylene dichloride (EDC) is produced by direct chlorination of ethylene to produce EDC. The process is exothermal and evolves around 218 kJ/mole of energy. The EDC produced during the reaction is fed into the cracking chamber, requiring no purification. The heat produced during the process can be used for drying PVC or can be used for heating the columns in the Ethylene Dichloride distillation column.

C2H4 + Cl2 C2H4Cl2 + 218 kJ/mole

1. **Oxychlorination of Ethylene**: Ethylene reacts with HCl in the presence of oxygen (oxychlorination) to produce EDC. The reaction is exothermal and produces a huge amount of energy.

C2H4 + 2 HCI + ½ O2 C2H4Cl2 + H2O + 238 KJ/mole

Ethylene Dichloride produced by the oxychlorination process must pass through a distillation unit for purification.

Finally, EDC produced through chlorination or oxychlorination of ethylene undergoes cracking to produce Vinyl Chloride Monomer (VCM). Further, in the unconverted EDC, hydrogen chloride is separated in a distillation unit. Unconverted EDC is sent back to the cracking unit for further process, and Hydrogen chloride returns to the oxychlorination unit.

Further, process water obtained during the production of VCM contains waste gases and by-products. The process water is fed into a Hydrogen chloride recovery unit where hydrogen chloride, carbon dioxide, and water are recovered. Recovered hydrogen chloride is sent to the oxychlorination unit for reuse; therefore, input chlorine is completely used in the manufacturing process.

|  |  |
| --- | --- |
| Expected Consumption Figures for Raw Materials and Utilities per 1000 kg VCM product | |
| Ethylene (100 %) | 459 Kg |
| Chlorine (100%) | 575 Kg |
| Oxygen (100%) | 139 Kg |
| Steam | 250 Kg (Combined figure for VCM / PVC Plant) |
| Fuel gas | 2.7GJ |

*Source: - Vinnolit GmbH & Co. KG*

The Vinnolit process has the following distinctive features mentioned below:

1. **High Operation Reliability** which includes reliable reaction control, state-of-the-art process control system and time proven equipment and materials.
2. **High Economic Efficiency**
3. Low on energy consumption
4. High Yield of products
5. Low maintenance cost
6. Optimized reaction conditions along with reaction control
7. Utilization of by- products containing chlorine coupled with recycling of Hydrochloride gas
8. Low maintenance cost and high on-stream factor.
9. **Low on Pollution levels**
10. Very low VCM emission (<\_ 0.01 ppm of VCM)
11. Low on wastewater quantities
12. Treatment of thermal waste gas produced during the process.

**Product and Applications**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Application** | **K-Value** | **Viscosity Number** | **Bulk Density g/l** | **Screen Analysis <63µm>250µm>315µm** | | | **Plasticiser  Absorption** |
| **Test method** | **ISO 1628/2** | **ISO 1628/2** | **DIN 53468** | **DIN 53734** | | | **DIN53417** |
| Injection Moulded articles, rigid film, hollow articles | 57 | 80 | 600 | 2% | <1% | <0.1% | low |
| Rigid Film, injection-moulded articles, bristles | 60 | 89 | 570 | 2% | <1% | <0.1% | medium |
| Rigid and semi- rigid sections | 65 | 105 | 580 | 1% | <5% | <0.1% | medium |
| Rigid pipes and sections | 67 | 112 | 570 | 1% | <5% | <0.1% | medium |
| Rigid pipes and sections | 68 | 116 | 570 | 1% | <5% | <0.1% | medium |
| Plasticised film, sections and flexible tubing | 65 | 124 | 510 | 5% | <1% |  | high |
| Plasticised film, sections, injection-moulded articles, cable | 70 | 124 | 480 | 5% | <1% |  | high |
| Plasticised film and profiles, medical articles | 75 | 145 | 470 | 5% | <1% | <0.1% | high |

*Source: Vinnolit GmbH & Co. K*

**Process Description**

1. **EDC Manufacturing Process**
2. **EDC Process (Direct Chlorination of Ethylene)**

In the direct chlorination process, EDC is produced by a reaction of ethylene and chlorine, which is exothermic in nature.

Vinnolit's direct chlorination process uses an innovative boiling reactor with natural convection flow.

Vinnolit has developed compact natural circulation (CNC). In the CNC reactor, the natural circulation is established in an internal loop consisting of a riser section and a downcomer section, leading to more contact and cost-saving reactor design.

The Direct Chlorination process operates at boiling conditions with a temperature of 120°C. The heat of the reaction is removed by boiling off EDC from the boiling reactor. Several heat recovery techniques, such as heating distillation columns in the EDC distillation unit or a fluidized bed PVC dryer in the PVC plant, can recover a measured amount of this heat.

The riser portion of the CNC reactor is where the reaction is conducted. In contrast to previous methods, the CNC reactor's gaseous ethylene is first fully pre-dissolved in the lower portion of the riser section. A very modest circulating EDC side stream that is removed in the CNC reactor's downcomer section and chilled to improve pre-dissolution receives gaseous chlorine addition via an injector nozzle. Another chance to recover reaction heat is offered by this cooling.

In the reaction zone of the riser, the ethylene solution and the fully dissolved chlorine are combined, and they quickly react to form EDC in a liquid-phase reaction that significantly reduces the formation of byproducts.

The EDC begins to boil because of the lower static pressure head in the top part of the riser. The product amount and some extra EDCs are removed from the CNC reactor's upper section and sent to the product vessel and a stripping column to, if necessary, achieve "Sales EDC" quality. The primary reactor loop receives the extra EDC.

The Vinnolit Direct Chlorination process uses a complex chemical as a catalyst rather than FeCl3 like competing direct chlorination technologies do. The catalyst ensures greater selectivity to EDC and inhibits the generation of by-products.

Vinnolit Direct Chlorination therefore combines the EDC purity of the low-temperature chlorination (LTC) method with the energy efficiency of the high-temperature chlorination (HTC) technique. Prior to start-up, the reactor loop is fed with the catalyst, and in normal operation, there is no need to top it off.

The Vinnolit chlorination process has the following advantages:

* The energy recovery solutions substantially decreased CO2 emissions.
* Utilizing reaction heat, such as for drying PVC or heating distillation columns, can reduce steam use by up to 700 kg per tonne of EDC.
* High raw material yields
* Significantly less high-boiling component production occurs.
* Very little low-boiling components are produced in the process (only a few ppm)
* No scrubbing water is required
* No catalyst is discharged with the product
* Low Investment costs

Diagram, schematic

Description automatically generated

*Source: Vinnolit GmbH & Co. KG*

1. **Oxychlorination of Ethylene**

The oxychlorination process is distinguished from direct chlorination by more capital expenditure, higher operational expenses, and slightly less pure EDC output. EDC is created during the oxychlorination process by the extremely exothermal catalytic reaction between ethylene, hydrogen chloride, and oxygen.

C2H4 + 2 HCI + ½ O2 C2H4Cl2 + H2O + 238 KJ/mole

The process takes place in a fluidized-bed reactor, and the heat generated during the reaction is used to generate steam. Condensation removes a large amount of the reaction water in the downstream quench column. The reaction water is sent to the effluent treatment facilities to remove minor amounts of chlorinated hydrocarbons.

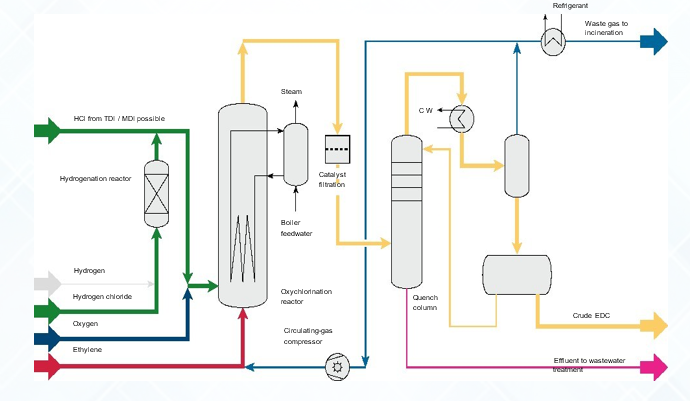
The raw EDC is extracted by condensation after further cooling the reaction gases using cooling water (CW) and refrigerant (R) and is then sent to the EDC distillation unit where it is refined to produce "feed EDC quality".

Oxygen from air separation units and pressure swing adsorption (PSA oxygen) units can be used in the Vinnolit oxychlorination process. The catalyst in the reactor is fluidized by circulating gas. Only enough oxygen is given to the reactor to keep the circulating gas concentration below the combustible limit (oxygen lean operation). The relatively tiny off-gas stream of inserts and carbon oxides produced throughout the process is delivered directly to the HCl recycle unit. At a temperature of > 200°C, the reaction mixture of C2H4, HCl, and O2 is catalytically transformed to EDC in the fluidized-bed reactor in a highly exothermal process. Internal cooling coils disperse the heat, which is then recovered to make steam. The generated steam maintains a consistent pressure regardless of load.

It is feasible to maintain a steady temperature, guarantee little by-product production, and achieve the best process control thanks to the fluidized bed's good distribution.

The catalyst particles are removed from the reaction gas as it travels through a filter unit. A wastewater treatment section with a precipitation and sludge filtration step can be developed, depending on the needs of the customer. The heated reaction gases are quenched to remove the reaction water, and the EDC is condensed using cold water in a multi-stage condensation apparatus. In an EDC distillation unit, the raw EDC is cleaned to produce "feed EDC quality”.

The reaction water obtained is passed to the wastewater treatment facilities to remove the small quantities of chlorinated hydrocarbons it contains.



*Source: - Vinnolit GmbH & Co. KG*

**Oxychlorination of Ethylene**

The modern oxychlorination process of Vinnolit has the following distinctive features:

* Fluidized-bed reactor with good reaction heat distribution: no hot spots, no catalyst stickiness
* Proven materials and reliable and simple equipment
* Reactor and cooling coils made of carbon steel
* Crude EDC purity: 99.6%
* High conversion of C2H4 to EDC: 99.0%
* Low catalyst consumption
* Removal of catalyst fines either by simple wastewater treatment or by catalyst filtration
* High flexibility of the plant, wide range of load

1. **EDC Distillation**

To produce pure feed EDC, both the EDC obtained in the oxychlorination process, and the EDC unconverted in the cracking process (recycle EDC) are treated in the EDC distillation unit to remove water as well as low-boiling and high-boiling components.

The head column receives the wet raw EDC from the oxychlorination unit, which is then distilled to remove the water and low-boiling impurities. The wastewater treatment unit receives the water phase of the head product, which contains tiny amounts of chlorinated hydrocarbons and sodium chloride. The incineration unit receives the organic phase as well as the off gas.

In the high-boil and vacuum columns, the dry bottom product from the head column, as well as the unconverted EDC from the cracking process, are separated from the high-boiling compounds. These high-boiling chemicals are removed from the vacuum column's bottom and transferred to the incineration unit.

By default, the high-boil column is operated at elevated pressure, and this column's overhead vapors are used to heat the head column and the vacuum column. Other heat recovery options can be realized depending on the customer's requirements.

**Block Diagram of EDC Distillation**

Diagram

Description automatically generated

*Source: - Vinnolit GmbH & Co. KG*

1. **EDC Cracking**

The cracking of 1,2 dichloroethane (EDC) takes place in a cracking furnace heated by fuel. VCM and HCl are formed at temperatures of 480°C, the reaction being endothermic and incomplete.

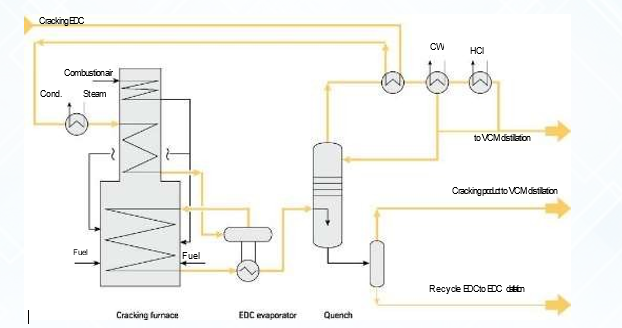
In addition to VCM and HCl, by-products of various chemical structures and coke are formed.

The external EDC pre-evaporation facility reduces the formation of coke in the cracking furnace considerably. The operating periods between two decoking intervals are very long (up to 2 years).

The advantages of Vinnolit’s modern EDC cracking process can be summarized as follows:

* High reliability due to low coke formation
* High savings in primary and secondary energy due to: - External EDC pre-evaporation using cracking gas heat - Utilization of flue gas and cracking gas heat to preheat combustion air, to generate steam, or to preheat EDC
* Low maintenance costs
* Proven materials and reliable equipment

1. **Block Diagram of EDC Cracking**



*Source: - Vinnolit GmbH & Co. KG*

1. **VCM Distillation**

VCM, HCl, unconverted EDC, and by-products of diverse chemical structures make up the cracking unit's output.

The HCl column recovers hydrogen chloride, which is then delivered to the oxychlorination unit. At the top of the VCM column, vinyl chloride is produced.

The HCl stripper cleans the VCM of any remaining HCl residue. Through the use of an H2O removal unit, which removes moisture from the distillation process and guards against moisture buildup, the overhead product of the HCl stripper is recycled to the HCl column.

After the low-boiling compounds have been converted by chlorination to high-boiling compounds, the bottom product of the VCM column, i.e., un-converted EDC, is returned to the EDC distillation process. As a result, it is not necessary to separate recycled EDC from other low boiling components, which is complex and energy intensive.

The Vinnolit EDC distillation machine can function without a low-boil column and the associated issues with recycle EDC.

**Advantages of the VCM column:**

* Without employing caustic, HCl content in VCM is less than 1 ppm.
* VCM distillation unit has a long on-stream period since there is no coke carryover from the hot quench system.
* No condensation system is required; vapour feed of HCl stripper overhead product to the HCl column.
* HCl condensation uses less energy than a low-pressure HCl column.

**Advantages of the Recycle EDC Chlorination**:

* Low-boiling compound separation is not necessary.
* Comparatively modest investment costs to a low-boil column
* Easy operation
* No steam consumption
* Low maintenance cost

**Wastewater Treatment**

A wastewater treatment facility receives the process effluent and any splash water from the VCM plant. Hydrogen chloride and chlorinated hydrocarbons are eliminated using distillation and caustic soda solution, respectively. Dry catalyst filtration during oxychlorination or wastewater treatment utilizing flocculation, sedimentation, and filtration both guarantee a copper level of less than 1 ppm.

**INOVYN Vinyls Technology (INEOS)**

* INOVYN’s Vinyls Technology is designed to produce superior suspension grade PVC using additives to create robust particle size, with low foaming recipes and excellent color resin with homogenous porosity. VCM is mixed with water and fed into the reactor where primary, secondary, build suppressant, antioxidant, and anti-swelling agents were added. Further, the feed is passed from the reactor to the blowdown vessel. An antifoaming agent is added to control the foaming in the blowdown vessel.
* The solution from the blowdown vessel is fed into the stripping column, where VCM is recovered and recycled to the feed. PVC is then obtained from the stripping column after the drying process.

**INEOS Process Block Flow Diagram**

Diagram

Description automatically generated

*Source: - INEOS*

**Additives Details**

Diagram

Description automatically generated with medium confidence

*Source: - INOVYN*

**The EVICAS Range of Antifouling Agents**

**EVICAS 90H**

EVICAS 90H is a water-based product.

Prevents polymer build-up in reactors, condensers, and paste/emulsion manufacturing.

**EVICAS XLB**

Water based product, does not require nitrogen blanketing.

Developed for better spray application and improved adhesion to reactor internals.

Leads to reduced consumption of antifouling agent.

**EVICAS CN4**

Water based product.

Potential improvement in PVC powder color of 20%.

Reduced dark specks due to improved application.

**EVICAS XL**

Newest generation of the world famous EVICAS range.

Developed to adhere very strongly to reactor internals.

Eliminates the need to apply antifouling agent to every batch.

**EVICAS 90CS**

Designed specifically to prevent build up in troublesome areas: agitator blades and shaft, internal baffles, and condenser tubes.

**The INOVOL Range of Suspending Agents**

**INOVOL PA4**

80% Degree of Hydrolysis Primary Suspending Agent

Optimized for demanding conditions such as high condenser heat removal, high monomer water ratio & direct steam injection.

**INOVOL PA6**

72% Degree of Hydrolysis Primary Suspending Agent

Good size control under demanding conditions.

High cloud point for excellent hot water charge stability.

**INOVOL PA7**

88% Degree of Hydrolysis Primary Suspending Agent.

Provides colloidal stability to recipes.

Improves long term heat stability.

**INOVOL SA4/b**

55% Degree of Hydrolysis Secondary Suspending Agent

Higher AD while maintaining equivalent or even lower residual VCM

Improved AD consistency

**The INOVOL Range of Suspending Agents**

**INOVOL SA5**

57-60% Degree of Hydrolysis Secondary Suspending Agent

Improved internal homogeneity and particle size distribution lead to better VCM “strippability.”

**INOVOL FP**

New Generation

Non-PVA Based Secondary Suspending Agent

Benefits: Improved homogeneity, low foaming, improved color, reduced “fish-eyes,” and improved VC/moisture loss.

**The INOVOL Range of Specialty Products For PVC**

**INOVOL AF12: ANTIFOAM**

Reduces foaming and carry-over in the stripper column, reactor or downstream vessels.

Developed as an effective antifoam without adversely affecting the melt characteristics or volume resistivity of the PVC resin.

**INOVOL AS30: ANTISWELLING**

Reduces or eliminates the swelling or foaming of the reactor contents, allowing for increased fill and productivity.

**INOVOL MS8: VCM INHIBITOR**

Developed to inhibit polymerization in recovered monomer plant.

Food contact approved inhibitor.

Proven in sPVC and mass processes.

**INOVOL AO: ANTIOXIDANT**

Water-based, multipurpose formulation with improved storage stability.

Effectively stops polymerization while ensuring good color and thermal stability.

Leads to excellent brightness of the PVC resin.

**VINYLS OXYCHLORINATION CATALYSTS**



*Source: - INOVYN*

**The IVOC Range of Fixed Bed Oxychlorination Catalysts**

The IVOC-P type catalysts are a series of well-proven promoted copper catalysts on alumina support. They are suited for Ethylene Oxychlorination in fixed bed reactors operating with air or oxygen, in the single, three and the newest two stage technology offered by INOVYN.

**Catalyst**

**IVOC-P1D and IVOC-P1DT**

FIRST Reactor Catalysts for 3-stage and 2-stage (T series) plants.

Low pressure drop, high pressure drop stability, low deactivation rate.

**IVOC-P2 and IVOC-P2T and IVOC-P2D**

FIRST & SECOND Reactor Catalysts for 3-stage and 2-stage (T series) plants

Low pressure drop, high activity, low deactivation rate

**IVOC-P3 and IVOC-P3T and IVOC-P3P**

SECOND & THIRD Reactor Catalysts for 3-stage and 2-stage (T series) plants

High Selectivity to 1,2-EDC, low combustion, high HCl conversion (low acidity)

**DILUENTS**

**IVOD-1 and IVOD-2F**

High performance graphite-based diluents for exothermal reactions (Oxychlorination)

High thermal stability and high purity material. Optimized shape for low pressure drops. The special shape of the 2F series allows the plant to achieve high capacity at the lowest pressure drop.

**The IVOC Range of Fluid Bed Oxychlorination Catalysts**

The IVOC-FB are a 1st Generation series of promoted copper catalysts on alumina support. Ideally suited for Ethylene Oxychlorination in fluid bed reactors operating with air or oxygen and are applicable to Oxychlorination technologies licensed by OxyVinyls, Vinnolit and Arkema.

Their specific composition assures main advantages such as: high selectivity to EDC, high activities and stable Oxychlorination reaction in the whole range of operating conditions. Proven in different technologies since 1999, they can operate in the whole range of temperature typical of fluid bed processes (from 200° to 250°C).

The IVOC-FB4\* represents the 2nd Generation of fluid bed catalyst which provides an improved efficiency and a higher stability at the different operating conditions. At standard capacity, lower consumption of cat-chem and high yield of ethylene and caustic can be achieved due to very high reactant conversions. The higher activity can also allow an increase of the production rate. It can operate in the normal range of fluid bed processes (from 220 to 260°C) and offer an excellent fluid-dynamic behavior even at severe conditions. FB4\* has been proven in the different Oxychlorination technologies since 2006.

The GM are series of promoted copper catalysts on alumina support. The GM5824 is ideally suited for Ethylene Oxychlorination in fluid bed reactors operating with oxygen and are specifically designed for technologies operating with reactor temperatures above 245°C (in particular Solvay heritage technology). Their specific compositions are tailor-made to achieve high EDC productivity at elevated temperature conditions while ensuring high selectivity to EDC, high activities and stable Oxychlorination reaction. The very high reactant conversion allows for high yield in ethylene and caustic.

**IVOC-FB2**

1st Generation LOW temperature catalyst

Operating temperature 210-230°C in air and oxygen-based processes

**IVOC-FB1**

1st Generation HIGH temperature catalyst

Operating temperature 235-255°C in air and oxygen-based processes

**IVOC-FB4\***

2nd Generation high performance catalyst

Operating temperature 220-260°C in air and oxygen-based processes

**GM Series**

Heritage generation of high temperature catalysts

Operating temperature above 245°C in oxygen-based processes

**JNC PVC Process Description**

Chisso Corporation is Japanese chemical company reorganized as a Japan New Chisso or JNC since 2012.

**Polymerization Section:**

* In the reactor, purified VCM, pure water and other chemicals, including an initiator are charged.
* Keeping good suspension conditions, the contents of the reactor are vigorously stirred inside the reactor.
* In the presence of the initiator and at elevated temperatures, VCM reacts to form the PVC particles.
* Finally, PVC particles yields by the reaction form dense slurry in the reactor.
* The unreacted VCM is recovered into a VCM gas holder when the reaction reaches its final stage, while the polymer slurry is transported from the reactor to a slurry tank.

**VCM Recovery Section:**

* In the recovery section, the unreacted VCM gas is compresses and condensed.
* The recovered liquid VCM is stored in a vessel and is reused as the feedstock for the succeeding polymerizing reaction.

**VCM Removal Section:**

* Steam is used to effectively strip the unreacted VCM out of the PVC slurry in the stripping column, which then feeds the stripped slurry to the drying section.
* Less than one (1) ppm of VCM is present in the final PVC product.
* A heat exchanger is used to minimize the steam consumption in the VCM removal system.
* Inside the stripping column, hot water is used for washing at each stage.
* This contributes to continuous operation for the long term without stopping the feed.
* The column’s unique design ensures high efficiency and low steam consumption can be achieved without any quality problem.

**Drying Section:**

* For the separation of wet PVC cakes from water, PVC slurry from the VCM slurry section is continuously fed into the centrifuge.
* From the centrifugation section, the wet PVC cakes are discharged into a fluidized bed dryer, where moisture is removed from the PVC powder.
* To eliminate any oversized particles, the dried PVC powder is passed through product sieves and is conveyed pneumatically to the product silos.
* The PVC product thus obtained maintains uniform quality

**Comparative Analysis in Process Technology of Vinnolit Process and INOVYN Vinyls Technology (INEOS)**

|  |  |
| --- | --- |
| **Vinnolit Process** | **INOVYN Vinyl’s Technology (INEOS)** |
| High conversion of Ethylene to EDC approximately 99.0 % | Inovyn technology uses VCM as a feedstock to produce PVC |
| Process has Low catalyst consumption | Inovyn process uses series of catalyst which has advantage of high selectivity & activity, high pressure drop stability |
| Fluidized-bed reactor with good reaction heat distribution: | Due to formation of hot spots, heat of distribution is affected. |
|  |
| Low maintenance costs | No information available |  |
| The energy recovery options led to a significant reduction of CO2-emissions | No information available |  |

Presently, existing PVC manufacturers are operating on the traditional model of BF Goodrich, which has now been merged with Vinnolit/ UHDE. In future capacity expansion and design of production process unit, Vinnolit/UHDE is most likely to be preferred for the client owing to its established infrastructure for design and technical support services, strong history of executed projects in India as compared to other competitors viz. INEOS, Chisso. Furthermore, as the client prefers the EDC production route, Chisso is ruled out owing to the production process via the Acetylene Carbide route.

Production of emulsion-grade PVC, which is being produced and supplied by limited players, can be seen as an opportunity for the client to produce and offer the same to prospective manufacturers of flexible products. Furthermore, this move will bridge the supply-demand gap and reduce the dependency on imports by a significant level where end users are procuring the product at higher costs.

**Plot Plan Estimates and Specification**

**Plot Plan Estimates: - Option-1 (Green Field Setup of ISBL + OSBL)**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No** | **Process Unit** | **Land Area in Hectare (Ha)** | **Land requirement in Acres** |
| 1 | Raw material Handling and Storage | 4.05 | 10 |
| 2 | VCM Unit | 5.87 | 14.5 |
| 3 | PVC Unit | 1.22 | 3 |
| **4** | **Total ISBL** | **11.14** | **27.5** |
| 5 | Steam Boiler & Co-generation facility | 1.01 | 2.5 |
| 6 | ETP and STP Plant | 0.81 | 2 |
| 7 | Utilities | 0.51 | 1.26 |
| 8 | Flare | 1.01 | 2.5 |
| 9 | Plant buildings | 0.51 | 1.26 |
| 10 | Administration Buildings | 0.3 | 0.74 |
| 11 | PVC warehouse/storage area | 1.01 | 2.5 |
| 12 | Others | 5.46 | 13.48 |
| **13** | **Total OSBL** | **10.62** | **26.24** |
| **14** | **Total ISBL+OSBL** | **21.76** | **53.74** |

**Plot Plan Estimates: - Option-2 (Green Field ISBL + Existing OSBL Facility)**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No** | **Process Unit** | **Land Area in Hectare (Ha)** | **Land requirement in Acres** |
| 1 | Raw material Handling and Storage | 4.05 | 10 |
| 2 | VCM Unit | 5.87 | 14.5 |
| 3 | PVC Unit | 1.22 | 3 |
| **4** | **Total ISBL** | **11.14** | **27.5** |
| 5 | Plant buildings | 0.51 | 1.26 |
| 6 | PVC warehouse/storage area | 1.01 | 2.5 |
| 7 | Others | 5.46 | 13.48 |
| **8** | **Total OSBL** | **6.98** | **17.24** |
| **9** | **Total ISBL+OSBL** | **18.12** | **44.74** |

*Note: - The plot plan is derived based on Primary and Secondary research, OSBL and OSBL data is anticipated to change post receiving the inputs from Technology / Licensors.*

1. **Utility Systems**

**Energy / Power Requirements**

The total power requirement for the plant to run is estimated to be around 13.5 MW.

**Steam Generation**

Around 0.8 tonnes of steam are required for producing 1 tonne of PVC through direct chlorination of Ethylene.

**Water Requirement**

Total water requirement will be 750 KLD for the Polyvinyl Chloride plant which will be used in cooling tower, manufacturing process, stream generation.

|  |  |  |
| --- | --- | --- |
| **Sr. No.** | **Usage** | **Water Consumption (KLD)** |
| 1. | Processing | 400 |
| 2. | Cooling | 200 |
| 3. | Others (Steam Generation, Washing, etc.) | 150 |
| Total | | 750 |

Source: Finolex Industries

**Wastewater Generation Details**

180-250 KLD of wastewater will be generated during the manufacturing of PVC. The waste generated from cooling tower, process, washing. The effluent will be treated in ETP having various treatment units like collection cum neutralization tank and finally evaporated in evaporator

**Waste Generation Break up**

The proposed plant will generate the following hazardous wastes

|  |  |  |
| --- | --- | --- |
| **Sr. No.** | **Waste Generated Through** | **Wastewater Generation (KLD)** |
| 1. | Process Waste/Residue | 60-75 |
| 2. | Cooling Tower | 100-135 |
| 3. | Others (Stream Condensate, Washing, DM water, etc.) | 20-40 |
| Total | | 180-250 |

Source: Finolex Industries

For a 350 KT PVC plant, the required cooling tower capacity will be approx. 6000-7000 m3/hour. It will depend on reactor efficiency, delta T, size & transfer area. Depending upon the PVC-VCM conversion value, the heat liberated value will determine (around 16000 KJ) & reaction time, & production requirement at the manufacturing time.

1. **Catalyst & Chemical Summaries Expected**

|  |  |  |  |
| --- | --- | --- | --- |
| Sr. No | Process | Catalyst used | Remarks |
| 1 | Acetylene Route Production | Mercuric chloride | Industrial production of VCM utilizes a mercuric chloride catalyst to promote the reaction of acetylene and hydrogen chloride |
| 2 | EDC Route | | |
| i) | *Direct Chlorination* | Ferric chloride | Ferric Chloride is used as chlorine adsorbents in the pyrolysis of PVC at 300 °C for the recovery of the chlorine. |
| ii) | *Oxychlorination* | Cupric chloride | It has the conversion per pass of the acetylene of more than 98%, the selectivity of the vinyl chloride of more than 99% and the service life of more than 8000 hours (Approx.) |

|  |  |
| --- | --- |
| **Supplier of Catalyst and Chemicals -PVC Resin (EDC and Acetylene Route)** | |
| Type | Supplier |
| Hydrogenation Catalyst - Palladium | Evonik Resources Efficiency GmbH |
| Zeolite | BASF SE |
| Stabilizer (40% Aquanox 60 Emulsion) | Aquapersions Ltd HK |
| Vanillin–Schiff's bases (VSB) | Solvay |
| 4-Bromo-2-Flourbiphenyl | Xian Caijing |
| VCM Inhibitor | Ineos Group |

1. **Offsite Storage System, Flare System, Effluent Treatment System**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PVC Offsite Storage Requirement for new capacity additions | | | | |
| Service | Tanks Type | No of Tanks / Spheres | Working Capacity of Each Tank in m3 | Total Capacity, m3 |
| Ethylene | Sphere | 3 | 2800 | 8400 |
| Intermediate EDC | Cone Roof with N2 Blanketing | 2 | 2630 | 5260 |
| VCM | Sphere | 4 | 2800 | 11200 |
| Off Spec VCM | Sphere | 1 | 2800 | 2800 |
| Ethylene | Double Wall Storage Tank | 1 | 21600 | 21600 |

**Flare System:**

Companies using EDC/VCM to manufacture PVC have no flare system. Instead, these companies are using an overhead condensation system that contains the recovery condenser to recover VCM and exhaust gases during the process. During the suspension polymerization reaction, Hydrochloric acids is released in minimal quantity as a slurry which is further neutralized during the downstream process.

The flare system is implemented during the production of VCM from ethylene and cost around INR30-45 Crore, depending on the plant size. Flare stacks are installed during the process to burn the uncontrolled gases.

**Effluent Treatment Plant:**

The effluent generated from the various units in various configurations, under the purview of the feasibility study, will be treated in the Effluent Treatment plant located inside the client’s complex. The effluent mainly consists of the following streams:

a. Oily water

b. Wastewater

c. Spent DM water, etc

**Nitrogen & Oxygen Requirement**

Additional EDCs are obtained in the Oxychlorination process using the HCL rich waste gas released during the direct chlorination reaction.

C2H4 + 2 HCl + ½ O2 ——> C2H4Cl2 + H2O + 238kJ/mole

For Every 1000 KG of VCM formed, 200 KG of Oxygen & 50 Kg of Nitrogen is Required.

To produce 350 KTPA of VCM, around 17.5 KTPA of N2 and 70 KTPA of Oxygen is required.

0-5% composition of O2 is present in the waste gas stream of an oxychlorination unit. Of the total production, 46% VCM is produced by oxychlorination process.

**VCM Storage Tank Facility**

VCM are stored in vessels made up of aluminium, copper & their alloys. VCM is a highly corrosive & flammable material and its contact with moisture, alkalis & alkali metals, oxygen & heat source is to be avoided. Inhibitors are added to prevent its polymerisation reaction.

For its storage, four storage tanks / bullets of 2800m3 capacity each are used.

Mostly, VCM are imported in India through, marine vessels in refrigerated/ pressurized parcels through a captive Marine Terminal Facility. It is polymerized in reactor to get PVC in slurry form which is transported to blow down tanks to recover unreacted VCM. Stripper & VCM recovery system further are used to get concentrated dried PVC.

1. **Feed, Product and Utility Prices**

**India Vinyl Chloride Monomer (VCM) - CFR Tuticorin and Ethylene Dichloride (EDC) Ex-Kandla Price, (FY 2013- FY 2021), USD/MT**

*Source: TechSci Research*

**Price Movement**

Since FY 2013, the offered quotations for the VCM at Ex-Kandla fluctuated within a rangebound of USD280-350 per tonne. At the same time, the imported volumes of VCM witnessed a constant yearly fluctuation depending upon the global supply-demand gap and raw material prices of ethylene in the international market. However, the market fundamentals observed a significant change in FY 2021, as the additional cost support induced by the limited availability of shipping freights hiked the quotations to an all-time high at DDP (delivery duty paid) at Kandla.

India is a net importer of VCM and EDC to produce PVC. Surging demand for PVC in the domestic market and increased prices of VCM and EDC in international markets resulted in increased import prices. Domestic producers are importing VCM and EDC to produce PVC. In FY 2021, EDC prices jumped by around 12% compared to FY 2020. Post lifting of COVID-19 restrictions in the domestic market in FY 2021, a sharp increase in prices of EDC and VCM is observed in the domestic market.

**India Ethylene Domestic Prices (FY 2013- FY 2021), USD/MT**

*Source: TechSci Research*

**Price Movement**

As a significant feedstock, the pricing trend of Ethylene in the Indian domestic market is majorly driven by Naphtha / natural gas prices in the international market. Domestic prices of Ethylene were in the price range of 800 - 1100 per MT from FY 2013 to FY 2021. The domestic price of Ethylene is mainly dependent upon naphtha prices. In FY 2021, the exponential growth of 20% in Ethylene prices is observed. The surge in crude oil and natural gas prices in international markets pushes the domestic prices of Ethylene. Moreover, an increase in prices resulted in a rise in operating costs at the refinery, thus making the domestic manufacturers pass the increased margin to end-use consumers.

**India Chlorine Ex- Mumbai Yearly Prices (FY 2013- FY 2021), USD/MT**

*Source: TechSci Research*

**Price Movement**

The market fundamentals of Caustic Soda primarily govern the selling prices of Chlorine. Chlorine is a highly hazardous and volatile material, so it cannot be stored for a very long time. Therefore, if the demand for Chlorine is low, whereas Caustic Soda is high, manufacturers are compelled to sell it at a lower price. In some cases, when there is muted demand for Caustic Soda, producing company optimizes production rates of Caustic Soda to make up for the overall bearish demand trend. In FY 2020, caustic soda prices have declined in the domestic and international markets. However, the prices of caustic soda in FY 2021 have shown a significant rise. The increase in caustic soda prices directly influences the country's chlorine prices. Similarly, the demand for downstream PVC, where Chlorine is majorly utilized in India, also plays a significant role in determining the market values of the product.

**Chlorine Gas Price Movement**

As per the analysis, the cost of Chlorine gas is primarily dependent upon energy prices; hence the prices of chlorine gas have increased in the past few years. However, as the final product, Liquid Chlorine is highly volatile to the market scenario, and its prices have witnessed a significant fluctuation depending on the demand pattern in the country. The cost of manufacturing chlorine gas is also marginally dependent upon the source (brine, rock salt etc.) and the quality of the salt used. The purity of salt, which ranges between 95-99.9%, also determines the quantity of treatment chemicals (Sulphuric Acid etc.) used, as salts of low quality, which are usually cheaper, require a more significant number of treatment chemicals. In FY 2021, the prices of chlorine gas witnessed an increase in price by 6.76% and are traded at USD87.45 per MT. Chlorine in India is produced alongside Caustic Soda primarily by membrane cell technology. In India, the average capacity of a Chlor Alkali plant is nearly 150-200 TPD; with every 150 MT of Caustic Soda, nearly 60MT of merchant Chlorine (Chlorine available for sales) is extracted while the rest

is utilized in captive production of Chlorine derivatives. However, considering the process, nearly 0.88 units of Chlorine is produced with a single unit of Caustic Soda. In the Chlor-Alkali industry, Caustic Soda, Chlorine, and Hydrogen manufacturing are achieved simultaneously. Production mainly requires water, salt, and extensive energy from electricity and steam.

Diagram

Description automatically generated

In the production process, electricity costs around 60% of the overall cost of production. The production cost of Chlorine produced in a Chlor-Alkali plant is calculated based on Prices of electricity

* Cost of steam
* Cost of the salt used
* Cost of treatment chemicals

The production cost of Chlorine generally does not vary as the electrolyzer operates on a fixed power of around 2300-2450 Kwh/MT. As per the manufacturing process, Chlorine production cost has not been more than INR3000 per MT in the last 3-4 years. The manufacturing cost is also marginally dependent upon the source (brine, rock salt etc.) and the quality of the salt used. The purity of salt, which ranges between 95-99.9%, also determines the quantity of treatment chemicals (Sulphuric Acid etc.) used as salts of low quality, which are usually cheaper and require a more significant number of treatment chemicals.

**India PVC Suspension Ex- Mumbai Yearly Prices (FY 2013- FY 2021), USD/MT**

*Source: TechSci Research*

**Price Movement**

Domestic PVC prices have shown an upward trend in FY 2021 because of the increase in demand from the construction sector. The domestic construction market witnessed an exponential demand post lifting COVID-19 restrictions in the country. Further, PVC bulk prices in India continued to trace an upward trajectory, pressurized by the prolonged import shortage and persistent hike in shipping charges across several trade routes along with Southeast Asia. PVC prices have been gaining momentum for a long time on the back of firming demand from the domestic market. Revision in the domestic price of PVC across the country worries downstream users, as it may squeeze their margin. However, the overall demand from the domestic end user section is high. In addition, brick-by-brick improvement in the domestic construction sector bolstered the demand fundamentals for PVC in the country, while downstream users were also expecting a further rise in demand from the agriculture sector in the forthcoming crop season.

1. **Regulations - Government Duties in Domestic Market**

The Government of India imposed 18% GST on PVC trade within the country. Custom duty imposed on import is 10%. PVC Resin is imported under 390410 HS code, Further, Emulsion and Suspension grade PVC is traded under 39041010 and 39041020 HS Code.

|  |  |
| --- | --- |
| **Import duty on PVC Resins HS Code (390410)** | **Percentage** |
| Basic Custom Duty | 10% |
| Integrated Goods & Services Tax (IGST) | 18% |
| Compensation Cess | Nil |
| Specific Duty | Not Applicable |
| Preferential Duty | Not Applicable |
| **Total Duty** | **29.8%** |

*Source: Department of Commerce, Ministry of Commerce and Industry, Government of India*

**Anti-PVC lobbies in Europe**

1. In 1997, the European Union commission launched a ‘horizontal initiative’ to monitor and evaluate the footprints of PVC environmentally. This initiative resulted in the publication of studies focused on waste management. Several European authorities signed to join a ‘Voluntary Commitment of the PVC industry’ which includes:
   1. ECVM – The European Council of Vinyl Manufacturers
   2. Eu-PC – The European Plastics Converters
   3. ECPI – The European Council for Plasticizers and Intermediates
   4. ESPA – The European Stabilizer Producers Association
2. Overall waste Management Strategy for PVC
   1. **Prevention via reduction at sources:** minimizing the volume and weight of waste at the production stage.
   2. **Re-use:** providing extended life for certain products.
   3. **Recycling:** making new products out of used goods.
   4. **Energy Recovery:** harnessing the high energy value of spent plastic goods to produce light, heat, and power.
   5. **Landfill:** for non-recoverable products and the residual waste from recovery operations.
3. **Green Paper on PVC COM (2000) 469 tackles two main issues**
   1. Environmental and health questions concerning the use of certain additives in PVC such as lead, cadmium, and phthalates.
   2. The question of waste management (landfill, incineration, recycling of PVC waste): PVC waste is expected to increase by about 80% over the next 20 years.
4. **Vinyl 2010:** is a 10-year voluntary program on the sustainable development of the whole PVC industry.

**The main commitments were:**

* 1. Compliance with ECVM charters on PVC production standards.
  2. Complete replacement of lead stabilizers by 2015.
  3. The recycling by the end 2010 of 200,000 tonnes per year of post-consumer PVC waste.
  4. The recycling of 50% of the collectible available PVC wastes.
  5. An R&D program on new recycling methodology and technology on the complete value chain.
  6. Implementation of the Social Charter involving European Mine, Chemical and Energy workers federation to maintain the sustainable development.

1. **The Vinyl 2010 is replaced by its successor VinylPlus in June 2011:** a next 10-year voluntary program built on the achievement of Vinyl 2010 on the sustainable development of the whole PVC industry.
   1. **Controlled Loop Management of PVC.**
      1. Recycle 800,000 tonnes/year of PVC by 2020.
      2. Develop and exploit innovative technology to recycle the targeted PVC.
   2. **Organochlorine Emissions**
      1. Engage with external stakeholders in the discussion of organo-chemical emissions and develop a plan to deal with the concerns.
      2. Risk assessment for the transportation of major raw materials (VCM).
      3. Target zero accident rate with VCM release during transportation in the next 10 years.
   3. **Sustainable Use of Additives**
      1. Lead replacement.
      2. Robust criteria for the sustainable use of additives to be developed.
      3. Validation of the robust criteria for the sustainable use of additives in conjunction with the downstream value chain.
   4. **Sustainable Energy & Climate Stability** 
      1. **PVC resin producers reduce their energy consumption by 20% in 2020.**
   5. **Sustainability Awareness**

**11.2. Duty Barriers in Export Market.**

**Free Trade Agreement Between the Republic of India and The Democratic Socialist Republic of Sri Lanka**

India and Sri Lanka have entered into a free trade agreement to promote the exchange of goods and products.

**Elimination of Tariffs**

The Contracting Parties hereby agree to establish a Free Trade Area for the purpose of free movement of goods between their countries through the elimination of tariffs on the movement of goods in accordance with the provisions of Annexures A & B, which shall form an integral part of this Agreement.

**Concession Offered by India**

The Government of India shall grant duty-free access to all exports from Sri Lanka in respect of items freely importable into India, except on items listed in Annex D of this Agreement, in accordance with the phase-out schedule detailed below:

* Upon entry into force of the Agreement: -
* Zero duty access for the items in Annexure ‘E.’
* 50% margin of preference on the remaining items except on items listed in Annexure D. Concessions on items in Chapters 51 to 56, 58 to 60 and 63 shall be restricted to 25%.
* The margin of preference on the items mentioned in (b) above shall be increased to 100% in two stages within three years of the coming into force of the Agreement, except for the textiles items referred to in 1(b) above.

**Concession Offered by Sri Lanka**

* The government of Sri Lanka shall provide tariff concessions on exports from India to Sri Lanka in respect of items freely importable into Sri Lanka, as detailed below: -
* Zero duty for the items in Annex ‘F’ – I, upon entering into force of the Agreement.
* 50% margin of preference for the items in Annex ‘F’ – II, upon coming into force of the Agreement. The margin of preference in respect of these items shall be deepened to 70%, 90%, and 100%, respectively, at the end of the first, second, and third year of the Agreement’s entry into force.
* For the remaining items except those in Annex ‘D’, the tariffs shall be brought down by not less than 35% before the expiry of three years and 70% before the expiry of the sixth year, and 100% before the expiry of eight years, from the date of the Agreement’s entry into force.

**\****No Special margin Preference is given for trade of PVC to Sri Lanka as per India Sri Lanka FTA*

*Source: Department of Commerce, Ministry of Commerce and Industry, Government of India*

**India Nepal Trade Treaty**

**Key Highlights of the Treaty**

ARTICLE III: Both the Contracting Parties shall accord unconditionally to each other treatment no less favorable than that accorded to any third country concerning (a) custom duties and charges of any kind imposed on or in connection with importation and exportation, and (b) import regulations including quantitative restrictions.

ARTICLE IV: The Contracting Parties agree, on a reciprocal basis, to be exempt from basic customs duty and quantitative restrictions. The import of such primary products may be mutually agreed upon by each other.

ARTICLE V: Notwithstanding the provisions of Article III and subject to such exceptions as may be made after consultation with the Government of Nepal. The Government of India agreed to promote the industrial development of Nepal through the grant based on non-reciprocity of especially favourable treatment to imports into India of industrial products manufactured in Nepal in respect of customs duty and quantitative restrictions normally applied to them.

ARTICLE VI: To facilitate the greater interchange of goods between the two countries, the Government of Nepal shall endeavour to exempt, wholly or partially, imports from India from customs duty and quantitative restrictions to the maximum extent compatible with their development needs and protection of their industries.

II. With Reference to Article II 1. It is understood that all goods of Indian or Nepalese origin shall be allowed to move unhampered to Nepal or India, without being subjected to any quantitative restrictions, licensing or permit system with the following exceptions: (a) Goods restricted for export to third countries, (b) Goods subject to control on price for distribution or movement within the domestic market, and (c) Goods prohibited for export to each other’s territories to prevent deflection to third countries.

**\****No Special margin Preference is given for trade of PVC to Nepal as per India Nepal Trade Treaty*

*Source: Department of Commerce, Ministry of Commerce and Industry, Government of India*

**India Malaysia CECA**

**Article 2.5**

**Tariff Reduction and Elimination**

1. Except as otherwise provided for in this Chapter, each Party shall gradually liberalize, where applicable, applied MFN tariff rates on originating goods of the other Party in accordance with its Schedule of Tariff Commitments as set out in Annex 2-1.

2. Nothing in this Chapter shall preclude any Party from unilaterally accelerating the reduction and/or elimination of the applied MFN tariff rates on originating goods of the other Party as set out in its Schedule of Tariff Commitments in Annex 2-1.

**Article 2.6**

**Customs Valuation**

To determining the customs value of goods traded between the countries of the parties, provisions of Part I of the WTO Agreement on Implementation of Article VII of GATT 1994, as may be amended, shall apply, mutatis mutandis, to this agreement.

Schedules of Tariff Commitments as per Annex 2-1

The tariff lines subject to tariff reduction and/or elimination under this Annex are categorized as follows: (a) Normal Track (i) Applied MFN tariff rates for tariff lines placed in the Normal Track will be reduced and subsequently eliminated in accordance with the following tariff reduction and elimination schedule: (AA) Normal Track 1: 1 July

2011 to 30 September 2013; (BB) Normal Track 2: 1 July 2011 to 30 June 2016 (ii) Where the applied MFN tariff rates are at 0%, they shall remain at 0%. Where they have been reduced to 0%, they shall remain at 0%. No Party shall be permitted to increase the tariff rates for any tariff line, except as otherwise provided in this Agreement. (b) Sensitive Track Applied MFN tariff rates above 5% for tariff lines in the Sensitive Track had been reduced to 5% by 30 June 2016.

**India-ASEAN Trade Agreements and India Singapore CECA agreement have no special privileges for the trade of PVC to these countries. The export duty of PVC is as per current tariff rates only.**

**ASIA-PACIFIC TRADE AGREEMENT**

The Asia Pacific Trade Agreement (APTA) was originally known as the Bangkok Agreement. The Bangkok Agreement was signed in 1975 and was the oldest Preferential Tariff Agreement (PTA) among the developing countries. It is facilitated by the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), which acts as its secretariat.

Its original members include Bangladesh, India, Lao PDR, Philippines, Sri Lanka, Thailand, and the Republic of Korea (ROK). Thailand and the Philippines did not ratify the agreement. Lao PDR has not issued any customs notifications on tariff concessions, and China joined the agreement in 2001.

A revision of the agreement was made in 2005 and was renamed the Asia Pacific Trade Agreement (APTA). APTA targets gradual tariff liberalization. The new agreement has devised a common rule of origin (RoO). Following the 1st and 2nd rounds of negotiations concluded in 1975 and 1990, respectively, a process of revitalization began in the early 2000s. This brought the conclusion of the 3rd round of negotiations in 2005. This round involved 4,270 products with an average Margin of Preference (MoP) of 27.22%. There is no special margin preference given for the trade of PVC to Bangladesh as per Asia Pacific Trade Agreement (APTA).

**Global Trade Ethylene Dichloride (EDC), Import by Top 10 Countries, (2011-2020), By Value (USD Million) and Volume (Thousand Tonnes).**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2011** | | **2012** | | **2013** | | **2014** | | **2015** | |
| **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** |
| Thailand | 146 | 315 | 99 | 371 | 165 | 440 | 165 | 349 | 144 | 455 |
| Germany | 122 | 259 | 109 | 227 | 147 | 316 | 201 | 404 | 161 | 438 |
| China | 189 | 399 | 154 | 557 | 225 | 658 | 303 | 686 | 178 | 602 |
| Brazil | 8 | 13 | 6 | 10 | 1 | 1 | 3 | 0 | 3 | 5 |
| Egypt | 4 | 8 | 15 | 29 | 37 | 62 | 47 | 78 | 37 | 33 |
| Spain | 20 | 53 | 5 | 0 | 18 | 0 | 14 | 30 | 9 | 33 |
| Taiwan | 61 | 123 | 32 | 118 | 58 | 172 | 93 | 216 | 74 | 251 |
| South Korea | 207 | 437 | 163 | 432 | 100 | 228 | 110 | 208 | 88 | 205 |
| Japan | 74 | 140 | 34 | 127 | 87 | 258 | 102 | 229 | 84 | 284 |
| Netherlands | 41 | 82 | 18 | 51 | 42 | 131 | 24 | 46 | 32 | 39 |
| Others | 255 | 511 | 222 | 674 | 181 | 461 | 272 | 599 | 197 | 632 |
| **Total** | **1128** | **2340** | **857** | **2597** | **1060** | **2726** | **1335** | **2844** | **1007** | **2978** |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2016** | | **2017** | | **2018** | | **2019** | | **2020** | |
| **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** |
| Thailand | 139 | 530 | 145 | 527 | 170 | 555 | 217 | 577 | 194 | 614 |
| Germany | 134 | 395 | 217 | 488 | 208 | 404 | 219 | 472 | 209 | 452 |
| China | 168 | 664 | 101 | 375 | 131 | 505 | 66 | 193 | 77 | 398 |
| Brazil | 0 | 0 | 19 | 83 | 22 | 87 | 86 | 283 | 95 | 356 |
| Egypt | 38 | 170 | 31 | 92 | 65 | 0 | 116 | 28ss2 | 95 | 299 |
| Spain | 0 | 0 | 26 | 85 | 97 | 278 | 109 | 309 | 83 | 280 |
| Taiwan | 64 | 267 | 79 | 295 | 73 | 253 | 104 | 286 | 67 | 236 |
| South Korea | 64 | 200 | 66 | 228 | 55 | 182 | 60 | 160 | 45 | 145 |
| Japan | 65 | 259 | 98 | 333 | 72 | 239 | 71 | 192 | 37 | 132 |
| Netherlands | 16 | 47 | 15 | 46 | 33 | 82 | 33 | 52 | 15 | 32 |
| Others | 190 | 704 | 222 | 771 | 268 | 828 | 313 | 828 | 259 | 123 |
| **Total** | **877** | **3238** | **1020** | **3324** | **1193** | **3413** | **1396** | **3635** | **1175** | **3068** |

*Source: International Trade Centre (ITC), HS Code: -* *290*

**Global Trade Ethylene dichloride (EDC), Export by Top 10 Countries, (2011-2020), By Value (USD Million) and Volume (Thousand tonnes)**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2011** | | **2012** | | **2013** | | **2014** | | **2015** | |
| **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** |
| United States of America | 246 | 609 | 149 | 682 | 265 | 935 | 417 | 1143 | 262 | 1242 |
| Saudi Arabia | 101 | 233 | 80 | 379 | 92 | 331 | 142 | 410 | 110 | 434 |
| Germany | 190 | 432 | 145 | 468 | 155 | 494 | 175 | 508 | 147 | 618 |
| Belgium | 67 | 156 | 67 | 159 | 80 | 181 | 69 | 176 | 78 | 269 |
| South Korea | 93 | 227 | 51 | 210 | 84 | 256 | 95 | 223 | 61 | 208 |
| United Kingdom | 66 | 134 | 65 | 120 | 92 | 162 | 145 | 266 | 112 | 271 |
| Indonesia | 88 | 201 | 76 | 324 | 104 | 318 | 147 | 347 | 52 | 215 |
| Taiwan | 31 | 63 | 27 | 103 | 20 | 60 | 20 | 47 | 6 | 25 |
| India | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 5 | 16 |
| Sweden | 11 | 19 | 15 | 26 | 14 | 25 | 24 | 46 | 13 | 38 |
| Others | 140 | 313 | 73 | 253 | 29 | 91 | 21 | 45 | 25 | 72 |
| Total | 1033 | 2386 | 749 | 2723 | 937 | 2858 | 1256 | 3211 | 870 | 3408 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2016** | | **2017** | | **2018** | | **2019** | | **2020** | |
| **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** |
| United States of America | 247 | 1265 | 305 | 1360 | 314 | 1068 | 439 | 1432 | 320 | 1271 |
| Saudi Arabia | 107 | 555 | 90 | 404 | 123 | 486 | 178 | 528 | 137 | 579 |
| Germany | 132 | 588 | 156 | 606 | 184 | 559 | 161 | 508 | 131 | 535 |
| Belgium | 75 | 272 | 131 | 376 | 137 | 345 | 124 | 360 | 119 | 366 |
| South Korea | 56 | 199 | 49 | 184 | 78 | 263 | 89 | 281 | 92 | 343 |
| United Kingdom | 88 | 225 | 151 | 309 | 178 | 307 | 178 | 0 | 174 | 309 |
| Indonesia | 58 | 264 | 69 | 289 | 54 | 219 | 90 | 270 | 66 | 276 |
| Taiwan | 4 | 18 | 41 | 161 | 34 | 160 | 42 | 123 | 20 | 70 |
| India | 0 | 0 | 7 | 31 | 4 | 24 | 27 | 71 | 18 | 56 |
| Sweden | 6 | 19 | 11 | 30 | 4 | 4 | 13 | 33 | 13 | 41 |
| Others | 40 | 141 | 5 | 12 | 8 | 17 | 19 | 28 | 12 | 27 |
| Total | 813 | 3546 | 1018 | 3762 | 1117 | 3450 | 1359 | 3634 | 1102 | 3874 |

*Source: International Trade Centre (ITC)*

*HS Code: -* *290315*

**Global Trade Export Potential of EDC (2020)**

*Note: - The Export Potential is calculated for 2020, by subtracting the import volume from exported Volume to calculate the net export potential* Map

Description automatically generated

*Note: The Export Potential is calculated for 2020, by subtracting the import volume from exported Volume to calculate the net export potential*

**Global Top 7 EDC Exporting Countries, 2020**

|  |  |
| --- | --- |
| **Country of Origin** | **Top Four Exporting Countries** |
| USA | Brazil, Egypt, India, Taiwan |
| Saudi Arabia | India, Thailand, Pakistan, China |
| Belgium | Germany, Spain, France, Norway |
| United Kingdom | Germany, Spain, Egypt, Belgium |
| Indonesia | Thailand, Taiwan, South Korea, India |
| South Korea | China, Japan, India, Thailand |
| Germany | Netherlands, Egypt, Czech Republic, Spain |

**Global Trade Vinyl chloride (VCM), Import by Top 10 Countries, (2011-2020), By Value and Volume, USD Million and Thousand Tonnes**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2011** | | **2012** | | **2013** | | **2014** | | **2015** | |
| **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** |
| China | 826 | 928 | 460 | 573 | 560 | 664 | 574 | 654 | 499 | 752 |
| India | 297 | 286 | 263 | 291 | 322 | 328 | 277 | 284 | 266 | 347 |
| Colombia | 355 | 400 | 340 | 405 | 338 | 410 | 347 | 407 | 262 | 414 |
| Vietnam | 194 | 245 | 194 | 0 | 224 | 261 | 236 | 275 | 204 | 228 |
| France | 277 | 306 | 200 | 226 | 230 | 228 | 217 | 232 | 178 | 244 |
| United Kingdom | 162 | 175 | 184 | 210 | 234 | 254 | 250 | 281 | 183 | 285 |
| Canada | 165 | 200 | 170 | 225 | 171 | 222 | 172 | 216 | 113 | 191 |
| Portugal | 196 | 221 | 160 | 201 | 160 | 195 | 128 | 166 | 103 | 160 |
| Netherlands | 194 | 217 | 162 | 0 | 227 | 232 | 197 | 212 | 156 | 212 |
| Philippines | 29 | 66 | 28 | 75 | 37 | 96 | 27 | 61 | 28 | 48 |
| Others | 828 | 961 | 697 | 865 | 705 | 880 | 362 | 397 | 555 | 893 |
| Total | 3522 | 4006 | 2856 | 3070 | 3209 | 3771 | 2787 | 3184 | 2549 | 3775 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2016** | | **2017** | | **2018** | | **2019** | | **2020** | |
| **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** |
| China | 505 | 790 | 553 | 812 | 567 | 810 | 650 | 986 | 589 | 955 |
| India | 236 | 332 | 361 | 441 | 364 | 466 | 394 | 506 | 359 | 461 |
| Colombia | 260 | 433 | 309 | 453 | 304 | 480 | 293 | 474 | 278 | 447 |
| Vietnam | 216 | 346 | 246 | 363 | 265 | 381 | 259 | 390 | 262 | 410 |
| France | 188 | 305 | 222 | 357 | 213 | 308 | 235 | 318 | 201 | 322 |
| United Kingdom | 159 | 263 | 216 | 312 | 194 | 297 | 147 | 254 | 129 | 253 |
| Canada | 114 | 207 | 124 | 206 | 134 | 238 | 112 | 239 | 97 | 222 |
| Portugal | 109 | 169 | 143 | 187 | 157 | 193 | 113 | 168 | 123 | 201 |
| Netherlands | 133 | 214 | 131 | 215 | 142 | 204 | 148 | 191 | 126 | 187 |
| Philippines | 51 | 79 | 77 | 105 | 80 | 106 | 93 | 126 | 94 | 139 |
| Others | 573 | 948 | 703 | 1029 | 731 | 1091 | 343 | 481 | 368 | 558 |
| Total | 2545 | 4087 | 3083 | 4480 | 3152 | 4574 | 2787 | 4133 | 2626 | 4154 |

*Source: International Trade Centre (ITC)*

*HS Code: -* *290321*

**Global Trade Vinyl chloride (VCM), Export by Top 10 Countries, (2011-2020), By Value and Volume, USD Million and Thousand Tonnes**

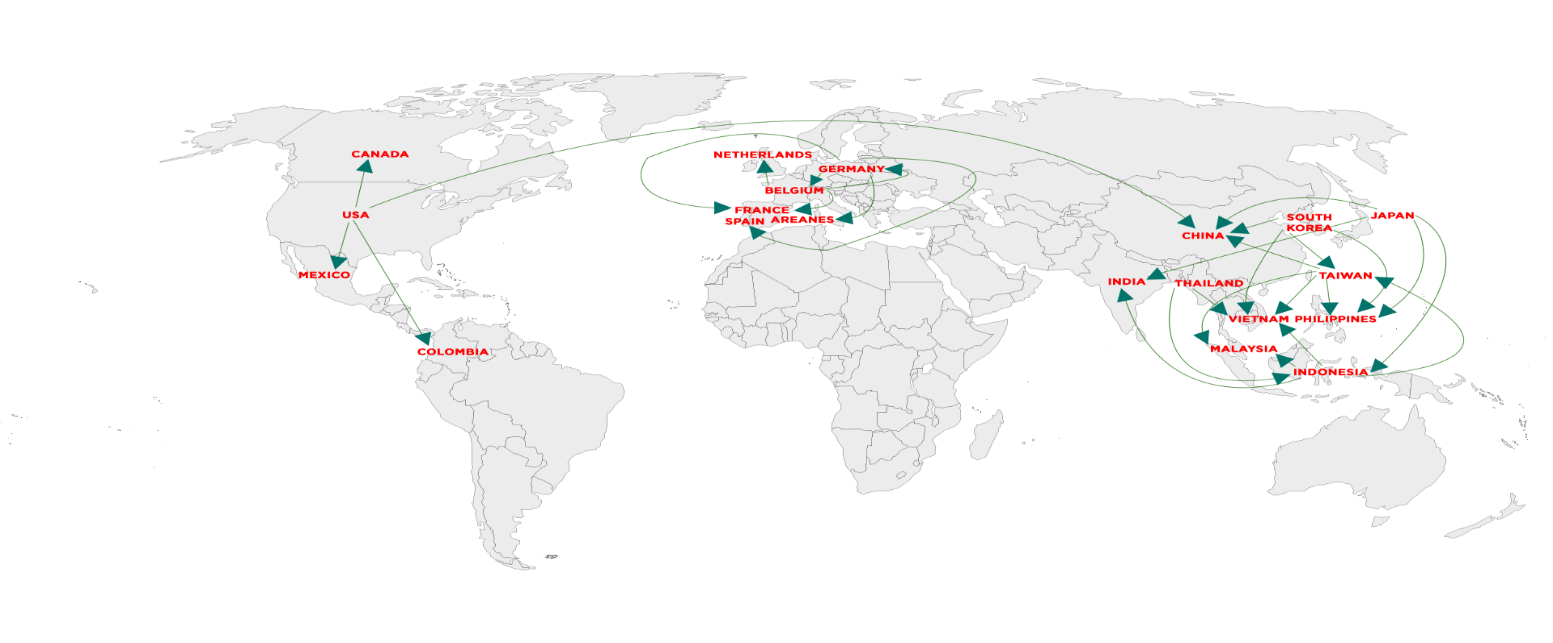
|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2011** | | **2012** | | **2013** | | **2014** | | **2015** | |
| **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** |
| United States of America | 865 | 1136 | 812 | 1148 | 852 | 1175 | 913 | 1191 | 654 | 1114 |
| Japan | 804 | 926 | 354 | 471 | 591 | 746 | 583 | 716 | 524 | 833 |
| Belgium | 5 | 6 | 7 | 8 | 19 | 21 | 32 | 36 | 24 | 38 |
| Taiwan | 292 | 336 | 283 | 369 | 253 | 328 | 282 | 346 | 248 | 407 |
| South Korea | 107 | 126 | 69 | 90 | 78 | 95 | 101 | 116 | 70 | 109 |
| Indonesia | 32 | 38 | 29 | 36 | 23 | 29 | 15 | 18 | 20 | 30 |
| Germany | 20 | 23 | 32 | 36 | 38 | 42 | 75 | 87 | 21 | 34 |
| Thailand | 53 | 58 | 62 | 78 | 93 | 111 | 62 | 72 | 58 | 86 |
| China | 16 | 15 | 7 | 8 | 7 | 8 | 49 | 56 | 30 | 43 |
| Saudi Arabia | 0 | 0 | 0 | 0 | 9 | 9 | 0 | 0 | 3 | 5 |
| Others | 252 | 310 | 280 | 349 | 99 | 131 | 13 | 15 | 72 | 122 |
| Total | 2447 | 2973 | 1936 | 2593 | 2061 | 2695 | 2125 | 2652 | 1723 | 2822 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2016** | | **2017** | | **2018** | | **2019** | | **2020** | |
| **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** |
| United States of America | 626 | 1124 | 793 | 1267 | 837 | 1322 | 814 | 1411 | 759 | 1211 |
| Japan | 507 | 868 | 620 | 941 | 596 | 904 | 578 | 897 | 580 | 958 |
| Belgium | 32 | 54 | 24 | 35 | 338 | 488 | 367 | 482 | 293 | 443 |
| Taiwan | 183 | 335 | 189 | 299 | 223 | 362 | 223 | 377 | 206 | 348 |
| South Korea | 69 | 113 | 39 | 57 | 39 | 56 | 139 | 213 | 153 | 248 |
| Indonesia | 80 | 122 | 111 | 166 | 143 | 212 | 130 | 196 | 128 | 198 |
| Germany | 77 | 123 | 112 | 171 | 137 | 190 | 116 | 169 | 107 | 183 |
| Thailand | 65 | 96 | 80 | 112 | 72 | 103 | 75 | 107 | 66 | 95 |
| China | 4 | 6 | 16 | 26 | 30 | 45 | 58 | 88 | 21 | 30 |
| Saudi Arabia | 3 | 6 | 4 | 7 | 3 | 6 | 0 | 0 | 15 | 23 |
| Others | 196 | 291 | 1 | 1 | 8 | 9 | 1 | 1 | 0 | 0 |
| Total | 1842 | 3137 | 1988 | 3084 | 2426 | 3696 | 2502 | 3940 | 2327 | 3739 |

*Source: International Trade Centre (ITC)*

*HS Code: -* *290321*

**Global Trade Export Potential of VCM (2020)**



*Note: - The Export Potential is calculated for 2020, by subtracting the import volume from exported Volume to calculate the net export potential.*

**Global Top 7 VCM Exporting Countries, 2020**

|  |  |
| --- | --- |
| **Country of Origin** | **Top Four Exporting Countries** |
| USA | Mexico, Colombia, Canada, China |
| Japan | China, Philippines, India, Indonesia |
| Belgium | France, Netherlands, Germany |
| Taiwan | China, Vietnam, Malaysia, Philippines |
| South Korea | China, Vietnam, Taiwan, Philippines |
| Germany | France, Belgium, Spain |
| Thailand | Indonesia, Vietnam |
| Indonesia | Vietnam, Malaysia, India, Taiwan |

**India Import Snapshot for Vinyl Chloride (VCM), (2020), By Top Four Countries**

**India Trade Import Details of VCM (2020)**

A map of the world

Description automatically generated with medium confidence

*Note: - The Import data is calculated for 2020 (calendar year from January 2020 to December 2020), India Import data vary as Import Export were taken from DGFT for Financial Year where FY 2021 means (April 2020 to March 2021).*

**India Import of VCM, By Country, 2020**

**India Import Snapshot for PVC Resin (PVC), (2020), By Top four Countries**

**India Trade Import Details of PVC (2020)**

A map of the world

Description automatically generated with low confidence

*Note: - The Import data is calculated for 2020 (calendar year from January 2020 to December 2020), India Import data vary as Import Export were taken from DGFT for Financial Year where FY 2021 means (April 2020 to March 2021).*

**India Import of PVC, By Country, FY2020**

**India Import Snapshot for EDC (EDC), (2020), By Top Four Countries**

**India Trade Import Details of EDC (2020)**

A map of the world

Description automatically generated with medium confidence

*Note: - The Import data is calculated for 2020 (calendar year from January 2020 to December 2020), India Import data vary as Import Export were taken from DGFT for Financial Year where FY 2021 means (April 2020 to March 2021).*

**India Import of EDC, By Country, FY2020**

**Prospective Export Potential of PVC from India in Neighbouring Countries**

A map of the world

Description automatically generated with medium confidence

|  |  |  |
| --- | --- | --- |
| **Neighbouring Importing Countries of PV** | | |
| **Country** | **2019** | **2020** |
| Nepal | 24.3 | 6.99 |
| Sri Lanka | 60.6 | 45.9 |
| Myanmar | 58.1 | 59.27 |
| Malaysia | 155.5 | 122.04 |
| Singapore | 28.71 | 34.52 |
| Bangladesh | 292.55 | 290.1 |

The companies operating in the domestic market can export PVC resins to neighbouring countries, which include Nepal, Bangladesh, Sri Lanka, Myanmar, Malaysia, and Singapore. In 2019 and 2020, Nepal's imports accounted for 24 and 7 thousand tonnes. Nepal mainly imports PVC from Thailand and Taiwan, contributing around 70% of the total import volume. No company in Nepal plans to set up a PVC plant because of viability and negligible demand in the country.

Bangladesh is one of the leading importers of PVC, with a total volume of around 290 thousand tonnes in 2020. The country imports most of its PVC from Taiwan, followed by China and Thailand. Therefore, the domestic producer has an excellent opportunity to export PVC from India due to its proximity to India. However, no company is producing PVC in Bangladesh due to capital costs and weak downstream industry.

Sri Lanka imported around 46 thousand tonnes of PVC in 2020 from Taiwan, the USA and Japan. The demand for PVC in Sri Lanka ranges from 45 to 50 thousand tonnes in 2020. There is no producer of PVC in Sri Lanka, thus creating an opportunity for domestic players to tap the Sri Lankan market. According to past import data, Myanmar has an export potential between 50 to 60 thousand tonnes. However, there is no producer of PVC due to weak

demand, and all the domestic market in Myanmar is met through import only. China, Thailand, Taiwan and the USA are the leading exporters of PVC in Sri Lanka.

Singapore is one of the trading hubs of chemicals and petrochemicals in the Asia Pacific market. The domestic import in Singapore ranges between 30-45 thousand tonnes. In 2020, the import of Singapore was around 37 thousand tonnes, and the country’s re-export was around 2.3 thousand tonnes. Indonesia, Taiwan, and Thailand are the leading exporters of PVC in Singapore. Further, no manufacturing unit of PVC is reported in the country.

Malaysia is among the major importers of PVC, with 206 and 170 thousand tonnes being imported in 2019 and 2020, respectively. In addition, the country exports around 45 to 50 thousand tonnes of PVC to other countries. No expansion of PVC capacity has been reported till now. Further, Bhutan has negligible imports of PVC from India.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Export Potential (‘000 Tonnes)** | | | | | | |
| **Countries** | **Import-2019** | **Export- 2019** | **Net** | **Import-2020** | **Export-2020** | **Net** |
| Bangladesh | 292.55 | 0 | 292.55 | 290.10 | 0 | 290.10 |
| Malaysia | 206.15 | 50.65 | 155.5 | 169.66 | 47.62 | 122.04 |
| Myanmar | 58.1 | 0 | 58.1 | 59.27 | 0 | 59.27 |
| Sri Lanka | 60.6 | 0 | 60.6 | 45.9 | 0 | 45.9 |
| Singapore | 30.04 | 1.34 | 28.71 | 36.87 | 2.35 | 34.52 |
| Nepal | 24.3 | 0 | 24.3 | 6.99 | 0 | 6.99 |
| Total Export Potential |  | | 619.76 |  | | 558.82 |

*Source: UN Comtrade and International Trade Centre*

**Overview of Source of Emissions**

**Emissions Related to PVC Production**

PVC production is associated with the emission of various harmful compounds. The process of PVC manufacturing includes two stages. The first stage involves the formation of ethylene and chlorine, which reacts to form ethylene dichloride (EDC). The ethylene formation entails the cracking of Naphtha, which is sourced from crude oil. The cracking process emits various GHGs, including methane, carbon dioxide, and other harmful by-products, which include propylene, butadiene, benzene, etc. In addition, the formation of chlorine from saltwater electrolysis releases mercury and asbestos into the environment.

The emission occurs during the steam cracking process, where feedstock (basically Naphtha) is mixed with the stream and passes through furnace tubes between 700°C to 900°C. Tubes are heated with the help of external burners, and different product mixes are obtained depending on the feedstock and specific CO2 emissions. Steam cracking is an endothermic process and thus requires a large amount of energy for steam generation and cracking, thus resulting in combustion-related CO2 emissions.

The ethylene and chlorine formed in the first stage undergo an oxychlorination step in the second stage to create EDC. Further, CO2 is also produced during the oxychlorination process and flaring of unconverted ethylene during the production of EDC.

The EDC formed in the above process undergoes cracking to form the Vinyl Chloride Monomer (VCM). During the conversion of VCM to PVC, no major emission is observed.

The VCM undergoes the Polymerization step to form the final PVC compound. The PVC is further processed to make final products, including pipes, cables, etc. This process includes the addition of various processing aids and fillers to reduce the cost and improve the mechanical and chemical properties of the PVC product. In addition, various

additives, such as phthalates, are released into the environment. Various additives, such as phthalates, are released into the environment in this process.

**Air Emissions**

Various sources of air pollution can be identified during the construction and operation phases. Vehicular emissions can be identified due to the movement of construction machinery and vehicles. Further, during the operation phase, sources of air emissions identified are a point source, line source, and fugitive emissions.

**Point Source**

The point source of air pollutants from project site shall be particulate matter (PM) and volatile organic compounds (VOCs) from process vents. Emissions from flue gas stacks shall contain air pollutants such as PM, SOx, NOx, etc.

**Line Source**

Particulate matter (PM) emissions from the movement of vehicles on roads & vehicular emissions like suspended particulate matter (SPM), carbon monoxide (CO) & Hydrocarbons (HCs) from the exhaust of vehicles can be classified as line source emissions.

**Fugitive Emissions**

Following is the list of fugitive emissions

1. Evaporation loss
2. Disposal of the waste gas stream
3. Equipment leaks from pumps, vessels, columns, reactors, etc.
4. Process venting

**Air Emissions Control Plan- Details of Flue Gas and Process Vents Emissions**

**Details of Flue Gas Stack Emissions and Control Measures**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr. No** | **Source of Emissions** | **Type of Fuel** | **Type of Emissions i.e., Air Pollutants** | **Air Pollution Control Measures** |
| 1 | Boiler | Coal/ Lignite | PM10, SO2, NOx | Electrostatic Precipitator (ESP) and Adequate Stack Height |
| 2 | Incinerator | Gas | PM10, SO2, NOx | Adequate Stack Height |
| 3 | Diesel Generators | High Speed Diesel (HSD) | PM10, SO2, NOx | Adequate Stack Height |

**Details of Process Vents Emissions and Control Measures**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr. No** | **Source of Emissions** | **Type of Emissions** | **Air Pollution Control Measures** |
| 1. | Process Vent | VOC | Incinerator |
| 2. | Flare | VOC | Smokeless Flare |
| 3. | Vent air from Dust Extraction System (DES) | PM | Bag Filter |
| 4. | Vent Scrubber | VOC | Water Scrubbing |
| 5. | Residue from VCM Production | -- | Incineration |
| 6. | Hydrogenation Units vent | VOC | Flare |
| 7. | Sludge and Filter Contaminated with Oil | -- | Incineration |

**12. Financial Analysis**

**Assumptions:**

1. For the calculation of total capital investment, equipment cost is derived through conducting various primary interviews with industry experts.

2. To calculate the plant's direct cost, the standard norms have been considered against the equipment cost. The below listed are the following norms-

- Purchased equipment installation: 20%

-Instrumentation and controls (installed): 18%

-Piping (installed): 2%

-Electrical (installed): 1%

-Buildings (including services): 2%

-Service facilities (installed): 5%

Note- The plant direct cost includes the equipment cost plus the above-listed parameters.

3. Total indirect plant cost includes Engineering and supervision, Construction expenses, Legal expenses, Contractor’s fee, Contingency, etc. which have been calculated using standard norms against the equipment cost.

4. ISBL facility includes equipment required in the process to manufacture PVC which constitutes around 70% of the total equipment cost. OSBL facility includes wastewater treatment plants, effluent treatment plants, different types of wet scrubbers to mitigate GHG emissions contributing about 20% to the equipment cost.

5. Total fixed capital investments is the summation of plant direct and indirect cost.

6. For calculating some of the parameters of operating cost, the following standard norms have been considered for PVC-

-Packaging Cost (calculated): 1% of Annual Sales Revenue @ 100 Percent Capacity Utilization

- Maintenance and repairs: 1.5% of Total Capital Investment

-Plant Overhead and Administrative Costs: 7.5% of Maintenance and repairs + Labour

-Distribution and selling costs: 2.5% of Annual Sales Revenue @ 100 Percent Capacity Utilization

-Research and development costs: 1.5% of Total Capital Investment

7. Expenditure of capital investment will be in the following phase-

-5% of Total Capital Investment: 2023

-25% of Total Capital Investment: 2024

-35% of Total Capital Investment: 2025

-35% of Total Capital Investment: 2026

8. Operating Revenue is bifurcated between-

- 350000 tons PVC merchant sale in option 1.

- 500000 tons PVC merchant sale in option 2.

- 500000 tons PVC merchant sale in option 3.

- 350000 tons PVC, 200000 tons Phenol, 120000 Acetone and coproducts merchant sale in option 4.

9. Operating revenue for each year is calculated by multiplying the capacity utilization for respective year to the annual sales revenue @ 100 percent capacity utilization considering inflation rate.

10. Operations will start in 2027.

11. Cash flow has been calculated till 2046.

12. Total operating cost is calculated based on capacity utilization at that period.

13. Inflation rate has been considered as 4.5%.

**Option 1: Capacity for 350 KTPA PVC Plant Using Captive Ethylene**

**CapEx**

|  |  |  |  |
| --- | --- | --- | --- |
| **Capacity for 350 KTPA PVC Plant Using Captive Ethylene** | | | |
| **INR Crore** | | | |
| **A** | **Total Fixed-Capital Investment** | **A1** + **A2** | **4,058** |
| **A1** | **Total Direct Plant Cost** |  | **3,004** |
| 1 | Delivered Main Equipment (Includes Auxiliary Equipment) | 100% | 2,027 |
| 2 | Purchased-Equipment Installation | 20% | 405 |
| 3 | Instrumentation And Controls (Installed) | 18% | 365 |
| 4 | Piping (Installed) | 2% | 41 |
| 5 | Electrical (Installed) | 1% | 20 |
| 6 | Buildings (Including Services) | 2% | 45 |
| 7 | Service Facilities (Installed) | 5% | 101 |
| **A2** | **Total Indirect Plant Cost** |  | **1,054** |
| 8 | Engineering And Supervision | 10% | 203 |
| 9 | Construction Expenses | 25% | 507 |
| 10 | Legal Expenses | 2% | 41 |
| 11 | Contractor’s Fee | 10% | 203 |
| 12 | Contingency | 5% | 101 |
| **B** | **Working Capital** |  | **101** |
| 13 | Safety and Hazard Analysis | 5% | 101 |
|  | **Total Capital Investment** | **A** + **B** | **4,159** |

**OpEx: Capacity for 350 PVC Plant using Captive Ethylene**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Capacity for 350 KTPA PVC Plant using Captive Ethylene** | | | | **INR Crore** |
| **Manufacturing Cost** | **Annual Qty** | **Unit Rate** |  | **1125.34** |
| Raw materials | **Tonne** | **INR / Tonne** |  | 769.64 |
| Ethylene | 161200 | 38499 |  | 620.61 |
| Chlorine | 206500 | 5900 |  | 121.84 |
| Oxygen | 49000 | 5550 |  | 27.20 |
| EDC | 0 | 0 |  | 0 |
| Catalyst & Chemicals |  |  |  | 102.50 |
| Labor |  |  |  | 26.91 |
| Salaries & Wages (calculated) |  |  | - | 26.91 |
| Variable Overheads |  |  |  | 157.20 |
| Packaging Cost (calculated) |  |  |  | 39.20 |
| Utilities (calculated) |  |  |  | 118.00 |
| Fixed Overheads |  |  |  | 69.09 |
| Maintenance and Repairs (1.5% of Fixed-Capital Investment) (Capex) |  |  | 1.5% | 62.39 |
| Plant Overhead and Administrative Costs |  |  | 7.5% | 6.70 |
| Selling Overheads |  |  |  | 77.79 |
| Distribution and Selling Costs (2.5% of sales value) |  |  | 2.5% | 65.41 |
| Research and development costs |  |  | 1.5% | 12.38 |
| **Total Operating Cost** |  |  |  | **1203.13** |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 350 KTPA PVC Plant using Captive Ethylene** | | | | | | |
| **Year of Operation** | | **1** | **2** | **3** | **4** |  |
| **Operating Period** | | **2023** | **2024** | **2025** | **2026** | **Total** |
| **Expenditure phasing / Capacity Utilization** | | **5%** | **25%** | **35%** | **35%** |  |
| **All Figures are in INR Crore** | | | | | | |
| 1 | **Capex (In INR Crore)** | **208** | **1040** | **1456** | **1456** | **4,159.45** |
|  | **Total Investment (In INR Crore)** | **208** | **1040** | **1456** | **1456** | **-4,159** |
| **2** | **Operating Revenue** |  |  |  |  |  |
|  | PVC |  |  |  |  | 1.000 |
| **3** | **Operating Cost** |  |  |  |  |  |
|  | Raw Material |  |  |  |  | 64.5% |
|  | Catchem |  |  |  |  | 8.6% |
|  | Labor |  |  |  |  | 2.2% |
|  | Variable Overheads |  |  |  |  | 12.8% |
|  | Fixed Overheads |  |  |  |  | 5.6% |
|  | Selling Overheads |  |  |  |  | 6.3% |
|  | **Total Operating Cost** |  |  |  |  |  |
| **4** | **Gross Margin (EBITDA/PBITDA)** |  |  |  |  |  |
|  | Margin % |  |  |  |  |  |
|  | Per MT Margin |  |  |  |  |  |
|  | **Net Cash Flow** | **-208** | **-1040** | **-1456** | **-1456** |  |
|  | Cost of Capital (10%) |  |  |  |  | 1 |
|  | Discounted Cash Flow |  |  |  |  |  |
|  | Undiscounted Cash Flow |  |  |  |  |  |
|  | Cumulative Cash Flow |  |  |  |  |  |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 350 KTPA PVC Plant using Captive Ethylene** | | | | | | |
| **Year of Operation** | | **5** | **6** | **7** | **8** | **9** |
| **Capacity Utilization** | | 70.00% | 90.00% | 100.00% | 100.00% | 100.00% |
| **Operating Period** | | **2027** | **2028** | **2029** | **2030** | **2031** |
| **All Figures are in INR Crore** | | | | | | |
| 1 | **Capex** |  |  |  |  |  |
|  | **Total Investment (In INR Crore)** | | | | | |
| **2** | **Operating Revenue** | **1831.36** | **2490.09** | **2925.97** | **3094.33** | **3272.38** |
|  | PVC | 1831.36 | 2490.09 | 2925.97 | 3094.33 | 3272.38 |
| **3** | **Operating Cost** |  |  |  |  |  |
|  | Raw Material | 538.75 | 734.05 | 865.44 | 917.68 | 970.58 |
|  | Catchem | 71.75 | 97.90 | 115.45 | 122.37 | 129.67 |
|  | Labor | 26.91 | 28.12 | 29.39 | 30.71 | 32.09 |
|  | Variable Overheads | 157.20 | 164.27 | 171.67 | 179.39 | 187.46 |
|  | Fixed Overheads | 69.09 | 72.20 | 75.45 | 78.84 | 82.39 |
|  | Selling Overheads | 77.79 | 81.29 | 84.95 | 88.77 | 92.77 |
|  | **Total Operating Cost** | **941.49** | **1177.83** | **1342.34** | **1417.77** | **1494.96** |
| **4** | **Gross Margin (EBITDA/PBITDA)** | **889.88** | **1312.26** | **1583.63** | **1676.56** | **1777.42** |
|  | Margin % | 48.59% | 52.70% | 54.12% | 54.18% | 54.32% |
|  | Per MT Margin | 36,321 | 41,659 | 45,247 | 47,902 | 50,783 |
|  | **Net Cash Flow** | **-3269.57** | **1312.26** | **1583.63** | **1676.56** | **1777.42** |
|  | Cost of Capital (10%) | 0.91 | 0.83 | 0.75 | 0.68 | 0.62 |
|  | Discounted Cash Flow | -2972.34 | 1084.51 | 1189.80 | 1145.12 | 1103.64 |
|  | Undiscounted Cash Flow | -3269.57 | 1312.26 | 1583.63 | 1676.56 | 1777.42 |
|  | Cumulative Cash Flow | -3269.57 | -1957.31 | -373.68 | 1302.88 | 3080.30 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 350 KTPA PVC Plant using Captive Ethylene** | | | | | | | |
| **Year of Operation** | | **10** | **11** | **12** | **13** | **14** | **15** |
| **Capacity Utilization** | | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
| **Operating Period** | | **2032** | **2033** | **2034** | **2035** | **2036** | **2037** |
| **All Figures are in INR Crore** | | | | | | | |
| 1 | **Capex** |  |  |  |  |  |  |
|  | **Total Investment (In INR Cr** | | | | | | |
| **2** | **Operating Revenue** | **3460.67** | **3659.80** | **3870.38** | **4093.09** | **4328.60** | **4577.67** |
|  | PVC | 3460.67 | 3659.80 | 3870.38 | 4093.09 | 4328.60 | 4577.67 |
| **3** | **Operating Cost** |  |  |  |  |  |  |
|  | Raw Material | 1027.85 | 1088.17 | 1152.49 | 1222.42 | 1290.71 | 1363.90 |
|  | Catchem | 137.32 | 145.42 | 154.00 | 163.09 | 172.71 | 182.90 |
|  | Labor | 33.53 | 35.04 | 36.62 | 38.27 | 39.99 | 41.79 |
|  | Variable Overheads | 195.90 | 204.72 | 213.93 | 223.55 | 233.61 | 244.13 |
|  | Fixed Overheads | 86.10 | 89.97 | 94.02 | 98.25 | 102.67 | 107.29 |
|  | Selling Overheads | 96.94 | 101.30 | 105.86 | 110.63 | 115.60 | 120.81 |
|  | **Total Operating Cost** | **1577.64** | **1664.63** | **1756.93** | **1856.21** | **1955.31** | **2060.82** |
| **4** | **Gross Margin (EBITDA/PBITDA)** | **1883.03** | **1995.17** | **2113.46** | **2236.88** | **2373.29** | **2516.85** |
|  | Margin % | 54.41% | 54.52% | 54.61% | 54.65% | 54.83% | 54.98% |
|  | Per MT Margin | 53,801 | 57,005 | 60,385 | 63,911 | 67,808 | 71,910 |
|  | **Net Cash Flow** | **1883.03** | **1995.17** | **2113.46** | **2236.88** | **2373.29** | **2516.85** |
|  | Cost of Capital (10%) | 0.56 | 0.51 | 0.47 | 0.42 | 0.39 | 0.35 |
|  | Discounted Cash Flow | 1062.92 | 1023.84 | 985.94 | 948.65 | 915.01 | 882.14 |
|  | Undiscounted Cash Flow | 1883.03 | 1995.17 | 2113.46 | 2236.88 | 2373.29 | 2516.85 |
|  | Cumulative Cash Flow | 4963.33 | 6958.50 | 9071.96 | 11308.83 | 13682.13 | 16198.98 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 350 KTPA PVC Plant using Captive Ethylene** | | | | | | | | | |
| **Year of Operation** | | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** |
| **Capacity Utilization** | | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
| **Operating Period** | | **2038** | **2039** | **2040** | **2041** | **2042** | **2043** | **2044** | **2045** |
| **All Figures are in INR Crore** | | | | | | | | | |
| 1 | **Capex** |  |  |  |  |  |  |  |  |
|  | **Total Investment (In INR Crore)** | | | | | | | | |
| **2** | **Operating Revenue** | **4841.07** | **5119.62** | **5414.21** | **5725.74** | **6055.20** | **6403.62** | **6772.08** | **7161.74** |
|  | PVC | 4841.07 | 5119.62 | 5414.21 | 5725.74 | 6055.20 | 6403.62 | 6772.08 | 7161.74 |
| **3** | **Operating Cost** |  |  |  |  |  |  |  |  |
|  | Raw Material | 1441.67 | 1522.36 | 1607.25 | 1696.71 | 1793.45 | 1896.27 | 2006.38 | 2120.77 |
|  | Catchem | 193.70 | 205.12 | 217.23 | 230.04 | 243.62 | 257.99 | 273.21 | 289.33 |
|  | Labor | 43.67 | 45.64 | 47.69 | 49.84 | 52.08 | 54.42 | 56.87 | 59.43 |
|  | Variable Overheads | 255.11 | 266.59 | 278.59 | 291.13 | 304.23 | 317.92 | 332.22 | 347.17 |
|  | Fixed Overheads | 112.12 | 117.17 | 122.44 | 127.95 | 133.71 | 139.72 | 146.01 | 152.58 |
|  | Selling Overheads | 126.24 | 131.92 | 137.86 | 144.06 | 150.55 | 157.32 | 164.40 | 171.80 |
|  | **Total Operating Cost** | **2172.51** | **2288.80** | **2411.06** | **2539.73** | **2677.63** | **2823.65** | **2979.09** | **3141.09** |
| **4** | **Gross Margin (EBITDA/PBITDA)** | **2668.56** | **2830.82** | **3003.15** | **3186.01** | **3377.57** | **3579.97** | **3792.98** | **4020.65** |
|  | Margin % | 55.12% | 55.29% | 55.47% | 55.64% | 55.78% | 55.91% | 56.01% | 56.14% |
|  | Per MT Margin | 76,245 | 80,881 | 85,804 | 91,029 | 96,502 | 1,02,285 | 1,08,371 | 1,14,876 |
|  | **Net Cash Flow** | **2668.56** | **2830.82** | **3003.15** | **3186.01** | **3377.57** | **3579.97** | **3792.98** | **4020.65** |
|  | Cost of Capital (10%) | 0.32 | 0.29 | 0.26 | 0.24 | 0.22 | 0.20 | 0.18 | 0.16 |
|  | Discounted Cash Flow | 850.29 | 819.99 | 790.82 | 762.71 | 735.06 | 708.28 | 682.20 | 657.41 |
|  | Undiscounted Cash Flow | 2668.56 | 2830.82 | 3003.15 | 3186.01 | 3377.57 | 3579.97 | 3792.98 | 4020.65 |
|  | Cumulative Cash Flow | 18867.53 | 21698.35 | 24701.50 | 27887.51 | 31265.09 | 34845.05 | 38638.04 | 42658.69 |

|  |  |
| --- | --- |
| [**NPV**](mailto:NPV@12%25) | **13375.98** |
| **IRR** | **20.03%** |
| **Payback Period After Project Completion (Simple)** | **3.22** |
| **Payback Period After Project Completion (Discounted)** | **3.33** |

**Option 2: Capacity for 500 KTPA PVC Plant (350 KTPA from captive ethylene & 150 KTPA EDC / VCM Outsourced)**

**Capex:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Capacity for 500 KTPA PVC Plant (350 KTPA from captive Ethylene and 150 KTPA EDC / VCM Outsourced)** | | | |
|  |  |  | **INR Crore** |
| **A** | **Total Fixed-Capital Investment** | **A1** + **A2** | **4,442.50** |
| **A1** | **Total Direct Plant Cost** |  | **3,288.60** |
| 1 | Delivered Main Equipment (Includes Auxiliary Equipment) (Considered EDC / VCM Import Facility) | 100% | 2,219 |
| 2 | Purchased-Equipment Installation | 20% | 444 |
| 3 | Instrumentation and Controls (Installed) | 18% | 399 |
| 4 | Piping (Installed) | 2% | 44 |
| 5 | Electrical (Installed) | 1% | 22 |
| 6 | Buildings (Including Services) | 2% | 49 |
| 7 | Service Facilities (Installed) | 5% | 111 |
| **A2** | **Total Indirect Plant Cost** |  | **1,154** |
| 8 | Engineering and Supervision | 10% | 222 |
| 9 | Construction Expenses | 25% | 555 |
| 10 | Legal Expenses | 2% | 44 |
| 11 | Contractor’s Fee | 10% | 222 |
| 12 | Contingency | 5% | 111 |
| **B** | **Working Capital** |  | **111** |
| 13 | Safety and Hazard Analysis | 5% | 111 |
| 14 | Open Jetty Facility for Ethylene, EDC and VCM Import |  | 1,500 |
|  | **Total Capital Investment** | **A** + **B** | **6,053** |

**Opex:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Capacity for 500 KTPA PVC Plant (350 KTPA from captive Ethylene and 150 KTPA EDC / VCM Outsourced)** | | | | **INR Crore** |
| **Manufacturing Cost** | **Annual Qty** | **Unit Rate** |  | **1764.19** |
| Raw materials | **Tonne** | **INR / Tonne** | **Basis** | 1437.05 |
| Ethylene | 161200 | 38499 |  | 620.61 |
| Chlorine | 206500 | 5900 |  | 121.84 |
| EDC | 200000 | 27800 |  | 556.00 |
| Oxygen | 49000 | 5550 |  | 27.20 |
| Catalyst & Chemicals |  |  |  | 111.41 |
| Labor |  |  |  | 30.68 |
| Salaries & Wages (Calculated) |  |  | - | 30.68 |
| Variable Overheads |  |  |  | 196.55 |
| Packaging Cost (Calculated) |  |  |  | 51.55 |
| Utilities (Calculated) |  |  |  | 145.00 |
| Fixed Overheads |  |  |  | 99.91 |
| Maintenance and Repairs (1.5% of Fixed-Capital Investment) (Capex) |  |  | 1.5% | 90.80 |
| Plant Overhead and Administrative Costs |  |  | 7.5% | 9.11 |
| Selling Overheads |  |  |  | 119.90 |
| Distribution and Selling Costs (2.5% of Selling Cost) |  |  | 2.5% | 93.44 |
| Research and Development Costs |  |  | 1.5% | 26.46 |
| **Total Production Cost** | | |  | **1884.09** |

**Cashflow:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 500 KTPA PVC Plant (350 KTPA from captive Ethylene and**  **150 KTPA EDC / VCM Outsourced)** | | | | | | |
| **Year of Operation** | | **1** | **2** | **3** | **4** |  |
|  | **Operating Period** | **2023** | **2024** | **2025** | **2026** | **Total** |
| **Capacity Utilization** | **5%** | **25%** | **35%** | **35%** |  |
| **All Figures are in INR Crore** | | | | | | |
| 1 | **Capex (In INR Crore)** | **303** | **1513** | **2119** | **2119** | **6,053.45** |
|  | **Total Investment (In INR Crore)** | **303** | **1513** | **2119** | **2119** | **-6,053** |
| **2** | **Operating Revenue** |  |  |  |  |  |
|  | PVC |  |  |  |  | 1.000 |
| **3** | **Operating Cost** |  |  |  |  |  |
|  | Raw Material |  |  |  |  | 72.4% |
|  | Catalyst and Chemicals |  |  |  |  | 5.6% |
|  | Labor |  |  |  |  | 1.5% |
|  | Variable Overheads |  |  |  |  | 9.7% |
|  | Fixed Overheads |  |  |  |  | 4.9% |
|  | Selling Overheads |  |  |  |  | 5.9% |
|  | **Total Operating Cost** |  |  |  |  |  |
| **4** | **Gross Margin (EBITDA/PBITDA)** |  |  |  |  |  |
|  | Margin % |  |  |  |  |  |
|  | Per MT Margin |  |  |  |  |  |
|  | **Net Cash Flow** | **-303** | **-1513** | **-2119** | **-2119** |  |
|  | Cost of Capital (10%) |  |  |  |  | 1 |
|  | Discounted Cash Flow |  |  |  |  |  |
|  | Undiscounted Cash Flow |  |  |  |  |  |
|  | Cumulative Cash Flow |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 500 KTPA PVC Plant (350 KTPA from captive Ethylene and 150 KTPA EDC / VCM Outsourced)** | | | | | | | | |
| **Year of Operation** | | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
| **Capacity Utilization** | | 70.00% | 90.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
|  | **Operating Period** | **2027** | **2028** | **2029** | **2030** | **2031** | **2032** | **2033** |
| **All Figures are in INR Crore** | | | | | | | | |
| 1 | **Capex (In INR Crore)** |  |  |  |  |  |  |  |
|  | **Total Investment** |  |  |  |  |  |  |  |
| **2** | **Operating Revenue** | **2616.23** | **3557.28** | **4179.96** | **4420.47** | **4674.83** | **4943.82** | **5228.28** |
|  | PVC | 2616.23 | 3557.28 | 4179.96 | 4420.47 | 4674.83 | 4943.82 | 5228.28 |
| **3** | **Operating Cost** |  |  |  |  |  |  |  |
|  | Raw Material | 1005.93 | 1368.57 | 1608.77 | 1702.52 | 1802.44 | 1910.67 | 2018.61 |
|  | Catalyst and Chemicals | 77.99 | 106.19 | 124.82 | 132.10 | 139.71 | 147.66 | 155.93 |
|  | Labor | 30.68 | 32.06 | 33.50 | 35.01 | 36.59 | 38.23 | 39.95 |
|  | Variable Overheads | 196.55 | 205.39 | 214.64 | 224.30 | 234.39 | 244.94 | 255.96 |
|  | Fixed Overheads | 99.91 | 104.41 | 109.11 | 114.02 | 119.15 | 124.51 | 130.11 |
|  | Selling Overheads | 119.90 | 125.30 | 130.93 | 136.83 | 142.98 | 149.42 | 156.14 |
|  | **Total Operating Cost** | **1530.96** | **1941.92** | **2221.78** | **2344.76** | **2475.25** | **2615.43** | **2756.71** |
| **4** | **Gross Margin (EBITDA/PBITDA)** | **1085.27** | **1615.36** | **1958.18** | **2075.71** | **2199.57** | **2328.39** | **2471.58** |
|  | Margin % | 41.48% | 45.41% | 46.85% | 46.96% | 47.05% | 47.10% | 47.27% |
|  | Per MT Margin | 31,008 | 35,897 | 39,164 | 41,514 | 43,991 | 46,568 | 49,432 |
|  | **Net Cash Flow** | **-4968.18** | **1615.36** | **1958.18** | **2075.71** | **2199.57** | **2328.39** | **2471.58** |
|  | Cost of Capital (10%) | 0.91 | 0.83 | 0.75 | 0.68 | 0.62 | 0.56 | 0.51 |
|  | Discounted Cash Flow | -4516.53 | 1335.01 | 1471.21 | 1417.74 | 1365.76 | 1314.32 | 1268.31 |
|  | Undiscounted Cash Flow | -4968.18 | 1615.36 | 1958.18 | 2075.71 | 2199.57 | 2328.39 | 2471.58 |
|  | Cumulative Cash Flow | -4968.18 | -3352.82 | -1394.64 | 681.07 | 2880.64 | 5209.03 | 7680.61 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 500 KTPA PVC Plant (350 KTPA from captive Ethylene and 150 KTPA EDC / VCM Outsourced)** | | | | | | | | |
| **Year of Operation** | | **12** | **13** | **14** | **15** | **16** | **17** | **18** |
| **Capacity Utilization** | | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
|  | **Operating Period** | **2034** | **2035** | **2036** | **2037** | **2038** | **2039** | **2040** |
| **All Figures are in INR Crore** | | | | | | | | |
| 1 | **Capex (In INR Crore)** |  |  |  |  |  |  |  |
|  | **Total Investment** | | | | | | | |
| **2** | **Operating Revenue** | **5529.12** | **5847.26** | **6183.72** | **6539.53** | **6915.81** | **7313.75** | **7734.58** |
|  | PVC | 5529.12 | 5847.26 | 6183.72 | 6539.53 | 6915.81 | 7313.75 | 7734.58 |
| **3** | **Operating Cost** |  |  |  |  |  |  |  |
|  | Raw Material | 2133.71 | 2255.37 | 2383.73 | 2523.88 | 2673.58 | 2833.29 | 3002.83 |
|  | Catalyst and Chemicals | 164.65 | 173.87 | 183.60 | 193.88 | 204.73 | 216.19 | 228.29 |
|  | Labor | 41.75 | 43.63 | 45.59 | 47.65 | 49.79 | 52.03 | 54.37 |
|  | Variable Overheads | 267.48 | 279.51 | 292.09 | 305.24 | 318.97 | 333.33 | 348.33 |
|  | Fixed Overheads | 135.97 | 142.09 | 148.48 | 155.16 | 162.14 | 169.44 | 177.07 |
|  | Selling Overheads | 163.17 | 170.51 | 178.18 | 186.20 | 194.58 | 203.34 | 212.49 |
|  | **Total Operating Cost** | **2906.73** | **3064.98** | **3231.68** | **3412.00** | **3603.80** | **3807.61** | **4023.37** |
| **4** | **Gross Margin (EBITDA/PBITDA)** | **2622.39** | **2782.29** | **2952.04** | **3127.53** | **3312.01** | **3506.14** | **3711.21** |
|  | Margin % | 47.43% | 47.58% | 47.74% | 47.82% | 47.89% | 47.94% | 47.98% |
|  | Per MT Margin | 52,448 | 55,646 | 59,041 | 62,551 | 66,240 | 70,123 | 74,224 |
|  | **Net Cash Flow** | **2622.39** | **2782.29** | **2952.04** | **3127.53** | **3312.01** | **3506.14** | **3711.21** |
|  | Cost of Capital (10%) | 0.47 | 0.42 | 0.39 | 0.35 | 0.32 | 0.29 | 0.26 |
|  | Discounted Cash Flow | 1223.37 | 1179.96 | 1138.14 | 1096.18 | 1055.31 | 1015.60 | 977.28 |
|  | Undiscounted Cash Flow | 2622.39 | 2782.29 | 2952.04 | 3127.53 | 3312.01 | 3506.14 | 3711.21 |
|  | Cumulative Cash Flow | 10303.00 | 13085.29 | 16037.33 | 19164.86 | 22476.87 | 25983.01 | 29694.22 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 500 KTPA PVC Plant (350 KTPA from captive Ethylene and 150 KTPA EDC / VCM Outsourced)** | | | | |  |  |
| **Year of Operation** | | **19** | **20** | **21** | **22** | **23** |
| **Expenditure phasing / Capacity Utilization** | | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
|  | **Operating Period** | **2041** | **2042** | **2043** | **2044** | **2045** |
| **All Figures are in INR Crore** | | | | |  |  |
| 1 | **Capex (In INR Crore)** |  |  |  |  |  |
|  | **Total Investment (In INR Crore)** | | | |  |  |
| **2** | **Operating Revenue** | **8179.63** | **8650.28** | **9148.02** | **9674.40** | **10231.06** |
|  | PVC | 8179.63 | 8650.28 | 9148.02 | 9674.40 | 10231.06 |
| **3** | **Operating Cost** |  |  |  |  |  |
|  | Raw Material | 3174.05 | 3354.69 | 3545.97 | 3750.74 | 3970.87 |
|  | Catalyst and Chemicals | 241.07 | 254.56 | 268.81 | 283.86 | 299.74 |
|  | Labor | 56.82 | 59.37 | 62.05 | 64.84 | 67.76 |
|  | Variable Overheads | 364.00 | 380.38 | 397.50 | 415.38 | 434.08 |
|  | Fixed Overheads | 185.03 | 193.36 | 202.06 | 211.15 | 220.66 |
|  | Selling Overheads | 222.05 | 232.04 | 242.48 | 253.39 | 264.80 |
|  | **Total Operating Cost** | **4243.01** | **4474.40** | **4718.86** | **4979.37** | **5257.90** |
| **4** | **Gross Margin (EBITDA/PBITDA)** | **3936.62** | **4175.88** | **4429.16** | **4695.03** | **4973.17** |
|  | Margin % | 48.13% | 48.27% | 48.42% | 48.53% | 48.61% |
|  | **Per MT Margin** | 78,732 | 83,518 | 88,583 | 93,901 | 99,463 |
|  | **Net Cash Flow** | **3936.62** | **4175.88** | **4429.16** | **4695.03** | **4973.17** |
|  | Cost of Capital (10%) | 0.24 | 0.22 | 0.20 | 0.18 | 0.16 |
|  | Discounted Cash Flow | 942.39 | 908.79 | 876.29 | 844.44 | 813.15 |
|  | Undiscounted Cash Flow | 3936.62 | 4175.88 | 4429.16 | 4695.03 | 4973.17 |
|  | Cumulative Cash Flow | 33630.84 | 37806.72 | 42235.88 | 46930.91 | 51904.08 |

|  |  |
| --- | --- |
| [**NPV**](mailto:NPV@12%25) | **15726.72** |
| **IRR** | **17.43%** |
| **Payback Period After Project Completion (Simple)** | **3.67** |
| **Payback Period After Project Completion (Discounted)** | **3.98** |

**Option 3: Capacity for 500 KTPA EDC / VCM to PVC Plant (EDC/VCM Outsourced)**

**Capex:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Capacity for 500 KTPA PVC Resin (EDC / VCM to PVC Plant (EDC/VCM Outsourced)** | | | | |
|  |  |  | **INR Crore** |
| **A** | **Total Fixed-Capital Investment** | **A1** + **A2** | **2,415.00** |
| **A1** | **Total Direct Plant Cost** |  | **1,852.50** |
| 1 | Delivered Main Equipment (Includes Auxiliary Equipment) (Considered EDC / VCM Import Facility) | 100% | 1,250 |
| 2 | Purchased-Equipment Installation | 20% | 250 |
| 3 | Instrumentation and Controls (Installed) | 18% | 225 |
| 4 | Piping (Installed) | 2% | 25 |
| 5 | Electrical (Installed) | 1% | 13 |
| 6 | Buildings (Including Services) | 2% | 28 |
| 7 | Service Facilities (Installed) | 5% | 63 |
| **A2** | **Total Indirect Plant Cost** |  | **563** |
| 8 | Engineering and Supervision | 10% | 125 |
| 9 | Construction Expenses | 18% | 225 |
| 10 | Legal Expenses | 2% | 25 |
| 11 | Contractor’s Fee | 10% | 125 |
| 12 | Contingency | 5% | 63 |
| **B** | **Working Capital** |  | **63** |
| 13 | Safety and Hazard Analysis | 5% | 63 |
| 14 | Open Jetty Facility for EDC and VCM Import |  | 1,950 |
|  | **Total Capital Investment** | **A** + **B** | **4,427.50** |

**Opex:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Capacity for 500 KTPA PVC Resin (EDC / VCM to PVC Plant (EDC / VCM Outsourced)** | | | | **INR Crore** |
| **Manufacturing Cost** | **Annual Qty** | **Unit Rate** |  | **2770.26** |
| Raw materials | **Tonne** | **INR / Tonne** | **Basis** | 2528.83 |
| EDC | 0 | 0 |  | 0.00 |
| VCM | 500500 | 48300 |  | 2417.42 |
| Catalyst & Chemicals |  |  |  | 111.41 |
| Labor |  |  |  | 24.50 |
| Salaries & Wages (Calculated) |  |  | - | 24.50 |
| Variable Overheads |  |  |  | 143.70 |
| Packaging Cost (Calculated) |  |  |  | 48.30 |
| Utilities (Calculated) |  |  |  | 95.40 |
| Fixed Overheads |  |  |  | 73.23 |
| Maintenance and Repairs (1.5% of Fixed-Capital Investment) (Capex) |  |  | 1.5% | 66.41 |
| Plant Overhead and Administrative Costs (7.5% of 52+ 58) |  |  | 7.5% | 6.82 |
| Selling Overheads |  |  |  | 106.96 |
| Distribution and Selling Costs (2.5% of Selling Cost) |  |  | 2.5% | 65.41 |
| Research and Development Costs |  |  | 1.5% | 41.55 |
| **Total Production Cost** |  |  |  | **2877.22** |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 500 KTPA PVC Resin (EDC / VCM to PVC Plant (EDC / VCM Outsourced)** | | | | | | |
| **Year of Operation** | | **1** | **2** | **3** | **4** |  |
|  | **Operating Period** | **2023** | **2024** | **2025** | **2026** | **Total** |
| **Operating Capacity** | **5%** | **25%** | **35%** | **35%** |  |
| **All Figures are in INR Crore** | | | | | | |
| 1 | **Capex (In INR Crore)** | **221** | **1107** | **1550** | **1550** | **4,427.50** |
|  | **Total Investment (In INR Crore)** | **221** | **1107** | **1550** | **1550** | **-4,428** |
| **2** | **Operating Revenue** |  |  |  |  |  |
|  | PVC |  |  |  |  | 1.000 |
| **3** | **Operating Cost** |  |  |  |  |  |
|  | Raw Material, Catalyst & Chemicals |  |  |  |  | 88.2% |
|  | Labor |  |  |  |  | 0.8% |
|  | Variable Overheads |  |  |  |  | 4.9% |
|  | Fixed Overheads |  |  |  |  | 2.5% |
|  | Selling Overheads |  |  |  |  | 3.6% |
|  | **Total Operating Cost** |  |  |  |  |  |
| **4** | **Gross Margin (EBITDA/PBITDA)** |  |  |  |  |  |
|  | Margin % |  |  |  |  |  |
|  | Per MT Margin |  |  |  |  |  |
|  | **Net Cash Flow** | **-221** | **-1107** | **-1550** | **-1550** |  |
|  | Cost of Capital (10%) |  |  |  |  | 1 |
|  | Discounted Cash Flow |  |  |  |  |  |
|  | Undiscounted Cash Flow |  |  |  |  |  |
|  | Cumulative Cash Flow |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 500 KTPA PVC Resin (EDC / VCM to PVC Plant (EDC / VCM Outsourced)** | | | | | | | | |
| **Year of Operation** | | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
| **Capacity Utilization** | | 70.00% | 90.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
|  | **Operating Period** | **2027** | **2028** | **2029** | **2030** | **2031** | **2032** | **2033** |
| **All Figures are in INR Crore** | | | | | | | | |
| 1 | **Capex (In INR Crore)** |  |  |  |  |  |  |  |
|  | **Total Investment (In INR Crore)** | | | | | | | |
| **2** | **Operating Revenue** | **2616.23** | **3557.28** | **4179.96** | **4420.47** | **4674.83** | **4943.82** | **5228.28** |
|  | PVC | 2616.23 | 3557.28 | 4179.96 | 4420.47 | 4674.83 | 4943.82 | 5228.28 |
| **3** | **Operating Cost** |  |  |  |  |  |  |  |
|  | Raw Material, Catalyst & Chemicals | 1770.18 | 2408.33 | 2831.57 | 2996.27 | 3170.56 | 3354.98 | 3550.13 |
|  | Labor | 24.50 | 25.60 | 26.75 | 27.96 | 29.22 | 30.53 | 31.91 |
|  | Variable Overheads | 143.70 | 150.17 | 156.92 | 163.99 | 171.36 | 179.08 | 187.13 |
|  | Fixed Overheads | 73.23 | 76.53 | 79.97 | 83.57 | 87.33 | 91.26 | 95.37 |
|  | Selling Overheads | 106.96 | 111.77 | 116.80 | 122.06 | 127.55 | 133.29 | 139.29 |
|  | **Total Operating Cost** | **2118.57** | **2772.40** | **3212.02** | **3393.84** | **3586.02** | **3789.14** | **4003.82** |
| **4** | **Gross Margin (EBITDA/PBITDA)** | **497.66** | **784.88** | **967.94** | **1026.63** | **1088.81** | **1154.68** | **1224.46** |
|  | Margin % | 19.02% | 22.06% | 23.16% | 23.22% | 23.29% | 23.36% | 23.42% |
|  | Per MT Margin | 14,219 | 17,442 | 19,359 | 20,533 | 21,776 | 23,094 | 24,489 |
|  | **Net Cash Flow** | **-3929.86** | **784.88** | **967.94** | **1026.63** | **1088.81** | **1154.68** | **1224.46** |
|  | Cost of Capital (10%) | 0.91 | 0.83 | 0.75 | 0.68 | 0.62 | 0.56 | 0.51 |
|  | Discounted Cash Flow | -3572.60 | 648.66 | 727.23 | 701.20 | 676.06 | 651.79 | 628.34 |
|  | Undiscounted Cash Flow | -3929.86 | 784.88 | 967.94 | 1026.63 | 1088.81 | 1154.68 | 1224.46 |
|  | Cumulative Cash Flow | -3929.86 | -3145.92 | -2177.98 | -1151.35 | -62.54 | 1092.14 | 2316.60 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 500 KTPA PVC Resin (EDC / VCM to PVC Plant (EDC / VCM Outsourced)** | | | | | | | | | | |
| **Year of Operation** | | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| **Capacity Utilization** | | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
|  | **Operating Period** | **2034** | **2035** | **2036** | **2037** | **2038** | **2039** | **2040** | **2041** | **2042** |
| **All Figures are in INR Crore** | | | | | | | | | | |
| 1 | **Capex (In INR Crore)** |  |  |  |  |  |  |  |  |  |
|  | **Total Investment (In INR Crore)** | | | | | | | | | |
| **2** | **Operating Revenue** | **5529.12** | **5847.26** | **6183.72** | **6539.53** | **6915.81** | **7313.75** | **7734.58** | **8179.63** | **8650.28** |
|  | PVC | 5529.12 | 5847.26 | 6183.72 | 6539.53 | 6915.81 | 7313.75 | 7734.58 | 8179.63 | 8650.28 |
| **3** | **Operating Cost** |  |  |  |  |  |  |  |  |  |
|  | Raw Material, Catalyst & Chemicals | 3756.63 | 3975.14 | 4206.36 | 4451.03 | 4709.94 | 4983.90 | 5273.80 | 5580.56 | 5905.16 |
|  | Labor | 33.34 | 34.84 | 36.41 | 38.05 | 39.76 | 41.55 | 43.42 | 45.37 | 47.41 |
|  | Variable Overheads | 195.56 | 204.36 | 213.55 | 223.16 | 233.20 | 243.70 | 254.66 | 266.12 | 278.10 |
|  | Fixed Overheads | 99.66 | 104.14 | 108.83 | 113.73 | 118.84 | 124.19 | 129.78 | 135.62 | 141.72 |
|  | Selling Overheads | 145.56 | 152.11 | 158.95 | 166.11 | 173.58 | 181.39 | 189.55 | 198.08 | 207.00 |
|  | **Total Operating Cost** | **4230.74** | **4470.59** | **4724.10** | **4992.07** | **5275.32** | **5574.73** | **5891.22** | **6225.76** | **6579.40** |
| **4** | **Gross Margin (EBITDA/PBITDA)** | **1298.38** | **1376.68** | **1459.61** | **1547.45** | **1640.49** | **1739.02** | **1843.37** | **1953.87** | **2070.89** |
|  | Margin % | 23.48% | 23.54% | 23.60% | 23.66% | 23.72% | 23.78% | 23.83% | 23.89% | 23.94% |
|  | Per MT Margin | 25,968 | 27,534 | 29,192 | 30,949 | 32,810 | 34,780 | 36,867 | 39,077 | 41,418 |
|  | **Net Cash Flow** | **1298.38** | **1376.68** | **1459.61** | **1547.45** | **1640.49** | **1739.02** | **1843.37** | **1953.87** | **2070.89** |
|  | Cost of Capital (10%) | 0.47 | 0.42 | 0.39 | 0.35 | 0.32 | 0.29 | 0.26 | 0.24 | 0.22 |
|  | Discounted Cash Flow | 605.70 | 583.85 | 562.74 | 542.37 | 522.71 | 503.73 | 485.42 | 467.74 | 450.69 |
|  | Undiscounted Cash Flow | 1298.38 | 1376.68 | 1459.61 | 1547.45 | 1640.49 | 1739.02 | 1843.37 | 1953.87 | 2070.89 |
|  | Cumulative Cash Flow | 3614.98 | 4991.66 | 6451.27 | 7998.72 | 9639.21 | 11378.23 | 13221.59 | 15175.46 | 17246.35 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Capacity for 500 KTPA PVC Resin (EDC / VCM to PVC Plant (EDC / VCM Outsourced)** | | | | |
| **Year of Operation** | | **21** | **22** | **23** |
| **Capacity Utilization** | | 100.00% | 100.00% | 100.00% |
|  | **Operating Period** | **2043** | **2044** | **2045** |
| **All Figures are in INR Crore** | | | | |
| 1 | **Capex (In INR Crore)** |  |  |  |
|  | **Total Investment (In INR Crore)** | | | |
| **2** | **Operating Revenue** | **9148.02** | **9674.40** | **10231.06** |
|  | PVC | 9148.02 | 9674.40 | 10231.06 |
| **3** | **Operating Cost** |  |  |  |
|  | Raw Material, Catalyst & Chemicals | 6248.65 | 6612.12 | 6996.72 |
|  | Labor | 49.55 | 51.78 | 54.11 |
|  | Variable Overheads | 290.61 | 303.69 | 317.36 |
|  | Fixed Overheads | 148.10 | 154.76 | 161.73 |
|  | Selling Overheads | 216.31 | 226.05 | 236.22 |
|  | **Total Operating Cost** | **6953.22** | **7348.40** | **7766.14** |
| **4** | **Gross Margin (EBITDA/PBITDA)** | **2194.80** | **2326.00** | **2464.93** |
|  | Margin % | 23.99% | 24.04% | 24.09% |
|  | Per MT Margin | 43,896 | 46,520 | 49,299 |
|  | **Net Cash Flow** | **2194.80** | **2326.00** | **2464.93** |
|  | Cost of Capital (10%) | 0.20 | 0.18 | 0.16 |
|  | Discounted Cash Flow | 434.23 | 418.35 | 403.04 |
|  | Undiscounted Cash Flow | 2194.80 | 2326.00 | 2464.93 |
|  | Cumulative Cash Flow | 19441.15 | 21767.15 | 24232.08 |

|  |  |
| --- | --- |
| [**NPV**](mailto:NPV@12%25) | **6440.47** |
| **IRR** | **11.95%** |
| **Payback Period After Project Completion (Simple)** | **5.05** |
| **Payback Period After Project Completion (Discounted)** | **5.10** |

**  
Option 4: Combined Capacity for 350 KTPA PVC Resin and 200 KTPA Phenol + 120 KTPA Acetone**

**Cashflow:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 350 KTPA PVC Resin and 200 KTPA Phenol + 120 KTPA Acetone** | | | | | | | |
| **Year of Operation** | | **1** | **2** | **3** | **4** |  | **5** |
| **Capacity Utilization** | | **5%** | **25%** | **35%** | **35%** |  | 70.00% |
|  | **Operating Period** | **2023** | **2024** | **2025** | **2026** | **Total** | **2027** |
| **All Figures are in INR Crore** | | | | | | | |
| 1 | **Capex (In INR Crore)** | **296** | **1482** | **2075** | **2075** | **5,929** |  |
|  | **Propane Furnace Addition** | **138** | **692** | **968** | **968** | **2,766** |  |
|  | **Propane Furnace Addition in DFCU** |  |  |  |  | **2,366** |  |
|  | **Propane Sourcing Infrastructure** |  |  |  |  | **400** |  |
|  | **Total Investment** | **435** | **2174** | **3043** | **3043** | **-8,694** |  |
| **2** | **Operating Revenue** |  |  |  |  |  | **4462.07** |
|  | PVC |  |  |  |  | 1.000 | 1831.36 |
|  | Phenol |  |  |  |  |  | 1386.69 |
|  | Acetone |  |  |  |  |  | 648.59 |
|  | Net Revenue Gain Over Base Case from Existing Products |  |  |  |  |  | 595.42 |
| **3** | **Operating Cost** |  |  |  |  |  |  |
|  | Raw Material |  |  |  |  | 72.8% | 1748.61 |
|  | Catchem |  |  |  |  | 4.6% | 92.91 |
|  | Labor |  |  |  |  | 1.8% | 53.82 |
|  | Variable Overheads |  |  |  |  | 12.0% | 336.37 |
|  | Fixed Overheads |  |  |  |  | 3.3% | 96.57 |
|  | Selling Overheads |  |  |  |  | 5.5% | 155.23 |
|  | **Total Operating Cost** |  |  |  |  |  | **2483.51** |
| **4** | **Gross Margin (EBITDA/PBITDA)** |  |  |  |  |  | **1978.56** |
|  | **Net Cash Flow** | **-415** | **-2075** | **-2905** | **-2905** |  | **-6715.56** |
|  | **Margin (%)** |  |  |  |  |  | 44.34% |
|  | Cost of Capital (10%) |  |  |  |  | 1 | 0.91 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 350 KTPA PVC Resin and 200 KTPA Phenol + 120 KTPA Acetone** | | | | | | | | | |
| **Year of Operation** | | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
| **Capacity Utilization** | | 90.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
|  | **Operating Period** | **2028** | **2029** | **2030** | **2031** | **2032** | **2033** | **2034** | **2035** |
| **All Figures are in INR Crore** | | | | | | | | | |
| 1 | **Capex (In INR Crore)** |  |  |  |  |  |  |  |  |
|  | **Propane Furnace Addition** | | | | | | | | |
|  | **Total Investment (In INR Crore)** | | | | | | | | |
| **2** | **Operating Revenue** | **5683.25** | **6387.42** | **6745.11** | **7122.96** | **7522.11** | **7943.78** | **8389.25** | **8859.84** |
|  | PVC | 2490.09 | 2925.97 | 3094.33 | 3272.38 | 3460.67 | 3659.80 | 3870.38 | 4093.09 |
|  | Phenol | 1631.03 | 1726.59 | 1827.74 | 1934.82 | 2048.17 | 2168.16 | 2295.18 | 2429.65 |
|  | Acetone | 762.12 | 805.98 | 852.35 | 901.40 | 953.26 | 1008.11 | 1066.12 | 1127.47 |
|  | Net Revenue Gain Over Base Case from Existing Products | 799.99 | 928.88 | 970.68 | 1014.36 | 1060.01 | 1107.71 | 1157.56 | 1209.65 |
| **3** | **Operating Cost** |  |  |  |  |  |  |  |  |
|  | Raw Material | 2155.69 | 2368.88 | 2507.63 | 2652.01 | 2806.03 | 2968.67 | 3141.20 | 3325.55 |
|  | Catchem | 126.77 | 149.50 | 158.46 | 167.91 | 177.82 | 188.31 | 199.42 | 211.19 |
|  | Labor | 56.24 | 58.77 | 61.42 | 64.18 | 67.07 | 70.09 | 73.24 | 76.54 |
|  | Variable Overheads | 372.31 | 389.06 | 406.57 | 424.86 | 443.98 | 463.96 | 484.84 | 506.66 |
|  | Fixed Overheads | 104.11 | 108.80 | 113.69 | 118.81 | 124.15 | 129.74 | 135.58 | 141.68 |
|  | Selling Overheads | 170.64 | 178.31 | 186.34 | 194.72 | 203.49 | 212.64 | 222.21 | 232.21 |
|  | **Total Operating Cost** | **2985.75** | **3253.33** | **3434.11** | **3622.50** | **3822.54** | **4033.42** | **4256.49** | **4493.83** |
| **4** | **Gross Margin (EBITDA/PBITDA)** | **2697.49** | **3134.09** | **3311.00** | **3500.45** | **3699.57** | **3910.37** | **4132.75** | **4366.01** |
|  | **Net Cash Flow** | **2697.49** | **3134.09** | **3311.00** | **3500.45** | **3699.57** | **3910.37** | **4132.75** | **4366.01** |
|  | Cost of Capital (10%) | 0.83 | 0.75 | 0.68 | 0.62 | 0.56 | 0.51 | 0.47 | 0.42 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 350 KTPA PVC Resin and 200 KTPA Phenol + 123 KTPA Acetone** | | | | | | |
| **Year of Operation** | | **14** | **15** | **16** | **17** | **18** |
| **Capacity Utilization** | | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
|  | **Operating Period** | **2036** | **2037** | **2038** | **2039** | **2040** |
| **All Figures are in INR Crore** | | | | | | |
| 1 | **Capex (In INR Crore)** |  |  |  |  |  |
|  | **Propane Furnace Addition** |  |  |  |  |  |
|  | **Total Investment (In INR Crore)** |  |  |  |  |  |
| **2** | **Operating Revenue** | **9357.01** | **9882.25** | **10437.15** | **11023.41** | **11642.80** |
|  | PVC | 4328.60 | 4577.67 | 4841.07 | 5119.62 | 5414.21 |
|  | Phenol | 2571.99 | 2722.67 | 2882.17 | 3051.03 | 3229.77 |
|  | Acetone | 1192.34 | 1260.95 | 1333.50 | 1410.23 | 1491.38 |
|  | Net Revenue Gain Over Base Case From Existing Products | 1264.08 | 1320.96 | 1380.41 | 1442.53 | 1507.44 |
| **3** | **Operating Cost** |  |  |  |  |  |
|  | Raw Material | 3514.86 | 3716.03 | 3929.13 | 4152.96 | 4389.21 |
|  | Catchem | 223.65 | 236.85 | 250.82 | 265.62 | 281.29 |
|  | Labor | 79.98 | 83.58 | 87.34 | 91.27 | 95.38 |
|  | Variable Overheads | 529.46 | 553.28 | 578.18 | 604.20 | 631.39 |
|  | Fixed Overheads | 148.06 | 154.72 | 161.68 | 168.96 | 176.56 |
|  | Selling Overheads | 242.66 | 253.58 | 264.99 | 276.92 | 289.38 |
|  | **Total Operating Cost** | **4738.67** | **4998.04** | **5272.15** | **5559.92** | **5863.21** |
| **4** | **Gross Margin (EBITDA/PBITDA)** | **4618.34** | **4884.21** | **5165.00** | **5463.49** | **5779.58** |
|  | **Net Cash Flow** | **4618.34** | **4884.21** | **5165.00** | **5463.49** | **5779.58** |
|  | Cost of Capital (10%) | 0.39 | 0.35 | 0.32 | 0.29 | 0.26 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Capacity for 350 KTPA PVC Resin and 200 KTPA Phenol + 123 KTPA Acetone** | | | | | | |
| **Year of Operation** | | **19** | **20** | **21** | **22** | **23** |
| **Expenditure phasing / Capacity Utilization** | | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
|  | **Operating Period** | **2041** | **2042** | **2043** | **2044** | **2045** |
| **All Figures are in INR Crore** | | | | | | |
| 1 | **Capex (In INR Crore)** |  |  |  |  |  |
|  | **Propane Furnace Addition** | | | | | |
|  | **Total Investment** |  |  |  |  |  |
| **2** | **Operating Revenue** | **12297.19** | **12988.59** | **13719.10** | **14490.92** | **15306.43** |
|  | PVC | 5725.74 | 6055.20 | 6403.62 | 6772.08 | 7161.74 |
|  | Phenol | 3418.99 | 3619.29 | 3831.32 | 4055.78 | 4293.39 |
|  | Acetone | 1577.19 | 1667.94 | 1763.92 | 1865.41 | 1972.75 |
|  | Net Revenue Gain Over Base Case from Existing Products | 1575.28 | 1646.16 | 1720.24 | 1797.65 | 1878.54 |
| **3** | **Operating Cost** |  |  |  |  |  |
|  | Raw Material | 4638.75 | 4904.77 | 5186.62 | 5486.05 | 5800.67 |
|  | Catchem | 297.89 | 315.47 | 334.08 | 353.79 | 374.67 |
|  | Labor | 99.67 | 104.16 | 108.84 | 113.74 | 118.86 |
|  | Variable Overheads | 659.80 | 689.49 | 720.52 | 752.94 | 786.83 |
|  | Fixed Overheads | 184.50 | 192.81 | 201.48 | 210.55 | 220.03 |
|  | Selling Overheads | 302.40 | 316.01 | 330.23 | 345.09 | 360.62 |
|  | **Total Operating Cost** | **6183.01** | **6522.70** | **6881.77** | **7262.16** | **7661.66** |
| **4** | **Gross Margin (EBITDA/PBITDA)** | **6114.18** | **6465.89** | **6837.32** | **7228.76** | **7644.77** |
|  | **Net Cash Flow** | **6114.18** | **6465.89** | **6837.32** | **7228.76** | **7644.77** |
|  | Cost of Capital (10%) | 0.24 | 0.22 | 0.20 | 0.18 | 0.16 |

|  |  |
| --- | --- |
| [**NPV**](mailto:NPV@12%25) | **25804.87** |
| **IRR** | **19.20%** |
| **Payback Period After Project Completion (Simple)** | **3.27** |
| **Payback Period After Project Completion (Discounted)** | **3.39** |

**Debt Service Coverage Ratio: Option-4**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Debt Service Coverage Ratio (DSCR): Combined Scenario** | | | | | | | | | |
| **(INR Crore)** | | | | | | | | | |
| **Particulars** | **1st Year** | **2nd Year** | **3rd Year** | **4th Year** | **5th Year** | **6th Year** | **7th Year** | **8th Year** | **9th Year** |
| (a) Profit After Tax | 829.97 | 1367.95 | 1694.66 | 1827.04 | 1968.81 | 2117.81 | 2275.55 | 2441.96 | 2616.51 |
| (b) Add Back Interest on Term Loan | 652.06 | 630.32 | 543.38 | 456.44 | 369.50 | 164.15 | 120.68 | 77.21 | 33.74 |
| **Total (a+b)** | **1482.03** | **1998.28** | **2238.04** | **2283.48** | **2338.31** | **2281.95** | **2396.22** | **2519.16** | **2650.24** |
| (c) Interest on Term Loan | 652.06 | 630.32 | 543.38 | 456.44 | 369.50 | 164.15 | 120.68 | 77.21 | 33.74 |
| (d) Term Loan Instalment | 0.00 | 869.41 | 869.41 | 869.41 | 869.41 | 869.41 | 869.41 | 869.41 | 869.41 |
| **Total (c+d)** | **652.06** | **1499.74** | **1412.80** | **1325.85** | **1238.91** | **1033.56** | **990.09** | **946.62** | **903.15** |
| **DSCR** | **2.27** | **1.33** | **1.58** | **1.72** | **1.89** | **2.21** | **2.42** | **2.66** | **2.93** |
| **Average DSCR (for Loan Period)** | **1.93** |  |  |  |  |  |  |  |  |

**Breakeven Point**

|  |  |
| --- | --- |
| **350 KTPA Break Even Unit at Optimum Capacity Utilization (4th Year)** | |
| **(Rs. Crore)** | |
| **(A) Gross Revenue** | **3094.33** |
| **(B) Variable Expenses** |  |
| Raw material and Catalyst & Chemicals | 1040.05 |
| Variable Overheads | 179.39 |
| Labor | 30.71 |
| Selling Overheads | 88.77 |
| **Total Variable Expenses** | **1338.93** |
| **(C) Contribution** | **1755.41** |
| **(D) Fixed Expenses** |  |
| Fixed Overheads | 78.84 |
| Interest on Term Loan | 311.96 |
| Depreciation | 415.94 |
| Total Fixed Cost | **806.75** |
| **(E) Break Even Point** | **45.96%** |

**Break Even Point- Sensitivity Analysis: 350 KTPA**

|  |  |  |
| --- | --- | --- |
|  | **Project Sensitivity** | **Break-Even Point** |
|  | Break Even Point (at optimum capacity utilization) | 45.96% |
| 1 | Selling Price decreases by 11%, Raw Material Price remains same | 57.01% |
| 2 | Increase in Raw Material price by 16.5 % with no change in selling price | 50.94% |
| 3 | Increase in raw material price by 9 % with decrease in selling price by 5% | 53.53% |
| 4 | Increase in Cost of Production by 14.5% with no change in selling price | 51.67% |

**Profitability- Sensitivity Analysis: 350 KTPA**

|  |  |  |
| --- | --- | --- |
| **Project Sensitivity Analysis** | | |
| **Project Sensitivity** | **Profit After Tax** | **Percentage Change** |
| Profit After Tax (at optimum capacity utilization) | 943.32 | Nil |
| Selling Price decreases by 11%, Raw Material Price remains same | 688.62 | 27% decrease |
| Increase in Raw Material price by 16.5 % with no change in selling price | 830.01 | 12% decrease |
| Increase in raw material price by 9 % with decrease in selling price by 5% | 765.74 | 19% decrease |
| Increase in Cost of Production by 14.5% with no change in selling price | 789.49 | 16% decrease |

|  |  |
| --- | --- |
| **500 KTPA Unit - Break Even Point at Optimum Capacity Utilization (4th Year)** | |
| **(Rs. Crore)** | |
| **(A) Gross Revenue** | **4420.47** |
| **(B) Variable Expenses** |  |
| Raw material and Catalyst & Chemicals | 1733.59 |
| Variable Overheads | 224.30 |
| Labor | 35.01 |
| Selling Overheads | 136.83 |
| **Total Variable Expenses** | **2129.73** |
| **(C) Contribution** | **2290.75** |
| **(D) Fixed Expenses** |  |
| Fixed Overheads | 114.02 |
| Interest on Term Loan | 454.01 |
| Depreciation | 605.35 |
| Total Fixed Cost | **1173.37** |
| **(E) Break Even Point** | **51.22%** |

**Break Even Point- Sensitivity Analysis: 500 KTPA**

|  |  |  |
| --- | --- | --- |
| Sr.No | **Project Sensitivity** | **Break-Even Point** |
|  | Break Even Point (at optimum capacity utilization) | 51.22% |
| 1 | Selling Price decreases by 11%, Raw Material Price remains same | 65.02% |
| 2 | Increase in Raw Material price by 16.5 % with no change in selling price | 58.53% |
| 3 | Increase in raw material price by 9 % with decrease in selling price by 5% | 61.31% |
| 4 | Increase in Cost of Production by 14.5% with no change in selling price | 59.20% |

**13. Project Schedule and Implementation Strategy**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **PROJECT IMPLEMENTATION SCHEDULE** | | | | | | | | | | | | | | | | | | | | | | | | |
| **Activity** |  | **Month** | | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 |
| 1. Kick Off Meeting, Detailed Engineering and Licensing |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **1. Engineering** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Basic Engineering / Documents |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Detail Engineering/ Documents |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **2. Civil Work** | | | | | | | | | | | | | | | | | | | | | | | | |
| Company Registration |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Land Acquisition |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Finalization of Building Design |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Invitation of Tenders and Award |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Factory Shed |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Auxiliary Building |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Administrative Block |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Other Construction |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Disbursal of Finances |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **3. Plant and Machinery** | | | | | | | | | | | | | | | | | | | | | | | | |
| Specification Detailing |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Invitation of Quotations |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Mechanical Piping & fitting |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Placing Orders |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Delivery at Plant Site & Inspection |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Installation and Commissioning |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Check-up of the Plant & Machinery |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **4. Arrangement of Power/Water** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **5. Other Items** | | | | | | | | | | | | | | | | | | | | | | | | |
| Finalize Management Reporting |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Finalize Official Practices |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Executive Systems |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **6. Training and Personnel** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **7. Start -up/ Commercial Production** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**14. SWOT Analysis:**

**O**

**T**

**Strengths**

* The company’s executives have decades of experience in plastic, engineering, and successful startups. Market know-how and network are vital advantages
* Being on the western side of the country, its proximity to the middle eastern region for sourcing key raw materials, i.e., EDC and VCM for manufacturing PVC, serves as the major strength.
* One of the leading suppliers of polymers in the Indian market and expansion plans to cater to the growing demand, the client is well-placed to benefit from an uptick in the PVC resin market
* The company has a good relationship with the firms that collect and distribute PVC resin.

**Weaknesses**

* PVC-Naphtha spread has reduced as Naphtha prices have risen sharply in the last six months. In 2020, this gap slightly improved from lower feedstock prices, offsetting weak product demand due to COVID-19.
* The company does not have a captive Chlor alkali unit; hence will rely on external procurement of chlorine.
* Energy prices have increased significantly and have insufficient nitrogen supply; therefore, procuring nitrogen from outside leads to raised capital costs and hampers the company’s optimum business operation.

**Opportunities**

* The demand outlook for suspension and paste resin will likely be relatively robust in the coming years due to a significant deficit and high import dependence in the domestic market. In addition, increasing tight supply at the global level for both these products augurs well for domestic manufacturers.
* Restricted EDC/VCM supply due to limited availability of chlorine in markets where ethylene is available results in lower capacity utilization of the companies which are not fully integrated.
* The client has an opportunity to have a fully integrated unit as the company has captive ethylene and assured supply from GACL, DCM Shriram, and Meghmani.

**Threats**

* Whenever the government regulations are updated, the company needs to develop a technically and economically feasible recycling solution that meets the standards.
* The company model is PVC dependent. Therefore, if the use of pipes, window frames, drainage pipes, etc., declines, the supply will be reduced.
* Fluctuation in the supply may occur. RIL Dahej unit is planning to add 1000 KTPA capacity in the near vicinity, which may result in oversupply conditions in the western regi

**PVC Industry SWOT Analysis**

**Strengths**

* Growing infrastructure and rising demand for PVC for the manufacturing of pipes and cables.
* The growing agriculture sector in the country, coupled with favourable government policies to provide clean drinking water across the country, is anticipated to derive the demand for PVC in the coming years.

**Weakness**

* Availability of raw materials such as chlorine and ethylene are major challenges for domestic manufacturers (PVC production from EDC/VCM).
* Shortage of Ethylene: As a producer prefers to produce other valuable derivatives derived from ethylene, the storage and handling of Ethylene becomes a major challenge.

**Opportunities**

* Rising demand from the construction sector because of government investments supported with schemes, for the manufacturing of PVC sheets, profiles, PVC windows and wood PVC composites in India
* Rising export potential in neighbouring countries, such as Bangladesh, Nepal, Myanmar, Sri Lanka, and Singapore

**Threats**

* Fluctuating raw material prices.
* Few countries have surplus PVC capacity and stagnant growth, which can potentially threaten new players as these players may dump their products at a lower cost.
* Customers will switch to HDPE when PVC prices are at par for the piping application.

Reliance Industries is the only Indian manufacturer with a complete integrated value chain to produce PVC. RIL has ethylene and Chlor-Alkali capacity through which the Indian petrochemical giant can produce PVC in bulk quantities, which is available in domestic and international markets. The integrated process allows RIL to streamline PVC production and, at the same time, control supply dynamics.

Chemplast Sanmar Limited and Finolex Limited are among those PVC manufacturers that rely heavily on imports of EDC or VCM depending on appropriate market dynamics. Importing EDC/VCM allows these manufacturers to produce PVC with relative ease. These manufacturers import EDC/VCM from Qatar, Saudi Arabia, the USA, and South Korea. However, depending only on imports leaves them vulnerable to market volatility, which is not an ideal scenario. Since the outbreak of COVID-19, the petrochemical market has been anything but stable, where marginal changes in supply dynamics locally have global repercussions.

Hence, Techsci Research strongly recommends client install an integrated process instead of depending on imports of EDC/VCM for PVC production. It will smoothen the production and make the Indian PVC market more competitive.

In the second alternative, EDC can be transported directly to the storage tanks via underground pipes from the marine terminal facility. In addition, an open jetty facility with a total CapEx of INR 1500-1800 is also required at the berth location of 10.5m. The storage of raw materials enables the company to ensure smooth operations functioning despite supply uncertainties and price volatilities. The stocking of inventories is based on long-term contracts and expected orders which are confirmed in the backdrop of a well-established relationship with customers.

* The client can also opt for a hybrid model where client can import a certain amount of EDC/VCM from the international market while adding some ethylene capacity and gradually starting its integrated PVC value chain. The client already has the edge in terms of location, whereas Dahej, being on the Western shores, provides ample opportunity to have LNG access from the Middle East.

**15. Risk Factors and Mitigation**

1. **Rising Feedstock Prices (Ethylene, Chlorine, Oxygen), Mitigation:** The client should mitigate this risk by adopting long-term contracts with the existing suppliers in the domestic and global markets.
2. **Dumping of PVC resins from surplus and low-cost PVC producing companies, Mitigation:** The client can reach nodal agencies for the imposition of anti-dumping duties.
3. **Availability and Transportation of Chlorine, Mitigation:** The client can reach out to caustic soda manufacturing companies for long-term contracts for procuring chlorine and transportation can be achieved by pipeline.

**16. Technology Licensors**

Technologies available for the EDC, VCM, and PVC are as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| EDC | | | |
| ABB Lummus Global! Solvay SA | Ethylene dichloride (EDC) | Ethylene and chlorine | High-yield direct chlorination; no purification prior to cracking; energy efficient |
| ABB Lummus Global! Solvay SA | Ethylene dichloride (EDC) | Ethylene, hydrogen chlorine and oxygen | Oxychlorination with small fluid-bed reactor design; high per-pass conversion; energy efficient |
| INEOS Technologies | Direct chlorination, high temperature chlorination | Ethylene, chlorine | Energy efficient process, product purity of 99.95%, low maintenance, no EDC washing |
| The Geon Co. | Ethylene dichloride (EDC) | Ethylene and chlorine | High temperature direct chlorination with catalyst, energy efficient |
| The Geon Co. | Ethylene dichloride (EDC) | Ethylene, hydrogen chloride and oxygen | Oxyhydrochlorination in fluid bed reactor with high efficiency catalyst |
| The Geon Co. | Ethylene dichloride (EDC), low temperature | Ethylene and chlorine | Low temperature process for direct chlorination offer.; high selectivity |
| VinTec | Ethylene dichloride | Ethylene and chlorine | High temperature direct chlorination |

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | VCM |  |
| ABB Lummus Global! Solvay SA | Vinyl chloride monomer (VCM) | EDC and/or ethylene, chlorine | Advanced pyrolysis design with high EDC conversion and long furnace run lengths; energy efficient |
| INEOS Technologies | Vinyl chloride monomer | Ethylene, chlorine and air/oxygen | Fixed-bed oxygen-based oxychlorination, low temperature, direct chlorination |
| John Brown Eng. & Constructors | Vinyl chloride monomer | Acetylene and hydrogen chloride | Large reactor design reduces capital costs |
| Mitsui Chemicals, Inc. | Vinyl chloride monomer | Chlorine, ethylene, oxygen | Oxygen-based balanced oxychlorination process, high temperature direct chlorination process |
| The Geon Co. | Vinyl chloride monomer (VCM) | Ethylene, chlorine and/or EDC | Pyrolysis of EDC yields VCM. Oxyhydrochlorination recycles by-product HCI |

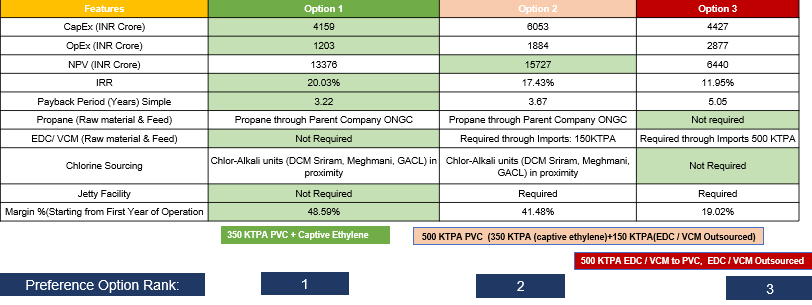
\**Formerly European Vinyls Corp.*

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | PVC |  |
| ABB Lummus Global! Solvay SA | Polyvinyl Chloride (Suspension) | Vinyl chloride monomer | On-site initiator synthesis and high reactor productivity minimizes operating costs; wide range of high-quality products |
| Chisso | Polyvinyl Chloride (suspension) | Vinyl chloride monomer | Batch process manufactures many PVC grades including commodity, high / low K values, matted type and copolymer PVC |
| INEOS Technologies | Polyvinyl Chloride (emulsion) | Vinyl chloride monomer | High productivity, high quality grades, low residual VCM, effective condenser usage |
| The Geon Co. | Polyvinyl Chloride (emulsion) | Vinyl chloride monomer | Technology offers computer control system and environmental control units |
| The Geon Co. | Polyvinyl Chloride (suspension) | Vinyl chloride monomer | Technology includes environmental, health and safety controls, high level DCS control systems |
| Vestolit GmbH / Hulls AG | Polyvinyl Chloride | Vinyl chloride monomer | Up to 200 m3 reactor technology, yields suspension, high-impact emulsion PVC |
| Vinnolit K GmbH / Krupp Uhde | Polyvinyl Chloride (emulsion) | Vinyl chloride monomer | Batch process, uses 2 or more reactors; special coating, build-up suppressant allows many batch operations before cleaning |
| Hanwha Corporation | PVC Suspension and Emulsion | Vinyl chloride monomer | High productivity with an option to produce all suspension and emulsion grades |

**17. Recommendations Based on Key Observations:**

**Most Suitable Plant Set-up Option: PVC**

* Option 1 includes the inhouse production of ethylene with propane already supplied by its parent company, and chlorine can be sourced from a nearby chlor-alkali unit through pipeline. Option 1 ranked 1st, supported by low CapEx and OpEx with attractive NPV, IRR, payback period, and percentage margin in the first year of operation.
* Option 2 will have the flexibility to go both for the ethylene and EDC/VCM route incurring high CapEx and low OpEx. This option will require the jetty facility for the import of EDC/VCM from the international market for the incremental 150 KTPA VCM/PVC unit, incurring an extra cost for setting up of the facility due to which an increase in CapEx of around 2000 INR Crore has been incurred as compared to Option 1 and 3. Moreover, the major challenges are the constrained supply and availability of EDC/VCM from the international market, mainly from the US, resulting in the volatility of EDC/VCM prices. Therefore, Option 2 is not recommended due to higher capex, low NPV, IRR, and availability of EDC/VCM. There is an additional cost of INR 2000 Crore for setting up the jetty facility.
* Option 3 will not require an oxychlorination unit to produce EDC as EDC/VCM will be sourced from the international market. However, the option will incur the CapEx of the jetty facility and EDC/VCM thermal cracking unit for the 500 KTPA EDC/VCM unit. Due to high OpEx, the option incurs an unappealing NPV, IRR, and payback period with a low percentage margin. Moreover, due to volatility of EDC/VCM prices, constraints in sourcing, and availability from the international market, Option 3 has been inadvisable. Prior to 2020, the convertors (primarily caustic soda manufacturers) are selling EDC at ethylene cash cost loss only because they must dispose of Chlorine, which they can’t store and hence the step-down production of EDC. However, the option has changed due to lower availability and firm prices of ethylene. Over one-third of EDC mix is ethylene & while the rest is chlorine and oxygen. VCM prices trend closely with PVC resin prices, i.e., the finished product prices. USD 150 is perceived a reasonable spread between the two for VCM buyers to sustain PVC business else, it would be better for them to buy PVC resin itself. Crude oil and the natural gas process has seen a sharp run-up since October 2021. Ethylene, a key input to EDC has also seen an increase.

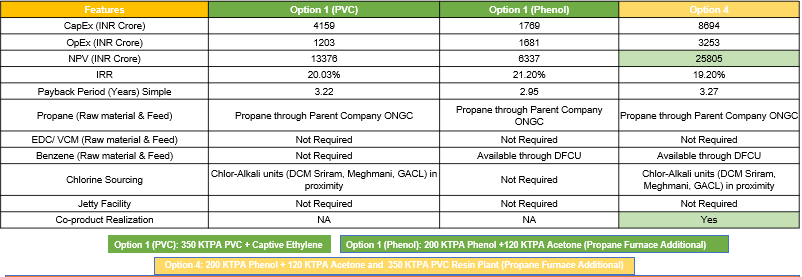


*The client will have sufficient ethylene, propylene, and benzene after commissioning the propane furnace. Therefore, Option 1 will have better NPV, IRR, Payback Period, and margin despite having the highest CapEx*

*The Option 1 is most feasible in terms of execution and realization as it won’t require EDC/VCM sourcing from the international market. The jetty facility will also be not needed****.***

Option 1, 2, 3, and 4 were presented to the client, wherein Option 4 emerged as the configuration with the highest NPV and was therefore recommended by TechSci for further pursue configuration and licensor identification. The report basis, financial analysis, and recommendations are based on the conventional execution mode. The client’s existing data was used to calculate ethylene production cost. At the same time, the cost of production is also calculated with the new feed structure, including the new propane furnace. Adding a propane furnace appears to be most practical as this will optimize the OpEx. The schedule will remain the same as informed above, and the cash flows, IRRs Capex and taxation etc., can be reassessed at client’s end based on their experience and choice of execution methodology.

**Most Suitable Plant Set-up Option: PVC+ Phenol**



The Option 4 appears to be the most feasible & realistic option among the other three options due to the attractive NPV, IRR, and payback period. Moreover, the margin percentage is also the highest. Furthermore, the coproduct will contribute to the PVC + phenol project with propane furnace addition to DFCU and be accounted in the revenue part. The revenue part of the cashflow considered additional LLDPE, PP, HDPE, and production with surplus ethylene and Propylene. Surplus ethylene shall be consumed to manufacture 35% LLDPE and 65% HDPE.

***The client will have sufficient ethylene, propylene, and benzene after commissioning the propane furnace. Therefore, Option-4 will have better NPV, and margin (coproduct revenue realization) despite having the highest CapEx.***

***Incremental ethylene and propylene availability due to other propane furnaces increase the incremental margin.***

**Factors Influencing the Position for the Proposed Project**

* Few players in domestic market
* High entry barrier for PVC market
* Strong brand image and leading market player in domestic and international market
* Strong distribution network
* Diversified product portfolio
* Strong growth in pipes and fittings, films, and sheets industry
* Higher demand-supply gap
* Export potential to neighboring countries
* High margin and likely to improve in near future
* The client is likely to be competitive in any market in India
* Access to all major feed and feedstocks
* Availability of chlorine is a challenge in producing EDC and VCM. Hence, integrated projects can be explored where the company will have the flexibility to produce or procure EDC / VCM. However, the existence of nearby caustic soda plants can be considered for the sourcing of chlorine.

**Action Plan and Strategies**

• The total cost of the proposed project of option 1 without EDC/VCM import facility is estimated at INR4176 Crores with a Debt Equity ratio of 3:1. An additional investment of INR1826 crore is required for option 2 with an annual capacity of 500 KTPA.

• Demand-Supply gap is expected to reach around 2500 thousand tonnes by FY 2026. Growing demand from the pipes & fitting industry coupled with Government favorable policy is expected to drive the demand for PVC in coming years.

• The client is recommended to complete the project as per the implementation schedule; otherwise, there will be a possibility of cost over-run as well as time over-run.

• Evaluating the Technology & Licensor for PVC resin production process needs to streamline post receiving the financial clearance from the Board of Directors.

• The overall profitability and cash accruals position is good.

• The client is recommended to implement a propane furnace to help the company meet the required ethylene to produce PVC resin.

• Project is viable, primarily on account of captive ethylene production using existing production coupled with the incorporation of propane furnace in dual feed cracker unit, which is expected to give an upper edge to the company in gaining higher profit margin.

• Increasing export potential in other Southeast Asian countries is expected to drive the demand for PVC resins in the coming years.

**Forecasting:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Approach: Growth Forecast Via Factors (Impact Analysis) India PVC Resin Market** | | | | |
| **Factors** | **Sources** | **Value** | **CAGR** | **Weightage** |
| **GDP Growth Rate (2021-2040 Period)** | ***World Bank, TechSci Estimates*** | ***Forecast*** | 7.50% | 25.00% |
| **GDP Per Capita (%)** | ***World Bank, TechSci Estimates*** | ***Forecast*** | 5.09% | 10.00% |
| **Average Selling Growth (%)** | ***TechSci Research Estimates*** | ***Forecast*** | 8.00% | 15.00% |
| **Growth in Construction Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 8.85% | 20.00% |
| **Growth in Agriculture Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 5.62% | 25.00% |
| **Market Growth in Historical Period**  **(2015-2020)** | ***Industry Sources & TechSci Research Estimates*** | ***Historical*** | 4.18% | 5.00% |
| **CAGR (2021-2040)** | **6.97%** | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Approach: Growth Forecast Via Factors (Impact Analysis) Global PVC Resin Market** | | | | |
| **Factors** | **Sources** | **Value** | **CAGR** | **Weightage** |
| **GDP Growth Rate (2021-2040 Period)** | ***World Bank, TechSci Estimates*** | ***Forecast*** | 3.22% | 20.00% |
| **GDP Per Capita (%)** | ***World Bank, TechSci Estimates*** | ***Forecast*** | 2.85% | 14.00% |
| **Average Selling Growth (%)** | ***TechSci Research Estimates*** | ***Forecast*** | 4.20% | 12.00% |
| **Growth in Construction Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 4.28% | 18.00% |
| **Growth in Agriculture Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 3.85% | 22.00% |
| **Market Growth in Historical Period**  **(2015-2020)** | ***Industry Sources & TechSci Research Estimates*** | ***Historical*** | 1.01% | 14.00% |
| **CAGR (2021-2040)** | **3.31%** | | | |

**Disclaimer:**

The contents of this report are based on information generally available to the public from sources and primary interviews which are believed to be reliable. No representation is made that it is timely, accurate or complete. TechSci Research has taken due care and caution in compilation of data as this has been obtained from various sources including primary interviews which it considers reliable and firsthand. However, TechSci Research does not guarantee the accuracy, adequacy or completeness of any information and it is not responsible for any errors or omissions or for the results obtained from the use of such information and especially states that it has no financial liability whatsoever to the subscribers / users of this report. The information herein, together with all estimates and forecasts, can change without notice. All the figures provided in this document are indicative of relative market size and are strictly for client’s internal consumption. Usage of the same for purpose other than internal will require prior approval of TechSci Research.

