GLOBAL EPOXY RESIN MARKET FORECAST & OPPORTUNITIES, 2030

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MARKET INTELLIGENCE. CONSULTING

Executive Summary

1. Brief insight about the company and project:

Established - 1973 **Turnover (Consolidated) - INR 5,39,238 Crore (FY Year 2020-21)**

1.1. Overview of the Company:

- Reliance Industries Limited is Indian based, one of the well-known brands involved in manufacturing and sales of diverse range of products including polymers, aromatics, elastomers etc. globally.
- The company caters customers and various industries viz., healthcare, automotive, packaging etc across over 70 countries worldwide.
- The company's total production capacity of PE, PP and PVC is 2.3, 2.9 and 0.7 million MT per annum as of 2019.
- The company exported 1.1 million MT of polymers globally in 2019.
- The company has 6 state-of-the-art manufacturing facilities to produce polymers.

1.2 Brief Profile of Board of Directors:

Mukesh Ambani: Mr. Mukesh D. Ambani is a Chemical Engineer from the Institute of Chemical Technology, Mumbai (erstwhile the University Department of Chemical Technology, University of Mumbai). He pursued an MBA from Stanford University in the US. He has been on the Board of Reliance since 1977.

Nita M. Ambani: Mrs. Nita M. Ambani (DIN 03115198) is a Commerce Graduate from Mumbai University and a diploma holder in Early Childhood Education.

Hital R. Meswani: Mr. Hital R. Meswani (DIN 00001623) is a Management & Technology graduate from the University of Pennsylvania (UPenn) in the USA.

Nikhil R. Meswani: Nikhil Meswani is an Executive Director on the Board of Reliance. A chemical engineer from the University Institute of Chemical Technology (UICT) Mumbai, he joined Reliance in 1986.

P.M.S. Prasad: PMS Prasad is an Executive Director at Reliance and one of the longest serving

members on the Board and the company.

P.K. Kapil: PK Kapil is an Executive Director on the Board of Reliance. With experience spanning four decades, he is a driving force in the HSE, Technology, Reliability and Operations of all manufacturing sites.

R.A. Mashelkar: RA Mashelkar is an independent Director on the Board of Reliance. An eminent scientist and champion of the Innovation Movement in India, he is the Chairman of Reliance Innovation Council.

Adil Zainulbhai: Adil Zainulbhai is an independent Director on the Board of Reliance. One of the world's foremost consultants, he is a mechanical engineering graduate from IIT and holds an MBA from Harvard University.

Mansingh L. Bhakta: Mansingh Bhakta is an independent Director on the Board of Reliance. An advocate par excellence, he has almost six decades of experience.

Dipak C. Jain: Dipak Jain is an independent Director on the Board of Reliance. One of the world's top educationalists, he is a former Dean of Kellogg School of Management and INSEAD.

Dharam Vir Kapur: Dharam Vir Kapur is an independent Director on the Board of Reliance. A technology, industrial development and project implementation expert, he has a long and illustrious career in the Indian government.

Mahesh P. Modi: Mahesh Modi is an independent Director on the Board of Reliance. He has in-depth management experience in the petrochemical, telecommunications, energy and insurance industries.

Yogendra P. Trivedi: Yogendra Trivedi is an independent Director on the Board of Reliance. He is an expert in the fields of economics, politics, education, sports, and social and professional services.

Ashok Misra: Ashok Misra is an independent Director on the Board of Reliance. An IIT Director from 2000-2008, Misra was the driving force behind its transformation into leading research and development institute.

1.3 Brief Project summary

The project is a greenfield project and for manufacturing of various types of epoxy resins such as Bisphenol-A and Bisphenol-F epoxy resin, cycloaliphatic epoxy resins, dimer acid modified epoxy resin and multifunctional epoxy resins (Epoxy-phenol Novolac resins and Epoxy-cresol Novolac resins). It falls under Category 5 (f) B, thereby the Environmental Clearance must be obtained from SEAC, Gujarat.

1.4. Key Highlights of the Project

Considering the growing market scenario, Reliance Industries Limited proposes to enter epoxy resin business. With the increasing demand (within India and across the globe), there is urgent need to world class epoxy resin manufacturing unit in India. The market of this product has gained pace tremendously and there are greater opportunities in the indigenous as well as export markets. Due to increasing demand of this product and to reduce the gap between demand and supply, the company proposes to manufacture various grade of epoxy resins.

Epoxy Resin (base liquid and blend), though produced indigenously, is also imported in substantial quantities into India. Moreover, the technology is totally proven and safe in all aspects. The project will help in bridging demand-supply gap. Various formulated resins based on liquid epoxy resin have export potential too.

Success for the project includes:

- Ease of Availability of skilled and non-skilled workers
- Cost Competitiveness
- Availability of well-developed infrastructure facility
- Positive impact on the socio-economic condition of the area in terms of direct and indirect employment due to the proposed project during construction / operation phase.
- India being the Top 10 preference for FDI Inflows in the country.
- India being the 4th largest producer of Chemicals & Petrochemical in Asia Pacific region.
- India is 3rd largest consumer of polymers globally.
- Development of Industrial Corridors across the country.
- “AatmaNirbhar Bharat” and “Make in India” policies are pushing domestic manufacturer to come up with green field capacity.

India Competitiveness for Setting Up Epoxy Resin Manufacturing Market

Region / Country	Raw Material Sourcing	Product Demand	Capital Cost	Operating Cost	Project Implementation	Overall Attractiveness
Middle East						
US						
Europe						
India						
China						


Unattractive


Highly Attractive

Source: TechSci Research

Real GDP Growth Forecast for Major Economies

Country	2023	2025	2030
India	**7.95%**	**7.52%**	**7.24%**
China	5.75%	5.60%	5.28%
France	2.32%	1.76%	2.05%
United Kingdom	1.94%	1.67%	1.92%
Germany	1.87	1.22%	1.44%
United States	2.35%	1.86%	2.05%
Russia	2.15%	1.85%	2.10%
Japan	1.26%	0.72%	1.25%
World	3.84%	3.56%	3.78%

Source: OECD, World bank

2. Product Profile

2.1. Product Overview (Introduction and Characteristics):

Epoxy resins have a set of unique combinations of properties and performance characteristics. These are thermosetting polymer, which crosslink & polymerize when mixed with the catalytic agent or “Hardener”.

Epoxy resin is classified into standard epoxy resin and specialized epoxy resins.

Standard epoxy resins: The standard epoxy resin also known as commodity epoxy resin includes only Bisphenol A and F based epoxy resin which constituted around 80% of the market in 2020.

- **Bisphenol-A Type Epoxy Resin:** The most common epoxy resins are produced by reacting Epichlorohydrin (ECH) with Bisphenol A (BPA). This reaction produces BADGE or DGEBA (Bisphenol A Diglycidyl Ether), which represents the smallest unit of a typical Epoxy Resin. Bisphenol A liquid epoxy resins are used in broad applications including coatings, civil engineering, adhesives, electrical insulating materials, and reactive intermediates.

- **Bisphenol-F Epoxy Resin:** This can be manufactured from Bisphenol F by similar methods to those used for bisphenol A and epichlorohydrin with a catalyst such as NaOH. These resins have lower viscosities than the equivalent DGEBA. EEW (Epoxy Equivalent Weight) value of Bisphenol F resin lies between 158-175 & viscosity 5000-7000 CPS (Centipoise) at 25°C.

Specialized epoxy resins: The specialized epoxy resin include cycloaliphatic epoxy resins, dimer acid modified epoxy resins and multifunctional epoxy resins (Epoxy phenol Novolac resins, Epoxy cresol Novolac resins, Diamino diphenyl methane-based epoxy resin, Para-aminophenol based epoxy resin, triglycidylether epoxy resin etc).

- **Multi-functional Epoxy Resins (Epoxy Phenol / Cresol Novolac Resins):** Epoxy phenol/cresol novolac (EPN) resins contain more than two epoxy groups per molecule and are therefore described as multifunctional epoxy resins. EPN resins are recommended in formulations for high-performance applications requiring excellent chemical resistance, solvent resistance, and high temperature resistance than the standard bisphenol-based epoxy resin. These EPN resins are also used in blends with Bisphenol-A and F epoxy resins to improve the performance. Novolac resins, which are the reaction products from

formaldehyde and excess phenol under acidic catalysis, when co-cured with high molecular weight solid bis-A epoxy resins result in coatings with excellent adhesion, film strength, flexibility, and chemical resistance. They are especially useful in powder coatings applications for corrosion resistant pipe reinforcing bars (rebars) and with brominated epoxy resins for FR3 electrical laminate production.

- **Cycloaliphatic Epoxy Resins:** Cycloaliphatic epoxy resins are characterized by non-aromatic saturated rings in their molecular structures. These resins are ideally suited for applications where inherently low viscosity, and excellent weathering electrical performance are required. In India, Cycloaliphatic epoxy resins are mainly used in weather resistant solvent-based coatings for outdoor applications.

- **Brominated Epoxy Resins:** Brominated epoxy resins are produced when tetrabrominated bisphenol A is added to the formulation. Fluorinated epoxy resins are used in high performance applications. Generally, it has been observed halogenated epoxy resins are used to cater to demand of flame retardant and other end uses. Brominated epoxy resins are widely used globally in flame retardant in electrical applications.

- **Glycidyl amine Epoxy Resins** are another specialized epoxy resins are heavily used in aerospace composite applications uses. They provide outstanding thermal stability and good adhesion strength making them ideal for high performance composites, adhesives, and coatings. These resins are higher functionality epoxies based on reaction between aromatic amines and epichlorohydrin resulting in cross-linking which invoke specific properties in the resins. Because of their low to medium viscosity at room temperatures, these are easier to process than standard epoxies. These have unique combination of properties making them highly end-use specific. Triglycidyl para-aminophenol (TGPAP) is one of the most widely used glycidyl amine epoxy resins around the world.

- **Solvent Cut Epoxy Resins-** These resins are mainly dissolved in various organic solvents which are primarily used in coating applications. Various solvents used in the production of different epoxy resins are xylene, MEK (methyl ethyl ketone), cyclohexane, butyl cellosolve, cyclohexanone, MIBK (methyl isobutyl ketone), n-butanol, PGM- Ac (propylene glycol mono-methyl ether acetate), toluene etc.

Epoxy resin can be also marketed as pure epoxy resin which is typically just a resin and a hardener. It cures at a slower rate than the other product classes (polyesters and epoxy acrylates) and, as a result offers less shrinkage, excellent adhesion, and high strength performance.

Epoxy resin can be further classified based on liquid, solid and semi-solid type.

- **Liquid epoxy resins** have minimum two epoxy groups in a molecule and are liquid at temperature of 20°C. Liquid epoxy is the standard type of epoxy resin which is highly versatile. These resins can be cured and modified and can deliver unique combination of properties. They find their applications in coatings, castings, constructions, adhesives, electrical and electronics and other end-user industries.
- **Solid epoxy resins** conventionally have more than three epoxy groups in a molecule and are at solid at temperature of 40°C. These are ideal for composites, industrial coatings, and preparation of epoxy ester resins because of their high flexibility, good abrasion resistance and good corrosion resistance.
- **Semi-Solid epoxy resins** have dual nature as they are in solid state at temperature of 20°C, while liquid at 40°C. They bridge the processing gap between liquid and solid epoxy resins by offering pourability at slightly high temperatures and having intermediate time-to-hardness during the curing process. These properties make semi-solid epoxy resins suitable for adhesives and coatings with varying level of tack and improved flow and levelling.

2.2. Production Routes and Related Details

Epoxy resin is usually synthesized by bulk polymerization. The material is available commercially at 98% purity & are colourless. Many commercial liquid resins consist essentially of low molecular weight diglycidyl ether of Bisphenol A together with small quantity of higher molecular weight polymer. In general, production of bisphenol A epoxy resin is divided into one step method & two-step process method.

In one-step method, Bisphenol A reacts directly with epichlorohydrin in order to prepare epoxy resin, which commonly used for the synthesis of low to medium molecular weight (MW) epoxy resins.

Mass Balance

Input	T/T	Output	T/T
BPA	0.7	Product	1
NaOH	0.04	Salt	0.336
ECH	0.56	Solid Waste (Waste Polymer)	0.096
48% NaOH	0.46	Reaction Water	0.33
Total	**1.76**	**Total**	**1.76**

The two-step method require continuation the reaction of low molecular weight resin with bisphenol A (BPA). High molecular weight (MW) epoxy resins can be synthesized via one step or in a two-step process.

One Step Process (BADGE): The one-step process proceeds via polycondensation reaction of epichlorohydrin (ECH) with bisphenol A (BPA).

Two Step Process: The two-step process is the reaction of bisphenol A (BPA) and epichlorohydrin (ECH) in presence of a catalyst (such as a quaternary ammonium salt). The first step is an addition reaction to form a diphenol-propane chlorohydrin ether as an intermediate. This closed loop reaction produces an epoxy resin.

Production process of Solid Bisphenol- A Epoxy Resin:

Taffy Process: In Taffy Process, bisphenol A is reacted at 85–95°C in a controlled excess of epichlorohydrin in the presence of caustic soda and an inert solvent. This reaction is used to produce lower molecular weight (LMW) epoxides.

Detailed Description of Taffy Process: A mixture of bisphenol A and 10% aqueous sodium hydroxide solution is introduced in a reactor equipped with high-speed powerful agitator. The mixture is heated up to 45°C and epichlorohydrin is added rapidly with agitation, giving off heat. The temperature is allowed to rise to 95°C, where it is maintained for approx. 80-85 minutes for the completion of reaction. Then agitation is stopped, and the mixture gets separate in two layers. The heavier aqueous layer is drawn off from bottom and the molten, taffy-like product is washed with hot water until the wash water gets a neutral pH. The taffy-like product is dried at 135°C to give a solid resin with softening point of 70-75°C and an EEW value of 500. Alternatively, epichlorohydrin is removed by vacuum distillation at temperatures up to 180°C approx. The crude

resin is then dissolved in a secondary solvent (Toluene or Xylene) to facilitate water washing and salt removal. This secondary solvent is then recovered via vacuum distillation to obtain the resin product.

Advancement Process: For manufacturing of higher molecular weight epoxy resins, liquid epoxy resin is reacted with calculated amount of bisphenol A. Further, catalyst solution is added to boost the reaction and the temperature is maintained at approx. 160°C. This process is known as Advancement process. High molecular weight epoxides are manufactured by Advancement process using Benzyl trimethyl ammonium hydroxide as a catalyst. It is widely practiced by coating producers to facilitate the handling of the high molecular weight, highly viscous epoxy resins used in many paint & coating formulations. The degree of polymerization is calculated by ratio of liquid epoxy resin (formed from BADGE Process) to bisphenol A, an excess of the former provides epoxy terminal groups. The actual molecular weight obtained depends on purity of the starting materials, solvents & catalyst used. Reactive mono-functional groups are used as chain terminators to control the molecular weight and viscosity build.

In the advancement process, bisphenol A and a liquid BADGE resin (170–180 EEW) are heated in the presence of a catalyst and reacted (i.e., advanced) to form a high MW resin. This process is exothermic and proceeds rapidly to completion. In the cases of higher MW resins, exotherm temperature can reach >190-205°C. Reaction catalysts facilitate the rapid preparation of medium to high MW linear resins, also control side reactions inherent with epoxy resin preparations, e.g, chain branching is done by addition of the epoxy group generated through chain-lengthening process with alcohol group. Nuclear Magnetic Resonance (NMR) spectroscopy method can be used to determine the extent of branching.

2.3 Applications and Properties

	Paints and Coatings (Coating Ingredients/ Ink Ingredients)	Electrical and Electronics (Impregnation/ Lamination/ FRP Molding)	Construction (Floor Coating Materials/ Linings/ Civil Engineering Repair Materials)	Adhesives/ Adhesive Ingredients	Composites
Bisphenol A Liquid Epoxy Resin	*		*	*	
Bisphenol A Solid Epoxy Resin	*		*	*	
Bisphenol F Liquid Epoxy Resin	*	*	*	*	
Brominated (Flame Retardant Types)		*		*	
Cresol Novolac Epoxy Resin		*		*	
Phenol/Modified Novolac Epoxy Resin	*	*		*	*
Cycloaliphatic Epoxy Resin		*		*	
Dimer Acid modified epoxy resin				*	
Diamino diphenyl methane-based epoxy resin	*			*	
Para-aminophenol based epoxy resin	*			*	*

** Represent use of epoxy resin in the mapped application.*

Grades	Features	Applications
Bisphenol A Liquid Epoxy Resin	Viscosity range - 450 to 26000 mPa-s High heat distortion temperature	Paints and Coatings (Coating Ingredients/ Ink Ingredients), Construction (Floor Coating Materials/ Linings/ Civil Engineering Repair Materials), Adhesives/ Adhesive Ingredients
Bisphenol A Solid Epoxy Resin	Viscosity range between 160 to 10,000 mPa.s	Paints and Coatings (Coating Ingredients/ Ink Ingredients), Construction (Floor Coating Materials/ Linings/ Civil Engineering Repair Materials), Adhesives/ Adhesive Ingredients
Bisphenol F Liquid Epoxy Resin	low viscosity low crystallization tendency	Paints and Coatings (Coating Ingredients/ Ink Ingredients), Construction (Floor Coating Materials/ Linings/ Civil Engineering Repair Materials), Adhesives/ Adhesive Ingredients, Electrical and Electronics (Impregnation/ Lamination/ FRP Molding)

Brominated (Flame Retardant Types) Epoxy Resin	High bromine type, solid content 60% toluene solution	Electrical and Electronics (Impregnation/ Lamination/ FRP Molding), Adhesives/ Adhesive Ingredients
Cresol Novolac Epoxy Resin	High viscosity High epoxy index	Electrical and Electronics (Impregnation/ Lamination/ FRP Molding), Adhesives/ Adhesive Ingredients
Phenol/Modified Novolac Epoxy Resin	Viscosity at 52°C (126°F): 600-50,000 cP. Epoxide equivalent weight (EEW): 160 – 270 g/eq.	Paints and Coatings (Coating Ingredients/ Ink Ingredients), Electrical and Electronics (Impregnation/ Lamination/ FRP Molding), Adhesives/ Adhesive Ingredients, Composites
Cycloaliphatic Epoxy Resin	Low-viscosity liquid epoxy, Low viscosity Cycloaliphatic Glycidyl Ether of Hydrogenated Bisphenol-A. Viscosity at 25 degree C Cp - 1800-2500	Electrical and Electronics (Impregnation/ Lamination/ FRP Molding), Adhesives/ Adhesive Ingredients
Dimer Acid modified epoxy resin	Viscosity -50000 cps@52 degree Celsius, EEW (g/eq) – 660	Adhesives/ Adhesive Ingredients
Diamino diphenyl methane-based epoxy resin	N/A	Paints and Coatings (Coating Ingredients/ Ink Ingredients), Adhesives/ Adhesive Ingredients
Para-aminophenol based epoxy resin	low viscosity high temperature high mechanical strength	Paints and Coatings (Coating Ingredients/ Ink Ingredients), Adhesives/ Adhesive Ingredients, Composites

Bisphenol A Liquid: *- Liquid Bisphenol A have standard undiluted liquid epoxy resin having good reactivity and resistance properties with high heat distortion temperature used in multiple application. Viscosity range between 450 to 26,000 mPa-s depending on the application and grade.*

Bisphenol A Solid: *- Solid bisphenol-A-based epoxy resins are a reaction product of lower molecular weight-based bisphenol-A-based epoxy resins. Therefore, solid bisphenol-A-based epoxy resins are mostly used as a part of two-component systems to create epoxy coatings. Viscosity range between 160 to 10,000 mPa.s depending on application.*

Bisphenol F Liquid: - *Bisphenol F liquid is based diglycidyl ether (BFDGE), a stabilizing compound, used alone or as a modifier to improves solvent resistance. The product is known for low viscosity, low crystallization tendency and have better chemical resistance.*

Brominated (Flame Retardant Types)*: - Brominated (flame retardant type) have higher heat resistance compared to other products. Due to its strong durability, binding properties and strong resistance properties, the product is used in electronic application and adhesive industry*

Cresol Novolac*: - The product is used for high temperature adhesives, electrical and laminating product areas. These products have higher viscosity and epoxy index to achieve higher thermal and chemical resistance.*

Cycloaliphatic Epoxy based Resin*: - These products have low-viscosity liquid epoxy. The major application is in outdoor electrical, casting applications and filament winding applications. Low-viscosity cycloaliphatic epoxy recommended for use in the manufacture of medium and high-voltage electrical insulating components.*

Dimer Acid modified epoxy resin: - *Dimer acid modified epoxy resin is an adduct of a DGEBA resin and a dimer fatty acid. At room temperature, it is a semi-solid which requires mild heating to assist flow or pumping.*

Phenol/Modified Novolac Epoxy Resin: *- An epoxy phenol novolac (EPN) is an epoxy resin where the epoxide functional group is attached to the phenolic oxygen of a phenolic novolac. In industrial settings, EPN resins are used for the epoxy coating of tanks, pipes, floors, automotive parts, electronic parts, etc. High chemical, solvent, and temperature resistance of EPNs are especially useful for high-performance applications and corrosion resistance.*

Diamino diphenyl methane-based epoxy resin: *- These epoxies comprise of four functional amine epoxy resins which have been successfully used for carbon fiber reinforced polymers (CFRPs) for primary aircraft structure resins. They are mainly used for CFRPs, heat resistant paints, heat resistant adhesives. This epoxy comes in different grades with different viscosity.*

Para-aminophenol based epoxy resin: - *This is a very reactive polyfunctional specialty epoxy resin based on p-aminophenol. This resin is suitable for high performance fiber reinforced composites, adhesives and coatings. It serves various benefits like high performance, low viscosity, high Tg, high temperature and chemical resistance and high mechanical strength.*

Paints and coatings *–*
Paints and coatings have major application in automotive and other sectors which require high heat resistance and medium viscosity ranges. Therefore, the most suitable epoxy resins for the application in paints and coatings are Bisphenol A Liquid, Bisphenol A Solid, Bisphenol F Liquid, and Phenol/Novolac Epoxy Resin. The viscosity range of Bisphenol A liquid Epoxy resin is from 450 to 26,000 mPa.s.

Electrical and Electronics –
Most of the electrical and electronic products require thermal and electrical resistance. Brominated epoxy resin is therefore used in electronics and electricals due to its flame retardant properties and high electrical insulation. Other epoxy resins that are useful for electronics and electricals include Bisphenol F liquid, Novolac, Phenol, and Cycloaliphatic epoxy resins.

Construction –
Epoxy resins are used in construction for floor coating materials, linings, and repair materials. Therefore, the material used should have high mechanical strength and medium viscosity range. Hence, the most suitable epoxy resins for construction applications include Bisphenol A liquid, Bisphenol A solid and Bisphenol F liquid. Bisphenol F is known for its low viscosity and chemical resistance hence, it is most preferred for construction applications.

Adhesives –
Nearly all the epoxy resins possess adhesive properties, therefore all the epoxy resins are suitable for adhesive applications. Depending upon the final application and the required mechanical strength, the materials can be used in different type of adhesive applications. For example: Brominated Epoxy resins have flame retardant properties therefore, they can be used in the adhesive applications where there is a risk of fire such as circuit boards etc.

Composites –
Phenol/ Modified epoxy resin is the most suitable for composite applications due to the property of high compatibility with other matrix materials such as glass fibre etc. the resin is used in composite materials with the help of dispersion of the matrix material into the resin followed by thermal curing of the material.

2.4 End of Life and Sustainability (Health, Safety & Environment (HSE))

Epoxy resins are classified under different health standard such as Occupational Safety and Health Administration (OSHA)-USA, Workplace Hazardous Material Information System-Canada, EU-OSHA, etc. Health standard hazards are classified and mapped in the table below.

Skin irritation	**Category 2**
Eye irritation	**Category 2B**
Skin sensitisation	**Sub-category 1B**

Epoxy resins have low potential to volatilize from water to air. Further, the material is toxic to aquatic life.

End of the life: Epoxy Resin have shelf life of 24 months when stored in a controlled environment as per guidelines suggested by manufacturers.

Storage and Handling: The product need to be stored in a sealed original container in a well-ventilated area. Further, Epoxy resins need to be stored in a cool and dry place and should be protected from direct sunlight. Containers that have been opened must be carefully resealed and to be kept upright to prevent leakage and to preserve the chemical properties of the product.

Transportation: Sealed containers need to be kept upright during the transit phase. The transportation guidelines are provided by the manufacturing companies, Further, guidelines vary from region to region and company to company.

2.5 Environmental Compliance

Applications and end products consuming epoxies are safe and do not risk to human health. Before application, epoxy resins are typically mixed with a hardener component following which a chemical reaction takes place producing an inert final material. The finished, hardened epoxy resin

does not pose any health risk and offers superior performance. However, production of petroleum-derived epoxy resins and the disposal of epoxy containing components pose several risks to the environment.

There should be no National Parks, Wildlife Sanctuaries, Biosphere reserves, Tiger/ Elephant Reserves, Wildlife corridors etc. within 10 km from the project site.

Ways of treating waste generated while epoxy resin production:

(1) Waste Disposal Method-Incineration

While industrial production of Epoxy Resins, by-products like NaCl and oligomers are also released. NaCl can be removed by washing with water one or more times, depending on the reaction requirement. An aqueous solution of sodium chloride called Brine formed resultantly can be further send to ETP plant for its treatment to decrease its concentration to the optimum level so that it can be disposed to sea or can be sent to Pollution control Board for further use. The resin is separated through filtration while solid polymeric particles (with high K-value) are discarded in a manageable way such as through landfilling. Manufacturers must essentially maintain an adequate ratio of ECH and BPA while Epoxy Resin manufacturing to minimize the waste generated.

(2) Carbon Footprint and Abatement of Epoxy Resin Process

The manufacturing of Epoxy Resin leads to production of various undesirable gases like CO2, CO, NOx, SOx, in addition to these flue gases it also generates particulate matter of various sizes. These products are harmful to environment and in the long run could harm humans and environment. To reduce waste generation, the company should plan for higher capacity power equipment and explore the use of renewable energy to the maximum extent possible. Installation of energy efficient devices and adoption of modes of alternative eco-friendly sources of energy like solar water heater, solar lighting, wind energy etc. are proposed for energy conservation.

For different gaseous emissions, different types of wet scrubbers are installed by the companies which effectively controls the air pollution by removing particles and gases from industrial exhaust streams. It operates by introducing the dirty gas stream with a scrubbing liquid – typically water.

(3) Re-engineering Epoxy's Hardening Component

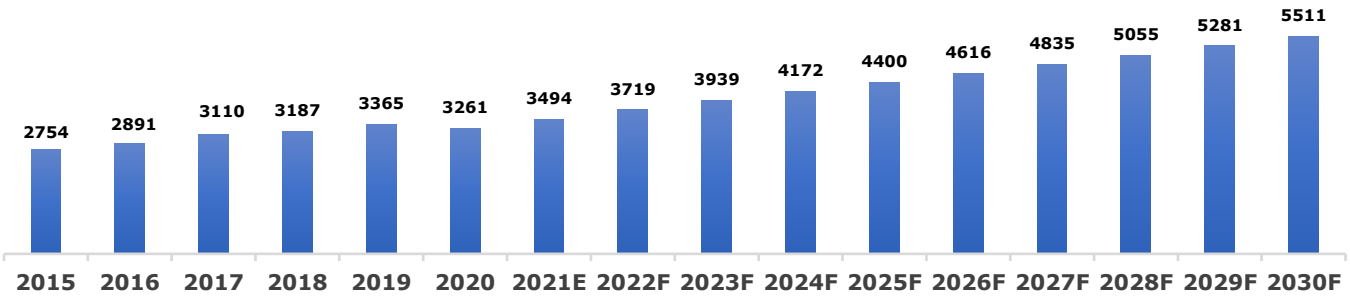
Usually, specially designed cured epoxy (resin and hardener mixed at the proper ratio and completely solidified) is NOT considered a "hazardous waste" and may be disposed of as non-hazardous solid waste material. One such cured Epoxy Resin is "Recyclamine" which can likely be recycled at any facility like other plastic products.

Recylamines are prepared by mixing bisphenol A diglycidyl ether with curing agents having amine groups that react with the ether's epoxide groups to result into hard cross-linked molecules. Recyclamine is the only type of completely recyclable epoxy resin adopted in India till date. Aditya Birla Chemicals acquired the use of Recyclamine Technology from Connora Technologies in 2019. The great thing about epoxies with Recyclamine hardeners is that they can be completely recycled without pyrolysis.

Chapter 3. Market Outlook and Relevance of the Project

3.1. Demand Supply Outlook – Global Epoxy Resin Market

Global Epoxy Resin Demand, By Volume (Thousand Tonnes), 2015–2030F



Source: TechSci Research

2015-2020
CAGR
3.44% By Volume

2021-2030
CAGR
5.19% By Volume

Global Epoxy Resin Demand-Supply Scenario, 2015-2030F (Thousand Tonnes)

Parameters	2015	2020	2021E	2025F	2030F
Installed Capacity	3766	4484	4534	4785	4785
Production	2866	3246	3485	3724	4119
Total Demand	2754	3261	3494	4400	5511
(Y-O-Y Growth Rate *(In Percentage)*	4.25%	-3.08%	7.14%	5.45%	4.37%
Demand – Supply Gap			-9	-676	-1392

Source: TechSci Research

Market Overview (Post Covid)

Global Epoxy Resin Demand Outlook, Realistic, Optimistic and Pessimistic, 2021E - 2030F (Thousand Tonnes)

Demand Scenario	2020	2021E	2024F	2028F	2030F
Realistic	3261	3494	4172	5055	5511
Optimistic	3261	3576	4580	6100	6974
Pessimistic	3261	3395	3718	4008	4121

Source: TechSci Research

Growing Usage for the construction of wind turbine blades

Sharp recovery in growth across the primary markets like automotive and aerospace

Import disruption and unavailability of feedstock resulted in lower operating rate in 2020 and H1 2021

Increased demand of brominated and waterborne epoxy resin

- Market Leader such as Hexion, Olin, Huntsman and Kukdo are leveraging their market position to benefit from secular growth trends in composite sector.
- Wind energy segment will be key drivers for specialized epoxy resin. Global wind energy installation is expected to grow by 8.0 percent range in coming 9 years due to rising awareness in developing countries like India and China.
- Technology enhancement, recovery in housing sector and infrastructure developments are likely to drive future growth.
- Specialty epoxy resin used with carbon composites help in weight reduction, fuel saving and CO2 emission from automobiles. Lightweight material usage in auto sector is anticipated to increase from 28% in 2015 to 47% by 2030.
- The growth of the market is majorly attributed to the reviving economy of the India, China, European Union, GCC Nations and Latin American countries and growing focus on infrastructural development by public and private entities.

Assumptions:

1. Forecasting generally assumes overall economic stability and no significant changes in the industry or market.
2. Historical conditions in the past will not carry over into the future.
3. Operating rate for new unit is considered as 60 percent for 1st year and 90 percent later.
4. Crude oil and commodity prices are likely to stabilize from 2nd half of 2022 onwards.
5. Raw material prices likely to stabilize from 2nd half of 2022 onwards.
6. Covid-19 situation is likely to dimmish from 2023 onwards after global roll out of vaccination.
7. Increased investment in infrastructure and construction sector.
8. BRIC nations will have higher growth in comparison to North America and Europe
9. Increased expenditure in research and development will lead to increased usage of superior grades.
10. The basis of the historic data is secondary databases like annual reports of the competitors, import-export and other socio-economic factors. Forecast has been done through forecast model and primary responses of key opinion leaders.

3.1.1. Capacity By Company & Location

Global Epoxy Resin Capacity, By Company (Thousand Tonnes), 2015-2030F

Company	Location	Capacity*				
		2015	2020	2021E	2025F	2030F
Olin Corporation	USA	170	170	170	170	170
	Germany	170	245	245	245	245
	Brazil	33	33	33	33	33
	Italy	20	20	20	20	20
	China	41	41	41	41	41
Kukdo Chemical Co., Ltd.	China	80	200	200	200	200
	South Korea	160	160	160	160	160
	India	0	40	40	40	40
Huntsman Corporation20	China	64	64	64	64	64
	USA	70	70	70	70	70
	Switzerland	50	120	120	120	120
	Brazil	10	10	10	10	10
Hexion Inc.	Netherlands	70	100	100	100	100
	USA	127	127	127	127	127
	Spain	10	32	32	32	32
Jiangsu Sanmu Group	China	170	220	220	220	220
Nan Ya Plastics Corporation	Taiwan	210	210	230	230	230
	China	247	247	247	247	247
The Dow Chemical Company	China	41	41	41	41	41
	USA	60	60	60	60	60
	South Korea	30	30	30	30	30
	Germany	30	30	30	30	30
	Japan	40	40	40	40	40
Grasim Industries Limited	India	44	66	66	90	90
	Thailand	38	100	100	100	100
Nantong Xincheng Synthetic Material Co Ltd	China	120	130	130	130	130
Nippon Steel Chemical & Material Co., Ltd.	Japan	100	120	120	120	120
NAMA Chemicals	Saudi Arabia	120	120	120	120	120
Zhuhai Hongchang Electronic Material Co Ltd	China	117	117	117	117	117
Chang Chung Plastics Co Ltd	Taiwan	50	100	100	100	100
Jiangsu Yangnong Kumho Chemical Co., Ltd.	China	75	95	95	95	95
Sinopec Baling Petrochemical Co.,Ltd	China	60	80	80	80	80
Kumho P&B Chemicals	South Korea	70	80	80	90	90
Changchun Chemical (Jiangsu) Co., Ltd.	China	75	75	75	75	75
Spolchemie A.S.	Czech Republic	60	60	60	60	60

Alchemie Ltd.	United Kingdom	60	60	60	60	60
Anhui Shanfu New Material Technology Co., Ltd.	China	58	58	58	58	58
Dalian Qihua New Material Co. Ltd.	China	50	50	50	50	50
Atul Limited	India	30	40	40	50	50
Japan Epoxy Resins	Japan	40	40	40	40	40
LEUNA-Harze GmbH	Germany	40	40	40	40	40
Izel Kimya	Turkey	40	40	40	40	40
Ciech Sarzyna	Poland	30	30	30	30	30
SIR Industriale SpA	Italy	20	20	20	20	20
Meghmani Finechem Limited	India	0	0	0	25	25
CHANGZHOU HONGCHANG ELECTRONICS CO	China	0	0	0	70	70
Sinopec Baling Petrochemical Co., Ltd.	China	60	60	60	100	100
Sika AG	Qatar	0	0	15	15	15
Hindusthan Speciality Chemicals Limited (HSCL)	India	0	30	30	30	30
Others	Rest of Global	506	563	578	650	650
Total		3766	4484	4534	4785	4785

Source: TechSci Research

**Only firm capacities (green field and brownfield expansion) have been considered during 2021- 2030 period. As of Q3 2021, five companies are going ahead with the expansion plans. Most of the global capacities other than India, and China are speculative only are in announcement phase and have not received financial closure as of now, hence not considered.*

Majority of epoxy resin capacities are strategically located in China. Rising industrialization and urbanization in developing nations such as India and China will influence the Epoxy Resin producers to expand the capacity in this region. Also, favourable government policies for renewables influences major epoxy resin producers to setup capacity in these countries. On the other hand, Capacities located in Western European and North American countries will show a moderate growth in expansion due to the market slowly reaching to its maturity in these regions. Also, government regulation to commercialize capacity is more stringent in these regions compared to Asia Pacific.

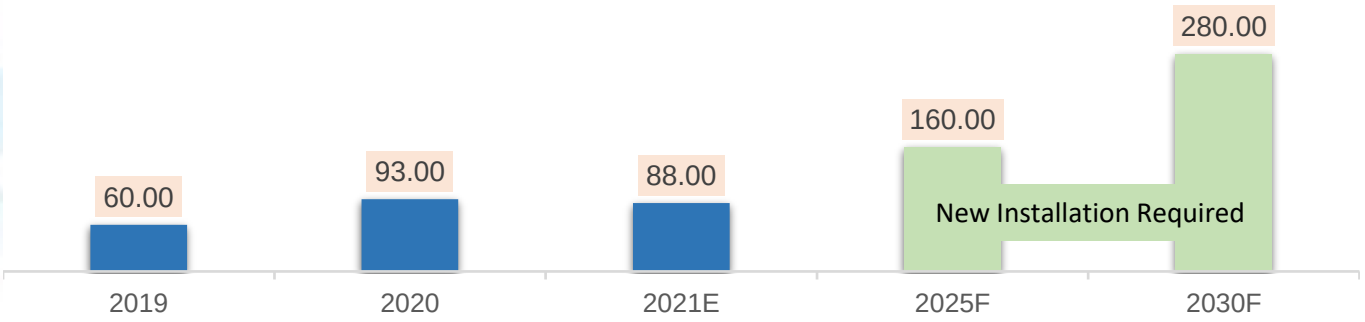
Expected Upcoming Capacities

Country	Project	Estimated Investment	Planned Capacities (000 Tonnes)	Expected Year of commissioning	References
India	Grasim Industries Ltd	USD 15 Million	24 (Brownfield Expansion)	2025	Primary research
China	Changzhou Hongchang Electronics Co	USD 94 Million	140 (Epoxy Resin System	2024	Primary Research

China	Sinopec Baling Petrochemical Co., Ltd.[1]	USD 3 Million	20 (Solid Epoxy Resin Plant)	2023	
Qatar	Sika AG[2]	USD 12 million (Epoxy Resin and Admixture)	15 (Greenfield Expansion)	2021	Company Press Releases
India	Meghmani Finechem Ltd	USD 55 Million	25 (Integrated ECH Epoxy Unit)	2024	Primary research
India	Atul Limited	USD 8 Million	10 (Brownfield Expansion)	2024	Primary research

1. https://www.echemi.com/cms/355037.html
2. https://www.sika.com/en/media/media-releases/2021/sika-exploits-further-growth-potential-in-qatar.html

Global Annual Wind Installation Required Under IEA's NZE2050, (In GW)



Source: IEA

Under the ambit of ambitious Net Zero Emissions by 2050 (NZE2050) target, several countries have introduced targets to achieve net-zero emissions by 2050. These targets are included and achieved in the sustainable development scenario (SDS). The investment in renewable sector to achieve net zero emissions target would be immense and estimated to be USD120 billion by 2030, with about one-third of that on strengthening and expanding the wind energy sector.

3.1.2. Production By Company

Global Epoxy Resin Production, By Company (Thousand Tonnes), 2015-2030F

Company	2015	2020	2021E	2025F	2030F
Olin Corporation	324	337	368	408	442
Kukdo Chemical Co., Ltd.	187	238	258	262	291
Huntsman Corporation	144	177	179	188	212
Nan Ya Plastics Corporation	402	408	426	420	470
Hexion Inc.	160	180	196	210	236
Jiangsu Sanmu Group	137	165	175	172	198
The Dow Chemical Company	149	153	156	162	178
Grasim Industries Limited	57	123	131	165	173
Nantong Xincheng Synthetic Material Co Ltd	99	100	106	101	117
Nippon Steel Chemical & Material Co., Ltd.	82	99	97	106	114
NAMA Chemicals	91	90	88	94	106
Zhuhai Hongchang Electronic Material Co Ltd	102	91	98	99	111
Chang Chung Plastics Co Ltd	37	69	77	80	90
Jiangsu Yangnong Kumho Chemical Co., Ltd.	61	71	76	74	86
Sinopec Baling Petrochemical Co.,Ltd	51	67	69	68	76
Kumho P&B Chemicals	55	57	61	72	79
Changchun Chemical (Jiangsu) Co., Ltd.	64	57	60	59	68
Spolchemie A.S.	44	44	45	48	53
Alchemie Ltd.	44	42	47	49	54
Anhui Shanfu New Material Technology Co., Ltd.	45	48	50	49	55
Dalian Qihua New Material Co. Ltd.	41	41	40	39	45
Atul Limited	19	29	32	44	45
Japan Epoxy Resins	30	28	29	30	34
LEUNA-Harze GmbH	30	24	26	28	31
Izel Kimya	31	34	35	36	38
Ciech Sarzyna	20	20	23	24	26
SIR Industriale SpA	15	14	15	16	18
Meghmani Finechem Limited	0	0	0	13	21
CHANGZHOU HONGCHANG ELECTRONICS CO	0	0	0	53	60
Sinopec Baling Petrochemical Co., Ltd.	51	67	69	83	93
Sika AG	0	0	9	14	14
Hindusthan Speciality Chemicals Limited (HSCL)	0	16	21	25	25
Others	294	357	423	434	461
Total	2866	3246	3485	3724	4119

Source: TechSci Research

3.1.3. Operating Efficiency by Company

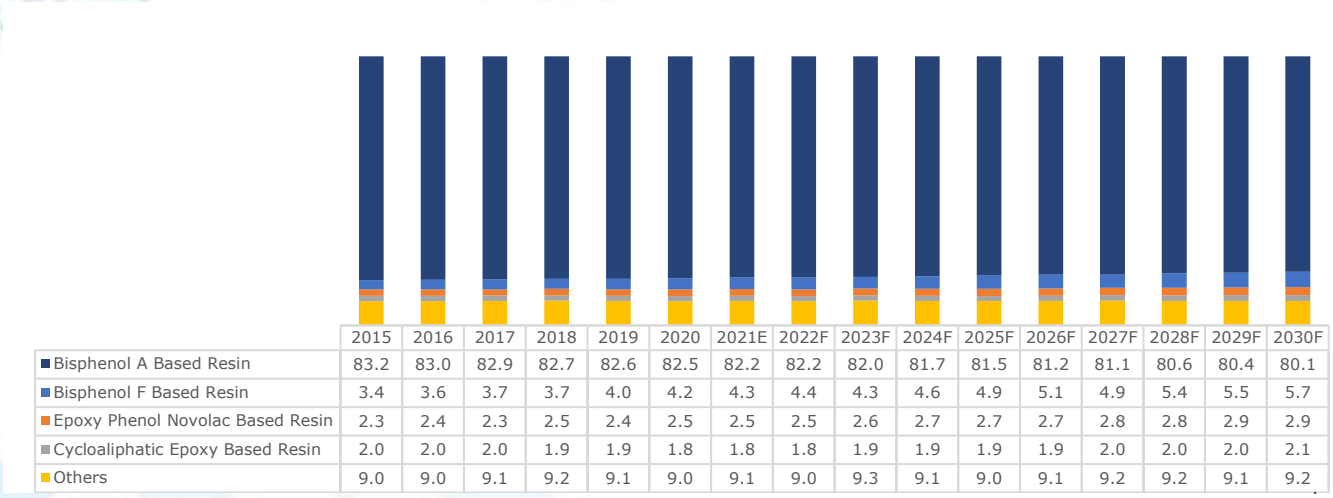
Global Epoxy Resin Capacity, Operating Efficiency, By Company (Percentage), 2015-2030F

Company	2015	2020	2021E	2025F	2030F
Olin Corporation	75	66	72	80	87
Kukdo Chemical Co., Ltd.	78	60	65	66	73
Huntsman Corporation	74	67	68	71	80
Nan Ya Plastics Corporation	88	89	89	88	99
Hexion Inc.	77	69	76	81	91
Jiangsu Sanmu Group	81	75	80	78	90
The Dow Chemical Company	74	76	78	81	89
Grasim Industries Limited	70	74	79	87	91
Nantong Xincheng Synthetic Material Co Ltd	83	77	82	78	90
Nippon Steel Chemical & Material Co., Ltd.	82	83	81	88	95
NAMA Chemicals	76	75	73	78	88
Zhuhai Hongchang Electronic Material Co Ltd	87	78	84	85	95
Chang Chung Plastics Co Ltd	74	69	77	80	90
Jiangsu Yangnong Kumho Chemical Co., Ltd.	81	75	80	78	91
Sinopec Baling Petrochemical Co.,Ltd	85	84	86	85	95
Kumho P&B Chemicals	79	71	76	80	88
Changchun Chemical (Jiangsu) Co., Ltd.	85	76	80	79	91
Spolchemie A.S.	73	73	75	80	88
Alchemie Ltd.	73	70	78	82	90
Anhui Shanfu New Material Technology Co., Ltd.	78	83	86	84	95
Dalian Qihua New Material Co. Ltd.	82	82	80	78	90
Atul Limited	63	73	80	88	90
Japan Epoxy Resins	75	70	73	75	85
LEUNA-Harze GmbH	75	60	65	70	78
Izel Kimya	78	85	88	90	95
Ciech Sarzyna	67	67	77	80	87
SIR Industriale SpA	75	70	75	80	90
Meghmani Finechem Limited	0	0	0	52	84
CHANGZHOU HONGCHANG ELECTRONICS CO	0	0	0	75	85
Sinopec Baling Petrochemical Co., Ltd.	0	0	0	83	93
Sika AG	0	0	60	90	90
Hindusthan Speciality Chemicals Limited (HSCL)	0	53	70	83	83
Others	58	66	76	67	71

Source: TechSci Research

3.1.4. Demand By Type

Global Epoxy Resin Demand, By Type (Thousand Tonnes) (%), 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Bisphenol A Based Resin	83.2	83.0	82.9	82.7	82.6	82.5	82.2	82.2	82.0	81.7	81.5	81.2	81.1	80.6	80.4	80.1
Bisphenol F Based Resin	3.4	3.6	3.7	3.7	4.0	4.2	4.3	4.4	4.3	4.6	4.9	5.1	4.9	5.4	5.5	5.7
Epoxy Phenol Novolac Based Resin	2.3	2.4	2.3	2.5	2.4	2.5	2.5	2.5	2.6	2.7	2.7	2.7	2.8	2.8	2.9	2.9
Cycloaliphatic Epoxy Based Resin	2.0	2.0	2.0	1.9	1.9	1.8	1.8	1.8	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.1
Others	9.0	9.0	9.1	9.2	9.1	9.0	9.1	9.0	9.3	9.1	9.0	9.1	9.2	9.2	9.1	9.2

Source: TechSci Research

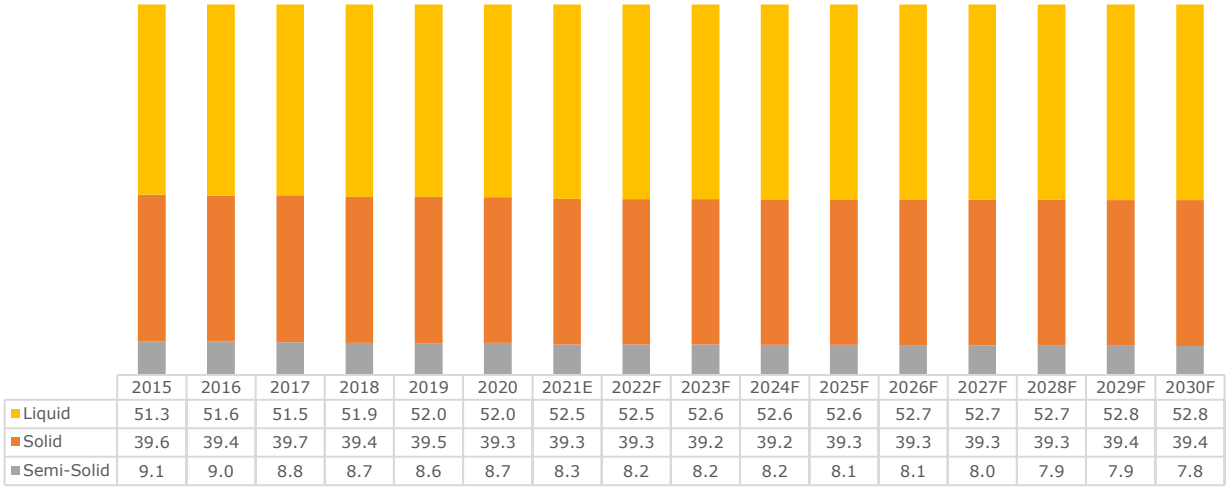
Demand by Type	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Bisphenol A Based Resin	2291	2401	2579	2636	2780	2689	2872	3585	4415
Bisphenol F Based Resin	95	103	115	118	134	137	150	217	315
Epoxy Phenol Novolac Based Resin	64	69	72	78	82	81	89	118	160
Cycloaliphatic Epoxy Based Resin	56	57	61	61	64	59	65	82	116
Others	248	261	284	294	305	295	319	398	505
Total	**2754**	**2891**	**3110**	**3187**	**3365**	**3261**	**3494**	**4400**	**5511**

Source: TechSci Research

- Bisphenol A (BPA) based Epoxy resins continues to pull strong number in terms of demand by type. However, increasing awareness towards harmful impacts of BPA and advent of several alternatives for production of Epoxy resins have resulted in consumers opting for comparatively safer alternatives.
- Recently, Bisphenol F based Epoxy resins have gained traction in the market and is likely to consolidate on the demand numbers in the coming years.
- Despite a dip in demand for BPA based Epoxy resins in last few years, they continue to dominate the market and are likely to maintain a large segment of demand in the coming decade.

3.1.5. Demand By Grade

Global Epoxy Resin Demand, By Grade (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Liquid	51.3	51.6	51.5	51.9	52.0	52.0	52.5	52.5	52.6	52.6	52.6	52.7	52.7	52.7	52.8	52.8
Solid	39.6	39.4	39.7	39.4	39.5	39.3	39.3	39.3	39.2	39.2	39.3	39.3	39.3	39.3	39.4	39.4
Semi-Solid	9.1	9.0	8.8	8.7	8.6	8.7	8.3	8.2	8.2	8.2	8.1	8.1	8.0	7.9	7.9	7.8

Demand by Grade	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Liquid	1414	1493	1602	1655	1748	1695	1833	2315	2911
Semi-Solid	250	261	275	277	288	284	289	357	430
Solid	1090	1138	1234	1255	1328	1283	1371	1727	2170
Total	**2754**	**2891**	**3110**	**3187**	**3365**	**3261**	**3494**	**4400**	**5511**

Source: TechSci Research

- Liquid epoxy resin remained the most widely used grade of epoxy which is heavily used across various sectors of applications and likely to grow further in coming years.
- Solid epoxy resin was also not far behind from liquid epoxy in absolute terms whose demand is likely to remain stable.
- The demand of semi solid is anticipated to grow at slower rate than liquid and solid grade due to its diminishing use in various end user industry.

3.1.6. Global Demand-Supply Gap

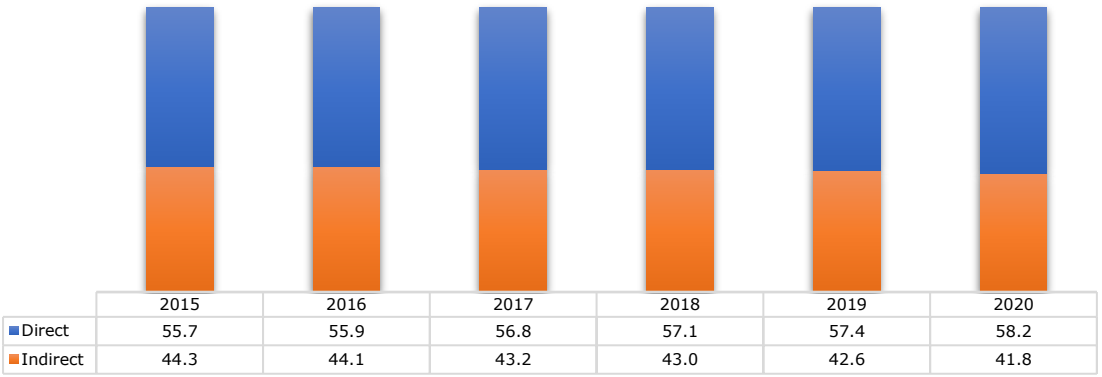
Global Epoxy Resin Market Demand-Supply Analysis, By Volume (Thousand Tonnes), 2015-2030F

	2015	2016	2018	2019	2020	2021E	2025F	2030F
Capacity	3766	3796	4284	4419	4484	4519	4648	4648
Production	2866	2986	3328	3470	3246	3485	3724	4119
Total Demand	2754	2891	3187	3365	3261	3494	4400	5511
Demand Supply Gap						-9	-676	-1392

Source: TechSci Research

3.1.7. Demand By Sales Channel

Global Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, 2015–2030F



Source: TechSci Research

Demand by Sales Channel	2015	2016	2017	2018	2019	2020
Direct Company Sale	1535	1615	1767	1818	1931	1899
Indirect	1219	1276	1343	1369	1433	1362
Total	**2754**	**2891**	**3110**	**3187**	**3365**	**3261**

Source: TechSci Research

3.1.8. Demand By Application

Global Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, 2015–2030F

	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Paints & Coatings	42.5	42.8	42.7	42.6	42.7	42.4	42.7	42.9	43.0	43.0	43.2	43.3	43.4	43.5	43.5	43.6
Electrical & Electronics	25.3	25.4	25.6	25.5	25.8	25.8	26.1	26.2	26.3	26.3	26.4	26.4	26.5	26.5	26.6	26.6
Composite Materials	11.7	11.9	11.9	12.1	11.9	11.6	11.5	11.4	11.4	11.4	11.3	11.3	11.3	11.2	11.2	11.2
Construction	9.5	9.4	9.5	9.4	9.4	9.2	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3
Adhesives	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.6
Others	4.6	3.9	3.8	3.8	3.7	4.4	4.0	3.8	3.5	3.5	3.2	3.1	3.0	2.9	2.8	2.7

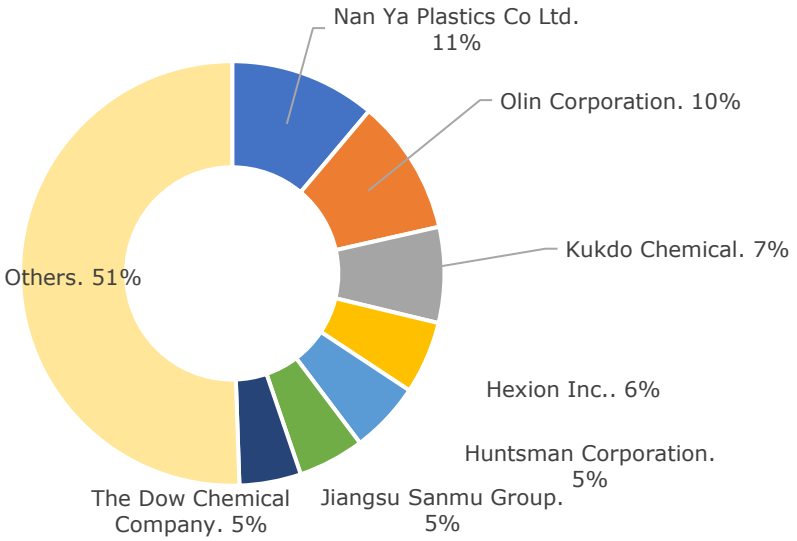
Source: TechSci Research

Demand by Application	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Paints & Coatings	1170	1238	1332	1362	1440	1386	1493	1902	2400
Electrical & Electronics	699	737	800	821	871	843	911	1159	1460
Construction	251	262	282	289	307	291	311	394	497
Composite Materials	328	347	370	380	400	381	407	506	630
Adhesives	172	185	198	204	214	208	223	283	356
Others	134	122	128	131	133	153	148	156	169
Total	**2754**	**2891**	**3110**	**3187**	**3365**	**3261**	**3494**	**4400**	**5511**

Source: TechSci Research

3.1.9. Sales By Company

Global Epoxy Resin Sales, By Company, By Volume, 2020



Others include Poliya, Hexion Inc., DIC Corporation, Saudi Arabia Industrial Resins Ltd.., Reinhold GmbH, Interplastic Corporation, Allnex Group, Sewon Chemical, Innovative Resins Pvt. Ltd., Orson Chemicals etc.

Source: TechSci Research

3.1.10. Demand By Region

Region/Country	2015	2020	2021E	2025F	2030F	CAGR (2015-2020)	CAGR (2021E-2030F)
Asia Pacific	1594	2040	2200	2870	3675	5.06%	5.87%
China	1205	1559	1714	2280	2924	5.30%	6.10%
South Korea	77	91	97	121	156	3.30%	5.40%
India	65	89	98	140	208	6.30%	8.70%
Others	247	302	292	330	386	4.10%	3.20%
Global APAC (Percentage Share)	57.90%	62.60%	63.00%	65.20%	66.70%		
Europe	507	551	582	675	822	1.67%	3.91%
Germany	131	153	161.4	191.6	226.2	3.20%	3.80%
Spain	29.2	31.4	33	38.2	44.4	1.50%	3.40%
Italy	68.5	65.1	68.8	80.7	94	-1.00%	3.50%
Others	278.2	301	318.9	364.6	457.2	1.60%	4.10%
Global Europe (Percentage Share)	18.40%	16.90%	16.70%	15.30%	14.90%		
North America	299	317	335	397	465	1.16%	3.73%
USA	240.5	253	260.3	291.4	326.6	1.00%	2.60%
Canada	36.8	47.2	56.8	84.1	112	5.10%	7.80%
Others	21.5	16.4	17.6	21.6	26.7	-5.20%	4.70%

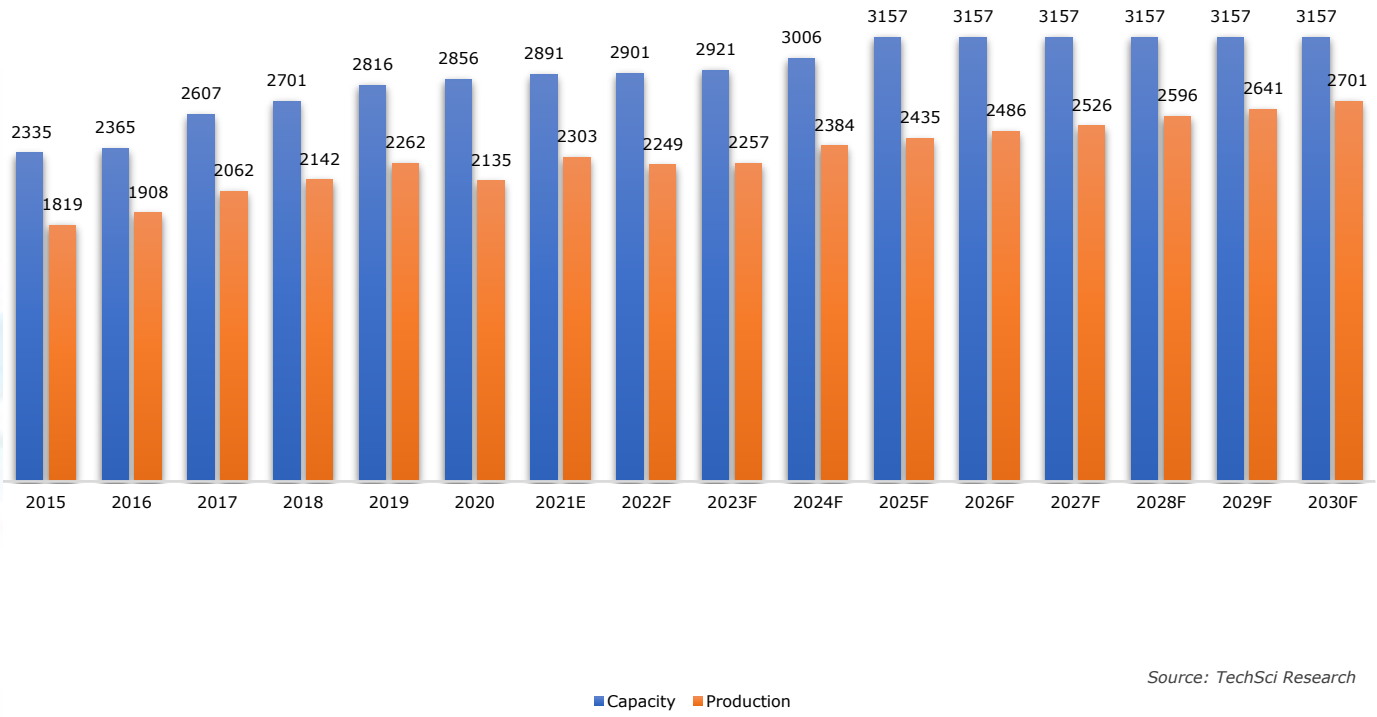
Global North America (Percentage Share)	10.90%	9.70%	9.60%	9.00%	8.40%		
South America	80	83	88	105	124	0.81%	3.94%
Brazil	58.7	62.6	65.8	78.5	93.1	1.30%	3.90%
Others	20.9	20.3	21.8	26.2	30.9	-0.60%	4.00%
Global South America (Percentage Share)	2.90%	2.50%	2.50%	2.40%	2.20%		
Middle East and Africa	274	271	289	352	425	-0.21%	4.38%
Saudi Arabia	54.6	60.1	63.5	80.5	107.7	1.90%	6.10%
Turkey	21.2	20.5	21.3	26	35.3	-0.70%	5.80%
Others	198	190.4	204.4	246	282.3	-0.80%	3.70%
Global MEA (Percentage Share)	9.90%	8.30%	8.30%	8.00%	7.70%		
Asia Pacific	1594	2040	2200	2870	3675	5.05%	5.86%
Europe	507	551	582	675	822	1.67%	3.91%
North America	299	317	335	397	465	1.16%	3.73%
South America	80	83	88	105	124	0.81%	3.94%
Middle East and Africa	274	271	289	352	425	-0.21%	4.38%
Global	2754	3261	3494	4400	5511	3.44%	5.19%

Source: TechSci Research

Region wise, Asia Pacific holds the major share of the global demand for Epoxy Resin with a market share of 62.6% in 2020, which is expected to rise gradually during the forecast period to around 66.68% in 2030. Epoxy Resin has major applications in areas like wind energy, automotive, electrical & electronics and other areas having a demand for high-performance materials with chemical resistance properties. Asia pacific, being home to the China & India are the developing & world's most populated country, so demand can directly link to this & simultaneously expected to have high demand in the forecast period. With the countries moving towards more and more sustainable energy solutions, the demand for wind energy is expected to grow exponentially in Asia Pacific during the forecast period; hence the region will keep the lion's share of global demand for Epoxy Resin.

ASIA PACIFIC EPOXY RESIN MARKET OUTLOOK

3.2.1. APAC Epoxy Resin Capacity & Production, By Volume, 2015 - 2030F (Thousand Tonnes)



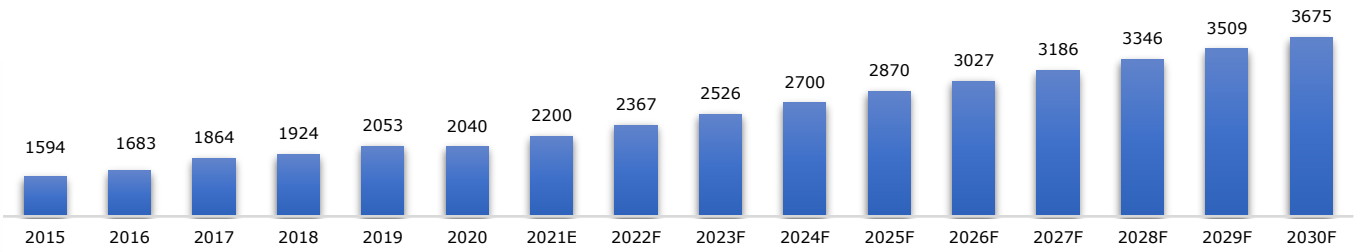
Source: TechSci Research

3.2.2. Capacity By Location

Company	Location	2015	2020	2030F
Nan Ya Plastics Corporation	China	247	247	247
	Taiwan	210	210	230
Kukdo Chemical Co., Ltd.	India	0	40	40
	China	80	200	200
	Taiwan	160	160	160
Jiangsu Sanmu Group	China	170	220	220
Nantong Xincheng Synthetic Material Co Ltd	China	120	130	130
Others	Rest of APAC	1348	1649	1930
Total		**2335**	**2856**	**3157**

3.2.3. Asia Pacific Demand

Asia Pacific Epoxy Resin Demand, By Volume (Thousand Tonnes), 2015–2030F



2015-2020

CAGR

5.05%% By Volume

2021E-2030F

CAGR

5.86% By Volume

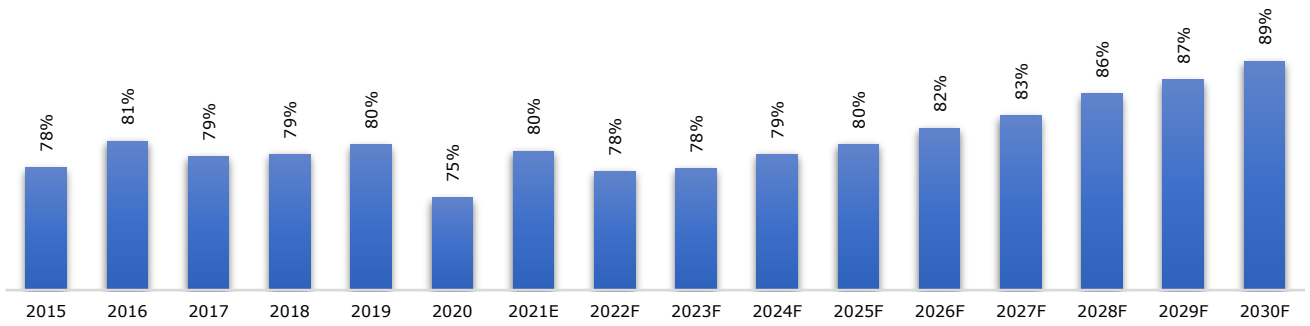
Source: TechSci Research

Approach: Growth Forecast Via Factors (Impact Analysis)				
Factors	**Sources**	**Value**	**CAGR**	**Weightage**
GDP Growth Rate (2021-2030 Period_	*World Bank, IMF, TechSci Estimates*	*Forecast*	6.12%	14.00%
GDP Per Capita (%)	*World Bank, IMF, TechSci Estimates*	*Forecast*	4.12%	5.00%
Average Selling Growth (%)	*TechSci Research Estimates*	*Forecast*	2.73%	3.00%
Growth in Construction Sector	*TechSci Research Estimates*	*Forecast*	6.12%	20.00%
Growth in Renewable Sector	*TechSci Research Estimates*	*Forecast*	7.00%	20.00%
Growth in Automotive Sector	*OICA*	*Forecast*	5.10%	12.00%
Paint & Coating Industry Growth	*Industry Sources & TechSci Research Estimates*	*Forecast*	6.00%	18.00%
Market Growth in Historical Period (2015-2020)	*Industry Sources & TechSci Research Estimates*	*Historical*	5.05%	8.00%
CAGR (2021-2030)	**5.86%**			

TechSci Research has followed this approach to calculate the growth rates by understanding the impact of various factors of the industry. These factors were given weightage according to the relative importance of each factor. Finally, each factor was multiplied with its weightage and their sum was used to calculate market growth.

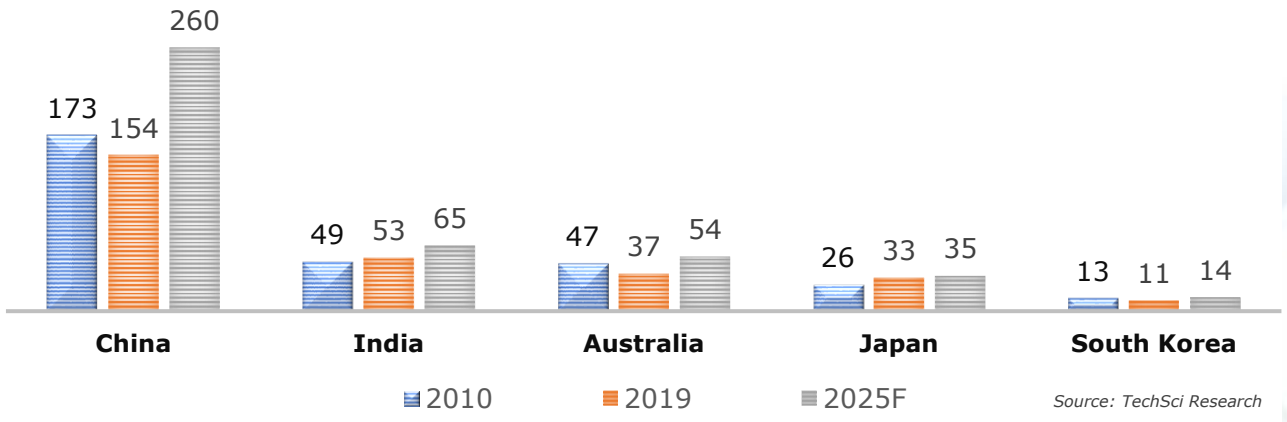
3.2.4. Operating Efficiency

Asia Pacific Epoxy Resin Operating Efficiency (Percentage), 2015-2030F



Source: TechSci Research

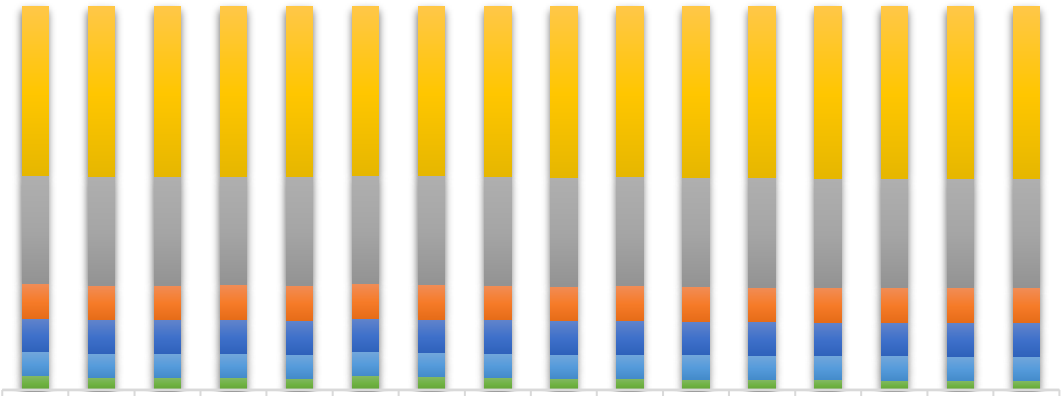
Asia Pacific Growth Trend in Foreign Direct Investment, (USD Billion), 2010, 2019 & 2025F



Source: TechSci Research

3.2.5. Demand By Application

Asia Pacific Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Paints & Coatings	44.0	44.4	44.3	44.2	44.2	44.0	44.1	44.3	44.4	44.3	44.5	44.6	44.7	44.7	44.7	44.8
Electrical & Electronics	28.2	28.3	28.4	28.4	28.4	28.4	28.4	28.4	28.5	28.5	28.5	28.5	28.5	28.5	28.6	28.6
Construction	9.1	9.1	9.1	9.2	9.2	9.0	9.0	9.0	9.0	9.0	9.1	9.1	9.1	9.1	9.1	9.1
Composite Materials	8.8	8.8	8.8	8.8	8.8	8.7	8.7	8.7	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
Adhesives	6.3	6.3	6.3	6.3	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.4
Others	3.7	3.3	3.2	3.2	3.1	3.7	3.5	3.3	3.1	3.1	2.8	2.7	2.6	2.5	2.5	2.4

Others Marine, Defence, Encapsulation etc.

Source: TechSci Research

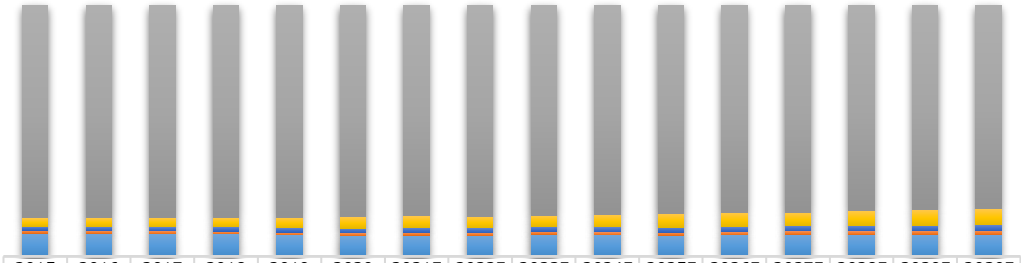
Demand by Application	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Paints & Coatings	702	747	825	850	907	897	971	1278	1646
Electrical & Electronics	450	476	529	546	583	578	625	818	1050
Construction	144	153	170	176	190	184	199	260	334
Composite Materials	140	147	164	169	181	178	192	252	324
Adhesives	100	105	116	121	128	128	138	181	233
Others	58	55	60	62	64	75	75	81	88
Total	**1594**	**1683**	**1864**	**1924**	**2053**	**2040**	**2200**	**2870**	**3675**

Source: TechSci Research

Coating	Composites	Electronics	Construction
Demand of Liquid and Solid Epoxy Resin witnessed a strong demand from Auto and Consumer durable leading to uptick in realization and sales volume in China, India, South Korea and Thailand.	Demand for composites from renewables, marine and aerospace are rising due to rapid urbanization and industrial and aviation sector growth and considerable opportunities exist for specialized epoxy resin manufacturers to tap the growing market in Asia Pacific region.	Growing IoT ecosystem is expected to uplift demand for electronics products in coming years. Northeast Asia, with the highest concentration of electronic component manufacturing, seems to be making aggressive moves towards expanding their facilities to match global demand. The region holds the largest share in the market.	Construction industry will be focusing on major investments in the housing, energy, and utility infrastructure. According to estimates, the construction industry in APAC region is likely to grow by 7.8% in 2021 after a slowdown in the past year due to COVID-19.

3.2.6. Demand By Type

Asia Pacific Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Bisphenol A Based Resin	84.6	84.5	84.4	84.3	84.4	84.2	83.9	83.9	83.5	83.2	82.8	82.5	82.4	81.7	81.4	81.1
Bisphenol F Based Resin	3.5	3.6	3.8	3.8	4.2	4.6	4.6	4.7	4.5	5.0	5.5	5.7	5.3	6.1	6.2	6.4
Epoxy Phenol Novolac Based Resin	1.5	1.6	1.5	1.8	1.7	1.8	1.9	1.8	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.2
Cycloaliphatic Epoxy Based Resin	1.2	1.2	1.2	1.1	1.2	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.3	1.4	1.5
Others	9.3	9.2	9.1	9.0	8.5	8.3	8.5	8.4	8.8	8.5	8.5	8.6	8.9	8.8	8.8	8.8

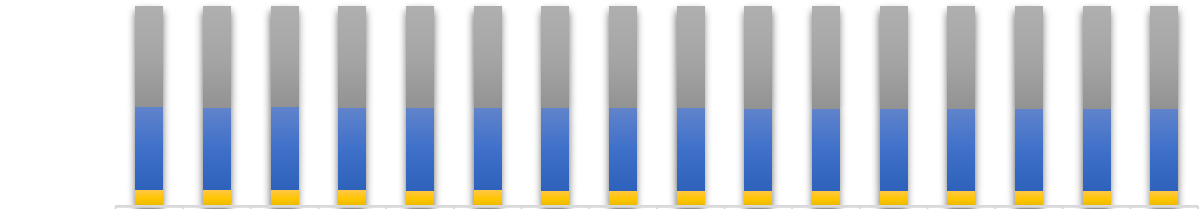
Source: TechSci Research

Demand by Type	2015	2016	2017	2018	2019	2020	2021F	2025F	2030F
Bisphenol A Based Resin	1348	1421	1573	1622	1732	1718	1846	2378	2979
Bisphenol F Based Resin	55	61	71	73	87	93	102	158	237
Epoxy Phenol Novolac Based Resin	24	26	28	34	35	37	41	58	79
Cycloaliphatic Epoxy Based Resin	19	20	22	22	24	22	25	34	56
Others	148	155	170	173	175	170	186	242	324
Total	**1594**	**1683**	**1864**	**1924**	**2053**	**2040**	**2200**	**2870**	**3675**

Source: TechSci Research

3.2.7. Demand By Grade

Asia Pacific Epoxy Resin Demand, By Grade (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Liquid	50.1	50.4	50.2	50.4	50.4	50.6	50.7	50.7	50.7	50.8	50.8	50.8	50.9	50.9	50.9	50.9
Solid	41.4	41.1	41.5	41.3	41.5	41.2	41.2	41.2	41.2	41.2	41.2	41.2	41.3	41.3	41.3	41.3
Semi-Solid	8.5	8.4	8.3	8.3	8.2	8.2	8.1	8.1	8.1	8.0	8.0	8.0	7.9	7.9	7.8	7.8

Source: TechSci Research

Demand by Grade	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Liquid	799	849	935	970	1034	1032	1115	1458	1872
Semi-Solid	135	142	155	159	168	168	179	229	285
Solid	660	692	774	794	851	840	907	1183	1519
Total	**1594**	**1683**	**1864**	**1924**	**2053**	**2040**	**2200**	**2870**	**3675**

Source: TechSci Research

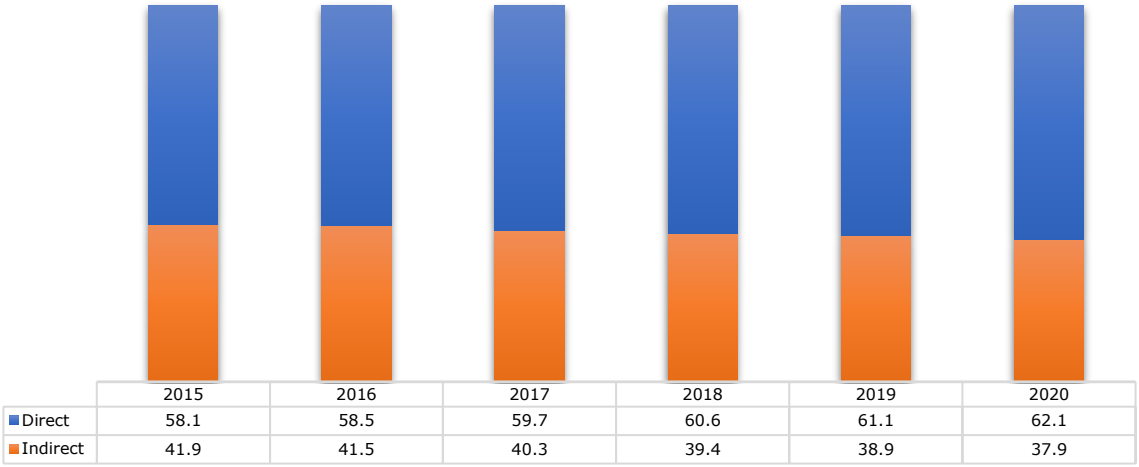
3.2.8. Asia-Pacific Epoxy Resin Market Demand-Supply Analysis, By Volume, 2015-2030F (Thousand Tonnes)

	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Capacity	2335	2365	2607	2701	2816	2856	2891	3030	3030
Production	1819	1908	2062	2142	2262	2135	2303	2435	2701
Import	383	417	464	446	474	556			
Export	607	642	662	665	683	650			
Total Demand	1594	1683	1864	1924	2053	2040	2200	2870	3675
Demand Supply Gap							102	-435	-974

Source: TechSci Research

3.2.9. Demand By Sales Channel

Asia Pacific Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020
Direct	58.1	58.5	59.7	60.6	61.1	62.1
Indirect	41.9	41.5	40.3	39.4	38.9	37.9

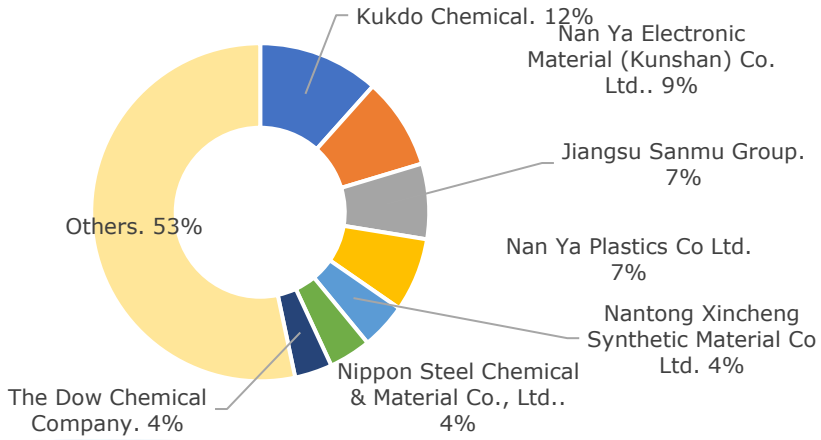
Source: TechSci Research

Demand by Sales Channel	2015	2016	2017	2018	2019	2020
Direct Company Sale	927	984	1113	1165	1255	1266
Indirect	667	699	751	758	798	774
Total	**1594**	**1683**	**1864**	**1924**	**2053**	**2040**

Source: TechSci Research

3.2.10. Sales By Company

Asia Pacific Epoxy Resin Sales, By Company, By Volume, 2020



Region	Demand Volume Share (%)	2020	2021E	2020	2021E
Asia Pacific	Kukdo Chemical	238	221	11.61%	10.87%
Asia Pacific	Nan Ya Electronic Material (Kunshan) Co. Ltd.	179	189	8.74%	9.28%
Asia Pacific	Jiangsu Sanmu Group	148	151	7.22%	7.44%
Asia Pacific	Nan Ya Plastics Co Ltd	144	147	7.06%	7.21%
Asia Pacific	Nantong Xincheng Synthetic Material Co Ltd	90	87	4.42%	4.29%
Asia Pacific	Nippon Steel Chemical & Material Co., Ltd.	82	88	4.04%	4.32%
Asia Pacific	The Dow Chemical Company	73	80	3.59%	3.95%
Asia Pacific	Others	1094	1073	53.32%	52.64%

Source: TechSci Research

APAC Epoxy Resin Sales, By Company, By Volume, 2020

Driven by the outstanding performance in the electronics sector in the APAC region, particularly in China and Japan where a trend has been observed which shows increase in the disposable incomes of the middle class. Consequently, sharp rise in demand has also been witnessed consolidating on the substantial growth in electronics and gadgets. Kukdo Chemical a highly specialized company which manufactures highest quality of epoxy resin in the market hold around 11 percent share in Asia Pacific region in 2020. Building on the growth in consumer electronics industry in Asia Pacific region, Nan Ya Electronic Material another key player in the APAC has observed significant growth in its epoxy numbers. The company hold 8.74 percent share in 2020

and is anticipated to increase its market hold in APAC region. Moreover, Market participants will further look to gain from the strengthening construction sector which has been led by infrastructure development and residential buildings.

APAC Market Insights

The Asia Pacific Epoxy Resin market has registered a CAGR of 5.05% between 2015-2020 and is anticipated to grow at a CAGR of 5.86% in the period of forecast. As per ChemAnalyst report, the regional Epoxy Resin demand currently stands at 2200 thousand tonnes and is anticipated to reach 3675 thousand tonnes by 2030. The region's total Epoxy Resin capacity is 2891 KTPA and the region's cumulative operating efficiency stands around 77.51% in the estimated year (2021).

While China leads the ranks of countries having strong FDIs, a gradual shift in the interest of global players since the pandemic, poses a risk to the country's industrial progress. Strong FDIs in India due to favourable government policies like PLI scheme, Atmanirbhar Bharat Mission and incentivisation of MSMEs are likely to support FDIs in the Indian Epoxy Resin industry and propel the market growth in the period of forecast. As per our market projections, due to favourable conditions, India is likely attract FDIs worth USD 65 Billion by 2025.

Based on application, the Asian Epoxy Resin market has been segmented into Paints and Coatings, Electrical and Electronics, Construction, Composite Materials, Adhesives and Others. Paints and Coatings region's total demand. Paints and Coatings sector reported strong growth since 2016 on account of strong performances from construction and automotive sectors. However, since then stabilization has been observed in sector epitomizing the slowdown in economies in APAC region. Furthermore, demand measured a sharp decline in 2020 due to consumption weakening from the key application sectors. Strong signs of improvement have been evident in 2021 for paints and coatings industry as construction sector accelerated consumption after the slump of 2020. On the back of demand strengthening from downstream sectors, it has been estimated that Paints and Coatings industry will be revived in terms of demand by application and is projected to consolidate on 2021 impetus. Technological advancements in the material sciences are likely to affirmatively impact the demand growth trajectory for composite materials after the decline in demand in 2020 due to halt in manufacturing

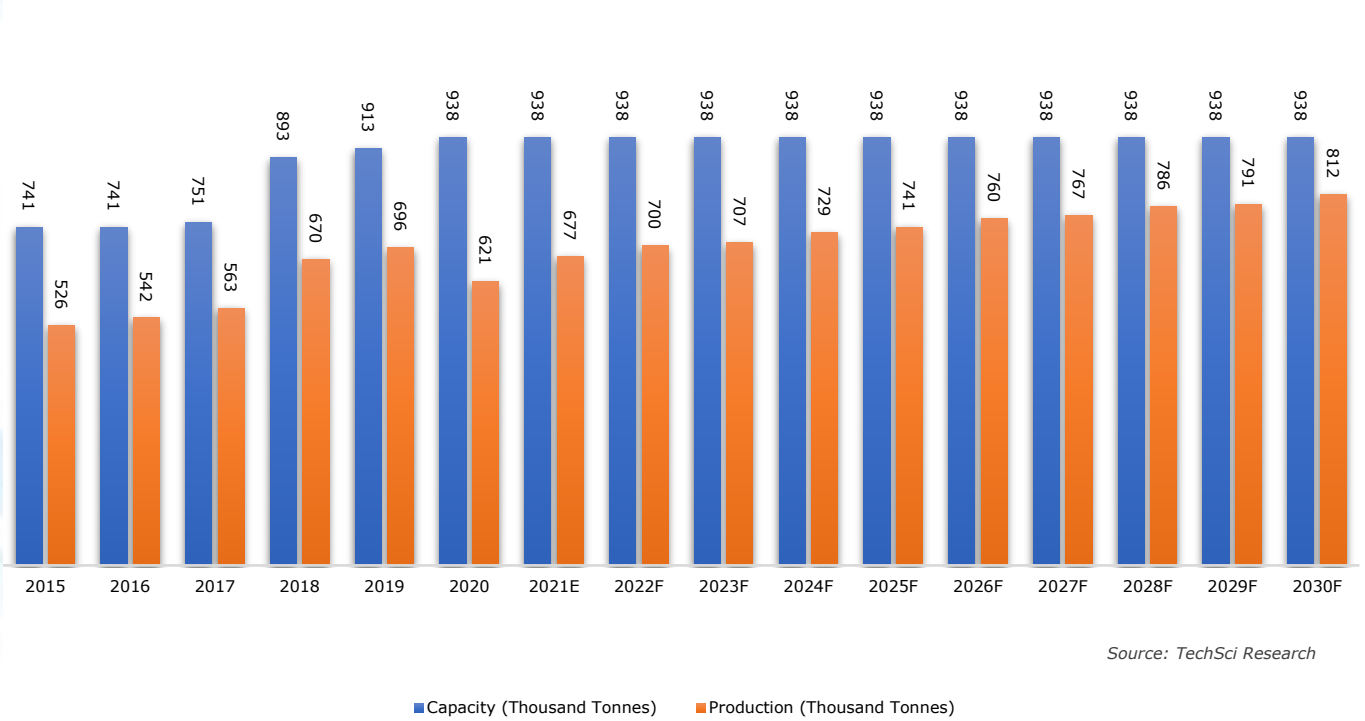
activities around the globe. Aerospace and defence industries are paving for improved consumption and spearheading demand for composite materials.

Based on type, Bisphenol A (BPA)-based Epoxy Resins continue to pull strong number from the total market. However, increasing awareness towards harmful impacts of BPA and advent of several alternatives for production of Epoxy Resins have resulted in consumers opting for comparatively safer alternatives. Recently, Bisphenol F based Epoxy Resins have gained traction in the market and is likely to consolidate on the demand numbers in the coming years. Despite a dip in demand for BPA based Epoxy Resins in last few years, they continue to dominate the APAC Epoxy Resin market and are likely to maintain a large segment of the demand in the coming decade.

By Grade, Liquid Epoxy Resin (LER) remained the most widely used grade of Epoxy, holding demand share of around 50% in 2021. LERs are heavily used across various sectors of applications and likely to grow further in coming years. Solid Epoxy Resins are not far behind from liquid Epoxy and its demand is likely to remain stable in the period of forecast. Epoxy Resins are mostly available to the buyers via Direct Company sales.

EUROPE
EPOXY RESIN
MARKET OUTLOOK

3.3.1 Europe Epoxy Resin Capacity & Production, By Volume (Thousand Tonnes), 2015 - 2030F



Source: TechSci Research

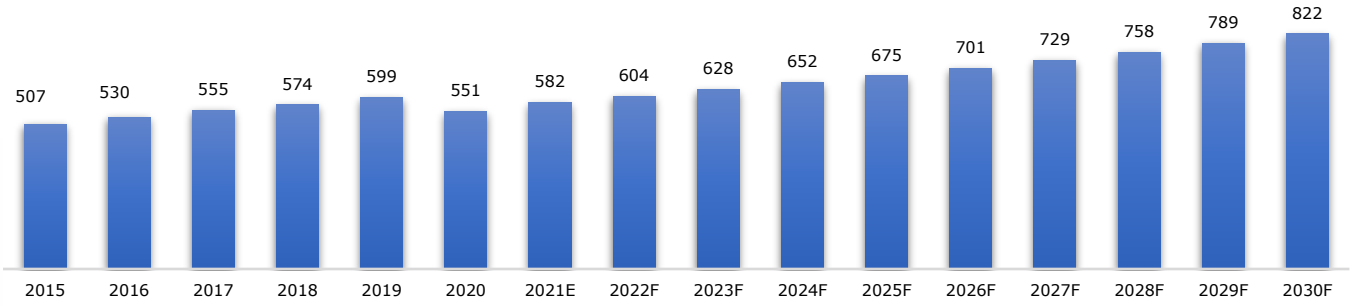
3.3.2. Capacity By Location, By Volume (Thousand Tonnes)

Company	Location	2015	2020	2030F
Olin Corporation	Germany	170	245	245
	Italy	20	20	20
Hexion Inc.	Spain	10	32	32
	Netherlands	70	100	100
Huntsman Corporation	Switzerland	50	120	120
Alchemie Ltd.	United Kingdom	60	60	60
Spolchemie A.S.	Czech Republic	60	60	60
Others	Rest of Europe	301	301	301
Total		741	938	938

Source: TechSci Research

3.3.3. Europe Epoxy Resin Demand

Europe Epoxy Resin Demand, By Volume (Thousand Tonnes), 2015–2030F



2015-2020

CAGR

1.67% By Volume

2021E-2030F

CAGR

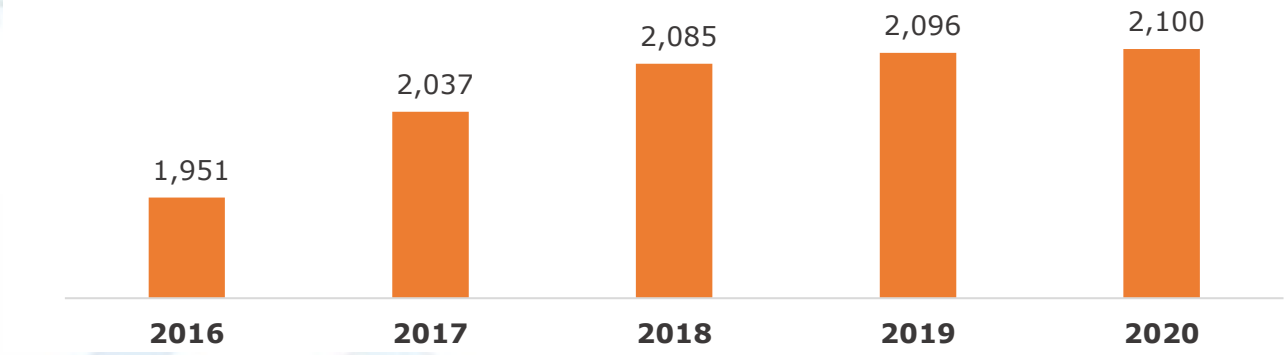
3.91% By Volume

Source: TechSci Research

Approach: Growth Forecast Via Factors (Impact Analysis)				
Factors	**Sources**	**Value**	**CAGR**	**Weightage**
GDP Growth Rate (2021-2030 Period_	*OECD, IMF, TechSci Estimates*	*Forecast*	3.92%	20.00%
GDP Per Capita (%)	*OECD, IMF, TechSci Estimates*	*Forecast*	3.22%	10.00%
Average Selling Growth (%)	*TechSci Research Estimates*	*Forecast*	2.38%	8.00%
Growth in Construction Sector	*TechSci Research Estimates*	*Forecast*	4.16%	10.00%
Growth in Renewable Sector	*TechSci Research Estimates*	*Forecast*	4.55%	20.00%
Growth in Automotive Sector	*OICA, ACEA*	*Forecast*	5.00%	14.00%
Paint & Coating Industry Growth	*Industry Sources & TechSci Research Estimates*	*Forecast*	4.50%	10.00%
Market Growth in Historical Period (2015-2020)	*Industry Sources & TechSci Research Estimates*	*Historical*	1.67%	8.00%
CAGR (2021-2030)	**3.91%**			

TechSci Research has followed this approach to calculate the growth rates by understanding the impact of various factors of the industry. These factors were given weightage according to the relative importance of each factor. Finally, each factor was multiplied with its weightage and their sum was used to calculate market growth.

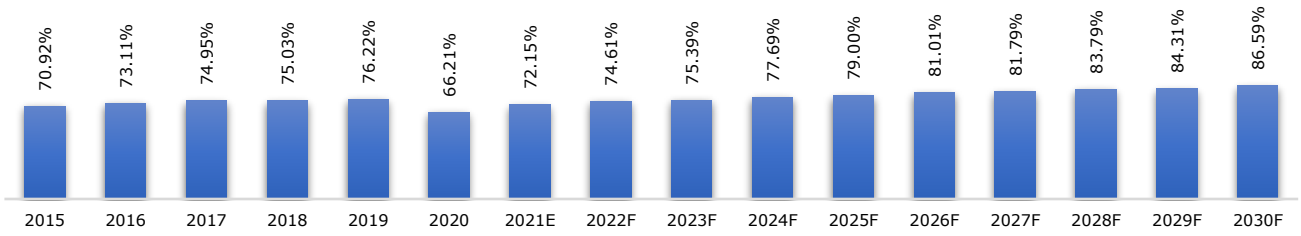
Europe Construction Market Size, By Value (USD Billion), 2016-2020



Source: Eurostat

3.3.4. Operating Efficiency

Europe Epoxy Resin Operating Efficiency (Percentage), 2015-2030F



Source: TechSci Research

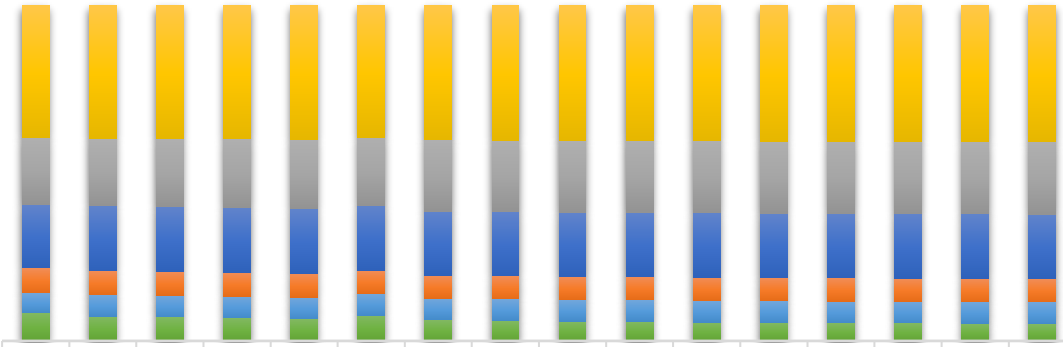
European Countries Real Estate Investment, 2020 (USD Billion)

Countries	Investment (USD Billion)
Germany	57
France	28
Netherland	14
Spain	12

Source: TechSci Research

3.3.5. Demand By Application

Europe Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Paints & Coatings	39.4	39.7	39.7	39.6	39.8	39.2	39.9	40.1	40.2	40.1	40.3	40.4	40.5	40.5	40.6	40.6
Electrical & Electronics	19.9	20.1	20.2	20.6	20.8	20.5	21.3	21.4	21.4	21.4	21.5	21.5	21.5	21.5	21.6	21.6
Composite Materials	18.9	19.3	19.3	19.3	19.3	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.3	19.3
Construction	7.4	7.2	7.2	7.1	7.1	7.0	6.8	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Adhesives	6.0	6.4	6.4	6.5	6.4	6.4	6.4	6.4	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Others	8.4	7.4	7.2	6.9	6.6	7.7	6.3	6.1	5.9	5.9	5.7	5.5	5.4	5.4	5.2	5.1

Others Marine, Defence, Encapsulation etc.

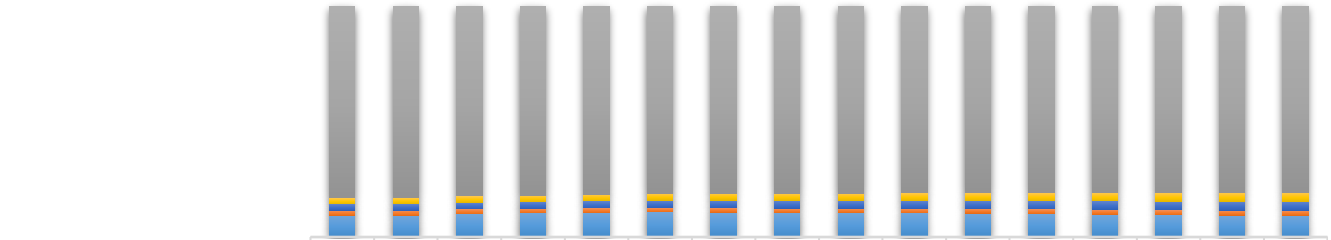
Source: TechSci Research

Demand by Application	2015	2020	2021E	2025F	2026F	2030F
Paints & Coatings	200	216	232	272	283	334
Electrical & Electronics	101	113	124	145	151	177
Construction	38	38	40	46	48	57
Composite Materials	96	106	112	130	135	158
Adhesives	30	35	37	44	45	54
Others	42	42	37	38	39	42
Total	**507**	**551**	**582**	**675**	**701**	**822**

Source: TechSci Research

3.3.6. Demand By Type

Europe Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Bisphenol A Based Resin	83.0	82.8	82.2	81.9	81.4	81.0	80.9	81.0	81.0	80.9	80.9	80.9	80.9	80.9	80.8	80.8
Bisphenol F Based Resin	2.6	2.7	2.7	2.8	2.9	3.1	3.1	3.2	3.3	3.3	3.2	3.5	3.5	3.7	3.7	3.8
Epoxy Phenol Novolac Based Resin	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.3	3.4	3.5	3.5	3.7	3.7	3.9	3.9
Cycloaliphatic Epoxy Based Resin	2.2	2.2	2.2	2.0	2.0	1.9	2.0	1.9	2.0	2.0	2.0	2.0	2.1	2.0	2.0	2.1
Others	9.4	9.4	10.1	10.4	10.6	10.8	10.7	10.5	10.6	10.4	10.4	10.1	9.9	9.7	9.5	9.4

Source: TechSci Research

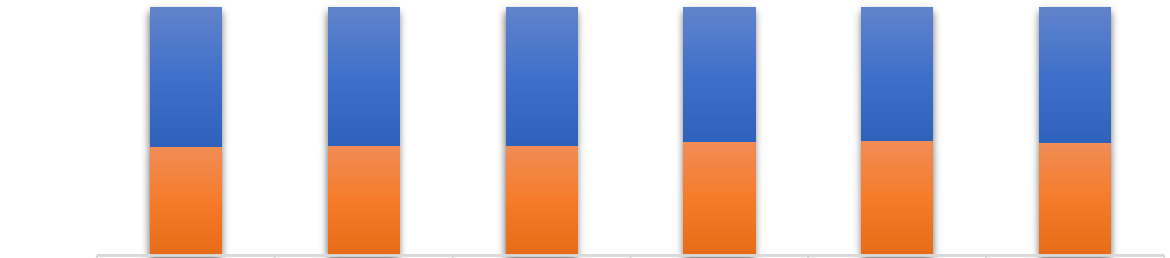
3.3.7. Europe Epoxy Resin Market Demand-Supply Analysis, By Volume, 2015-2030F (Thousand Tonnes)

	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Capacity	741	741	751	893	913	938	938	938	938
Production	526	542	563	670	696	621	677	741	812
Import	250	270	283	211	225	210			
Export	260	273	282	296	310	270			
Total Demand	507	530	555	574	599	551	582	675	822
Demand Supply Gap							95	66	-10

Source: TechSci Research

3.3.8. Demand By Sales Channel

Europe Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, 2015–2020



	2015	2016	2017	2018	2019	2020
Direct	56.1	55.6	55.7	54.0	53.8	54.5
Indirect	43.9	44.4	44.3	46.0	46.2	45.5

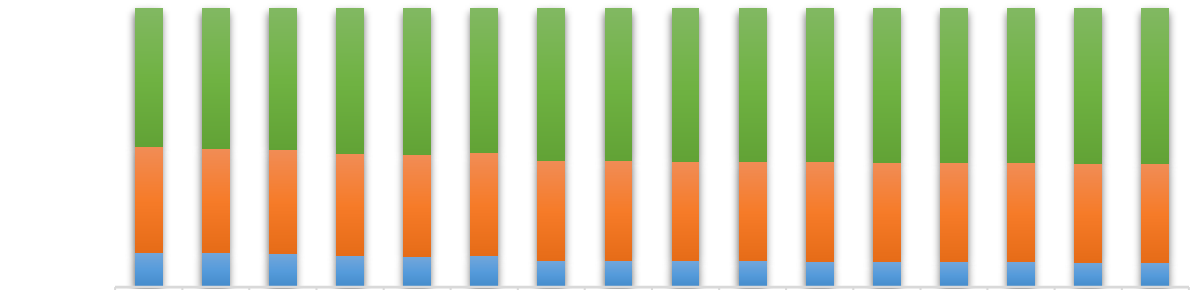
Source: TechSci Research

Demand by Sales Channel	2015	2016	2017	2018	2019	2020
Direct Company Sale	284	295	309	310	322	300
Indirect	222	236	246	264	277	250
Total	**507**	**530**	**555**	**574**	**599**	**551**

Source: TechSci Research

3.3.9. Demand By Grade

Europe Epoxy Resin Demand, By Grade (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Liquid	49.5	50.0	50.4	51.8	52.3	51.7	54.4	54.5	54.8	54.9	55.0	55.0	55.2	55.3	55.4	55.6
Solid	38.0	37.5	37.6	36.9	36.8	36.9	36.0	36.0	35.7	35.7	35.7	35.7	35.6	35.6	35.6	35.5
Semi-Solid	12.5	12.5	12.0	11.2	10.9	11.5	9.6	9.5	9.5	9.5	9.4	9.3	9.2	9.1	9.0	8.9

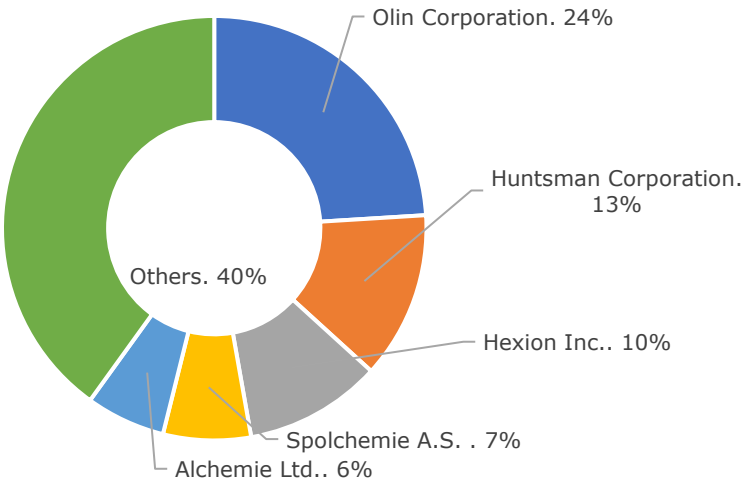
Source: TechSci Research

Demand by Grade	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Liquid	251	265	279	297	314	284	317	371	457
Semi-Solid	63	66	67	64	65	63	56	63	73
Solid	193	199	209	212	221	203	209	241	292
Total	**507**	**530**	**555**	**574**	**599**	**551**	**582**	**675**	**822**

Source: TechSci Research

3.3.10. Sales By Company

Figure 38: Europe Epoxy Resin Sales, By Company, By Volume, 2020



Source: TechSci Research

Region	Demand Volume Share (%)	2020	2021E
Europe	Olin Corporation	132	145
Europe	Huntsman Corporation	70	67
Europe	Hexion Inc.	58	66
Europe	Spolchemie A.S.	37	40
Europe	Alchemie Ltd.	33	37
Europe	Others	221	227

2020	2021E
24.02%	24.93%
12.73%	11.47%
10.46%	11.27%
6.68%	6.83%
6.06%	6.44%
40.05%	39.06%

Source: TechSci Research

Olin Corporation, Huntsman Corporation and Hexion Inc are the major producers of epoxy resins in the European region, mirroring the trend of North American region. All three are global players catering to the epoxy demand worldwide. Paints and coatings industry has been the key driver of epoxy growth in the region with automotive sector following closely. However, the growth in automotive sector has been underwhelming owing to global shortage of semiconductor chips. All key manufacturers have outstanding previous quarters gaining from the economic recovery in the region. Recent energy crises across Europe have resulted in some unprecedented challenges in the last few years adversely impacting petrochemical industry. This might have a bearing over the producers' approach in the long term while assessing the market dynamics.

Europe Market Insights

Demand for Epoxy Resins has projected a CAGR of around 1.67% from 2015-2020. Between 2021-2030, the demand for Epoxy Resin is expected to witness a CAGR of 3.91%, supported by the increasing consumption of Epoxy resins from downstream automotive and construction sectors

Although, 2020 slowed the demand growth as automotive sector suffered in the wake of covid-pandemic. Demand accelerated as construction sector in Europe has been flourishing in 2021 and pulling some outstanding demand numbers for Epoxy Resins.

Olin Corporation and Hexion Inc. are the two leading producers of Epoxy Resin in Europe, having capacities of 265 and 132 KT, respectively. No expansions are scheduled in the next 10 years as the European market is deemed exhaustive for any capacity additions in the near term.

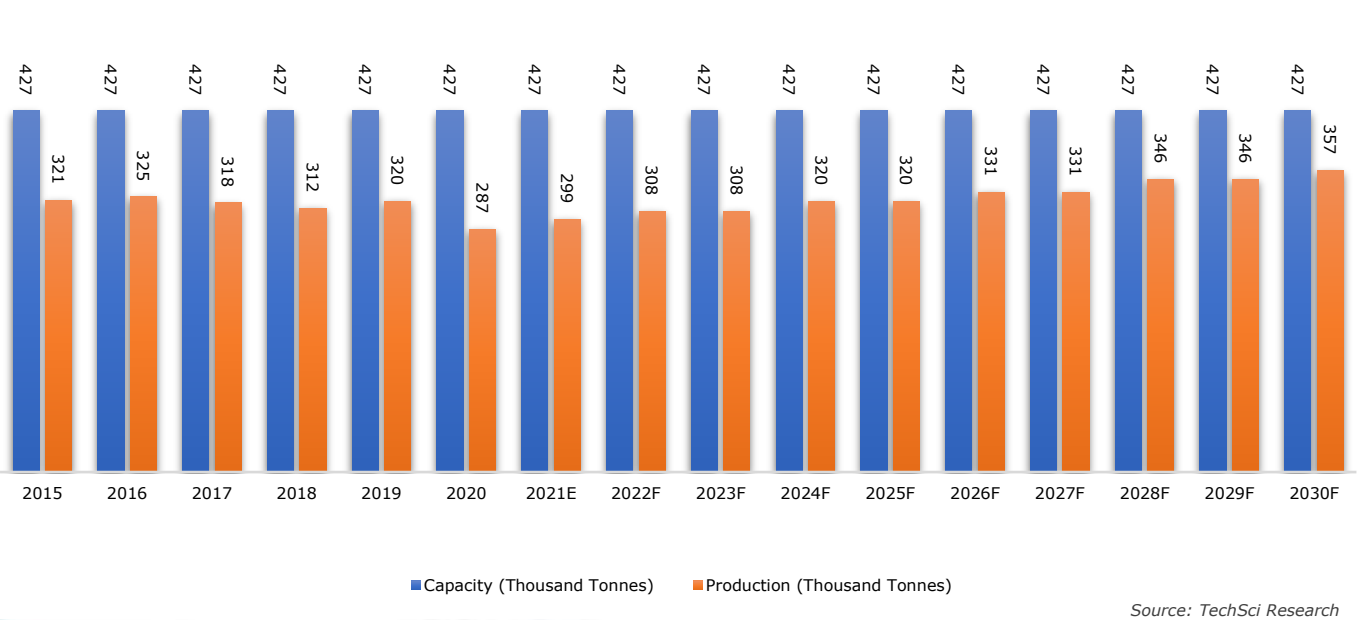
Paint & Coating along with construction sector garners majority of Epoxy Resin demand in the region. Use of advanced technologies like nanotechnology along with inclination towards eco-friendly paints provide ample opportunities for paints and coatings sector to grow in coming years.

Composite Materials is a potential segment where the demand for Epoxy Resin is expected to grow substantially due to a line of advancements expected in the material science sector.

Bisphenol A Based Resin type drives more than 80% of the overall demand in the European Region.

NORTH AMERICA EPOXY RESIN MARKET OUTLOOK

3.4.1. North America Epoxy Resin Capacity & Production, By Volume, 2015 - 2030F (Thousand Tonnes)

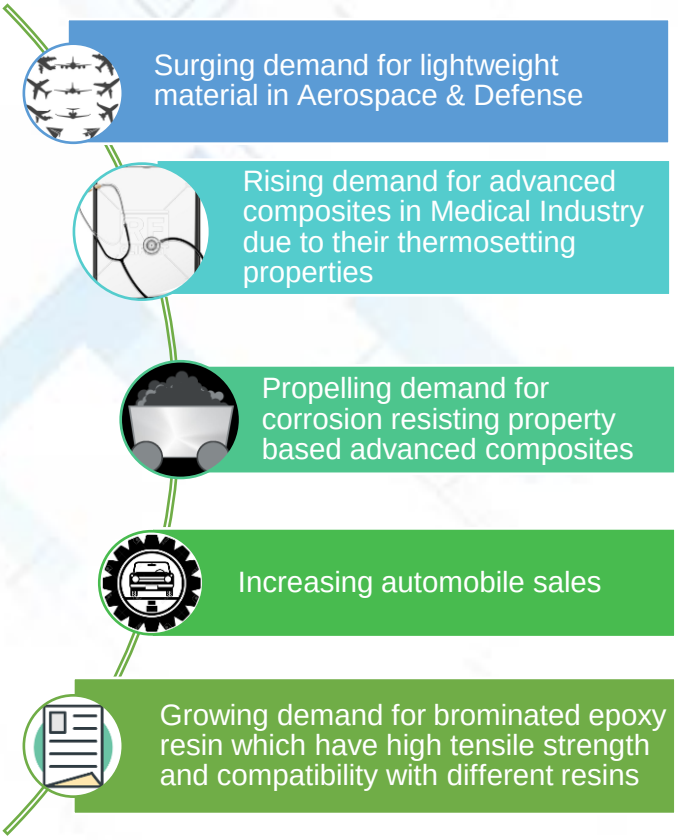


Source: TechSci Research

Company	Location	2015	2020	2030F
Hexion Inc.	USA	127	127	127
Olin Corporation	USA	170	170	170
Huntsman Corporation	USA	70	70	70
Dow Chemical	USA	60	60	60
Total		427	427	427

Source: TechSci Research

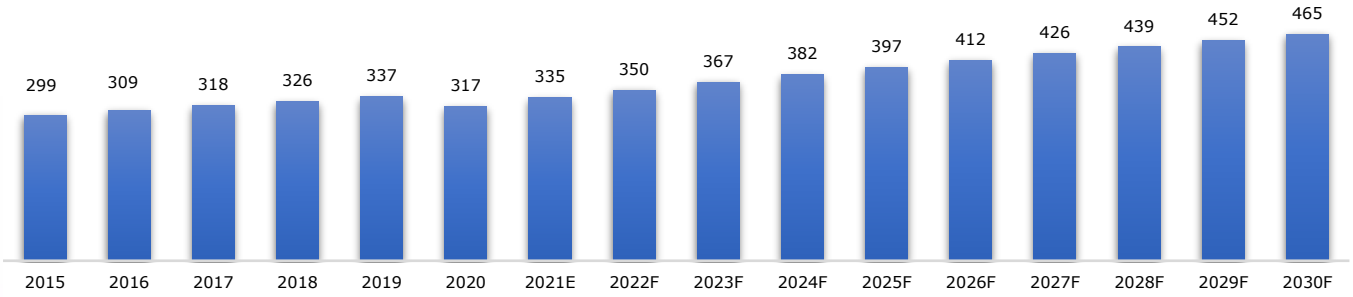
Major Factors Accounting for Growing Demand of Epoxy Resin in North America:



- **Strong Economy (**Low Inflation, Stable Lending Rate, Competitive Tax System, Strong Banking System)
- **Ease of Doing Business**
  - Competitive Business Cost
  - Ease in Establishing and Conducting New Business
- **Better Life Index** (Ranked highest among the G7 countries by OECD based on housing, income, employment, health, safety, etc.)
- Epoxy resin is widely used in green buildings as they significantly reduce the carbon footprint of the building. The demand for sustainable products is increasing owing to the growing trend of ethical consumerism which is boosting the growth of the North America Epoxy Resin Market.
- Renewable energy is the fastest-growing energy source in the US. Renewable energy contributed to more than 17% of the net US electricity generation in 2018, with the bulk coming from hydropower (7.0%) and wind power (6.6%). Currently, 15 US states including California, Hawaii, Maine, Minnesota, Nevada, New Jersey, New Mexico among others have 100% renewable energy/clean energy targets in the next 15-20 years. The increasing use of epoxy-based composites in the manufacturing of rotor blades in wind turbines will boost the North America Epoxy Resin market.

3.4.2. North America Demand

North America Epoxy Resin Demand, By Volume (Thousand Tonnes), 2015–2030F



2015-2020
CAGR
1.16% By Volume

2021E-2030F
CAGR
3.73% By Volume

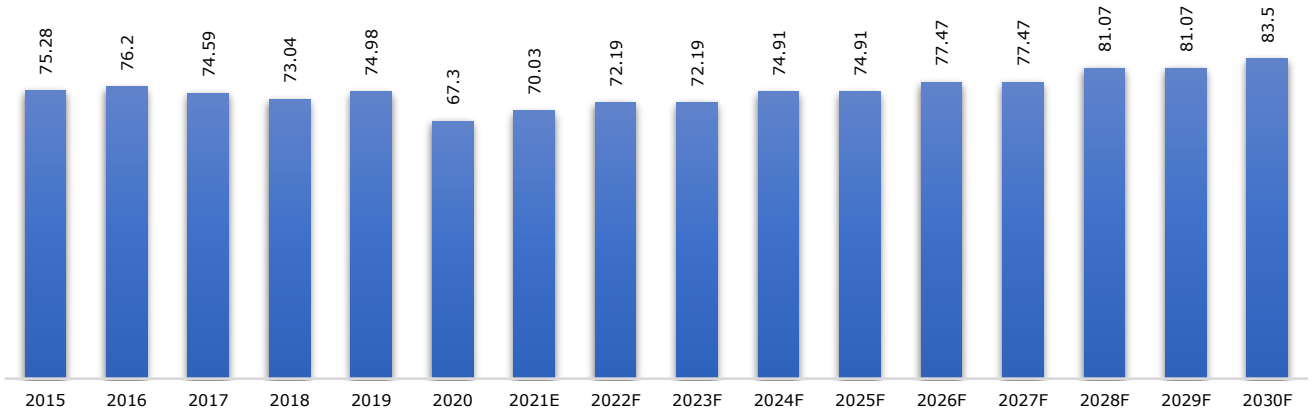
Source: TechSci Research

Approach: Growth Forecast Via Factors (Impact Analysis)				
Factors	**Sources**	**Value**	**CAGR**	**Weightage**
GDP Growth Rate (2021-2030 Period)	*World Bank, IMF, TechSci Estimates*	*Forecast*	4.70%	18.00%
GDP Per Capita (%)	*World Bank, IMF, TechSci Estimates*	*Forecast*	3.26%	10.00%
Average Selling Growth (%)	*TechSci Research Estimates*	*Forecast*	3.10%	15.00%
Growth in Construction Sector	*TechSci Research Estimates*	*Forecast*	4.40%	8.00%
Growth in Renewable Sector	*TechSci Research Estimates*	*Forecast*	4.00%	15.00%
Growth in Automotive Sector	*OICA, EMA*	*Forecast*	3.45%	8.00%
Paint & Coating Industry Growth	*Industry Sources & TechSci Research Estimates*	*Forecast*	4.15%	19.00%
Market Growth in Historical Period (2015-2020)	*Industry Sources & TechSci Research Estimates*	*Historical*	1.16%	7.00%
CAGR (2021-2030)	**3.73%**			

TechSci Research has followed this approach to calculate the growth rates by understanding the impact of various factors of the industry. These factors were given weightage according to the relative importance of each factor. Finally, each factor was multiplied with its weightage and their sum was used to calculate market growth.

3.4.3. Operating Efficiency

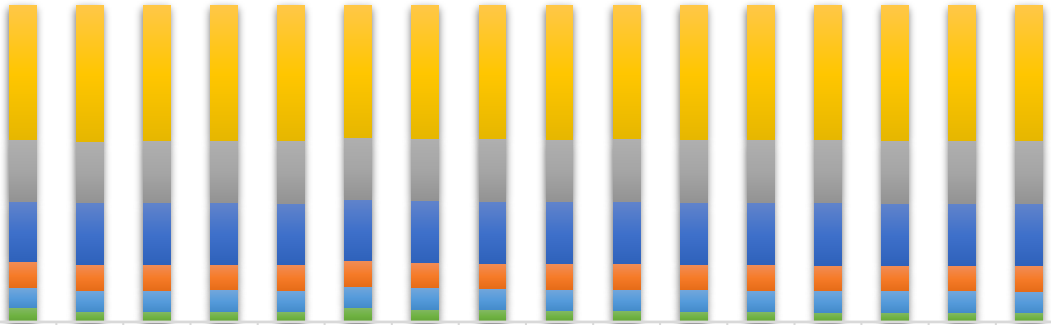
North America Epoxy Resin Operating Efficiency (Percentage), 2015-2030F



Source: TechSci Research

3.4.4 Demand By Application

North America Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Paints & Coatings	42.5	42.9	42.8	42.7	42.7	41.8	42.0	42.2	42.3	42.3	42.5	42.6	42.6	42.6	42.7	42.7
Electrical & Electronics	19.4	19.5	19.6	19.7	19.7	19.4	19.7	19.7	19.8	19.8	19.8	19.8	19.8	19.8	19.9	19.9
Composite Materials	19.0	19.4	19.4	19.4	19.4	19.5	19.5	19.5	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.7
Construction	8.2	8.1	8.1	8.1	8.2	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Adhesives	6.4	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.9	6.9	6.9	6.9	6.9	6.9
Others	4.4	3.3	3.3	3.3	3.2	4.6	4.1	3.8	3.6	3.6	3.3	3.2	3.1	3.0	2.9	2.9

Others Marine, Defence, Encapsulation etc.

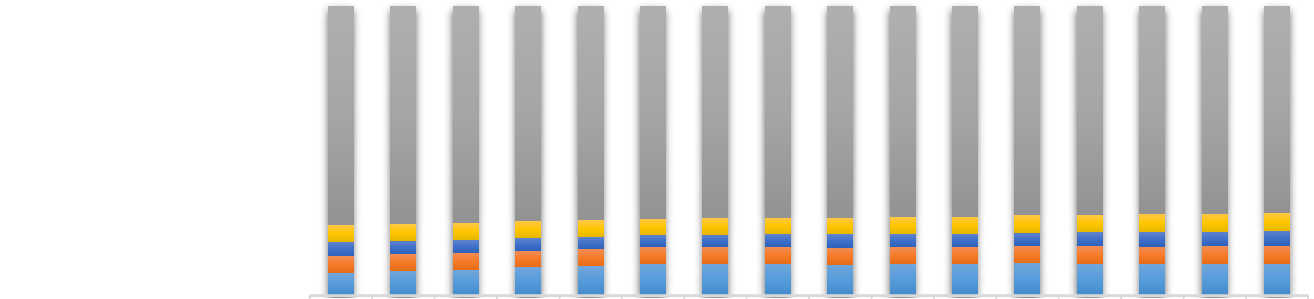
Source: TechSci Research

Demand by Application	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Paints & Coatings	127	132	136	139	144	132	141	169	199
Electrical & Electronics	58	60	62	64	66	61	66	79	92
Construction	25	25	26	27	28	25	27	32	37
Composite Materials	57	60	62	63	65	62	65	78	91
Adhesives	19	21	22	22	23	21	23	27	32
Others	13	10	10	11	11	16	13	12	14
Total	**299**	**309**	**318**	**326**	**337**	**317**	**335**	**397**	**465**

Source: TechSci Research

3.4.5. Demand By Type

North America Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, 2015–



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Bisphenol A Based Resin	75.5	75.0	74.8	74.0	73.8	73.2	73.0	72.8	72.9	72.6	72.5	72.0	71.9	71.8	71.6	71.3
Bisphenol F Based Resin	5.8	5.8	5.7	5.8	5.7	5.6	5.7	5.7	5.8	5.8	5.9	6.0	6.0	6.1	6.2	6.2
Epoxy Phenol Novolac Based Resin	4.9	4.7	4.5	4.4	4.3	4.2	4.3	4.4	4.5	4.6	4.5	4.6	4.9	5.0	5.1	5.2
Cycloaliphatic Epoxy Based Resin	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.9	5.9	5.9	5.9	6.0	6.1	6.0	6.1	6.1
Others	8.1	8.9	9.2	10.0	10.4	11.2	11.2	11.2	10.9	11.1	11.2	11.4	11.2	11.1	11.1	11.2

Source: TechSci Research

Demand by Type	2015	2020	2021F	2025F	2030F
Bisphenol A Based Resin	226	232	244	288	332
Bisphenol F Based Resin	17	18	19	23	29
Epoxy Phenol Novolac Based Resin	15	13	14	18	24
Cycloaliphatic Epoxy Based Resin	17	18	20	24	28
Others	24	35	37	45	52

Total	299	317	335	397	465

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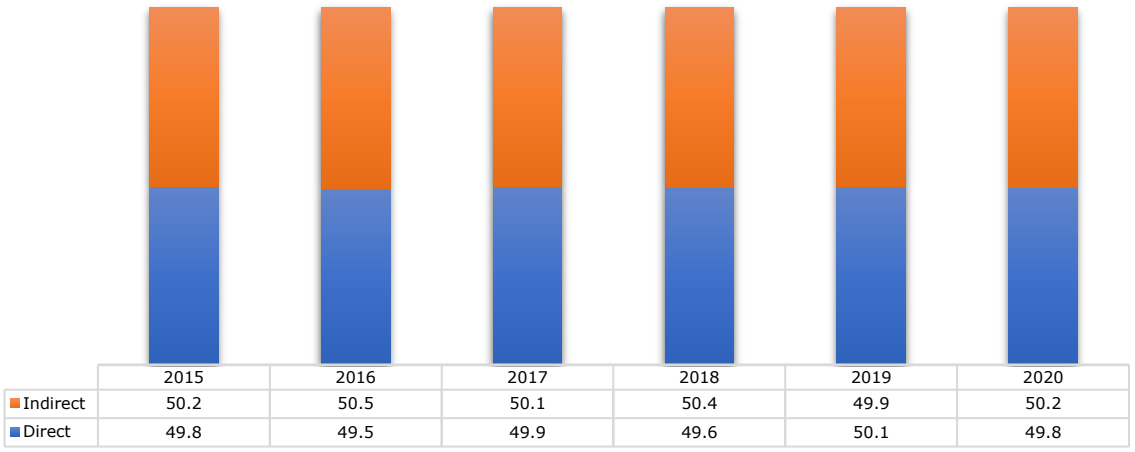
Source: TechSci Research

3.4.6. Demand By Sales Channel

North America Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, 2015–2020



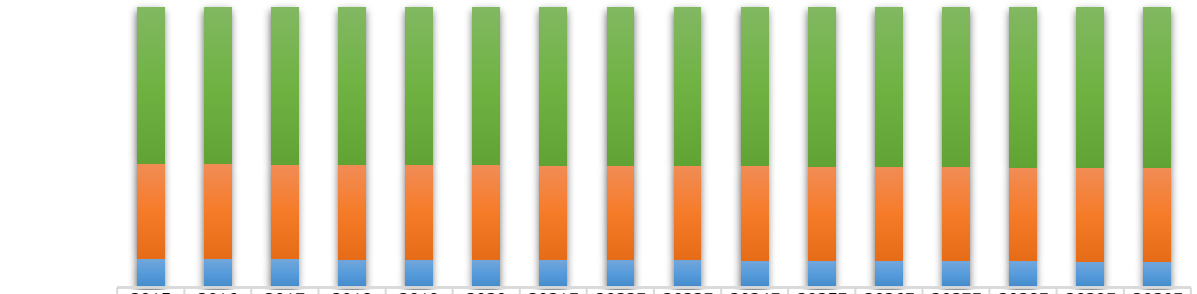
Source: TechSci Research

Demand by Sales Channel	2015	2016	2017	2018	2019	2020
Direct Company Sale	149	153	159	162	169	158
Indirect	150	156	160	165	168	159
Total	299	309	318	326	337	317

Source: TechSci Research

3.4.7. Demand By Grade

North America Epoxy Resin Demand, By Grade (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Liquid	55.7	55.9	56.0	56.1	56.1	56.2	56.3	56.4	56.5	56.6	56.7	56.8	56.9	57.0	57.1	57.2
Solid	34.0	33.8	33.8	33.7	33.8	33.7	33.7	33.7	33.6	33.6	33.6	33.5	33.5	33.5	33.5	33.4
Semi-Solid	10.3	10.3	10.3	10.2	10.1	10.1	10.0	9.9	9.9	9.8	9.7	9.7	9.6	9.5	9.4	9.4

Source: TechSci Research

Demand by Grade	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Liquid	166	173	178	183	189	178	188	225	266
Semi-Solid	31	32	33	33	34	32	33	39	44
Solid	102	104	107	110	114	107	113	133	156
Total	**299**	**309**	**318**	**326**	**337**	**317**	**335**	**397**	**465**

Source: TechSci Research

Liquid Epoxy resin (LER) is anticipated to be the fastest growing segment due to increased demand for coating and adhesives application. LER based resins are also find its usage in manufacturing of specialized application such as composites and electronics industry. In coming years, solids epoxy resin using liquid epoxy resin will continue to grow. Liquid epoxy resin is also used for tank linings.

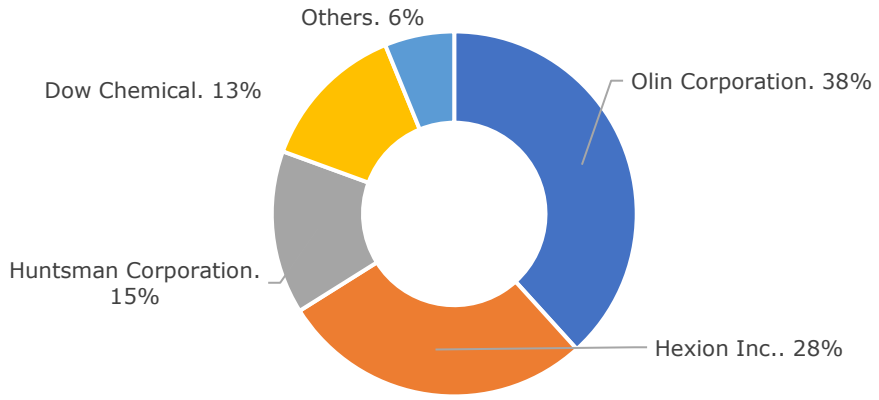
3.4.8. North America Epoxy Resin Market Demand-Supply Analysis, By Volume, 2015-2030F (Thousand Tonnes)

	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Capacity	427	427	427	427	427	427	427	427	427
Production	321	325	318	312	320	287	299	320	357
Import	86	96	118	126	136	122			
Export	102	106	112	105	113	87			
Total Demand	299	309	318	326	337	317	335	397	465
Demand Supply Gap							-36	-77	-109

Source: TechSci Research

3.4.9. Sales By Company

North America Epoxy Resin Sales, By Company, By Volume, 2020



Source: TechSci Research

Region	Demand Volume Share (%)	2020	2021E
North America	Hexion Inc.	88	92
North America	Olin Corporation	121	122
North America	Dow Chemical	42	45
North America	Huntsman Corporation	46	52
North America	Others	20	24

2020	2021E
27.81%	27.51%
38.28%	36.32%
13.26%	13.42%
14.48%	15.51%
6.17%	7.24%

Source: TechSci Research

Olin Corporation and Hexion Inc. are the two most important manufacturers of epoxy resins in the North American region, where both shares between them close to two-third of the market share by sales. After slump of 2020 in terms of demand, 2021 brought economic recovery. Demand has increased significantly in the wake of rising consumption from construction industry, electrical and electronics industry along with other sectors. Olin and Hexion both had outstanding quarters Q1 and Q2 in terms of sales where both companies have shown significantly improved performance from the respective quarters of 2020. In the region, Dow Chemical and Huntsman Corporation also produce substantial amounts of epoxy resins where both companies have 13% and 15% of market share by sales, respectively, in the region. There has been no new announcement of upcoming brown field or green field projects from any of the above manufacturer, however given the increasing demand of epoxy resin globally, new capacity or capacity expansion is likely to be around the corner.

North America Market Insights

The total epoxy resin capacity in North America stood at 427 thousand tonnes in 2020 without seeing any expansion or commissioning of new plant facilities in the historical years. The key market players include Olin Corporation, Hexion Inc., Huntsman Corporation and Dow Chemical. The production in 2020, reaching to 287.36 thousand tonnes, registered a decrement of 10% from the volumes produced in 2019 owing to the slow operations and difficulties in feedstock availability during COVID19 pandemic period. With rebounding of plant operations, the production is expected to take an upward trend and rise to 356.56 thousand tonnes by 2030.

The market share for epoxy resin in North America has shown a gradual increase in the historical years reaching 317 thousand tonnes after registering a CAGR of 1.16%. The easy feedstock availability also favoured its continued demand in the past years. The epoxy resin market in the upcoming years demonstrates a positive outlook in terms of demand backed by the flourishing construction sector, which is likely to lead with the raging trend in North America to use sustainable products in green buildings. The demand is, therefore, is expected to rise at a healthy CAGR of 3.73% reaching to a consumption volume of 465 thousand tonnes by 2030.

The market players operated with 73-75% utilization of total installed capacity of epoxy resins in the historical years. However, the impact of supply chain disruptions and lockdown constraints marred the operating rate in the Asia-Pacific region to as low as 67% in 2020. The slow recovering operations got further hit in 2021 after the landfall of hurricane Ida causing volatile feedstock

prices which resulted to only slight improvement in the operating rates. After the revival of the supply chains an improvement in the operating efficiency is expected and will reach to around 83.5% by the year 2030.

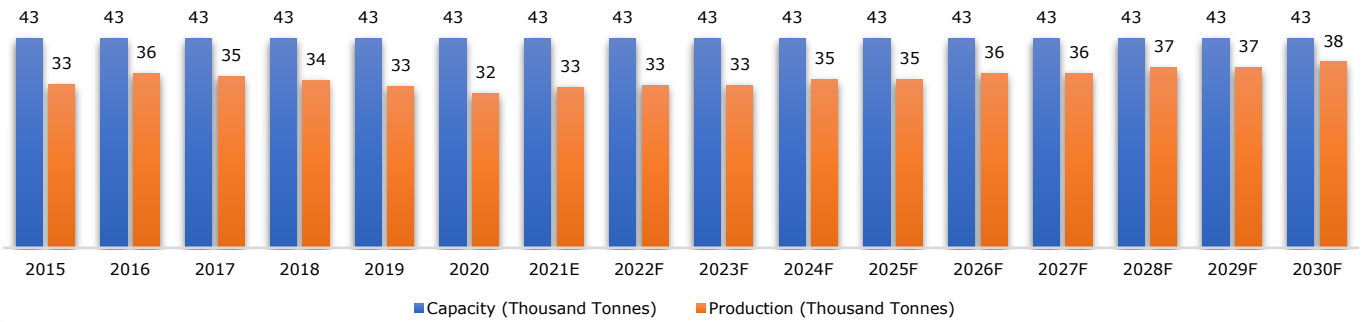
Epoxy resin, owing to its strong binding ability and long durability, finds its varied applications in paints and coatings sector which owns the highest market share of epoxy resin in North America. Epoxy resin is heavily used in concrete reinforcing due to their flexible applicability while automotive, marine, and aerospace apply epoxy coatings for corrosion protection as primers. Rapid growth in industrial coatings as well as automotive coatings is likely to propel paints and coatings sector growth in coming years.

Bisphenol A based resin, Bisphenol F based resin, Epoxy phenol Novalac based resin and cycloaliphatic epoxy-based resin are the major types of epoxy resins where Bisphenol A based resin has the highest demand due to its wide applications in coatings, adhesives, electrical insulating materials. Their demand is expected to see a steady growth over the forecast years.

Both direct and indirect sale channels are prevalent in North America with indirect sales channel taking the lead only by a small margin.

SOUTH AMERICA EPOXY RESIN MARKET OUTLOOK

3.5.1. South America Epoxy Resin Capacity & Production, By Volume, 2015 - 2030F (Thousand Tonnes)



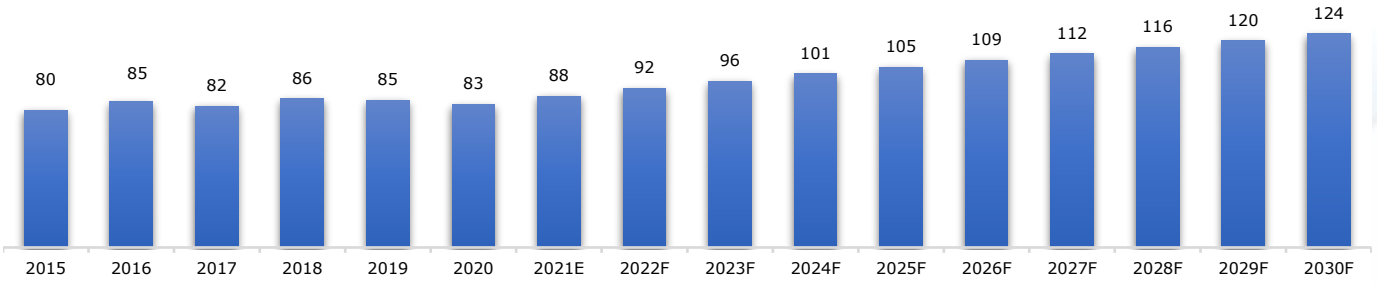
Source: TechSci Research

Company	Location	2015	2020	2030F
Olin Corporation	Brazil	33	33	33
Huntsman Corporation	Brazil	10	10	10
Total		43	43	43

Source: TechSci Research

3.5.2. South America Epoxy Resin Demand

South America Epoxy Resin Demand, By Volume (Thousand Tonnes), 2015–2030F



2015-2020

CAGR

0.81% By Volume

2021E-2030F

CAGR

3.94% By Volume

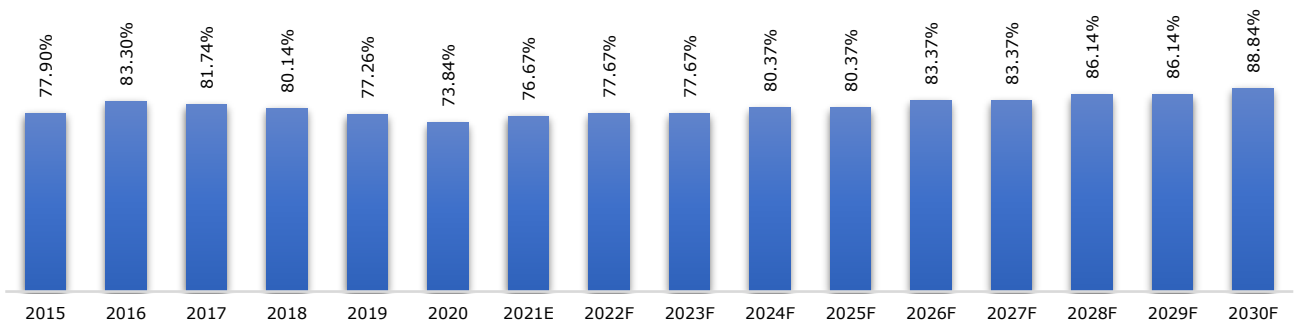
Source: TechSci Research

Approach: Growth Forecast Via Factors (Impact Analysis)				
Factors	**Sources**	**Value**	**CAGR**	**Weightage**
GDP Growth Rate (2021-2030 Period)	*World Bank, IMF, TechSci Estimates*	*Forecast*	4.25%	26.00%
GDP Per Capita (%)	*World Bank, IMF, TechSci Estimates*	*Forecast*	3.55%	10.00%
Average Selling Growth (%)	*TechSci Research Estimates*	*Forecast*	2.12%	8.00%
Growth in Construction Sector	*TechSci Research Estimates*	*Forecast*	5.04%	12.00%
Growth in Renewable Sector	*TechSci Research Estimates*	*Forecast*	5.00%	16.00%
Growth in Automotive Sector	*OICA*	*Forecast*	4.05%	4.00%
Paint & Coating Industry Growth	*Industry Sources & TechSci Research Estimates*	*Forecast*	3.88%	18.00%
Market Growth in Historical Period (2015-2020)	*Industry Sources & TechSci Research Estimates*	*Historical*	0.81%	6.00%
CAGR (2021-2030)	**3.94%**			

TechSci Research has followed this approach to calculate the growth rates by understanding the impact of various factors of the industry. These factors were given weightage according to the relative importance of each factor. Finally, each factor was multiplied with its weightage and their sum was used to calculate market growth.

3.5.3. Operating Efficiency

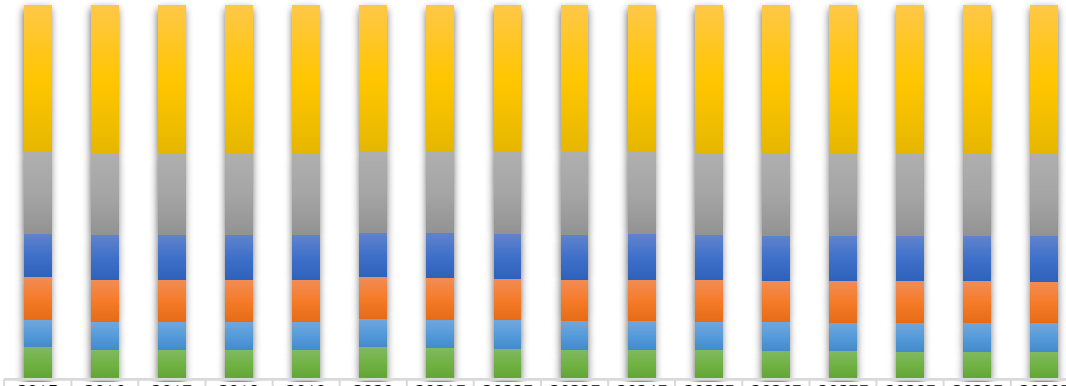
South America Epoxy Resin Operating Efficiency (Percentage), 2015-2030F



Source: TechSci Research

3.5.4. Demand By Application

South America Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Paints & Coatings	39.2	39.5	39.4	39.3	39.4	38.8	38.9	39.1	39.2	39.1	39.3	39.4	39.4	39.5	39.5	39.6
Electrical & Electronics	21.8	21.8	21.9	21.8	21.9	21.9	21.9	22.0	22.0	22.0	22.0	22.0	22.1	22.1	22.1	22.1
Composite Materials	11.7	12.1	12.1	12.1	12.2	12.0	12.0	12.0	12.0	12.1	12.1	12.1	12.1	12.1	12.1	12.1
Construction	11.4	11.1	11.1	11.2	11.2	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.2	11.2
Adhesives	7.1	7.6	7.6	7.6	7.5	7.6	7.6	7.6	7.6	7.6	7.6	7.7	7.6	7.7	7.7	7.7
Others	8.8	8.0	8.0	7.9	7.8	8.7	8.5	8.3	8.1	8.1	7.8	7.7	7.7	7.6	7.5	7.4

Others Marine, Defence, Encapsulation etc.

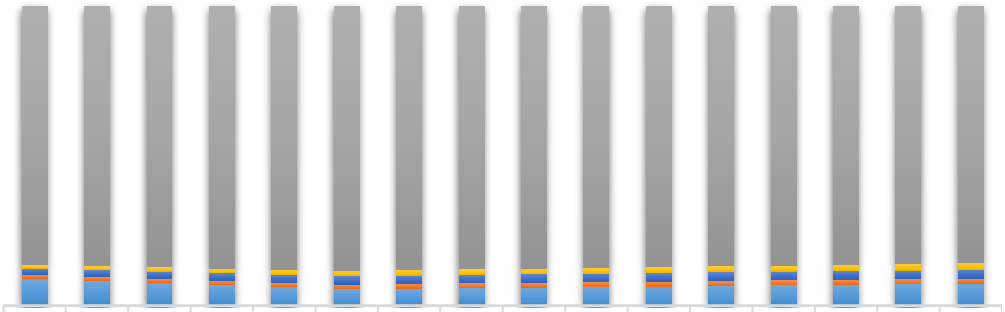
Source: TechSci Research

Demand by Application	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Paints & Coatings	31	33	32	34	34	32	34	41	49
Electrical & Electronics	17	18	18	19	19	18	19	23	27
Construction	9	9	9	10	10	9	10	12	14
Composite Materials	9	10	10	10	10	10	11	13	15
Adhesives	6	6	6	7	6	6	7	8	10
Others	7	7	7	7	7	7	7	8	9
Total	**80**	**85**	**82**	**86**	**85**	**83**	**88**	**105**	**124**

Source: TechSci Research

3.5.5. Demand By Type

South America Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Bisphenol A Based Resin	86.3	86.7	87.1	87.4	87.8	88.2	87.9	87.7	87.4	87.2	86.9	86.7	86.4	86.2	86.0	85.7
Bisphenol F Based Resin	1.2	1.4	1.5	1.6	1.8	1.9	1.9	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.2
Epoxy Phenol Novolac Based Resin	2.0	2.2	2.3	2.5	2.6	2.7	2.7	2.8	2.8	2.8	2.8	2.9	2.9	2.9	2.9	3.0
Cycloaliphatic Epoxy Based Resin	1.2	1.3	1.3	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.7
Others	9.2	8.5	7.8	7.1	6.4	5.7	5.8	6.0	6.2	6.4	6.6	6.7	6.9	7.1	7.3	7.5

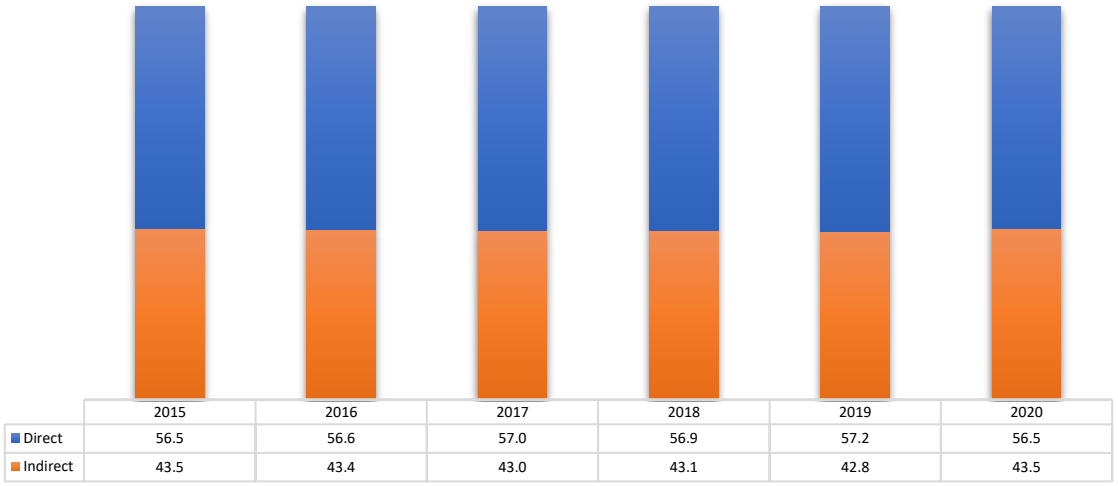
Source: TechSci Research

Demand by Type	2015	2016	2017	2018	2019	2020	2021F	2025F	2030F
Bisphenol A Based Resin	69	73	71	75	75	73	77	91	106
Bisphenol F Based Resin	1	1	1	1	2	2	2	2	3
Epoxy Phenol Novolac Based Resin	2	2	2	2	2	2	2	3	4
Cycloaliphatic Epoxy Based Resin	1	1	1	1	1	1	1	2	2
Others	7	7	6	6	5	5	5	7	9
Total	**80**	**85**	**82**	**86**	**85**	**83**	**88**	**105**	**124**

Source: TechSci Research

3.5.6. Demand By Sales Channel

South America Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020
Direct	56.5	56.6	57.0	56.9	57.2	56.5
Indirect	43.5	43.4	43.0	43.1	42.8	43.5

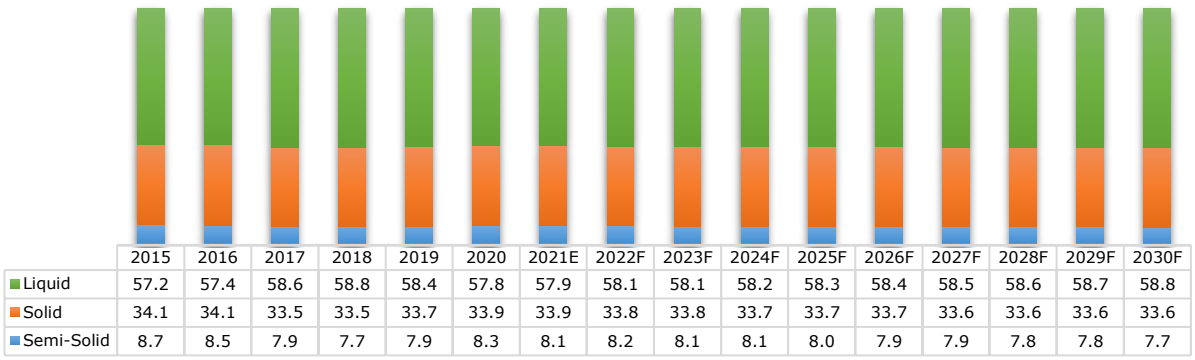
Source: TechSci Research

Demand by Sales Channel	2015	2016	2017	2018	2019	2020
Direct Company Sale	45	48	47	49	49	47
Indirect	35	37	35	37	37	36
Total	**80**	**85**	**82**	**86**	**85**	**83**

3.5.7. Demand By Grade

Source: TechSci Research

South America Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Liquid	57.2	57.4	58.6	58.8	58.4	57.8	57.9	58.1	58.1	58.2	58.3	58.4	58.5	58.6	58.7	58.8
Solid	34.1	34.1	33.5	33.5	33.7	33.9	33.9	33.8	33.8	33.7	33.7	33.7	33.6	33.6	33.6	33.6
Semi-Solid	8.7	8.5	7.9	7.7	7.9	8.3	8.1	8.2	8.1	8.1	8.0	7.9	7.9	7.8	7.8	7.7

Source: TechSci Research

Demand by Grade	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Liquid	46	49	48	51	50	48	51	61	73
Semi-Solid	7	7	6	7	7	7	7	8	10
Solid	27	29	28	29	29	28	30	35	42
Total	**80**	**85**	**82**	**86**	**85**	**83**	**88**	**105**	**124**

Source: TechSci Research

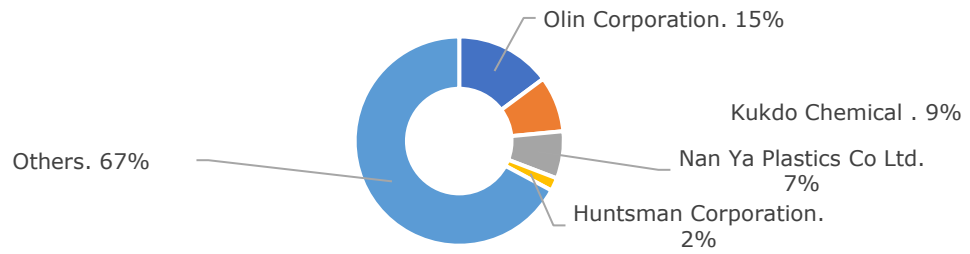
3.5.8. South America Epoxy Resin Market Demand-Supply Analysis, By Volume, 2015-2030F (Thousand Tonnes)

	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Capacity	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Production	33.5	35.8	35.2	34.5	33.2	31.8	33.0	34.6	38.2
Import	52.1	55.1	52.6	57.1	56.3	54.2			
Export	6.0	6.2	5.7	5.4	4.2	3.1			
Total Demand	79.6	84.7	82.0	86.2	85.3	82.9	87.6	104.7	124.0
Demand Supply Gap							-54.6	-70.1	-85.8

Source: TechSci Research

3.5.9. Sales By Company

South America Epoxy Resin Sales, By Company, By Volume, 2020



Region	Demand Volume Share (%)	2020	2021E
South America	Olin Corporation	16.68	17.18
South America	Huntsman Corporation	2.27	2.44
South America	Kukdo Chemical	9.72	9.66

2020	2021E
14.84%	14.80%
2.02%	2.10%
8.65%	8.32%

Source: TechSci Research

South America	Nan Ya Plastics Co Ltd	8.23	8.22		7.32%	7.08%
South America	Others	75.51	78.61		67.17%	67.70%

Source: TechSci Research

Various other region leaders across the globe are having a stronghold in the South American epoxy market. Primarily, Olin Corporation, a prominent epoxy resin producer globally has been dominating the market with the market share of 15% in terms of sales by an individual company. Other key manufacturers include Korean headquartered Kukdo Chemical, producing highly varied and specialized epoxy resins. Nan Ya Plastics has been another major player capturing a significant market share with 7% by sales in the region.

South America Market Insights

Total capacity of Epoxy resin in South America stood at about 43 KTPA with Olin Corporation holding largest chunk of market share with annual capacity of 33 KTPA.

The South American epoxy resin market grew at an average CAGR of 0.81% in terms of volume during the period 2015-2020 and is forecasted to grow at an average CAGR of 3.94 %. Thereby increasing the total capacity to about 125 thousand tons in absolute terms by 2030.

As the South American market recovers to its pre pandemic levels of economic activity, the demand for resins in general is going to increase significantly showing operating efficiency of more than 70 %

Demand by Application

The future of epoxy resin in the composites industry in South America looks good with opportunities in the transportation, marine, wind energy, aerospace, pipe & tank, construction, electrical and electronics, and consumer goods.

In South America, Epoxy resin has major applications in paints and coatings followed by electronics industry, construction, composites etc.

In the backdrop of an emerging global consensus on a sustainable development agenda, demand for epoxy resin is expected to find greater application in Green Buildings and wind turbine industry.

South America being an emerging market is expected to see robust growth rates across sectors like aviation, construction (incl. green buildings), electronics, automotive, telecommunication, roads and railways, renewable energy etc., which in turn would create demand for the resins market.

Thus, our forecast for the decade (2021 to 2030) predicts a strong growth in demand by volume across various verticals concerning epoxy resin market as shown in the bar graph .

Demand by Type

The Bisphenol A Based epoxy resin is the most widely used epoxy type as it finds its application in protective coatings, industrial maintenance paints, underwater coatings, structural adhesives and civil engineering applications. The demand for this type is expected cross the hundred-thousand-ton mark by 2030.

The Bisphenol F based epoxy resin type finds its applications in coatings, civil engineering, adhesives, electrical insulating materials, and reactive intermediates. Its demand by volume in absolute terms is expected to increase by 50% by 2030.

The Epoxy phenol Novolac based Resin type finds its usage in high temperature structural adhesives, electrical laminates, high performance composites, and molded parts. Its demand is expected to double by 2030.

The cycloaliphatic Epoxy Resin type finds its application in exterior coatings and adhesives, potting compounds and encapsulations for electronics and electrical components, gel coats, laminates, fiber composites, and various cationic and UV curable resin products. Demand in absolute terms for this resin type is also expected to double by 2030.

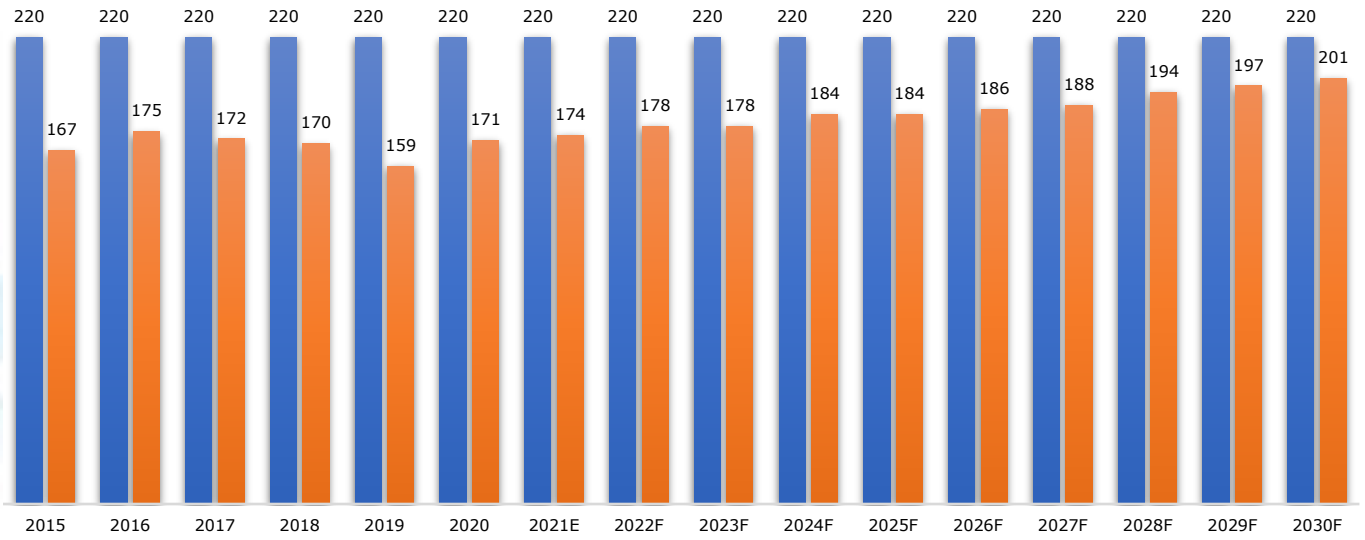
Demand by Grade

The demand for liquid grade epoxy resin type is expected to increase by more than twenty thousand tons in absolute terms by 2030.

The demand for semi-solid and solid grade resin types is expected to increase by three thousand tons and twelve thousand tons in absolute terms respectively by 2030.

MIDDLE EAST & AFRICA EPOXY RESIN MARKET OUTLOOK

3.6.1. Middle East & Africa Epoxy Resin Capacity & Production, By Volume, 2015 - 2030F (Thousand Tonnes)



Source: TechSci Research

Company	2015	2020	2030F
NAMA Chemicals	120	120	120
Izel Kimya	40	40	40
Others	60	60	60
Total	220	220	220

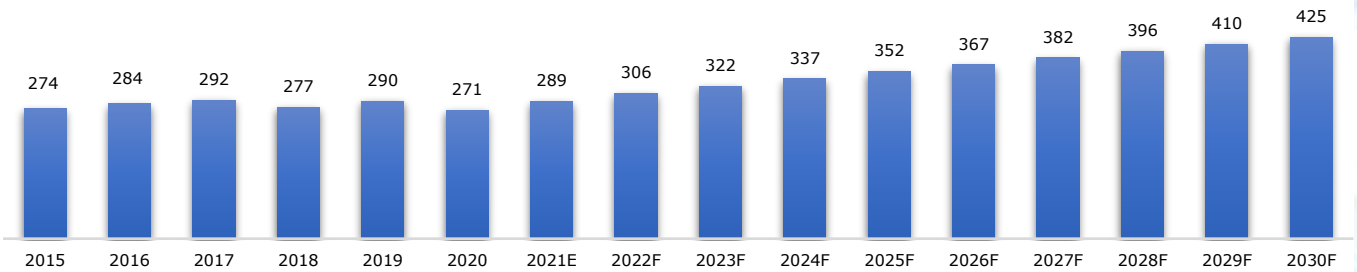
Source: TechSci Research

Key Goals and Objectives of Vision Document (Saudi Arabia)
• Boosting the government's revenue from USD159.99 billion in 2016 to USD1866.52 billion by 2030. • To increase share of non-oil-based exports from around 16% in 2016 to around 50% by 2030. • To increase the share of Foreign Direct Investment (FDI) in GDP from 3.8% in 2020 to 5.7% by 2030. • To boost the share of small and medium scale enterprises from 20% in 2020 to 35% by 2030. • To increase the contribution of private sector to around 65% of GDP by 2030, thereby opening different sectors for private players. • The country aims to set up a sovereign wealth fund amounting to around USD2.00 trillion to support the development projects associated with the Vision. FDI worth USD1.00 trillion during 2021-2032 is anticipated to flow in Saudi Arabia, thereby boosting the growth of private sector.

GCC nations are at the forefront in developing smart cities. Countries such as Saudi Arabia, Qatar and UAE plan to develop smart cities. Saudi Arabia government plans to invest USD100 billion for the development of King Abdullah smart city and the country has initiated plans to convert Jeddah into smart city. Similarly, UAE government also announced plans to expand Masdar smart city, for an investment of USD20 billion, due to be completed by 2030. Lusail City in Qatar is another smart city project that would be capable of accommodating about 450,000 people. The project is estimated to cost USD45 billion and is slated for completion by 2020. A major chunk of investment in developing these smart cities would be used in developing power transmission and distribution networks, thereby acting as a driving force in boosting growth in the region's epoxy resin market.

3.6.2. Middle East & Africa Epoxy Resin Demand

Middle East & Africa Epoxy Resin Demand, By Volume (Thousand Tonnes), 2015–2030F



2015-2020 CAGR -0.21% By Volume

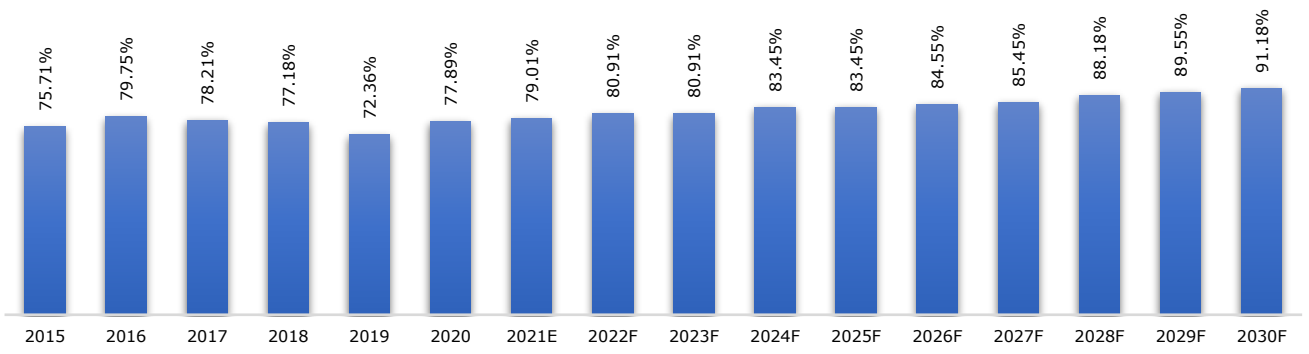
2021E-2030F CAGR 4.38% By Volume

Approach: Growth Forecast Via Factors (Impact Analysis)				
Factors	**Sources**	**Value**	**CAGR**	**Weightage**
GDP Growth Rate (2021-2030 Period)	*World Bank, IMF, OECD, TechSci Estimates*	*Forecast*	4.86%	29.00%
GDP Per Capita (%)	*World Bank, IMF, OECD, TechSci Estimates*	*Forecast*	4.38%	10.00%
Average Selling Growth (%)	*TechSci Research Estimates*	*Forecast*	3.18%	6.00%
Growth in Construction Sector	*TechSci Research Estimates*	*Forecast*	4.00%	15.00%
Growth in Renewable Sector	*TechSci Research Estimates*	*Forecast*	6.50%	18.00%
Paint & Coating Industry Growth	*Industry Sources & TechSci Research Estimates*	*Forecast*	3.45%	17.00%
Market Growth in Historical Period (2015-2020)	*Industry Sources & TechSci Research Estimates*	*Historical*	-0.21%	5.00%
CAGR (2021-2030)	**4.38%**			

TechSci Research has followed this approach to calculate the growth rates by understanding the impact of various factors of the industry. These factors were given weightage according to the relative importance of each factor. Finally, each factor was multiplied with its weightage and their sum was used to calculate market growth.

3.6.3. Operating Efficiency

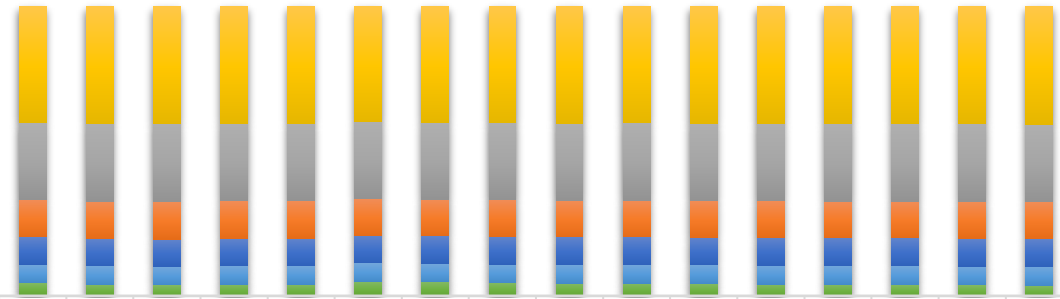
Middle East & Africa Epoxy Resin Operating Efficiency (Percentage), 2015-2030F



Source: TechSci Research

3.6.4. Demand By Application

Middle East & Africa Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Paints & Coatings	40.2	40.6	40.6	40.4	40.3	39.9	40.0	40.1	40.2	40.1	40.3	40.4	40.5	40.5	40.6	40.6
Electrical & Electronics	26.6	26.7	26.8	26.8	26.8	26.6	26.7	26.7	26.7	26.7	26.7	26.7	26.8	26.7	26.8	26.8
Construction	12.8	12.9	13.0	13.0	13.0	12.6	12.7	12.7	12.7	12.6	12.7	12.7	12.7	12.7	12.7	12.7
Composite Materials	9.5	9.5	9.5	9.5	9.6	9.5	9.5	9.5	9.6	9.6	9.6	9.6	9.6	9.6	9.7	9.7
Adhesives	6.4	6.3	6.3	6.3	6.3	6.4	6.4	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.6
Others	4.6	4.1	3.8	4.1	4.1	5.0	4.8	4.6	4.4	4.5	4.2	4.1	4.0	3.9	3.8	3.7

Others Marine, Defence, Encapsulation etc.

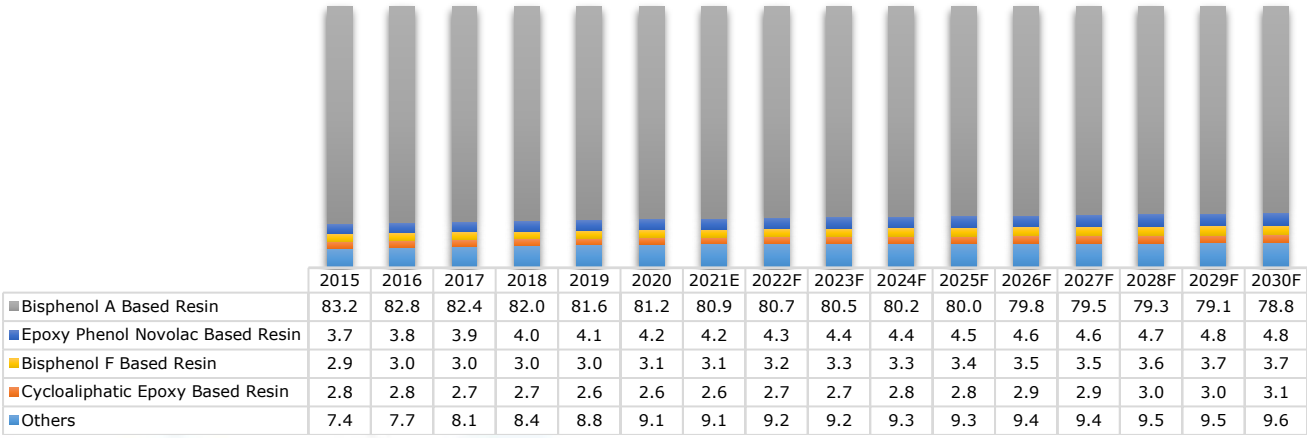
Source: TechSci Research

Demand by Application	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Paints & Coatings	110	115	118	112	117	108	116	142	173
Electrical & Electronics	73	76	78	74	78	72	77	94	114
Construction	35	37	38	36	38	34	37	45	54
Composite Materials	26	27	28	26	28	26	28	34	41
Adhesives	17	18	18	18	18	17	19	23	28
Others	13	11	12	11	11	14	12	14	15
Total	**274**	**284**	**292**	**277**	**290**	**271**	**289**	**352**	**425**

Source: TechSci Research

3.6.5. Demand By Type

Middle East & Africa Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, 2015–2030F



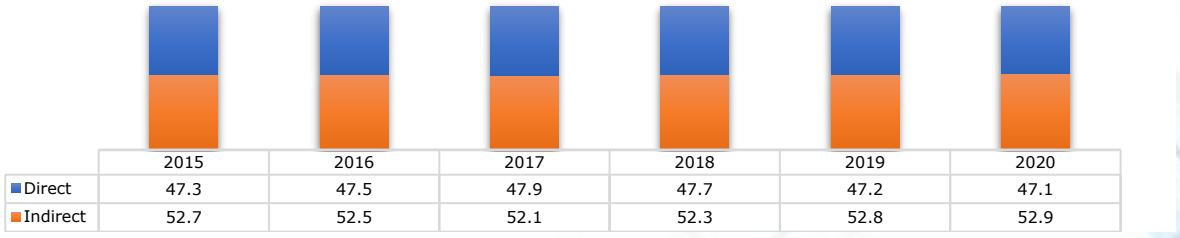
	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Bisphenol A Based Resin	83.2	82.8	82.4	82.0	81.6	81.2	80.9	80.7	80.5	80.2	80.0	79.8	79.5	79.3	79.1	78.8
Epoxy Phenol Novolac Based Resin	3.7	3.8	3.9	4.0	4.1	4.2	4.2	4.3	4.4	4.4	4.5	4.6	4.6	4.7	4.8	4.8
Bisphenol F Based Resin	2.9	3.0	3.0	3.0	3.0	3.1	3.1	3.2	3.3	3.3	3.4	3.5	3.5	3.6	3.7	3.7
Cycloaliphatic Epoxy Based Resin	2.8	2.8	2.7	2.7	2.6	2.6	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.0	3.1
Others	7.4	7.7	8.1	8.4	8.8	9.1	9.1	9.2	9.2	9.3	9.3	9.4	9.4	9.5	9.5	9.6

Source: TechSci Research

Demand by Type	2015	2016	2017	2018	2019	2020	2021F	2025F	2030F
Bisphenol A Based Resin	228	235	240	227	237	220	234	282	335
Bisphenol F Based Resin	8	8	9	8	9	8	9	12	16
Epoxy Phenol Novolac Based Resin	10	11	11	11	12	11	12	16	21
Cycloaliphatic Epoxy Based Resin	8	8	8	7	8	7	8	10	13
Others	20	22	24	23	25	25	26	33	41
Total	**274**	**284**	**292**	**277**	**290**	**271**	**289**	**352**	**425**

3.6.6. Demand By Sales Channel

Middle East & Africa Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020
Direct	47.3	47.5	47.9	47.7	47.2	47.1
Indirect	52.7	52.5	52.1	52.3	52.8	52.9

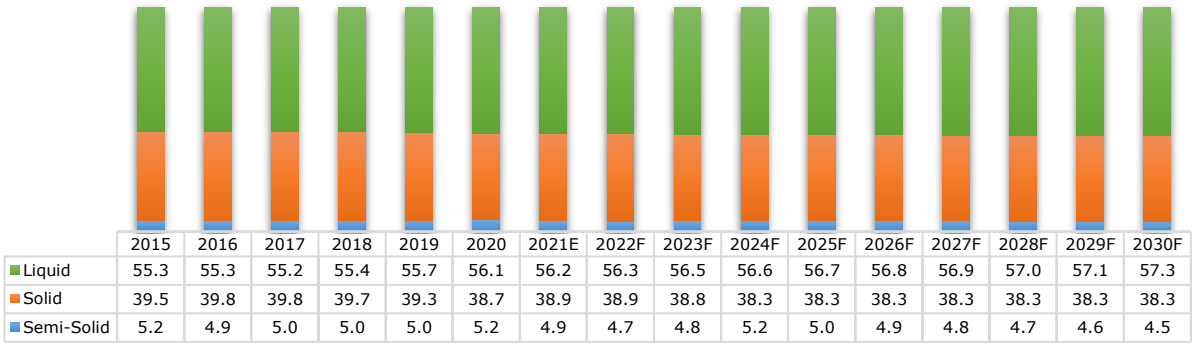
Source: TechSci Research

Demand by Sales Channel	2015	2016	2017	2018	2019	2020
Direct Company Sale	130	135	140	132	137	128
Indirect	144	149	152	145	153	143
Total	**274**	**284**	**292**	**277**	**290**	**271**

Source: TechSci Research

3.6.7. Demand By Grade

Middle East & Africa Epoxy Resin Demand, By Grade (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Liquid	55.3	55.3	55.2	55.4	55.7	56.1	56.2	56.3	56.5	56.6	56.7	56.8	56.9	57.0	57.1	57.3
Solid	39.5	39.8	39.8	39.7	39.3	38.7	38.9	38.9	38.8	38.3	38.3	38.3	38.3	38.3	38.3	38.3
Semi-Solid	5.2	4.9	5.0	5.0	5.0	5.2	4.9	4.7	4.8	5.2	5.0	4.9	4.8	4.7	4.6	4.5

Source: TechSci Research

Demand by Grade	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Liquid	152	157	161	154	162	152	163	200	244
Semi-Solid	14	14	15	14	14	14	14	18	19
Solid	108	113	116	110	114	105	113	135	163
Total	**274**	**284**	**292**	**277**	**290**	**271**	**289**	**352**	**425**

Source: TechSci Research

3.6.8. MEA Epoxy Resin Market Demand-Supply Analysis, By Volume, 2015-2030F (Thousand Tonnes)

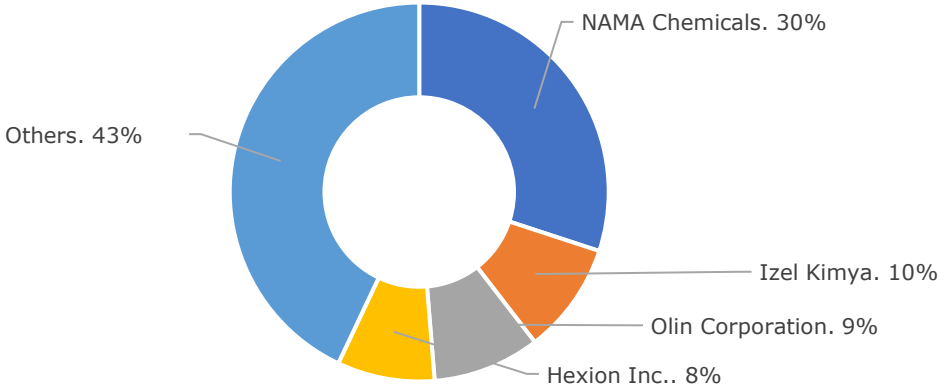
	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Capacity	220	220	220	220	220	220	220	220	220
Production	167	175	172	170	159	171	183	197	214
Import	145	161	185	166	180	146			
Export	34	48	62	55	46	44			
Total Demand	274	284	292	277	290	271	289	352	425

Demand Supply Gap		-106	-155	-211

Source: TechSci Research

3.6.9. Sales By Company

Middle East & Africa Epoxy Resin Sales, By Company, By Volume, 2020



Source: TechSci Research

Region	Demand Volume Share (%)	2020	2021E
MEA	NAMA Chemicals	81	95
MEA	Izel Kimya	26	35
MEA	Olin Corporation	25	31
MEA	Hexion Inc.	23	16
MEA	Others	116	112

2020	2021E
30.04%	32.82%
9.51%	12.08%
9.15%	10.64%
8.33%	5.65%
42.97%	38.81%

Source: TechSci Research

NAMA Chemicals, Al-Jubail headquartered, Saudi Arabian petrochemical giant is the key player in the Middle East epoxy resin market as it captures close to one-third of the market in terms of sales by an individual company. Demand from paints and coatings along with electrical & electronics industries have been the critical drivers of epoxy resin growth in the region. Izel Kimya and Olin Corporation are other two significant epoxy manufacturers in the Middle East and African region. Economic recovery across the world has resulted in increasing demand for energy feedstocks, market participants will be aware of these developments and will look to consolidate by putting an optimistic approach in the long-term which is likely to reflected in new green field and brown field projects.

Middle East & Africa Market Insights

Total capacity of Epoxy resin in Middle East stood at about 220 KTPA with NAMA Chemicals holding largest chunk of market share with annual capacity of 120 KTPA.

The Middle East epoxy resin market grew at a negative CAGR of 0.21% in terms of volume during the period 2015-2020 and is forecasted to grow at an average CAGR of 4.38% by 2030.

Operating Efficiency

Operating efficiency of all the key manufactures is observed to be more than 70%. There has been a gradual increase in efficiency till 2020.However in the year 2020, companies faced backlog in production owing to supply-chain disruptions as well as lockdown constraints being imposed due to the pandemic. As the Middle East market recovers to its pre pandemic levels of economic activity, the demand for resins in general is going to increase significantly

Demand By Application

Epoxy resin has a wide range of applications including paints and coatings, electronics industry, construction, composites etc.

Demand of epoxy resin in paint & coating industry holds the largest market share at 40% as of 2021 in the MEA region. Other applications of epoxy resin include marine, defense, encapsulation etc. The demand of epoxy resins from the Paints and Coatings sector stood at 108 KT in 2020. The sector is estimated to hold a demand share of more than 40% in the forecast period.

Demand By Type

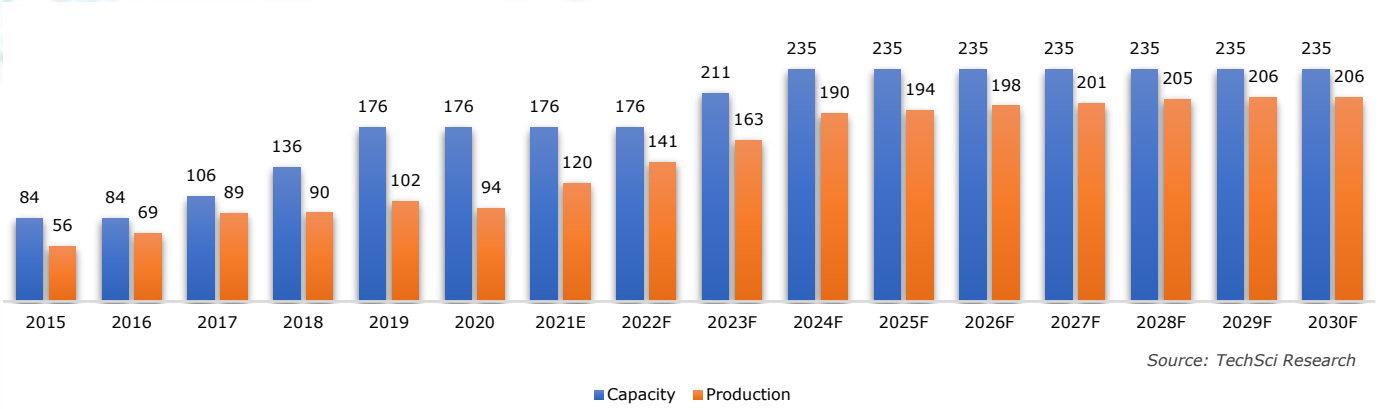
Based on type, BPA-based epoxy resin is holds the largest demand share followed as on 2021. Bisphenol A (BPA) based Epoxy resins continue to dominate the market among other categories. However, growing awareness regarding toxic impacts of BPA and awareness about several alternatives for production of Epoxy resins have resulted in consumers opting for comparatively safer alternatives. Bisphenol F based Epoxy resins seem to attract attention of several player into Epoxy Resin production in the coming years.

Demand By Grade

Liquid epoxy resin (LER) remained highest in demand, holding a demand share of 56.2% in the MEA epoxy resin market. Solid epoxy resin seems to be second in the league while Demand in semi-solid epoxy resin has witnessed a negative growth and will further decline in coming years.

INDIA EPOXY RESIN MARKET OUTLOOK

3.7.1. India Epoxy Resin Capacity & Production, By Volume, 2015 - 2030F (Thousand Tonnes)



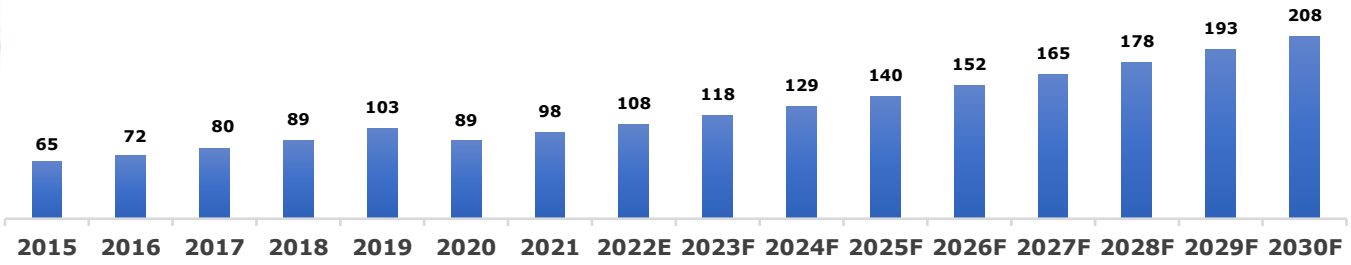
Source: TechSci Research

Company	Location	2015	2020	2030F
Kukdo Chemical India Private Limited	Gujarat	0	40	40
Grasim Industries Ltd.	Gujarat	44	66	90
Atul Limited	Gujarat	30	40	50
Meghmani Finechem Limited	Gujarat	0	0	25
Hindusthan Specialty Chemicals Ltd	Gujarat	0	30	30
Others		0	0	0
Total		74	176	235

Source: TechSci Research

- Apart from Grasim Industries, Atul Ltd., Hindustan Specialty and Kukdo Chemical, who manufacture the Base Epoxy Resin in addition to formulations and downstream products, around 10 to 15 small units are also engaged in making formulations of epoxies and epoxy-based products. Epoxy Resin, though produced indigenously, is also imported in substantial quantity into India. Both the raw materials, Bisphenol-A and Epichlorohydrin are imported. Meghmani Finechem Ltd. will become the first manufacturer of ECH with capacity of 50 KTPA.
- Aditya Birla Epoxy India Ltd, renamed as Grasim Industries India Ltd. (Chemicals Division) is the largest manufacturer of basic Epoxy Resin with installed capacity of 66 KTPA. This project was commissioned during the year 2013.
- Atul Ltd., part of the Lalbhai Group, is the second largest producer of Epoxy Resins located at Valsad, Gujarat. The company has a capacity of 40 KTPA for manufacturing Epoxy Resin.

3.7.2. India Epoxy Resin Demand, By Volume (Thousand Tonnes), 2015-2030F



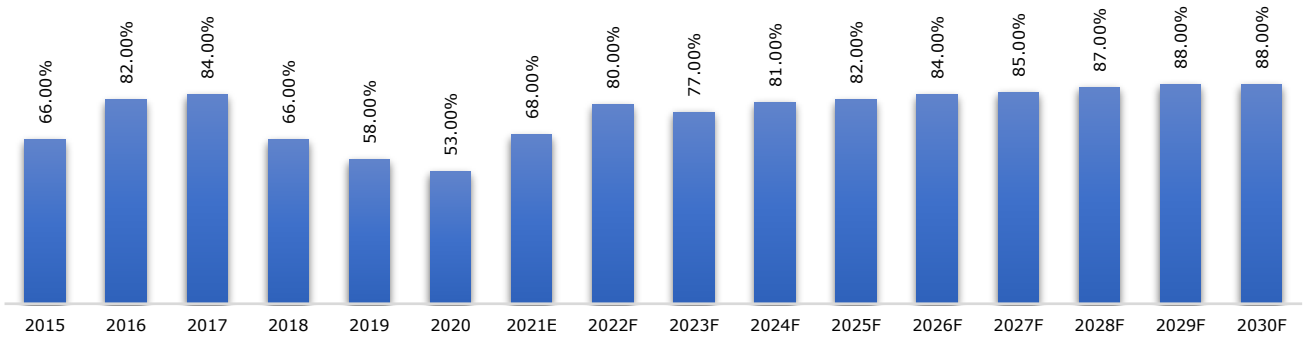
2015-2020
CAGR
6.31% By Volume

2021-2030F
CAGR
8.69% By Volume

Source: TechSci Research

3.6.3. Operating Efficiency

India Epoxy Resin Operating Efficiency (Percentage), 2015-2030F



Source: TechSci Research

Approach: Growth Forecast Via Factors (Impact Analysis)				
Factors	**Sources**	**Value**	**CAGR**	**Weightage**
GDP Growth Rate (2021-2030 Period_	*World Bank, TechSci Estimates*	*Forecast*	7.50%	12%
GDP Per Capita (%)	*World Bank, TechSci Estimates*	*Forecast*	5.09%	3%
Average Selling Growth (%)	*TechSci Research Estimates*	*Forecast*	2.50%	3%
Growth in Construction Sector	*TechSci Research Estimates*	*Forecast*	8.85%	21%
Growth in Renewable Sector	*TechSci Research Estimates*	*Forecast*	9.50%	23%
Growth in Automotive Sector	*OICA, SIAM*	*Forecast*	7.80%	14%
Paint & Coating Industry Growth	*Industry Sources & TechSci Research Estimates*	*Forecast*	10.50%	24%
Market Growth in Historical Period (2015-2020)	*Industry Sources & TechSci Research Estimates*	*Historical*	7.11%	1%
CAGR (2021-2030)	**8.69%**			

Source: TechSci Research

TechSci Research has followed this approach to calculate the growth rates by understanding the impact of various factors of the industry. These factors were given weightage according to the relative importance of each factor. Finally, each factor was multiplied with its weightage and their sum was used to calculate market growth.

3.7.3. India Epoxy Resin Capacity, By Technology, By Process, By Volume, 2015 - 2030F (Thousand Tonnes)

Company	Technology	Process	2015	2020	2030F	References
Kukdo Chemical India Private Limited	In house Technology	Advancement	0	40	40	Primary Research*, Company Press Releases
Grasim Industries Ltd.	Tohto Kesia	BADGE & Advancement	44	66	90	Company Press Releases
Atul Limited	Ciba-Geigy	BADGE & Advancement	30	40	50	Primary Research*
Meghmani Finechem Limited	In house Technology	BADGE & Advancement	0	0	25	Company Press Releases
Hindusthan Specialty Chemicals Ltd	Ciba-Geigy	BADGE & Advancement	0	30	30	Primary Research*
Total			74	176	235	

Source: TechSci Research

*****We do multiple interviews in one organisation at different levels (Mid-Senior) and departments (Sales, Marketing, Production etc.)*

India Trade Dynamics, By Value (USD million), By Volume (Thousand tonnes), 2019 - 2021

Imported Country	2019		2020		2021	
	Value	Volume	Value	Volume	Value	Volume
South Korea	24.84	9.31	32.21	14.41	36.30	14.96
China	8.98	2.40	8.76	2.64	5.92	2.20
Taiwan	7.89	2.58	7.05	2.66	5.82	1.78
Japan	10.37	1.85	9.73	1.55	9.87	1.37
Netherland	4.93	1.68	5.41	1.99	4.02	1.14
Others	32.35	8.55	30.02	8.81	28.21	8.36
Total	89.36	26.37	93.18	32.05	90.14	29.81
Exported Country	2019		2020		2021	
	Value	Volume	Value	Volume	Value	Volume
Germany	18.92	7.18	12.07	5.59	13.10	5.61
Italy	19.70	7.89	14.51	6.96	10.64	4.51
United Arab Emirates	13.28	5.02	7.88	3.54	4.72	1.72
Saudi Arabia	2.81	1.13	2.11	0.95	2.46	0.98
Turkey	1.57	0.54	2.78	0.95	2.88	0.85
Others	24.13	7.90	20.46	7.47	16.58	5.66
Total	80.41	29.66	59.81	25.47	50.38	19.32

Source: DGFT

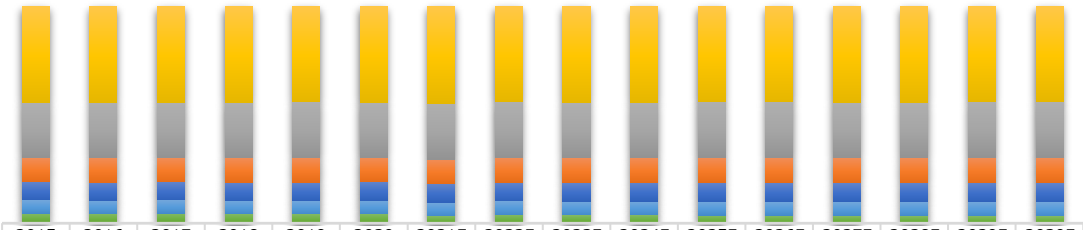
3.6.8. India Epoxy Resin Market Demand-Supply Analysis, By Volume, 2015-2030F (Thousand Tonnes)

	2015	2016	2017	2018	2019	2020	2021E	2025F	2030F
Capacity	84	84	106	136	176	176	176	235	235
Production	56	69	89	90	102	94	120	194	206
Total Demand	65	72	80	89	103	89	98	140	208
Demand Supply Gap							36	27	13

Source: TechSci Research

3.7.4. Demand By Application

India Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Paints & Coatings	44.1	44.3	44.2	44.1	43.9	44.2	44.6	44.0	44.2	44.1	44.0	44.0	44.1	44.1	44.0	43.9
Electrical & Electronics	25.7	25.5	25.6	25.6	25.9	25.3	25.9	25.8	25.7	25.6	25.7	25.8	25.7	25.7	25.8	25.8
Construction	11.2	11.3	11.2	11.3	11.4	11.4	11.4	11.4	11.5	11.5	11.5	11.6	11.6	11.6	11.6	11.7
Composite Materials	8.3	8.4	8.3	8.4	8.4	8.5	8.5	8.5	8.6	8.6	8.6	8.6	8.7	8.7	8.7	8.8
Adhesives	6.1	6.2	6.1	6.2	6.2	6.3	6.3	6.3	6.3	6.4	6.4	6.4	6.5	6.5	6.5	6.5
Others	4.6	4.5	4.6	4.4	4.2	4.4	3.4	4.0	3.8	3.9	3.8	3.6	3.5	3.4	3.4	3.4

Others Marine, Defence, Encapsulation etc .

Source: TechSci Research

Demand by Application	2015	2016	2017	2018	2019	2020	2025F	2030F
Paints & Coatings	29	32	35	39	46	40	57	85
Electrical & Electronics	17	18	20	23	26	23	33	50
Construction	7	8	9	10	12	10	15	22

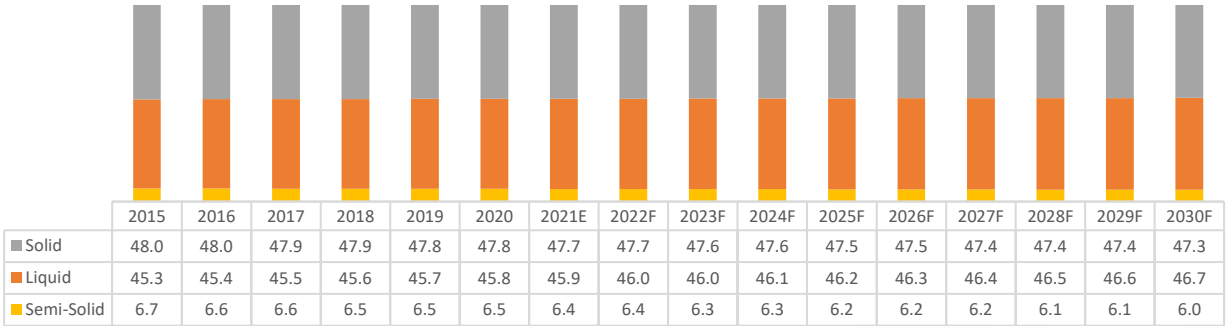
Composite Materials	5	6	7	8	9	8	11	17
Adhesives	4	4	5	6	6	6	8	13
Others	3	3	4	4	4	3	5	6
Total	65	72	80	89	103	89	**193**	**208**

Source: TechSci Research

The rapid growth in the Indian paints and coatings industry (mainly automotive, industrial coatings, Medical Sector & wind energy) is expected to propel the growth of the epoxy resins market during the forecast period. Epoxy resin is extensively used in electrical and energy distribution systems as adhesives, coatings, and sealants, also in the manufacturing of transformers, insulators and bushings (these are used as protective coatings in large generators & on printed circuit board). In Commercial construction, it provides particularly strong bonding adhesives, sealants and fillers, epoxy resins are suitable for internal and external use given them strength, durability and chemical resistance of mechanical fixings and to repair bridge & decks.

3.7.5. Demand By Grade

India Epoxy Resin Demand, By Grade (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Solid	48.0	48.0	47.9	47.9	47.8	47.8	47.7	47.7	47.6	47.6	47.5	47.5	47.4	47.4	47.4	47.3
Liquid	45.3	45.4	45.5	45.6	45.7	45.8	45.9	46.0	46.0	46.1	46.2	46.3	46.4	46.5	46.6	46.7
Semi-Solid	6.7	6.6	6.6	6.5	6.5	6.5	6.4	6.4	6.3	6.3	6.2	6.2	6.2	6.1	6.1	6.0

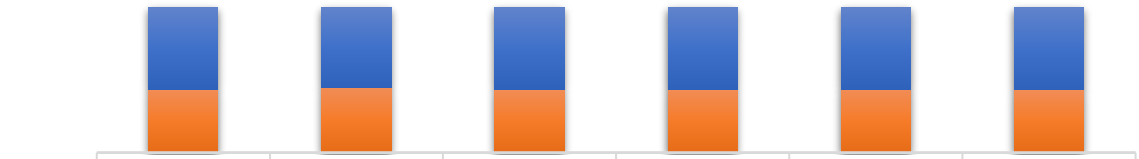
Source: TechSci Research

Demand by Grade	2015	2016	2017	2018	2019	2020	2025F	2030F
Liquid	30	33	36	41	47	41	90	98
Semi-Solid	4	5	5	6	7	6	12	97
Solid	31	34	38	43	49	42	91	13
Total	**65**	**72**	**80**	**89**	**103**	**89**	**193**	**208**

Source: TechSci Research

3.7.6. Demand By Sales Channel

India Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020
Direct	56.2	55.1	56.3	56.3	56.2	56.8
Indirect	43.8	44.9	43.7	43.7	43.8	43.2

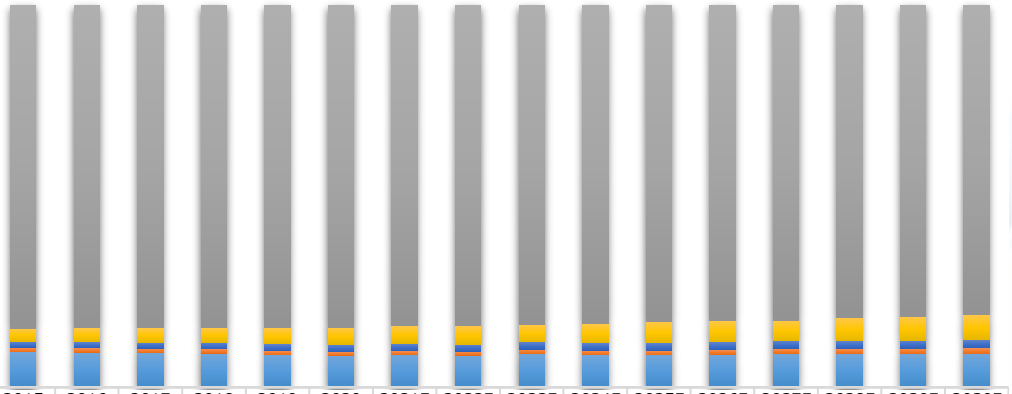
Source: TechSci Research

Demand by Sales Channel	2015	2016	2017	2018	2019	2020
Direct Company Sale	37	40	45	50	58	50
Indirect	29	32	35	39	45	38
Total	**65**	**72**	**80**	**89**	**103**	**89**

Source: TechSci Research

3.7.7. Demand By Type

India Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, 2015–2030F



	2015	2016	2017	2018	2019	2020	2021E	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Bisphenol A Based Resin	84.6	84.5	84.4	84.3	84.4	84.2	83.9	83.9	83.5	83.2	82.8	82.5	82.4	81.7	81.4	81.1
Bisphenol F Based Resin	3.5	3.6	3.8	3.8	4.2	4.6	4.6	4.7	4.5	5.0	5.5	5.7	5.3	6.1	6.2	6.4
Epoxy Phenol Novolac Based Resin	1.5	1.6	1.5	1.8	1.7	1.8	1.9	1.8	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.2
Cycloaliphatic Epoxy Based Resin	1.2	1.2	1.2	1.1	1.2	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.3	1.4	1.5
Others	9.3	9.2	9.1	9.0	8.5	8.3	8.5	8.4	8.8	8.5	8.5	8.6	8.9	8.8	8.8	8.8

Source: TechSci Research

Demand by Type	2015	2016	2017	2018	2019	2020	2025F	2030F
Bisphenol A Based Resin	57	64	69	78	90	77	110	170
Bisphenol F Based Resin	1	1	2	2	3	3	4	13
Epoxy Phenol Novolac Based Resin	1	1	2	2	2	2	3	4
Cycloaliphatic Epoxy Based Resin	1	1	1	1	1	1	2	3
Others	5	5	6	7	7	6	10	18
Total	**65**	**72**	**80**	**89**	**103**	**89**	**129**	**208**

Source: TechSci Research

3.7.8. India Epoxy Resin Market Demand and Gap Analysis, By Volume, 2021, 2024, 2028 and 2030 – Optimistic, Pessimistic and Realistic

Demand Scenario	2020	2021E	2024F	2028F	2030F
Pessimistic	**88.83**	**92.09**	**110.92**	**137.53**	**168.44**
Demand Supply-Gap		**27.71**	**79.08**	**67.47**	**41.56**
Realistic	**88.83**	**98.11**	**128.53**	**178.41**	**207.44**
Demand Supply-Gap		**21.69**	**61.47**	**26.59**	**13.01**
Optimistic	**88.83**	**103.25**	**144.75**	**220.08**	**255.62**
Demand Supply-Gap		**16.55**	**45.25**	**-15.08**	**-45.62**

Realistic

There are certain challenges which include volatility in the energy market and demand deterioration by pandemic as well as logistics problems in the short term. However, in the long term these factors will have little to no impact on overall growth of epoxy resin market resulting in a balanced performance during the forecasted period. For the major part, market will be driven by the opportunities in the downstream sectors on the back of stable recovery of GDP growth rate levels in India. Demand growth is likely to revert back to pre-pandemic levels gradually prompting producers to look towards expansion in capacities around the country.

India Projected GDP growth rate FY2023, FY2025 and FY2030

Country	2023	2025	2030
India	7.95%	7.52%	7.24%

Source: OECD, World Bank

Optimistic

Driven by V-shaped recovery of the GDP growth rate in the region, consumption levels from key downstream sectors will increase sharply. Government schemes including “Housing for All”, “Smart Cities Mission” to promote the growth of construction sector will push the country’s Epoxy Resin demand growth. Due to its growing inclination towards digitization, demand for Epoxy Resin reinforced PCBs looks to gain traction with Bharat Net and growing push for complete digital literacy. Indian government has envisioned to make the country a manufacturing hub and increasing its GDP share to 25% by 2022. In lieu of that, the Indian government has taken several initiatives and made various policy changes to attract FDIs as well as promote local manufacturing. India is in line with its renewable energy targets and its investments in renewable sources of energy, particularly wind energy is growing tremendously. Advancements in material science present opportunities to explore growth in the renewable energy sector through manufacturing of wind turbines and other equipment manufacturing. Growth prospects in the construction industry, electrical and electronics industry along with automotive industry will led the Epoxy Resin demand growth and will propel capacity expansions in the coming years.

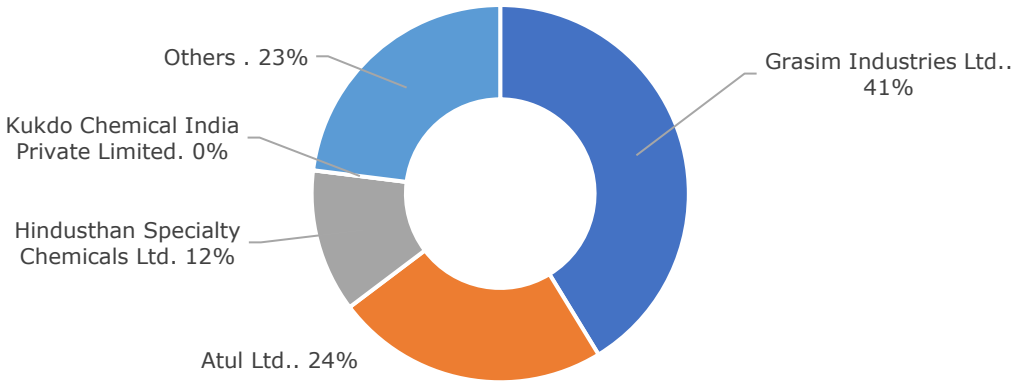
Pessimistic

Epoxy Resin market in India is likely to face numerous challenges in the long-term starting from volatility in the energy market. Being a key importer of crude oil and key raw materials, uncertainties in energy feedstock market outlook adversely impact the country’s petrochemicals market. In lieu of that, the India’s Epoxy Resin market is subject to acute volatility. Series of covid waves due to multiple variants of coronavirus will be a key market determinant in the long term which may affect the GDP growth rate. Covid in the past has resulted in demand deterioration and supply chain disruptions which turned global market upside down and sent GDP growth rates worldwide onto a downward spiral. Growth in economy is vital to some key sectors including construction. The Indian construction industry is driven by infrastructure and housing development, any stagnancy or dip in GDP number is likely to be reflect in its consumption pattern and may hamper epoxy demand growth. Continuous increase in the cost of production (due to rising costs of raw materials, logistics problems and other factors) has also resulted in lopsided

market dynamics. In the wake of above factors, manufacturers may take a conservative approach which results in stagnant production and constrained supply fundamentals in the long term.

3.7.9. Sales By Company

India Epoxy Resin Sales, By Company, By Volume, 2020



Source: TechSci Research

Sales Volume (Thousand Tonnes)	2020	2021E
Grasim Industries Ltd.	36	39
Atul Ltd.	20	21
Hindustan Specialty Chemicals Ltd	10	17
Kukdo Chemical India Private Limited	0	2
Import - Others (Nan Ya Plastics, Kukdo Japan, Aditya Birla Thailand, Hexion)*	23	19

2020	2021
40.27%	39.34%
22.45%	21.62%
11.60%	17.80%
0.00%	1.57%
25.68%	19.67%

Source: TechSci Research

**TechSci Research has not included the shares of Kukdo Japan and Aditya Birla Thailand in their subsidary and parent companies operating in India.*

Indian Epoxy resin market has three key manufacturers mainly, Grasim Industries, Atul Industries and Hindustan Specialty Chemicals. Among these manufacturers Grasim Industries has the largest market share in terms of sales where company held more than 40% of market share. The company has shown outstanding numbers in previous two quarters i.e., Q4 2021 and Q1 2022 where Grasim Industries observed substantial increase in its net profits consolidating on the economic recovery in the Indian sub-continent region. Huge boost in advanced materials has been at the helm of driving demand in renewable energy which dually benefitted epoxy prospects in the region. Impressive performance in last quarter of 2021 for Atul industries in its epoxy business has been building on the demand growth, however a dip in Q1 2022 numbers has been witnessed epitomizing the effects of second covid wave in the region. Overall, epoxy market sentiments look optimistic and will consolidate on the demand growth in the region.

India Epoxy Resin Demand

Epoxy resin demand in stood at 98 KTPA in FY21 and the demand is expected to register a robust CAGR of 8.69% between 2021-2030. Rise in the market growth is largely attributed to growth in the country's construction sector and increasing industrialisation and incentivisation of domestic producers.

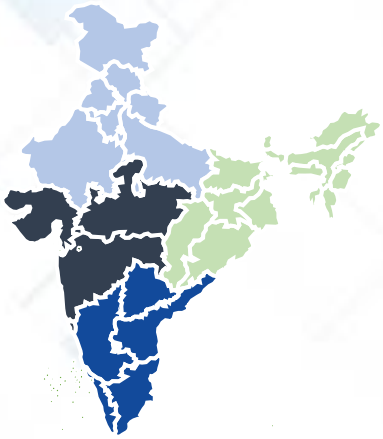
Kukdo Chemical India Private Limited, Grasim Industries, Atul Limited are top three players operating in the India Epoxy Resin market. As per our market study, BADGE and Advancement process is mainly used in Epoxy Resin manufacturing. While Kukdo chemicals and Meghmani use in- house technology for Epoxy Resin manufacturing, other Indian manufacturers have sourced technologies from Japan (Tohto Kesia) and Germany (Ciba-Geigy) for Epoxy Resin manufacturing.

India is the key importer of Epoxy Resin with South Korea, China, Taiwan, Japan, Netherlands as its key trade partners between 2019-2021. India also exported significant volumes of Epoxy Resin to Germany, Italy, UAE, Saudi Arabia, Turkey and other countries between 2019-2020.

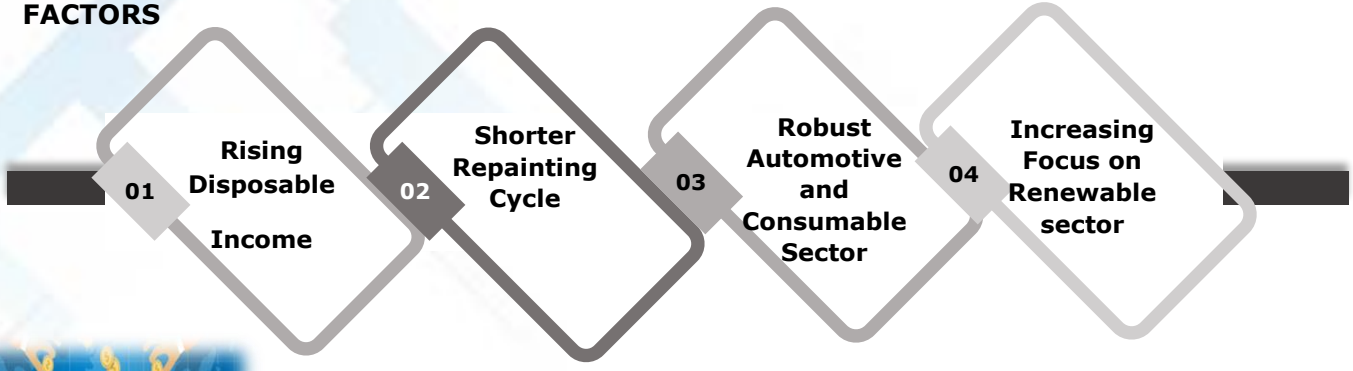
Paints and Coatings industry dominates the India Epoxy Resin Demand, holding around 44.2% demand share in 2021. Electrical and electronics and construction sector collectively hold nearly 30% share in the India Epoxy Resin demand. Epoxy Resins are being used as a replacement for mechanical fixings to provide internal and external strength, weather resistance and durability in Construction and Electrical and Electronics Industry specifically. India is witnessing high growth in the demand of epoxy resins due to increased consumption in protective coatings to prevent corrosion in Food and Beverage Sector, Automotive/Transportation etc.

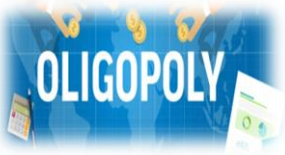
The demand for Solid Epoxy Resin is estimated at around 47.7 KT in 2021 while demand for Liquid Epoxy Resin (LER) stands at 45.8 KT in the same period. It is expected that there would be substantial growth in demand for LER in the coming years while some slowness could be sensed in the demand for Solid Epoxy Resins. In India, majority of Epoxy Resin is sourced directly from producing companies. Bisphenol A (BPA)-based Epoxy Resins hold majority share the country's Epoxy Resin demand. Due to growing awareness about environmental and toxic impacts of BPA-based Epoxies, it is expected that the demand for Bisphenol-F based will increase tremendously as a substitute of BPA.

West and South are the dominating region in India Epoxy Resin Market



KEY GROWTH FACTORS





Steady demand growth tied to transportation, population growth and institutional support.

Imported Grades are perceived to be superior in comparison to locally available grades

India's demand supply balance is likely to tighten through 2027

Reduction in GST rate helped them to pass on the cost benefits to end users

Market is highly oligopolistic in nature with presence of few large dominant players

India Industrial Dynamics

1. ***Market is highly oligopolistic in nature with the presence of few large dominant players***

Currently, there are only four business groups that are indulging in the production of epoxy resin in India. The market players include Kukdo Chemical India Pvt. Ltd., Grasim Industries, Atul Limited, Hindustan Specialty Chemicals Ltd. Grasim Industries is the oldest market player that hold the highest production capacity in India and has plans to further expand its epoxy resin production by 2025. Atul Limited has been an active player in epoxy resin production in the past and is expecting to raise the production capacity by 2024. Due to growing epoxy resin demand in coatings, adhesives, and composites applications and low market competitiveness has attracted a few more players to foray into epoxy resin production. For instance, Hindustan Specialty Chemicals started operating 30 KTPA epoxy resin plant in 2018. Kukdo Chemical India Pvt. Ltd. also ventured in epoxy resin production last year with its 40 KTPA production unit in Dahej, Gujarat. On the other hand, Meghmani Fine Chemicals is in plans to bring on-steam a 25 KTPA epoxy resin plant in Gujarat by 2024. The advent of new players in this field has mostly remained restricted owing to the high investment cost and dependence on imports for feedstocks. However, the fast-growing epoxy resin market in India and limited competition from other players is expected to compensate the investment cost with high output returns, making the India epoxy resin market and an attractive spot for new entrants.

2. ***Reduction in GST rate helped them to pass on the cost benefits to end users***

The Goods and Services Tax (GST) is an indirect tax imposed on goods and services sold domestically. Replacing all other kind of taxes levied by the state or central governments, GST is a single tax charged by the last dealer and is borne by the end-user alone. The imposition of GST has benefitted the chemical industries by ridding them from the burden of added taxations that led to high production costs. Now, with mitigation of VATs, CGST, SGST, IGST etc., that eventually caused the manufactures to pay more under the cascading effect, the gross production costs are significantly reduced giving the manufacturers more room to expand and sell their products anywhere across India. The low production costs are eventually passed on to end users who enjoy procurement of the chemical products at stable and affordable prices.

3. ***Steady demand growth tied to transportation, population growth and institutional support***

Engrossed with properties like high mechanical strength, strong adhesion, electrical insulation, chemical resistance, and low toxicity makes it a vital component in important end-user industries like transportation, buildings and construction, electricals and electronics, aerospace, wind-turbines etc. The growing population in India and their improving standard of living drives the growth in the transport and construction sectors with growing affordability. Hence, the transport sector where epoxy resins are extensively used in paints, engine components, structural inserts, and the construction sector where epoxy resins have multitudinous applications in coatings, paints, primers, sealers, flooring etc., are expected to maintain a firm demand for epoxy resins in the market.

4. ***Imported grades are perceived to be superior in comparison to locally available grades***

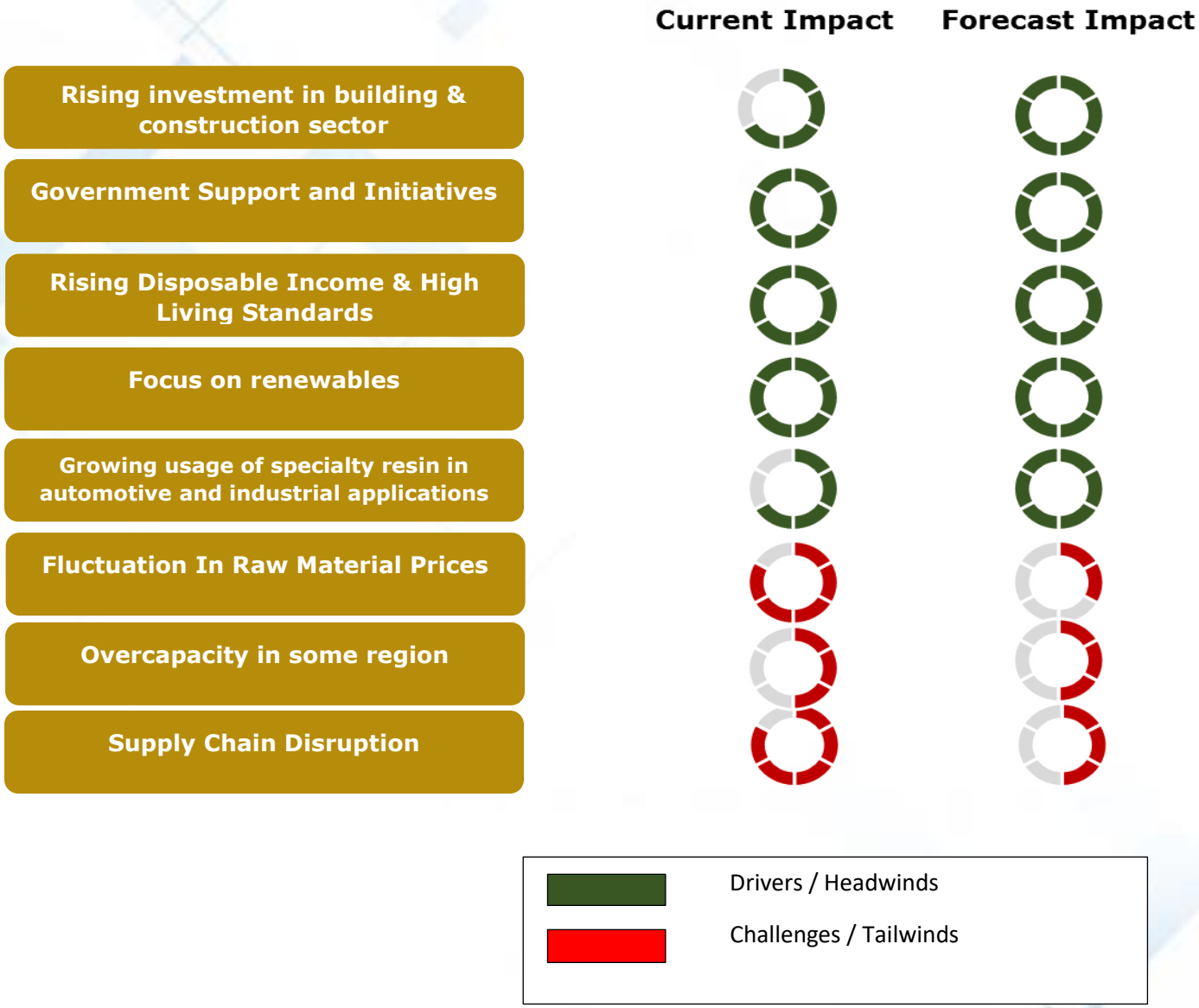
The imported epoxy resin grades like DERTM 337-DA97 (liquid phase) and DERTM 660-B80 (solid phase) from Olin Corporation, ARALDITE from Huntsman Corporation, EPONTM Resin 824 from Hexion, have gained huge popularity among the Indian end-user sectors due to their remarkable product quality. The imported epoxy resin grades have captured a significant share in the Indian market due to a general perception of being superior and reliable in comparison to the locally produced grades. Entrance of a player having technological expertise and could produce epoxy resin grades with qualities at par with imported ones, could really prove to be a game changer in the current scenario. The increase in high quality epoxy resin capacities could reduce India's reliance from overseas imports and strengthen its position in the international exports.

5. ***India's demand supply balance is likely to tighten through 2027***

The total consumption of epoxy resin is met through domestic production and overseas imports. The projected heavy growth in the transport industry as well as the construction activities in the coming 5 years is expected to raise the demand for epoxy resin by more than 50% of the volume consumed in 2020. The projected surge in epoxy resin demand without any significant additions in the production capacities are expected to bring a discord in the supply-demand balance. This could lead to increased dependence of the end user industries on imports which are bound to escalate under the influence of supply

deficit market, a scenario liable to set the inflation rates high. However, the prospects of addition of new capacities could steer the market dynamics in its favor by catering to the rising demand in the end-user industries.

3.8. MARKET DYNAMICS



Market Drivers

Rising Investments in Building & Construction Sector

The increasing population and continuously evolving economies have given way to increased expenditure on advanced infrastructure across the globe. Factors such as significant rise in purchasing power parity, especially in developing nations, and growing investments in the real estate sector are boosting the growth of construction sector, globally. Hence, the construction sector remained the major driver of epoxy resin market all throughout the historical years. After witnessing subdued activity during the COVID19 pandemic spread, the construction sector is rebounding in full force as the incomplete projects are being expedited and new projects are under pipeline. Various government sponsored projects across the globe such as smart cities, AMRUT, freight corridor and urban transport, etc., are expected to further accelerate the construction activities in the coming years in Southeast Asia, GCC, Central Europe and North Africa, thereby positively impacting the global epoxy resin market.

European Countries Real Estate Investment, 2020 (USD Billion)

Countries	Investment (USD Billion)
Germany	59
France	29
Netherland	16
Spain	13
Italy	10

Source: Meed Projects

Government Support and Initiatives

Driven by strong demand from various end-use industries such as wind energy, transportation, electrical and electronics, defense, aerospace, pipes and tanks, construction and marine, the composite industry, also known as fiber-reinforced plastics (FRP) industry, has witnessed a sharp rise in the past decade. The per capita consumption of composites in the United States, China and India were reported to be 11.4 kg, 2.8 kg, and 0.36 kg respectively. Owing to its multitudinous applications in various segments of the construction sector, the composite industry is set to play a pivotal role in supporting government's initiatives across various developing countries. For instance, the 'Make in India' and 'Housing for All' initiatives launched by the Indian government warrant a surge in the construction activities that are expected to give a big push to the epoxy resin market. The increasing demand for composites manufacturing across the globe for numerous applications including aerospace structure & other composite parts would spur the demand for Epoxy Resins in the coming years.

Growing usage of specialty resin in automotive and industrial applications aerospace sector

Epoxy resin has a history of serving the automobile industry owing to its robustness, adhesive quality, and heat resistance nature. Epoxy resins are predominantly used to add protective coatings on automobile metal parts to increase their shelf life by preventing them from corrosion. The anti-corrosion epoxy coatings are applied as a primer on the metal parts using the 'waterborne cathodic electrodeposition' technique. Germany, boasting the largest automobile industry in Europe, owns a huge share in the epoxy resin consumption. China with its huge electronics base and high industrial growth also exhibits high consumption rate of epoxy resin. The flourishing automobile sector backed by the increasing population and growing income slab of the middle-class communities in the developing countries are expected to propel the demand for epoxy resins in the automobile industry in the coming years.

Epoxy resins form an indispensable part of the continuously evolving aerospace technologies, owing to its ability to withstand harsh conditions of space and resist microcracking. High-quality epoxy resins are in great demand in spacecraft for a myriad of applications like coating, bonding, encapsulation, staking, sealing, potting. Epoxy resins based composite fabrics have also gained a huge preference for the designing of durable and lightweight spacesuits with flame retardancy properties. With the growing government thrust towards active research in new space programs and increasing space excursions by the world's top research organizations, the aerospace sector

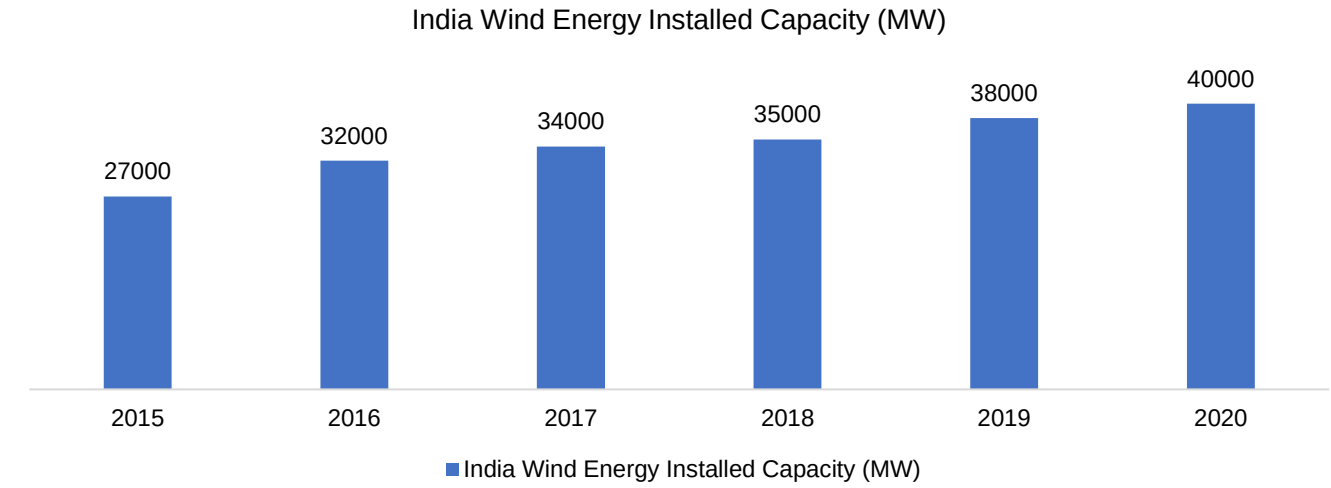
is expected to pick momentum by 2030 thereby becoming a large hub for the consumption of epoxy resins.

Rising Disposable Income & High Living Standard

As the industrialization and economic growth across the world has enhanced dynamically, there has been a significant rise in the earned income and expenditure incurred on lavish lifestyles by the people across the globe, thus giving impetus to the epoxy-based lightweight coatings and adhesives over the years. The high living standards across developed nations and the improving disposable income across developing countries is going to further drive the demand for advanced and premium quality paints & coatings in the housing and construction sector where epoxy resins are extensively applied in the forthcoming years. The demand will get further support from increasing per capita expenses on premium cars across the globe which will be driving the epoxy resin market worldwide.

Focus on Renewables

Many countries are targeting to reduce global carbon footprint by increasing investments in renewable energies which has attracted around USD 1.9 trillion capital spending in 2021 and the investment rate is expected to gain 10% year-on-year growth in the upcoming years. India has set a target of having 175 GW of renewables capacity by 2022. This shows that the country is focusing on renewable energy for its energy needs. India is also a party to the United National Convention on Climate Change which requires India to have some commitments till 2030 in order to support the world in the fight against climate change. India's commitment includes that 40% of the country's total electricity needs should come from renewable energy. This has caused the demand for wind energy to rise in India and globally. As epoxy resins are a major component of the composite material used to manufacture windmills, the demand for epoxy resins is also set to rise in India with the rise in the demand of wind energy. The energy outlook varies from country-to-country, however the favorable government policies across the world is enough to instigate confidence among the existing and new market players towards renewables business that is eventually going to strengthen the global demand for epoxy resin.



Source: MNRE

Market Challenges

Volatility in Raw Material Prices

An increase in the cost of raw materials, i.e., ECH and BPA, that are being used in the manufacturing of the epoxy resin have driven down the market sales since last year due to several disruptions caused by the COVID-19 outbreak worldwide followed by the energy crunch and crude oil price surge in the current year. The rising crude oil prices directly impact the operating cost and profit margins of the industry, and transportation costs, adding up the price of epoxy resins in the global market. However, the petrochemical sector is walking the path to recovery with loosening of pandemic constraints and return of workforce. Furthermore, the crude oil prices in a few regions, like North America, have begun to fall in the fourth quarter of 2021, which should ripple across the other parts of the world in the following year. These trends advocate the optimism in stabilization in the prices of raw materials in future favoring a positive epoxy resin market outlook.

Supply Chain Disruptions

Due to onset of COVID-19, disruptions in business cycles impacted the demand for all core industries, globally. The virus outbreak has affected supply chain, trade and industries worldwide. Severity of pandemic was compounded by the fact that many industries are operating at reduced capacity, consequently lowering the number of employees as well. Pandemic outbreak also led to delays in all commercial decisions in the short term, but the long-term impact remains unknown as the longevity of the crisis is uncertain. Moreover, in second half of 2021, traffic at the Chinese

ports coupled with the tightened availability of freight vessels gathered adequate momentum to strengthen the will of manufacturers to raise the offered quotations in the APAC market.

Most of Indian businesses are traditionally run with procurement of raw materials done through a lengthy and complex decision-making process. This necessitated forward contracts and long-term contracts to hedge against uncertainties. Changing geopolitical pattern coupled with onset of the global pandemic COVID-19 has re-routed the procurement process, with procurement professionals targeting more short-term contracts for institutional and bulk purchases. Similarly, changing equations between India and China have curbed Chinese supply and Indian importers are now shifting their focus to other Southeast Asian countries for product sourcing.

3.9. Market Trends & Developments

Liquid Epoxy Resin (LER)-Feedstock Margin Spread

As of October 2021, FOB Ningbo price of Liquid Epoxy Resin was around $5915-6000/ tonne, while the price at the end of June was less than $4900/tonne. The abrupt surges in LER pricing are largely attributed to high priced feedstock Epichlorohydrin (ECH).

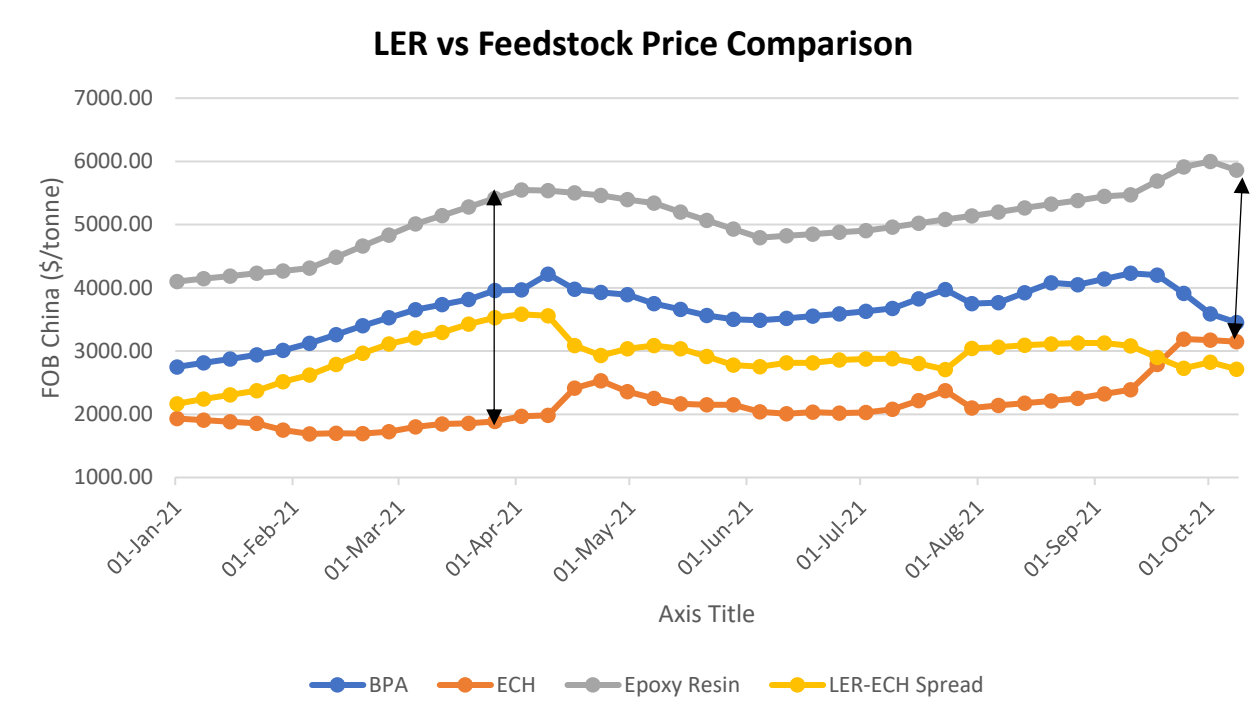
Several Chinese Epoxy producers complained of compressed margins and ChemAnalyst data shows that the spread between ECH and Epoxy Resins narrowed to USD 2710 per tonne levels in October. over USD 3500 level in April. 2021. This is majorly attributed to strong ECH pricing environment and dramatic contraction of Epoxy Resin supplies in East China.

With China's latest norms on energy consumption and dual control management, companies with captive power plants, boilers, and steam need to meet the compliance with many Epoxy Resin companies in Jiangsu in the ranks. Due to uncertain market outlook, many Epoxy Resin companies have curtailed their operating rates and many have also closed. As per traders, several end-users are obviously resistant to high prices and waiting for the situation to normalise. The demand for coatings, laminates, electrical and electronics continues to improve in October due to peak demand season in Q4 2021.

Moreover, rising crude oil prices, lead to increase in production cost of essential raw materials such as epichlorohydrin and BPA.

Liquid Epoxy Resin (LER) Price Forecast

It is estimated that the market price of LER will remain at high levels, with slight fluctuations as the market has already attained consolidation. FOB East China prices in China will likely stay between $5900-6000/mt in October. The relationship between resin supply and demand is tight, and the prices will stay firm in October. In China, raw material epichlorohydrin (ECH) supply may further tighten in China as a major facility in Jiangsu province may remain shut in the wake of the country's new environmental policies.



Cost pressure over downstream industries

Several downstream consumers of Epoxy Resins reported pressured margins due to unexpected surges in Epoxy Resin pricing in Q3. For example, in August 2021, because of the rise in the price of Epoxy Resin in China, the price of copper clad laminates also showed signs of increase. In its interim report Changchun Chemical announced price increase of its copper clad laminates in Q3 due to soaring price of Epoxy Resin in addition to other key raw materials used in the laminate manufacturing. The company also projected in its financials that prices copper clad laminates may increase again in the future due to high raw material cost. Changchun announced that the prices of all copper clad laminate products increased by 10% early in September. In addition, Hong Kong based Kingboard laminates increase HB/VO (all thickness) price w.e.f.

August 30. In August itself, Shengyi Technology also announced an increase in the price of copper clad laminates led by strong copper foil and Epoxy Resin pricing.

(The primary raw material for Printed Circuit Boards is the Copper Clad laminates (CCL) which are made up of copper foil, Glass fibre and Resin. The cost breakup for CCL is- 30-50%: copper foil, 24-40%: Glass fibre and 25-30%: Epoxy Resin)

Expansion of Production Facilities

With the growing demand for Epoxy Resin in various sectors such as automotive, construction, electrical & electronics etc., companies have started investing in expanding and setting up manufacturing facilities across multiple locations worldwide. Moreover, companies are increasingly focusing on investing largely across developing nations due to the availability of cheap labor such as in India, China and others. For instance, Kukdo Chemical Pvt Ltd, one of the leading Korea-based companies, has recently set up greenfield epoxy resin production unit in India with a capacity of around 40 KTPA in 2020 and is further planning to expand its capacity by 60 KTPA by 2024 to address the growing demand across the country and to capture the maximum share in Asian market.

Growing Demand for Lightweight Material in Automotive and Auto Ancillaries Sectors

Rising demand for polypropylene and other petrochemical derivatives in the automotive sector is increasing as companies are focusing more on the development of new products and reducing the carbon footprint. Most of the automotive manufacturers are launching hybrid and electric vehicles across the globe. Furthermore, with rising investments in new product development and adopting new technologies, companies are focusing on using more light and composite materials for automotive manufacturing, which is leading to a surge in the demand for petrochemicals and their derivatives.

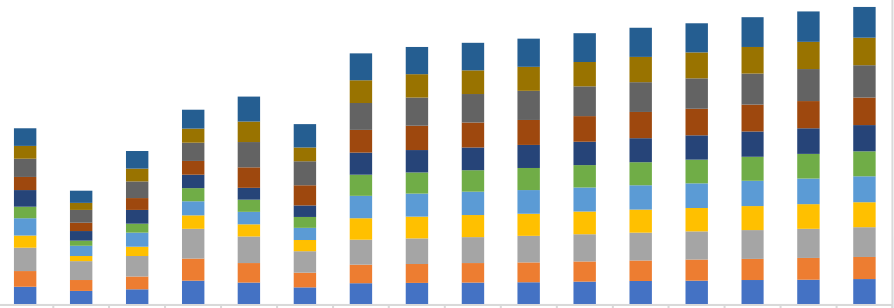
Hazards of Bisphenol A and the related shift from Bisphenol A market

BPA is used in the manufacturing of epoxy resins and due the high demand and related mass production, the presence of BPA is ubiquitous in the environment, and it can enter the body via the digestive tract, respiration system, and dermal tract. BPA by nature is an endocrine disruptor and affects the hormonal levels in the body. BPA has estrogen and anti-androgen effects which damages tissues and organs including the reproductive system, immune system, and neuroendocrine system. Due to its hazardous properties BPA is being replaced by BPS in thermal

paper in Europe. The ECHA restriction for BPA in thermal paper was implemented in 2020. Similar restrictions are expected in the US market in the upcoming years. this has caused the shift from the Bisphenol A market to various substitutes including BPS.

3.10 Pricing Analysis Epoxy Resin (USD/ ton)

Epoxy resin market fundamentals differs region by region, and usually prices vary with fluctuations in raw material cost. Steep economic rebound has favoured sharp hike in price of raw material coupled with rising consumptions across global market, that supported the steep rise in Epoxy resin prices. Countries like UK, frequently face scarcity of raw material bisphenol A (BPA), as industries based in UK are highly dependent on imports. There were other factors which also impacted the trade activities, like spiralling freight cost, crippling availability of shipping containers, and rise in countries' domestic consumption in effect of revival from pandemic repercussion. Moreover, during Q1 2021, USA faced devastating weather that caused disturbance in manufacturing of upstream chemicals, conclusively exacerbated the overall halt in USA-Europe trade activities. Meanwhile, India had to battle with second wave of pandemic during Q2 2021 that overall dented the Epoxy resin market sentiments for a considerable timespan. However, revival of industrial activities has improved the demand fundamentals in Indian market since August 2021. Conclusively Epoxy resin prices witnessed an overseas hike since the month of January 2021.



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Solid Epoxy Resin FOB Texas	3976	2680	3938	4210	5640	5208	5976	6096	6187	6262	6393	6489	6568	6706	6806	6889
Liquid Epoxy Resin FOB Texas	2849	1604	2827	3153	4548	3063	5134	5206	5289	5406	5503	5640	5759	5909	6044	6142
Solid Epoxy Resin FOB Hamburg	4058	2906	3751	4101	5653	5404	5976	6297	6398	6478	6594	6693	6834	6977	7138	7253
Liquid Epoxy Resin FOB Hamburg	2931	1830	2640	3044	4567	4491	5134	5475	5557	5625	5743	5829	5900	6023	6114	6188
Solid Epoxy Resin FOB Seoul	3733	2176	3088	3017	2704	2617	4932	5001	5081	5145	5237	5373	5486	5601	5730	5822
Liquid Epoxy Resin FOB Seoul	2606	1100	1977	2965	2657	2420	4680	4746	4821	4928	5016	5142	5250	5386	5510	5599
Solid Epoxy Resin FOB Ningbo	3833	2276	3188	3114	2801	2709	5030	5131	5208	5271	5381	5462	5528	5644	5729	5798
Liquid Epoxy Resin FOB Ningbo	2706	1200	2077	3063	2754	2512	4778	4845	4922	4984	5074	5150	5258	5368	5492	5580
Solid Epoxy Resin Ex-Mumbai	5235	4195	4601	6650	5931	4783	5613	5725	5840	5933	6082	6227	6321	6447	6563	6695
Semi Solid epoxy Epoxy Resin Ex-Mumbai	3497	2474	2859	4916	4399	3300	4183	4267	4339	4409	4506	4614	4692	4786	4853	4950
Liquid Epoxy Resin Ex-Mumbai	4108	3119	3490	5451	4986	3946	4836	4933	5031	5112	5240	5365	5446	5555	5655	5768

Source: TechSci Research

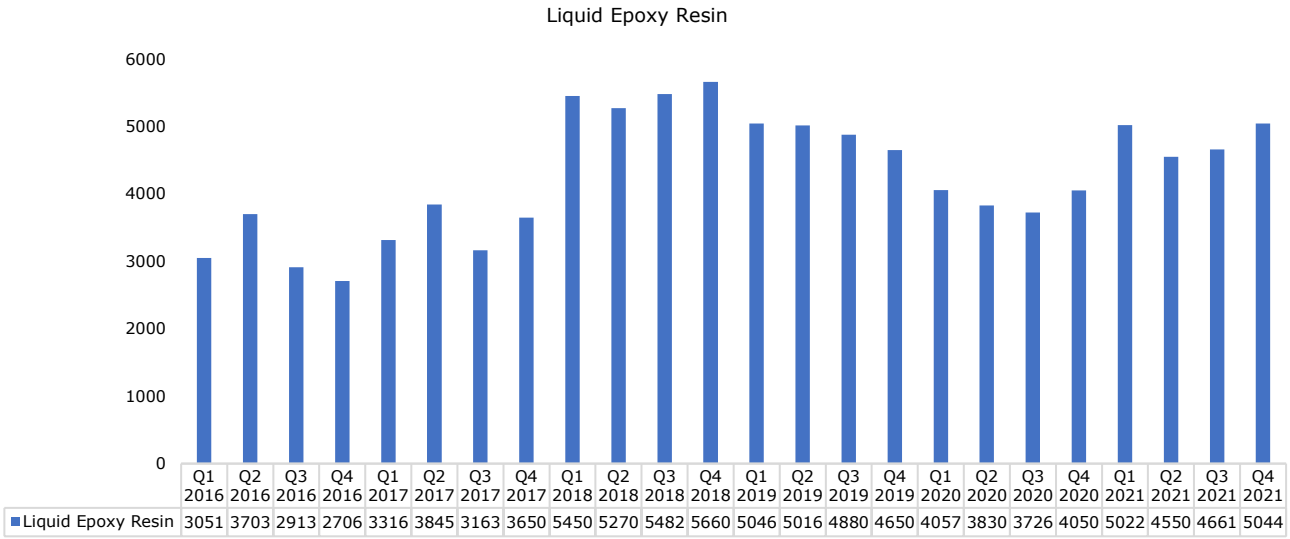
Epoxy Resin pricing varies geographically as quality of the product differs region-wise. In H1 2021, raw material pricing and availability remained a key issue for North America and Europe while the Asian stocks have shown a different picture altogether due to better product availability and lower production cost. As per our study, the same Epoxy Resin grade of the European origin is much costlier over the Asian make. For e.g., Huntsman quotes the same material at a higher price than the Chinese/Indian material. Hence, brand makes a significant difference if we talk of Epoxy Resins (both solid and liquid).

The Asian Epoxy Resin market is more fragmented with greater number of competitors operating locally. Higher competition over other regions weighs over the Asian Epoxy Resin pricing. In addition, better labour availability, particularly in Asia and variation in contract terms country over country make the prices differ with respect to location.

Epoxy resin pricing dynamics have been different by region. In Asia, resin prices escalated dramatically in early 2018 and moderated during the first and second quarters of 2018. In North America and Europe, prices increased late in Q4 2017 and through the beginning of the second quarter of 2018 and then eased slightly. Hence, overall market dynamics and timeframes for price increases vary significantly in different regions.

In addition, some global producers also show greater flexibility for contract buyers observing a structural shift in demand patterns after the pandemic.

Largest crude oil price slump of modern history in 2016, impacted most of the downstream commodities including Epoxy resin across global market. Epoxy resin prices slipped significantly during that period, despite of stable demand fundamentals across the global market. In Asia, Chinese Epoxy market usually influence other neighbouring countries. During 2019, China witnessed a huge fall in prices of Epoxy resin, bolstered by astonishing decline in price of its raw materials including Epichlorohydrin (ECH) and BPA, that also affected the overall Asian market during that timeframe. Meanwhile, Europe and North America market wasn’t affected from this price trend due to a significant demand-supply gap in respective markets. Later, during 2020, COVID-19 pandemic related restrictions further squeezed market dynamics across Asia and marked a significant dent on Europe and North America regional market. Global market has been recovering from the repercussion of pandemic since January, thus witnessing a consistent inclination in prices of Epoxy across global market.



Basis for Price Forecasting

The price of epoxy resin has been forecasted by using annual average delta method, wherein:

- the price during last ten years is considered.
- these prices, if available monthly or quarterly are averaged on annual basis.
- the annual delta for last ten years is worked out.
- the average annual delta is computed.

The delta takes into consideration the anomalies of price fluctuation due to many factors such as:

- Exchange rate
- Conversion rate
- Demand / availability scenario
- Feedstock price changes
- Geo-political scenario
- Global economy, etc.
- Inflation
- Taxation.

The annual average delta is used to forecast the price taking current price as a base. The above factors are in- built in annual average delta.

Presently, crude oil price fluctuations are showing considerable volatility due to several socio-political factors worldwide. Various influencing factors for price forecast include raw-materials / feedstock prices and demand – supply balances in the region which built the relationship of product to substitute products having comparable properties and common end-uses as well as their prices.

Feedstock prices directly affect the price of product. Increased feedstock prices, if passed on to end-users, increase the inflation and if not, they squeeze the margins of producers leading to making the industry unattractive for further investments. This leads to supply crunch and shortage of product in the market. The shortage leads to further increase in prices of product.

The uncertainty over development of economic environment renders the forecasting exercise futile. Therefore, the forecasting exercise is always done with set of assumptions. The assumptions in this exercise are as under:

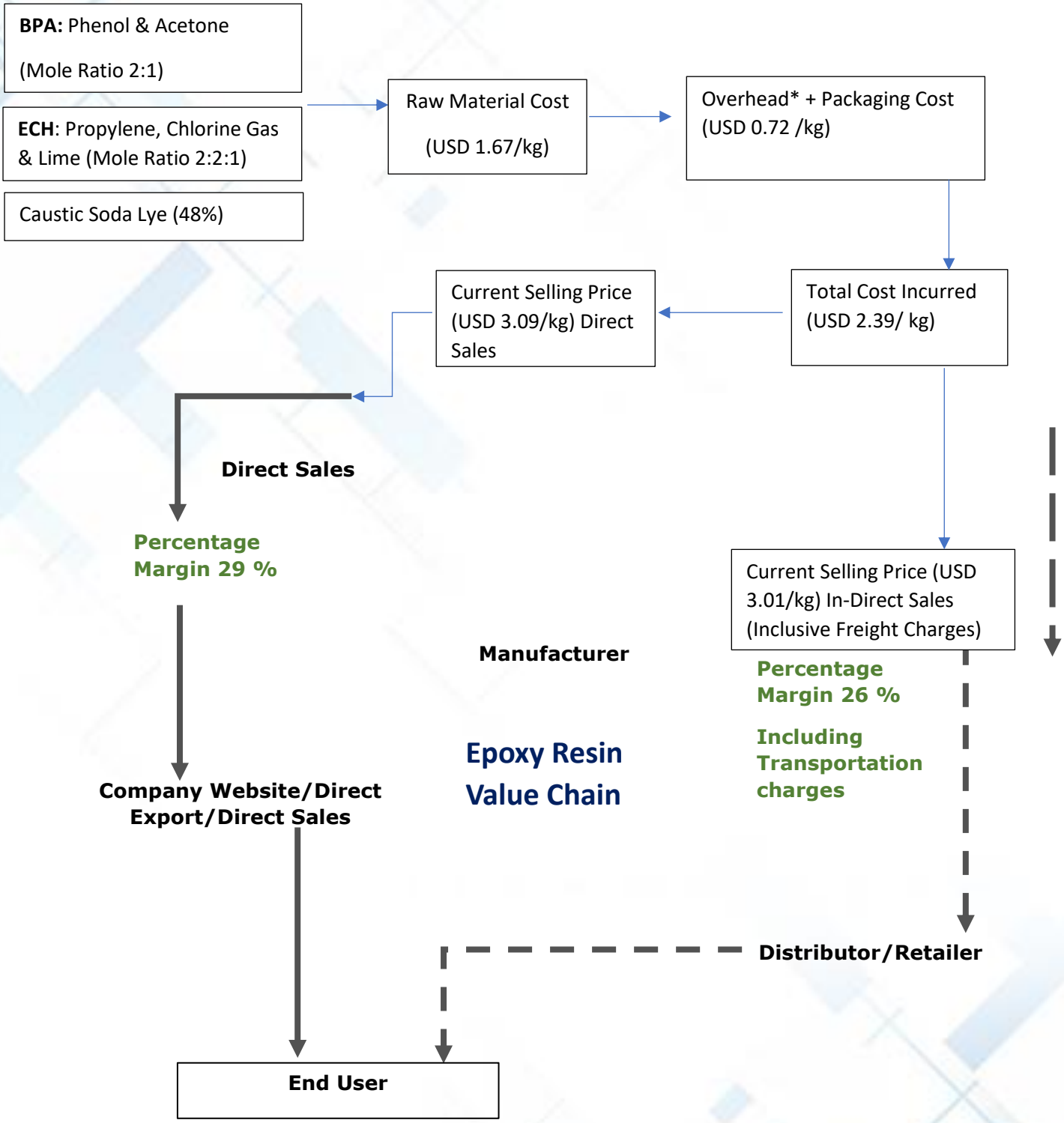
- The crude oil prices will remain within average limits during the next ten years.
- The technologies in exploration and production activities will continuously evolve leading to lower cost of production, better margins and extra investment in E&P activities.
- No technological innovations of substantial magnitude will take place which may lead to sea-change in technologies / processes used today.
- Current Exchange Rate will change during the forecast period.

3.12. Value Chain Analysis

This section shows the variety of activities that are incorporated to bring epoxy resin from conception, throughout the intermediary stages of production and reaching to final consumer. In epoxy resin value chain analysis, the raw material cost contributes the major share in the selling price of epoxy resin. Through direct sales, the company undergoes more profit margin than indirect sales. Captive refers to direct consumption of the product manufactured either as a main product or as a by-product. Non-Captive refers to extraction of the product for usage and trading of the products.

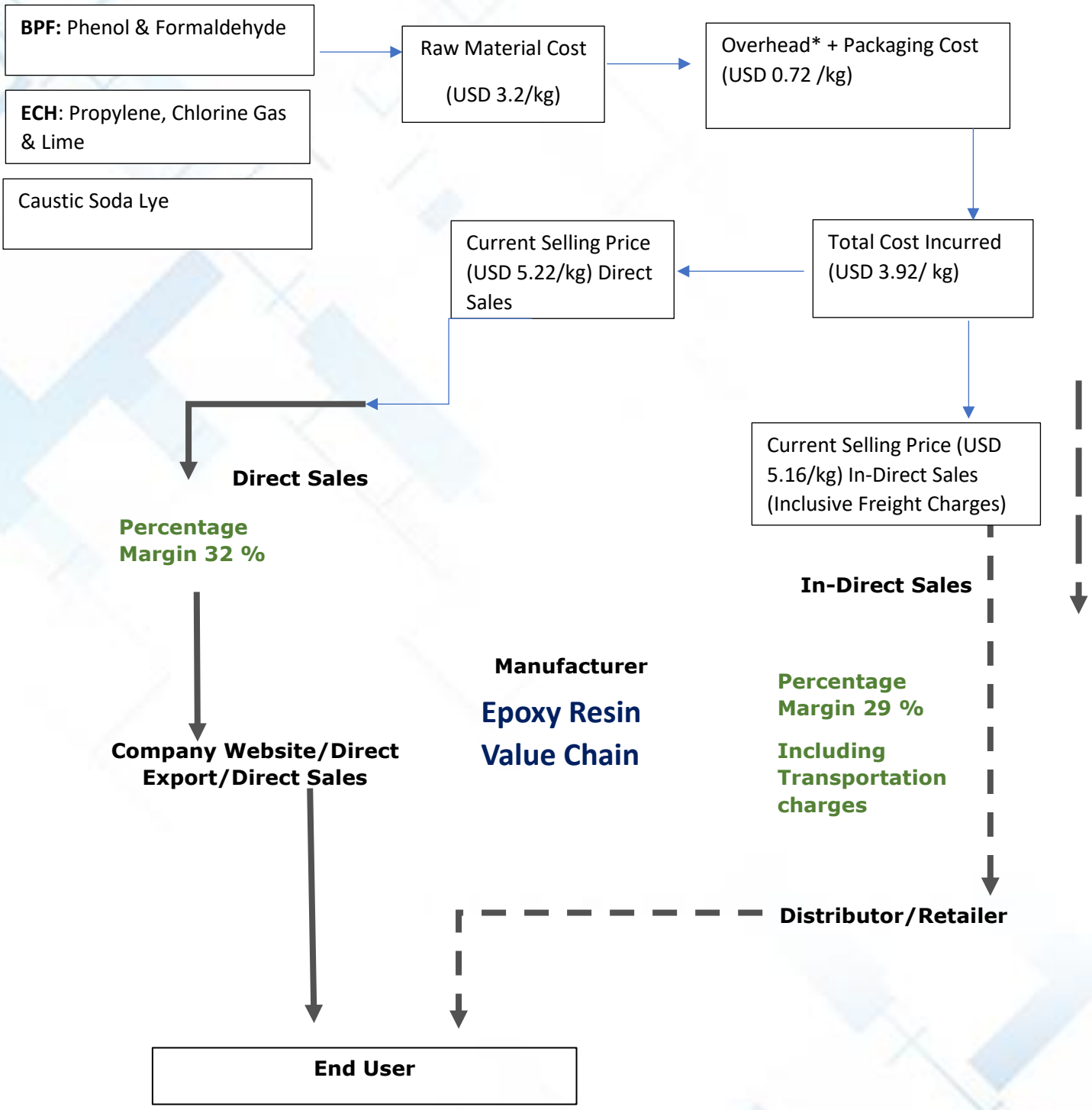
NOTE- The value chain has been calculated based on prevailing prices during the month of September 2021.

Value Chain Flow for Captive Liquid Epoxy Resin Manufacturer (Bisphenol A)



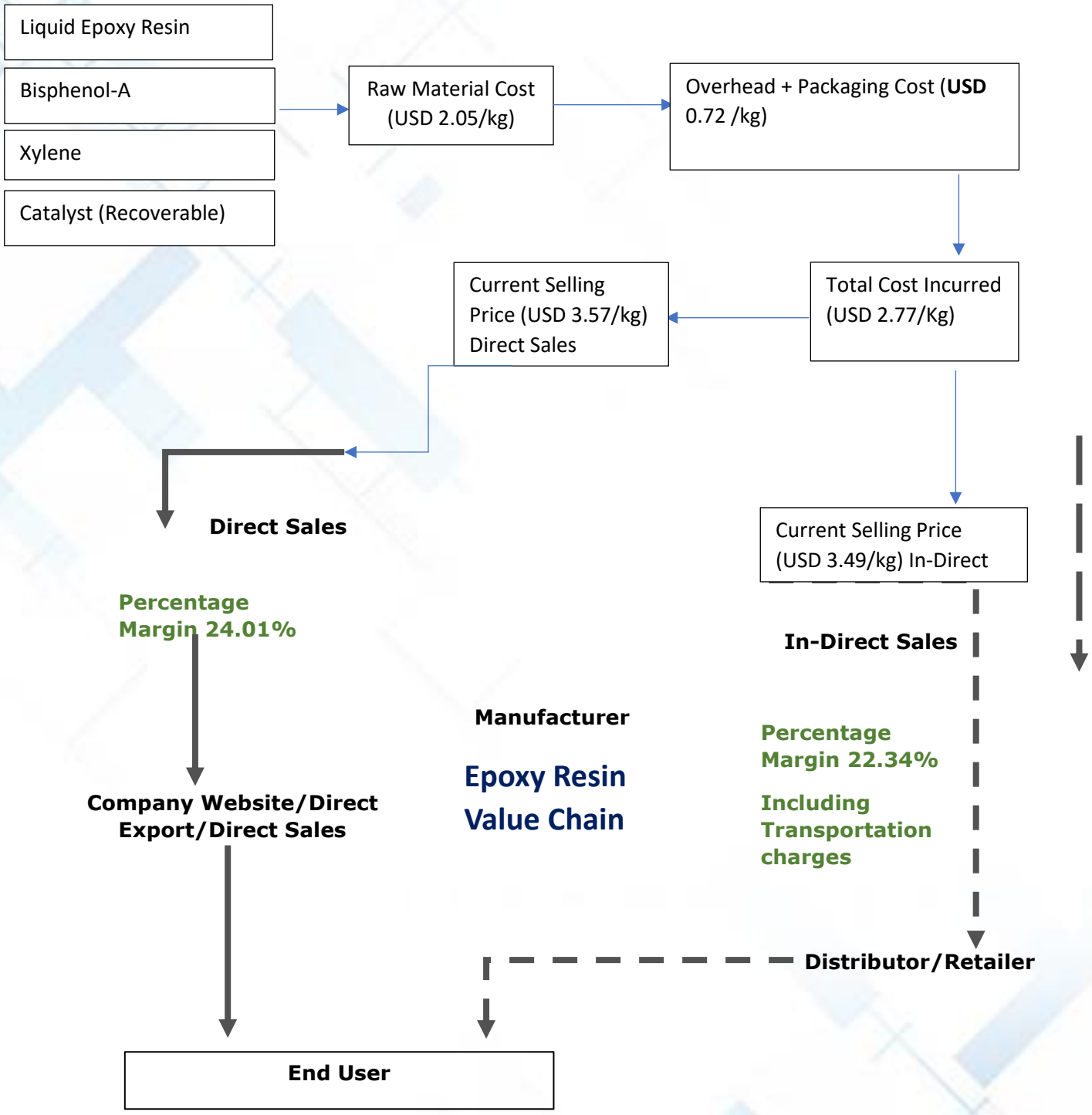
**Overhead Cost includes Rent, Insurance and Utilities expenses*

Value Chain Flow for Captive Liquid Epoxy Resin Manufacturer (Bisphenol F)

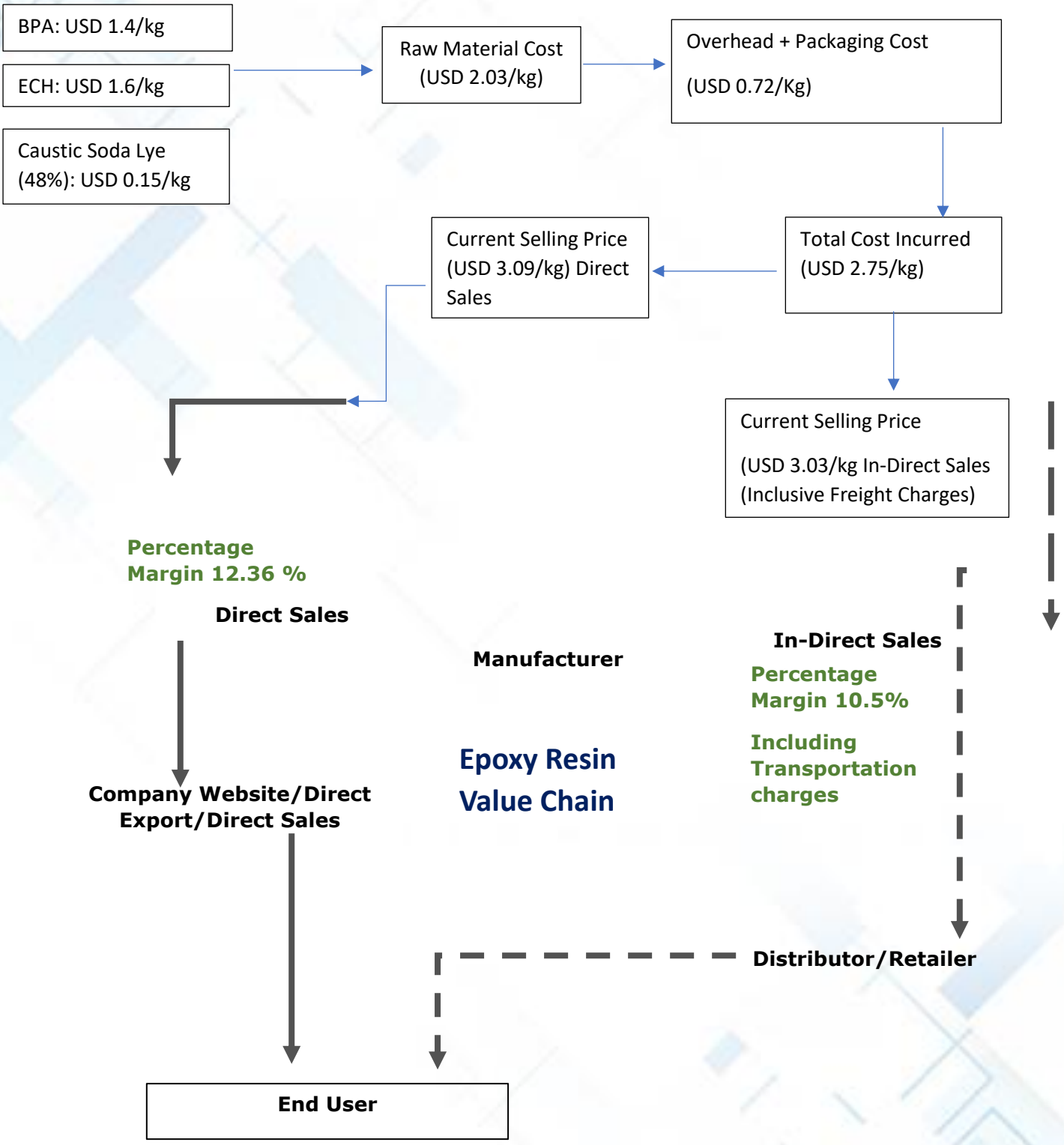


**Overhead Cost includes Rent, Insurance and Utilities expenses*

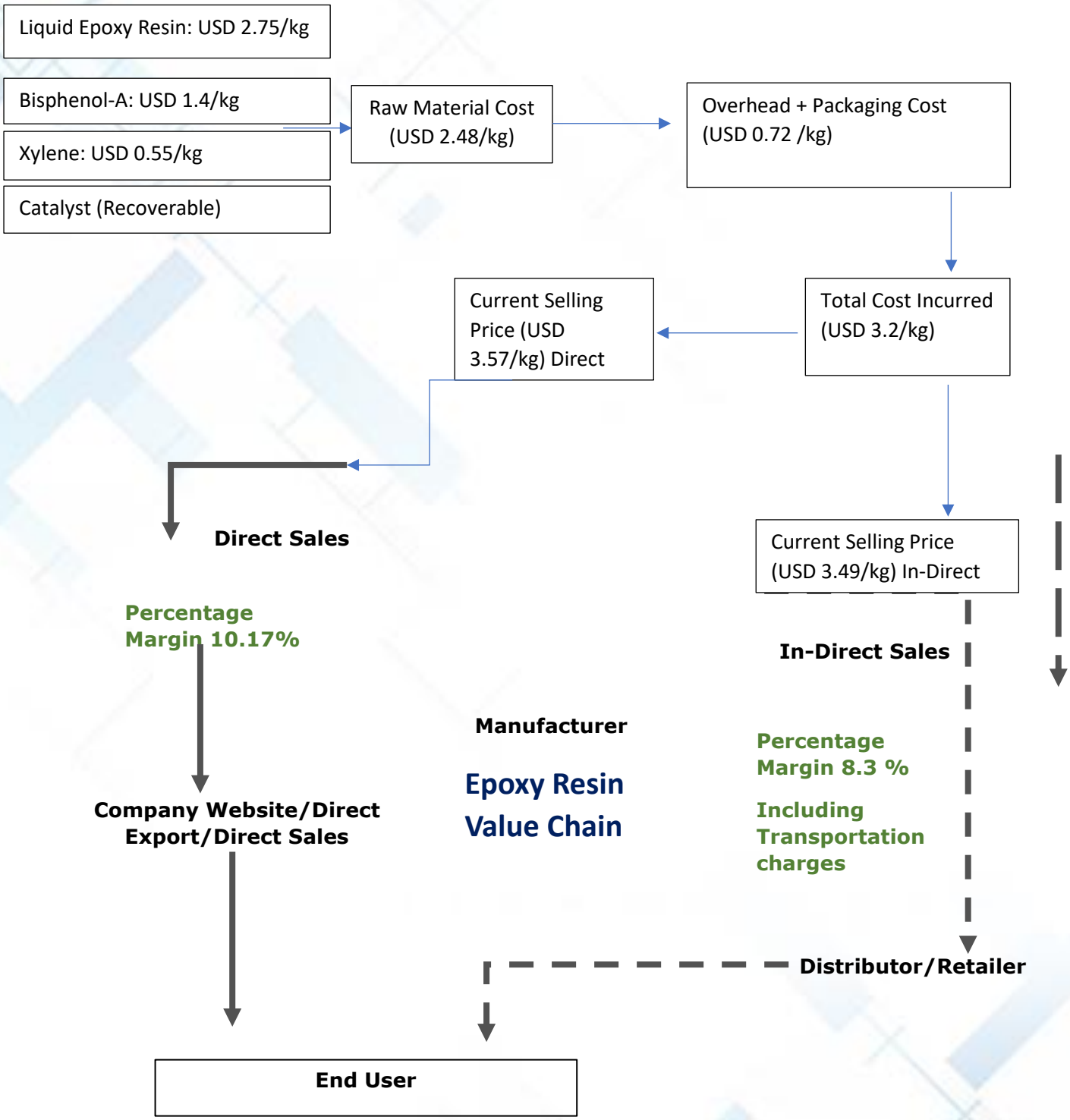
Value Chain Flow for Captive Solid Epoxy Resin Manufacturer



Value Chain Flow for Non-Captive Liquid Epoxy Resin Manufacturer



Value Chain Flow for Non-Captive Solid Epoxy Resin Manufacturer



3.13. Customer Analysis

Country	Product Description	Customer / Distributor Name	End Use Application	Plant Location	Supplier Name	Annual Off-take Quantity (Tonnes)	Price Ranges (USD/kg)
India	Bisphenol A based liquid epoxy resin	Ppg Asian Paints Private Limited	Paints & Coatings	Mumbai, Bangalore, New Delhi, Chennai	Ppg Industries Korea Ltd, South Korea & Kumho P & G Chemicals Ltd., South Korea	6250	1.46-1.81
India	Bisphenol A based liquid epoxy resin	Kansai Nerolac Paints Limited	Paints & Coatings	Mumbai, Bangalore, New Delhi	Kukdo Chemical Co Ltd, South Korea & Aditya Birla Chemicals Thailand Ltd., Thailand	5100	2.9-3.61
India	Bisphenol A based liquid epoxy resin	Kansai Nerolac Paints Limited	Paints & Coatings	Mumbai, Bangalore, New Delhi	Kukdo Chemical Co Ltd, South Korea & Aditya Birla Chemicals Thailand Ltd., Thailand	5000	2.25-2.8
Indonesia	Bisphenol A based liquid epoxy resin	Pt. Nipsea Paint And Chemicals	Paints & Coatings	Jakarta	Aditya Birla ChemicalsLtd., Thailand & Nan Ya Plastics Corporation, Taiwan	2150	2.44-3.04
Indonesia	Bisphenol F based liquid epoxy resin	Pt. Sika Indonesia	Adhesives and Chemicals	Bekasi, West Java	Aditya Birla ChemicalsLtd., Thailand & Nan Ya Plastics Corporation, Taiwan	1360	4.49-5.59
India	Bisphenol A based liquid epoxy resin	Jotun India Private Limited	Paints & Coatings	Mumbai	Kukdo Chemical Co.Ltd., South Korea	1250	2.03-2.52
India	Bisphenol A based liquid epoxy resin	Siegwerk India Private Limited	Adhesives	Mumbai, Bangalore, New Delhi	Qualipoly Chemical Corporation, Taiwan & Eternal Materials Co., Ltd. Taiwan	1180	2.84-3.53
Indonesia	Bisphenol F based liquid epoxy resin	Pt. Hempel Indonesia	Paints & Coatings	Jawa Barat	Chang Chun Plastics Co.,Ltd, Taiwan	1050	3.92-4.87
Indonesia	Bisphenol F based liquid epoxy resin	Pt. Panasonic Industrial Devices Batam	Electronics	Jakarta	Panasonic Industrial Devices Singapore, Singapore	990	11.13-13.85
India	Bisphenol A based liquid epoxy resin	Jotun India Private Limited	Paints & Coatings	Mumbai, Kanchipuram	Kukdo Chemical Co.Ltd., South Korea	950	2.92-3.63
India	Bisphenol F based liquid epoxy resin	Napino Auto Electronics Ltd	Electronics	Mumbai, New Delhi	Shindengen Electric Manufacturing, Japan	850	4.33-5.39
Indonesia	Bisphenol F based liquid epoxy resin	Pt. Propan Raya Industrial Coating Chemicals	Paints & Coatings	Tangerang, Banten	Aditya Birla Chemicals (Thailand) Ltd., Thailand	800	3.67-4.57
India	Bisphenol F based liquid epoxy resin	Huntsman International India Pvt Ltd	Adhesives	Mumbai, Bangalore, New Delhi	Huntsman Advanced Materials Europe Bvba, United Kingdom & Germany	750	5.36-6.66
India	Bisphenol F based liquid epoxy resin	Stonera Systems Pvt Ltd	Electronics	Mumbai, Bangalore, New Delhi	Isep Srl, Italy	600	3.65-4.54
India	Bisphenol F based liquid epoxy resin	Vimal Intertrade Pvt Ltd	Composites	Mumbai	Evonik Ressource Efficiency Gm, Germany	600	7.42-9.23
India	Bisphenol A based liquid epoxy resin	Champion Advanced Materials Pvt Ltd	Composites	Bangalore	Kukdo Chemical Co.Ltd., South Korea	240	2.03-2.52
India	Bisphenol F based liquid epoxy resin	Yamaha Motor Electronics India Private Limited	Automotive	Mumbai, Bangalore	Yamaha Motor Electronics Taiwan Co., Taiwan & Towa Denki Trading (S) Pte Ltd, Singapore	230	21.72-27.03

Pakistan	Bisphenol A based liquid epoxy resin	Berger Paints Pakistan Limited.	Paints & Coatings	Karachi	Hls Technology Development, China	200	2.83-3.52
Pakistan	Bisphenol F based liquid epoxy resin	Awan Sports Industries (Pvt) Ltd	Consumer Durables	Sialkot	Kukdo Chemical Co.Ltd., South Korea	190	3.78-4.7
Pakistan	Bisphenol A based liquid epoxy resin	Famsa Polymers Industry Private Limited	Paints & Coatings	Karachi	Jubail Chemical Industries Co. (Jana)., Saudi Arabia	90	1.91-2.37
India	Bisphenol F based liquid epoxy resin	Precision Electronic Component Mfg Co	Electronics	Mumbai	Synresalmoco Bv, Netherlands	25	8.55-10.64
India	Bisphenol F based liquid epoxy resin	Fasto Advance Adhesive Technologies	Adhesives	Bangalore	Fastfix-It Enterprise Co Ltd, Taiwan	25	5.24-6.52

**Estimated Consumption is of 2021 on the basis of 8 months actual data*

Source: TechSci Research

3.14. Global Epoxy Resin Foreign Trade Analysis, 2018-2020

Global Epoxy Resin Trade Dynamics – Import (USD Million and Thousand Tonnes), 2018-2020

Country	2018		2019		2020	
Import	**Value**	**Volume**	**Value**	**Volume**	**Value**	**Volume**
China	776.66	235.42	995.15	288.77	1255.09	404.81

Germany	550.57	169.86	570.11	155.49	491.00	142.12
United States	318.08	94.97	451.16	108.62	351.99	88.55
Italy	166.56	70.50	190.60	64.02	164.31	58.16
Turkey	107.77	44.33	168.58	56.39	154.10	52.96
Netherlands	100.26	41.98	134.65	42.40	157.70	45.77
Russia	109.71	38.84	151.31	47.90	145.13	45.74
United Kingdom	201.33	55.63	214.34	55.56	155.62	45.43
Japan	137.89	48.41	169.31	50.05	149.23	44.35
India	89.36	26.37	93.18	32.05	90.14	29.81
Others	397.79	156.73	588.1	242.73	433.1	151.07
Total	**2955.98**	**983.04**	**3726.49**	**1143.98**	**3547.41**	**1108.77**

Source: TechSci Research

Global Epoxy Resin Trade Dynamics – Export (USD Million and Thousand Tonnes), 2018-2020

Country	**2018**		**2019**		**2020**	
Export	**Value**	**Volume**	**Value**	**Volume**	**Value**	**Volume**
South Korea	531.18	174.35	515.11	192.77	508.36	206.53

Germany	709.79	170.67	646.04	161.96	599.19	161.67
Taiwan	406.23	131.75	395.48	145.36	408.98	153.53
USA	414.40	95.21	445.60	123.36	413.17	105.89
Netherlands	225.08	79.40	210.66	79.99	210.31	74.36
Thailand	110.80	34.13	105.40	35.19	104.84	38.01
Czech Republic	96.63	32.77	86.29	33.90	79.73	34.00
China	108.68	34.66	83.56	28.88	78.38	28.31
Switzerland	207.28	37.91	178.97	33.56	133.35	26.45
Japan	300.07	29.64	288.44	26.68	298.14	24.84
Others	667.44	263.15	612.34	282.33	640.37	255.17
Total	**3777.59**	**1083.63**	**3567.88**	**1143.98**	**3474.82**	**1108.77**

Source: TechSci Research

3.15. Suggested Capacities (Ideal Product Mix and Capacity recommendation)

Suggested capacity is 84 KTPA, which is to be implemented in two phases: 1st Phase - 2024 and 2nd Phase -2028.

Regarding Market distribution, in 1st phase of operation, 20-35% of the total base and novolac epoxy resin manufactured can be used as raw material for the Vinyl ester resin. Superior grades of formulated epoxy resins can be exported to Europe, Northeast Asia and North America.

Name of the Product	2025	2030 (Additional Capacity)
		Value in Tonnes
Liquid Epoxy Resin*	30,000	30,000
Bisphenol A (80%)	*25,000*	*25,000*
Bisphenol F and S (20%)	*5,000*	*5,000*
Solid and Semi Solid Epoxy Resin*	12,000	12,000
Novolac Epoxy Resin (75%)	*9,000*	*9,000*
others (25%)	*3,000*	*3,000*
Total	**42,000**	**42,000**
Epoxy System Plant Capacity		
Hardeners	5000	5000
Reactive diluents	**3000**	**3000**
Total	**8000**	**8000**

Global Scenario: The current global capacity of Epoxy Resin is approximately 4.5 million tonnes. Top ten producers account for 55 percent of the total capacity in 2021. In 2021, global consumption of Epoxy Resin was approximately 3.5 million tonnes. Regional analysis indicates surplus in Western Europe & APAC and deficit in North America, South America, Oceania, and Africa, resulting in heavy trade within the region as well as international trade. Within Asia, India (In optimistic case), Pakistan, Indonesia, Malaysia, and Vietnam are expected to remain deficit areas while South Korea and Taiwan are expected to be surplus.

Indian Scenario: Present capacity in the country is 0.18 million tonnes per annum. Entire capacity is shared by four manufacturers – Grasim Industries Ltd, Atul Ltd, Hindusthan Specialty and Kukdo Chemicals. The annual average consumption growth over the last five years period has remained 6.31 percent per annum and over the last 10 years, 8.4 percent per annum, indicating a healthy trend in consumption. It is expected that, based on individual end-use sector growth, consumption of Epoxy Resin will register an overall growth of about 8.8 percent per annum average growth over the next ten years' period.

India is expected to remain a deficit area despite capacity additions by existing suppliers in optimistic scenario.

Considering demand – supply situation and export market, enough scope exists in the country for a 84 thousand tonnes per annum epoxy resin unit by 2028 in two phases. Setting up a dedicated unit is

advisable so that niche grades can be produced. Adequate export market potential also exists. However, exports from India are not advisable as manufacturers tend to get better realization in terms of pricing within India over competing for exports. Moreover, due to high competition over quality, local selling of Epoxy Resins offers more lucrative opportunity for the domestic players.

Recommendations

- Reliance Industries Ltd may consider setting-up a 84 thousand tonnes Epoxy Resin (base resin, formulated resin, hardener and diluent) unit by the year 2028 as enough scope exists from demand – supply point of view. However, before taking up this decision, RELIANCE INDUSTRIES LTD should also consider the project from economic viability point of view.
- The company can use one third of epoxy resin (liquid and solid) to produce vinyl ester resin.
- Reliance Industries Ltd needs to explore export market for both standard and specialized epoxy resin.
- The capacity we have considered is in the ratio of 70:30 for standard vs Specialized Epoxy resin. The capacity ratio may change, and it is a discretionary power of the management to change the product-mix depending on prevailing demand-supply situation in the domestic and international market.
- Reliance Industries Ltd may consider of backward integration by setting up project of Epichlorohydrin, key raw material for Epoxy Resin (Liquid / Standard) which will be based on glycerine as feed stock which is obtained from 100% renewable resources. This is not a part of pre-feasibility study, however it is of great interest to downstream users who are concerned about a cost-effective production route whilst taking advantage of an abundant renewable feedstock to reduce their carbon footprint.

4. Project Description

4.1 Type of Project – This project will be categorized as greenfield project. Reliance Industries Ltd need to acquire fresh land for the project as entire project will require civil work including land acquisition. Reliance Industries Ltd is currently not producing any raw material hence unit will not be backward integrated.

4.2 Magnitude of the Operation-

It is an integrated petrochemical complex comprising of,

- Epoxy Resin plant 84 KTPA.
- Captive power plant focusing on renewable energy.
- Water Desalination Plant (RO process).
- All other associated utilities such as DM Plants, Effluent treatment plants, Sewage treatment plant, Compressed air & Nitrogen generation plant and infrastructure facility.

4.3 Setup Related Details

4.1.1. Target End-Use Applications (Grade wise application details of Epoxy Resin)

There are many customised Epoxy Resin types commercially available from global manufacturers, compatible with a wide range of modifying resins, reactive and nonreactive diluents, curing agents, additives, rheology modifiers, and fillers.

BISPHENOL-A BASED LIQUID EPOXY RESINS		
	EEW	Viscosity @ 25°C
Application	g/eq	mPa·s
Multiple application including Adhesive, Coating, Construction, Electrical and Composites	184 - 191	11,000 - 15,000
Coatings and Adhesive formulations	213 - 233	20,000 - 26,000
Adhesives and Prepregs	225 - 280	450 - 800 (70% solution in butyl corbitol)
Multiple application including Adhesive, Coating, Construction, Electrical and Composites	180 - 187	8,000 - 11,000
Coatings and Adhesives	280 - 300	500 - 1,500 (70% solution in butyl corbitol)

BISPHENOL-A BASED SOLID RESINS			
Application	EEW (g/eg)	Viscosity 25°C (mPa·s)	Softening point (°C)
Powder Coating formulation	653 - 704	375 - 475	80 - 90
Powder Coating formulation with high glass transition temperature	769 - 847	6,000 - 8,000 @ 150°C	Tg = Min 55

Hybrid powder coatings	714 - 752	500 - 600	95 - 101
Powder Coating formulation	781 - 855	480 - 580	85 - 90
Protective Coating	450 - 465	160 - 190	65 - 75
Enamels and exterior coating of cans and tubes	833 - 893	550 - 700	90 - 102
Internal coating of cans and tubes	1,695 - 1,887	1,800 - 2,600	110 - 120

BISPHENOL-F BASED LIQUID EPOXY RESINS		
Application	**EEW (g/eg)**	**Viscosity 25°C (mPa·s)**
Coating applications, Composites, Construction and Electrical casting	159 - 175	2,000 - 5,000
	164 - 172	2,000 - 3,300
	164 - 172	3,300 - 4,100
	159 - 172	5,000 - 7,000
Coatings, Composites, Construction applications and Floor coatings.	172 - 180	6,500 - 8,500
	174 - 182	4,500 - 6,500
High Solids coatings, Construction and Floor coatings.	185 - 196	6 860 - 960

CYCLOALIPHATIC RESINS		
Application	**EEW (g/eg)**	**Viscosity 25°C (mPa·s)**
Electrical component castings, Potting and Outdoor coatings.	159 - 182	500 - 1,100
Electrical cast components	180 - 200	350 - 750
Outdoor coatings, Flooring, Electrical castings and composite parts	220 - 240	2,000 - 4,000
Outdoor coatings, Flooring, Electrical castings and Composite	210 - 230	1,300 - 2,500
Electrical component castings, Potting and Outdoor coatings	130 - 143	250 - 450

EPOXY PHENOL NOVOLAC RESINS		
Application	**EEW (g/eg)**	**Viscosity 25°C (mPa·s)**

Composites, Electrical and Coating applications.	172 - 179	1,100 - 1,700 @ 52°C
Composites, Electrical, Chemical resistant coatings and Flooring	175 - 182	20,000 - 50,000 @ 52°C
Chemical resistant coatings, Electrical and Composite applications.	215 - 231	150 - 350
Chemical resistant coatings, Electrical and Composite applications.	215 - 231	800 - 1,500

GLYCIDYL AMINE BASED MULTIFUNCTIONAL RESINS			
Application	**EEW (g/eg)**	**Viscosity 25°C (mPa·s)**	**HyCl %**
High Performance Composites (aviation and marine)	117 - 134	7,000 - 11,000 @ 50°C	Max 0.10
	118 - 134	7,000 - 19,000 @ 50°C	Max 0.10
	111 - 117	3,000 - 6,000 @ 50°C	Max 0.10
	118 - 133	7,000 - 12,000	Max 0.10
	105 - 115	2,000 - 5,000	Max 0.30

5. BROMINATED RESINS			
Application	**EEW (g/eg)**	**Viscosity25°C (mPa·s)**	**Bromine content %**
Prepregs and Laminates	450 - 500^2	2,200 – 3,000	19 - 23
Electrical	250 - 280	700 – 1,100 @ 70°C	21 - 26
Vinyl Ester and Electronic components.	319 - 410	–	44 - 48

SOLVENT CUT RESINS			
Applications	**EEW (g/eg)**	**Viscosity^1 25°C (mPa·s)**	**Non-volatile content^2 %**
Films Coatings	–	50 - 350	50 - 55
Films Coatings	–	50 - 350	50 - 55
Coatings	294 - 323	600 - 850	79 - 81 (150°C/1h)
Paints and Coatings (Xylene is used as a solvent)	606 - 702	9,000 - 13,000	74 - 76 (105°C/2h)
	606 - 741	14,000 - 20,000	74 - 76 (105°C/2h)
Primers and Enamels	12500	2,000 - 5,000	49 - 51 (160°C/2h)
Paints and Coatings (Xylene is used as a solvent)	300 - 336	3,500 - 7,000	79 - 81

** Epoxide Equivalent Weight (EEW)*

EEW is the weight of the resin in grams that contains one gram equivalent of epoxy. An interchangeable term, Epoxy Value (EV) may also be used. EV represents the fractional number of epoxy groups contained by 1,000 grams of resin. EEW can be obtained if 1,000 is divided by EV.

**Softening point*

The softening point is the temperature at which a material softens beyond some arbitrary softness.

**Viscosity (Brookfield)*

Brookfield viscosity usually refers to a viscosity measurement performed with a Brookfield Viscometer, sometimes referred to as a Brookfield viscosimeter. There are several models of viscometer available from Brookfield, but the majority operate in the same manner: the viscometer motor rotates the spindle at a defined speed (measured in rpm) or shear rate and the viscometer measure the resistance to rotation and reports a viscosity value.

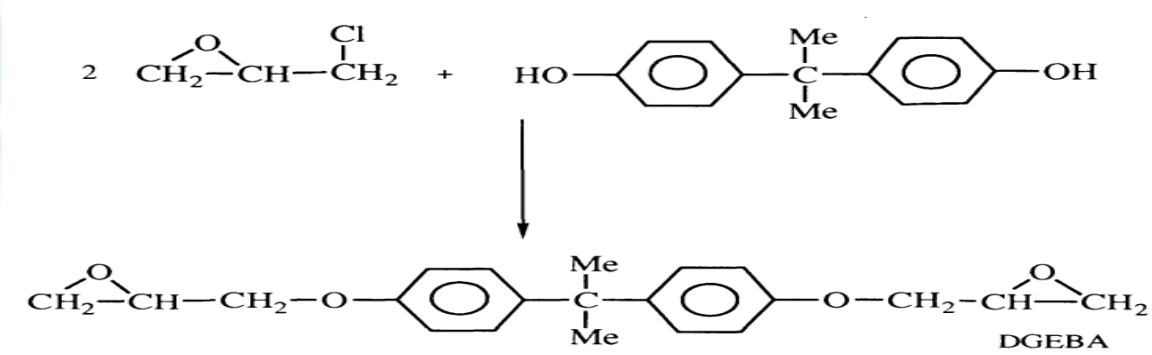
** HyCl*

The hydrolyzable chloride content of epoxy resins is a vital characteristic in deciding their reactivity and the expected properties of coatings made using such resins. HyCl is hydrolyze chloride content

4.1.2 Plant Process-description (Evaluation of major process commercially available for licensing):

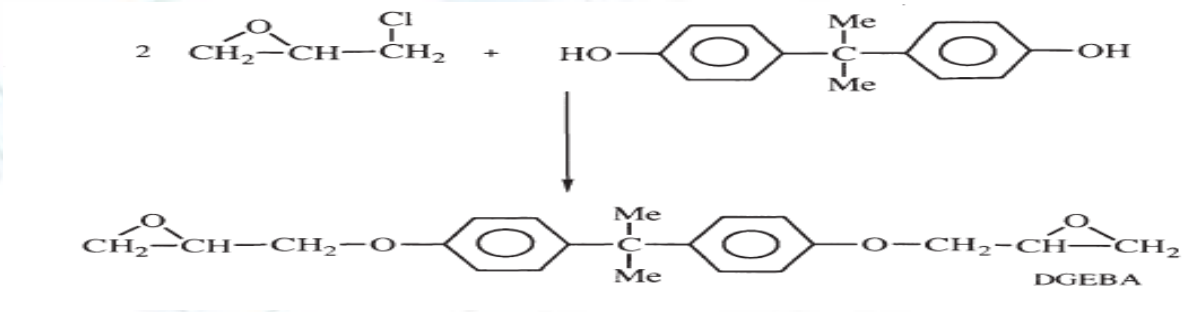
Production process of Liquid Bisphenol-A Epoxy Resin: The one-step process proceeds via polycondensation of reacting epichlorohydrin (ECH) with bisphenol A (BPA), resulted with different chemical liquid substance known as bisphenol A diglycidyle ether (commonly known as BADGE or DGEBA). Bisphenol A-based resins are most widely commercialised resins (75-80%).

Badge Process: Bisphenol A or 2,2'bis(p-hydroxyphenyl) propane is produced from acetone and phenol with an acid catalyst such as 75% sulphuric acid or dry hydrogen chloride. The reaction conditions will depend on the design of the production unit. The purity of the product is high, >95% p,p'-isomer (para-para); the other isomers formed are o,p'(ortho-para) and o,o (ortho- ortho)'. For resin manufacture the p,p' isomer (para-para) content should be at least 98%. The light-yellow colour of some Epoxy Resins may be due to trace impurities in the bisphenol A, such as iron, arsenic and highly coloured organic compounds. When a large excess of epichlorohydrin is reacted with bisphenol A with a stoichiometric amount of sodium hydroxide at about 65-70°C the resin produced contains about 50% diglycidyl ether of bisphenol A, DGEBA(BADGE) and the reaction may be represented formally as below:

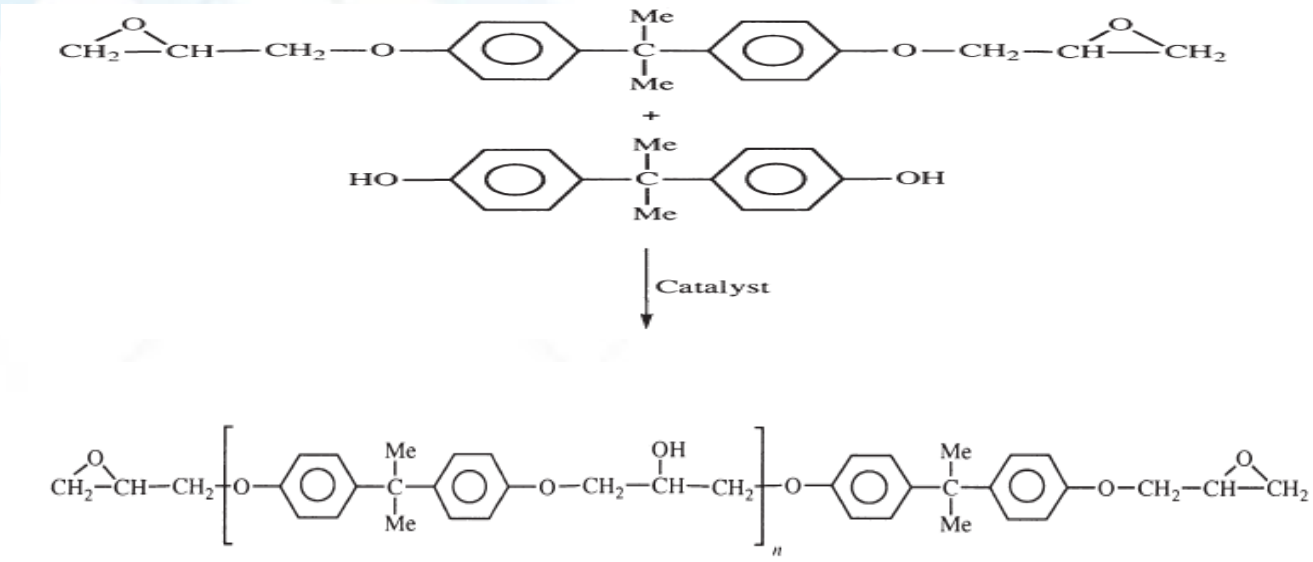


Two Step Process: The two-step process is the reaction of bisphenol A (BPA) and epichlorohydrin (ECH) in presence of a catalyst (such as a quaternary ammonium salt), the first step by an addition reaction is to form a diphenol-propane chlorohydrin ether as intermediate, and the second step is to be carried out in presence of Caustic, this closed loop reaction produces an Epoxy Resin.

Liquid Epoxy Resin (BADGE)



Solid Epoxy Resin (Advancement Process)



Production process of solid bisphenol A Epoxy Resin

Higher molecular weight bisphenol A resins: Bisphenol A/epichlorohydrin ratio is important for control of the average molecular weight of the resins produced. Larger the value of n the smaller the epichlorohydrin / bisphenol A ratio required. The purity of the reactants is important and monofunctional reactants are chain terminators and hence their concentration has to be controlled. However, it is also necessary to optimize the reaction conditions to achieve the degree of polymerization required. For the production of oligomers with 1 ≤n ≤ 4, the so-called 'Taffy' process

could be used but for much higher molecular weight polymers $3 \leq n \leq 20$ the fusion or chain extension process (also called advancement process) is used.

Taffy Process: In taffy process,1-3 bisphenol A is reacted at 85–95°C in a controlled excess of epichlorohydrin (ECH) (to give polymer molecules along with glycidyl ether groups, at both ends) in the presence of Caustic and an inert solvent. This reaction is used to produce lower molecular weight (MW) epoxides. The low molecular weight epoxides are polydisperse mix of epoxides with "n" values lies between 0 and 1 and have an average molecular weight of 340-600.

Detail Description of Taffy Process: A mixture of bisphenol A and 10% aqueous sodium hydroxide solution is introduced in a reactor equipped with high-speed powerful agitator. The mixture is heated up to 45^0 C and Epichlorohydrin is added rapidly with agitation, giving off heat. The temperature is allowed to rise to 95^0 C, where it is maintained for approx. 80-85 min for the completion of reaction. Agitation is stopped, and mixture gets separate in two layers. The heavier aqueous layer is drawn off from bottom and the molten, taffy-like product is washed with hot water until the wash water gets neutral PH. The taffy-like product is dried at 135^0 C, gives solid resin with softening point of 70-75^0 C and an EEW value of 500. Alternatively, epichlorohydrin are removed by vacuum distillation at temperatures up to 180^0 C approx. The crude resin is then dissolved in a secondary solvent (Toluene) to facilitate water washing and salt removal. This secondary solvent is then recovered via vacuum distillation in order to obtain the resin product.

One of the major drawbacks of this process is that insoluble polymers are formed, which create handling and disposal problem.

Advancement Process: For manufacturing of higher molecular weight Epoxy Resins, liquid Epoxy Resin (LER) is reacted with calculated amount of bisphenol A, further catalyst solution is added to boost the reaction and the temperature is maintained at approx. 160 °C. This process is known as "Advancement process". The high molecular weight epoxides are manufactured by "Advancement" process using Benzyl trimethyl ammonium hydroxide as a catalyst.

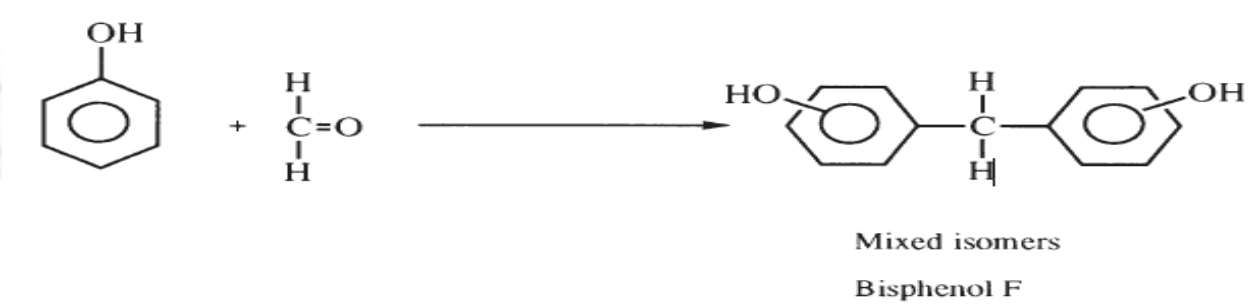
Detail Description of Advancement Process

Advancement process is widely practiced by coating producers to facilitate the handling of the high molecular weight, highly viscous Epoxy Resins used in many paint & coating formulations. The degree of polymerization is calculated by ratio of LER (formed from BADGE Process) to bisphenol A; an excess of the former provides epoxy terminal groups. The actual molecular weight obtained depends on purity of the starting materials, solvents & catalyst used. Reactive mono-functional groups are used as chain terminators to control MW and viscosity build. The below formula is used to calculate the amount of bisphenol A that is to be reacted with Epoxy Resin (LER) to obtain an advanced Epoxy Resin of predetermined EEW value. (EEW is Epoxy Equivalent Weight) is a measure of compounds which epoxy containing groups. The epoxy equivalent weight describes the mass in grams which one mole of epoxy groups contains.)

BisA = EEWi – 1 – EEWf – 1 EEWi – 1 + PEW – 1

EEWi is the EEW of the Epoxy Resin that is to be advanced (i stands for initial), EEWf is the EEW (f stand for Final) of the advanced Epoxy Resin, and PEW is the phenol equivalent weight of the bisphenol, its value is 115.1 g per equivalent for bisphenol A. In an advancement process, bisphenol A and a liquid BADGE resin (170–180 EEW) are heated to 155–199 ^{0}C in the presence of a catalyst and reacted (i.e., advanced) to form a high MW resin. This oligomerisation process is exothermic and proceeds rapidly to completion. The exotherm temperatures depends on the reaction mass and targeted EEW. In the cases of higher MW resins, exotherm temperature can reach >190-205 ^{0}C. Reaction catalysts facilitate the rapid preparation of medium to high MW linear resins, also control side reactions inherent with Epoxy Resin preparations, e g, chain branching, by addition of the alcohol group generated in the chain-lengthening process to the epoxy group. Nuclear Magnetic Resonance (NMR) spectroscopy Method can be used to determine the extent of branching.

Bisphenol F based Epoxy Resin: Any multifunctional, f ≥ 2, phenolic compound is a potential starting material for the manufacture of Epoxy Resins, these are 'formulated' to meet specific requirements. Also, some monofunctional phenols have been reacted with epichlorohydrin to produce monofunctional reactants for use as modifying diluent agents. The dihydric phenol which is produced by reaction of phenol with formaldehyde is called bisphenol F.



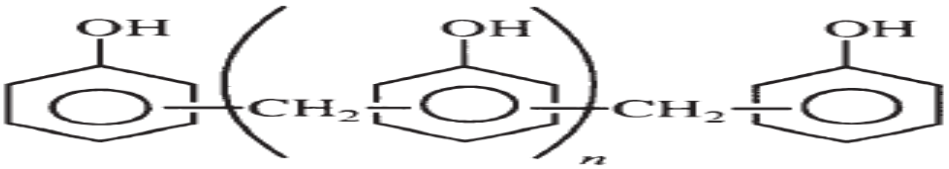
Mixed isomers

Bisphenol F

Resins can be manufactured from bisphenol F by similar methods to those used for bisphenol A and epichlorohydrin with a catalyst such as NaOH. These resins have lower viscosities than the equivalent DGEBA.

Bisphenol-F and Bisphenol-A/F Blends: One can go with pure Bisphenol -F, Bisphenol A or Bisphenol A/F based Epoxy Resin. Bisphenol-F based resins are best known for low viscosity, chemical resistance and low crystallisation tendency in cold conditions. Bisphenol-F based pure and Bisphenol-A/F blend resins are recommended in varying viscosities for several applications like coatings, composites, floor coatings and construction applications.

Epoxy Phenol Novolac (EPN) resins:

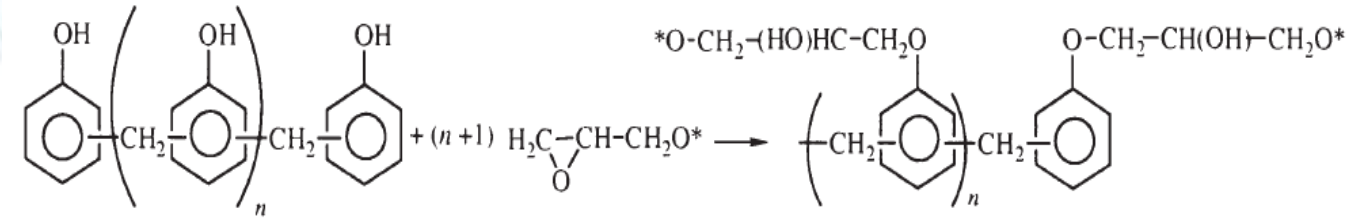


These are generally referred to as multifunctional epoxy resins as they consist of more than two epoxy groups per molecule. EPN resins are produced by reaction of phenolic novolac with epichlorohydrin. After curing they result in a mesh like structure possessing high cross-linking density.

The mechanism of formation involves reaction of phenolic novolac with epichlorohydrin in alkaline medium (sodium hydroxide). Initially phenol hydroxyl group is deprotonated by hydroxide ions

(OH^-) of NAOH, thereby producing nucleophilic phenyl hydroxide ($R\text{-}O^-$).

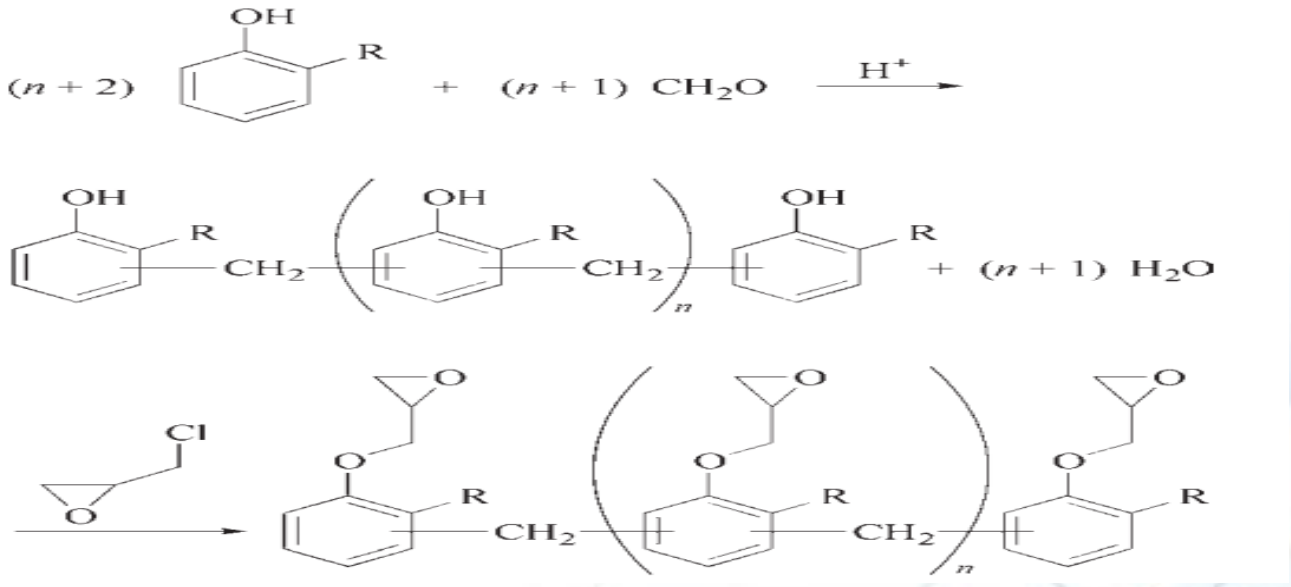
Further, the chloride of epichlorohydrin is substituted with the hydroxide of phenol hydroxyl group resulting in linking of phenolic unit with the epoxide.



Cresol Novolac Resin:

Epoxy novolac are multifunctional epoxies based on phenolic formaldehyde novolac. Epoxy Cresol Novolac Resin is formed by reacting Cresol with Formaldehyde to make Cresol Novolac, which is further reacted with Epichlorohydrin to make ECN (Epoxy Cresol Novolac Resin), here R is H in case of EPN (Epoxy Phenol Novolac Resin) & R is CH3 in case of ECN (Epoxy Cresol Novolac Resin)

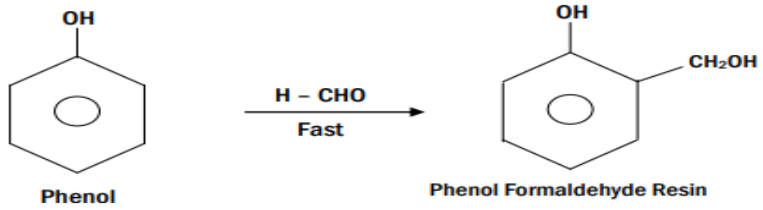
An increase in the molecular weight of the Novolac increases the functionality of the resin. This is accomplished by changing the cresol to formaldehyde ratio.



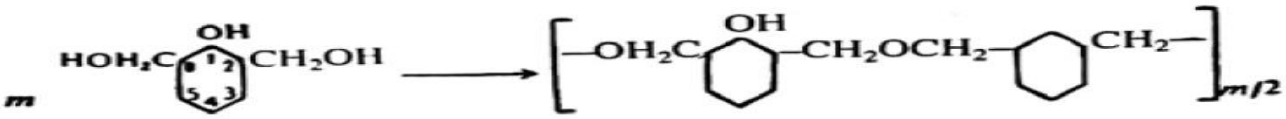
+ HCl

Phenol Formaldehyde Epoxy Resin (Basic Chemistry)

(a) **Methylol monomer formation:**



(b) **Linear Polymer**



(c) **Cross-linked tridimensional polymer**

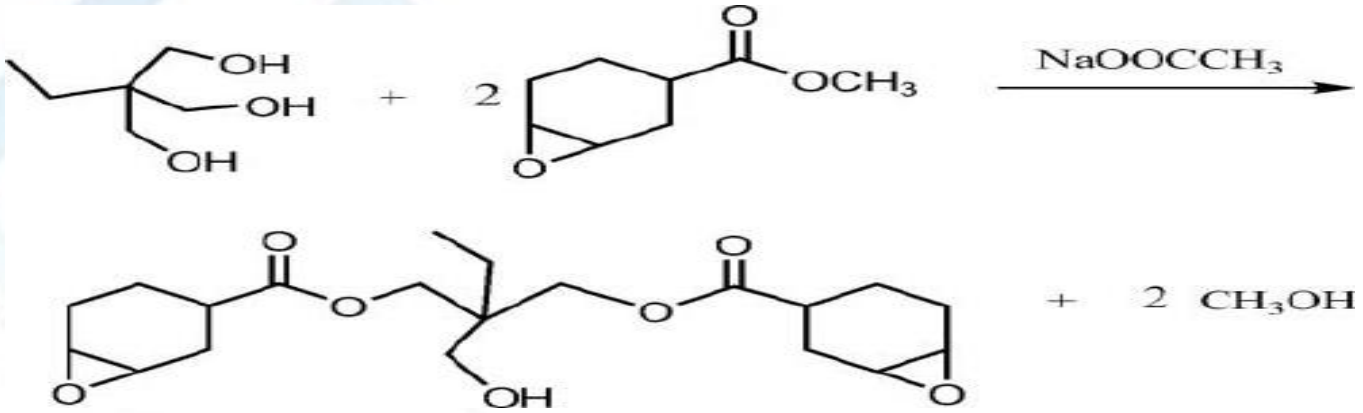
Phenolics are low-cost polymers with excellent physical & electrical properties and fast curing characteristics. Their poor colour characteristic can be partially overcome by adding pigment, dyes & fillers.

Cycloaliphatic Epoxy Resin:

Cycloaliphatic epoxy resins have been found to be useful in a variety of industrial applications, such as coatings, reactive diluents, vacuum pressure impregnation of coils, molded compounds, encapsulation of electronic circuit elements, and printed circuit board because of their low viscosity prior to curing, and good heat and chemical resistance, superior mechanical and electrical properties

after curing as well as excellent processability. They are highly resistant to ultraviolet light and more durable for outdoor applications such as electrical insulators.

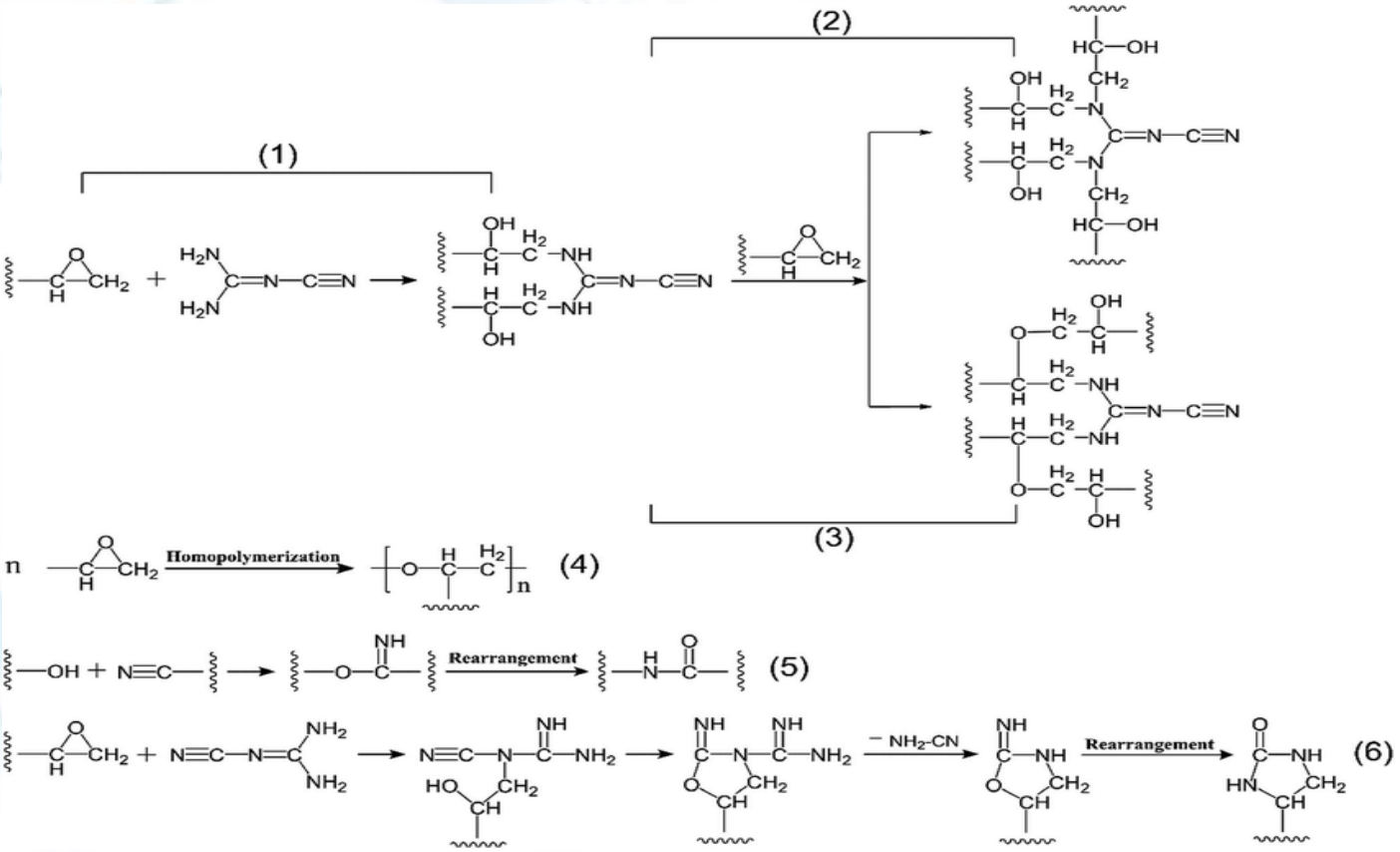
Cycloaliphatic epoxy resin containing hydroxyl group (DMTMP) is prepared by the transesterification between methyl-3, 4-epoxycyclohexane carboxylate (MEC) and trimethylolpropane (TMP) using anhydrous sodium acetate as catalyst as per the below given Reaction.



Properties of Cycloaliphatic epoxy resin:

- Higher resistance to UV and moisture
- Excellent electrical properties
- Superior deflection temperature
- Low viscosity

Glycidyl Amine Based Multifunctional Resins: These are high-performance multifunctional epoxy resins that are produced by the reaction of aromatic amines with epichlorohydrin.



They are commonly of two types:

- triglycidyl para-aminophenol (TGPAP)
- triglycidyl of 4-(4-aminophenoxy) phenol (TGAPP)

They are increasingly used in the manufacturing of high-performance composites, adhesives and coatings in aircraft and aerospace industry.

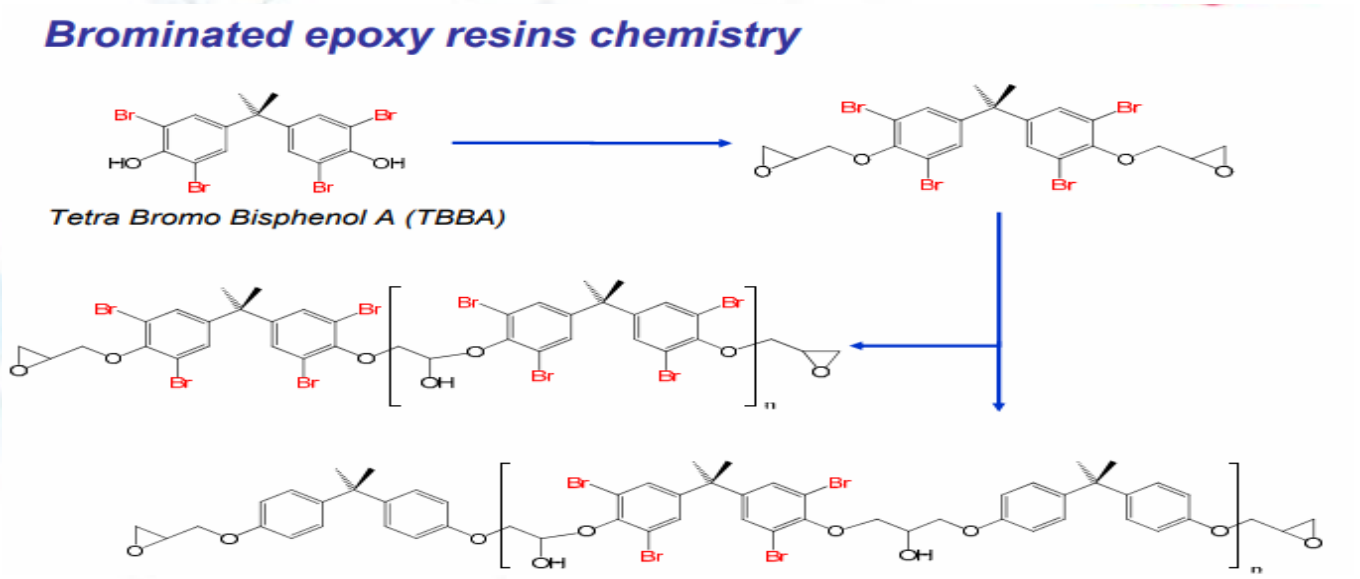
Brominated Epoxy Resin

Brominated Epoxy Resin:

Brominated epoxy resin was first developed by Tokyo shipo company in 1982.Because it has many excellent properties: excellent thermal stability and photostability, excellent melt flow speed, high flame retardant efficiency. In the electronics industry, brominated epoxy resin is the most used filling material. Especially, the high molecular weight brominated epoxy resin can be used as flame retardant and has very good effect. For the flame retardant material, it has good physical and mechanical properties

A common method of imparting this ignition resistance is the incorporation of tetrabromobisphenol A (TBBA), 2,2-bis(3,5-dibromophenyl) propane, or the diglycidyl ether of TBBA, 2,2-bis[3,5-dibromo-4-(2,3-epoxypropoxy) phenyl]propane, into the resin formulation.

The diglycidyl ether of TBBA is produced via conventional liquid epoxy resin processes. Higher MW resins can be produced by advancing LERs or diglycidyl ether of TBBA with TBBA



4.1.3. Process Flow Diagram & Technology Licensor

Technology licensor

The most accepted technology is currently Ciba-Geigy AG in India. Grasim licensed the technology from Tohto Kasei Co. Ltd. in 2014-2015 but Hindustan Speciality employed the technology of Ciba-Geigy AG. The manufacturing companies based in APAC region are based on Tohto Kasei Co. Ltd. whereas Ciba-Geigy AG's technology for epoxy resin production is globally proclaimed.

According to the key opinion leaders, the technology employed by Ciba-Geigy AG has low solvent requirement than the Tohto Kasei Co. Ltd. technology. Other than this, few variations in process parameters are the only observable differences.

Tohto Kasei (Japan) (Now known as Nippon Steel & Simikin Chemical Co Ltd.), leader in resin producer, have its own epoxy licensing technology arrangements with numerous resin manufacturers in Asia. In India Grasim, Vilayat use this technology.

Olin Systems: Olin Corporation is the leading manufacturer & distributor of Epoxy Resin, which offers highly advanced Epoxy & leading customer support worldwide. The company doesn't share their inhouse technology.

Kukdo's System (Korean Technology)**:** Kukdo's system is leading the global market through customized products and R&D. This companies all branches use their own technology.

Technology	Open for Third Party Licensing
Ciba-Geigy AG	✓
Tohto Kasei Co. Ltd.	✓
Kukdo Chemical Co., Ltd	✗
Olin Corporation	✗
Dow Chemicals	✗

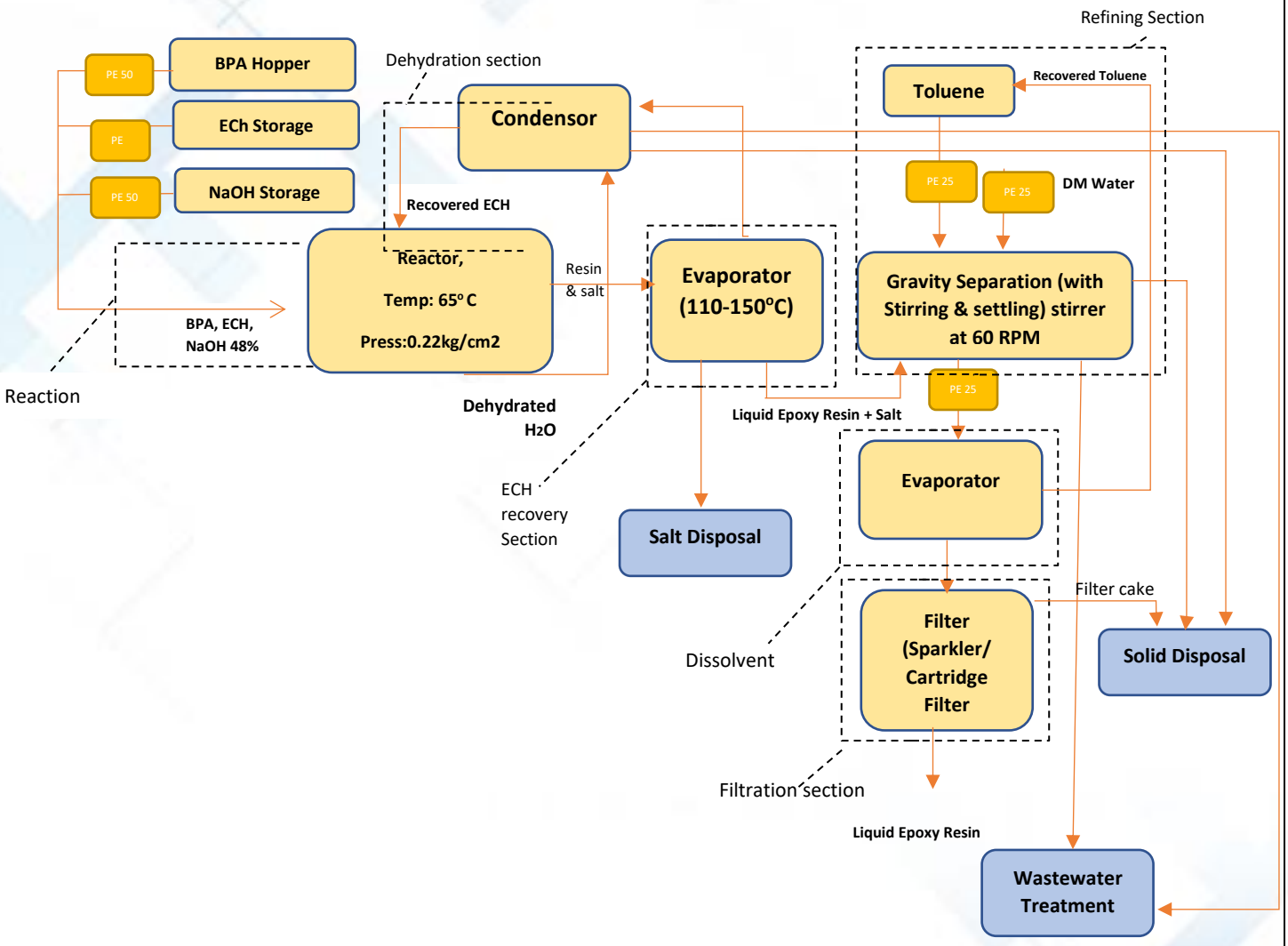
- The major licensors and manufacturers of Epoxy Resins. Only two of the following licensors i.e., Ciba-Geigy AG and Tohto Kasei Co., Ltd are open to share the technologies with new entrants.
- Both the technologies give favorable outcomes qualitatively & quantitatively. Also, both technologies are being used in India by leading epoxy resin manufacturers like Grasim Industries and Atul Ltd.
- Kukdo Chemical Co., Ltd and Olin Corporation do not share the technological process and process parameters and employ the manufacturing process in its own specific plants.
- The quality of product provided by Kukdo Chemical Co., Ltd is very superior in comparison to other technology licensors and it provides crystal clear liquid epoxy resin to the clients.
- Ciba- Geigy AG has low solvent requirements than the Tohto Kasai Co., Ltd.

4.1.5. Technology Licensor

Technology 1: CIBA Geigy

Process Flow Diagram: CIBA

The commercial interest in the epoxy resin was first made apparent by the publication of German patent by I.G. Farben in 1939. In 1943 P. This important process was subsequently explored by the **CIBA Company**.

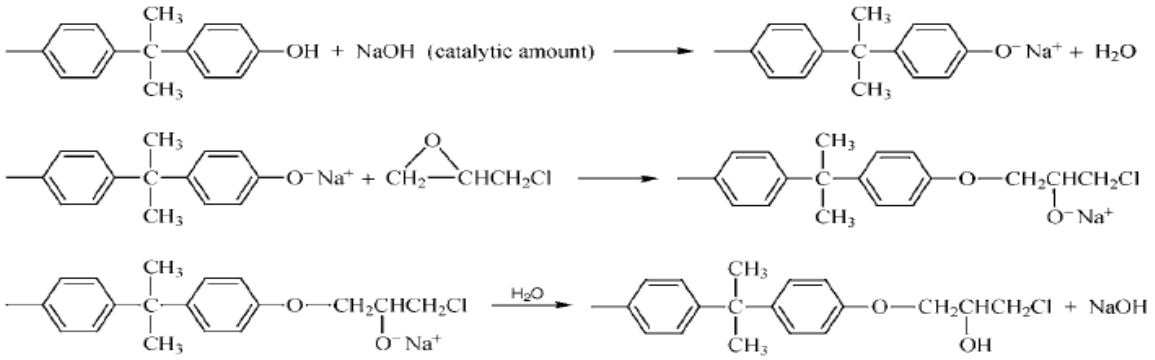


Source: PFD has been validated by Indian manufacturer And only major processes have been considered.

CIBA Process Flow Diagram Description

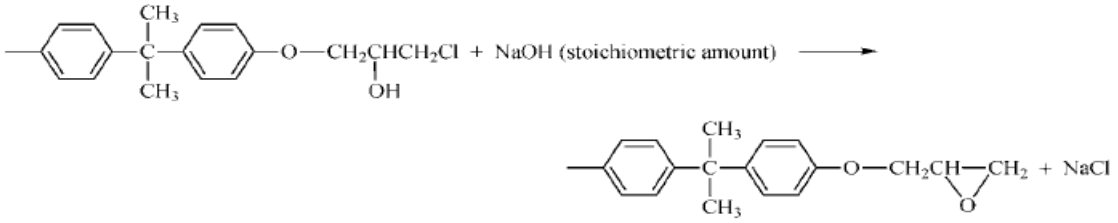
1. **Reaction Section**

Pre-Reactor: Reaction starts with adding Excessive quantity of Epichlorohydrin (Fresh & recovered) with prescribed quantity of Bisphenol-A by using NaOH (48%) as Catalyst to yield chlorohydrin. As result of this reaction, Bisphenol-A chlorohydrin intermediate is formed.



Reactor

In the same Reactor, Bisphenol-A chlorohydrin intermediate formed from the pre-reaction section is further charged with stoichiometric amount of NaOH (48%) to form liquid epoxy resin (i.e., by dehydrohalogenation of the chlorohydrin intermediate).



2. **Dehydration:**

Condenser: Water Evaporated during reaction contains ECH and water. Same is passed through condenser, it forms two layers of ECH & water, ECH is separated out & reused.

3. **ECH Recovery**

Evaporator: Here ECH is separated from Resin & Salt solution, temperature is increased further to 110-150^{o}C under vacuum, so that whole of the ECH is removed via Condenser. In order to protect the epoxy resin from thermal effect, vaporization of ECH is done under vacuum conditions, at the lowest possible temperature and in the shortest possible time. Approximately 95% ECH can be recovered which will further reduce the cost of production under the standard/developed procedure.

During this process, solid salt is produced as a by-product which may get disposed off via landfilling process.

4. **Refining Section**

Gravity Separator: In this section, washing & separation takes place at atmospheric pressure. Toluene is added to dissolve resin and the salt solution is separated from the resin manually by adding demineralised water. Three layers are formed; the resin and toluene stay in the upper layer (called organic layer) & NaCl-water in the lower layer & centre one is the unreacted BPA, it is called emulsion layer. Again, Demineralised (DM) water is added to wash the resin and remove the traces of salt from it.

The recovered unreacted BPA with impurities can be further purified and reused in the next batch once production process gets developed.

5. **Dissolvent:**

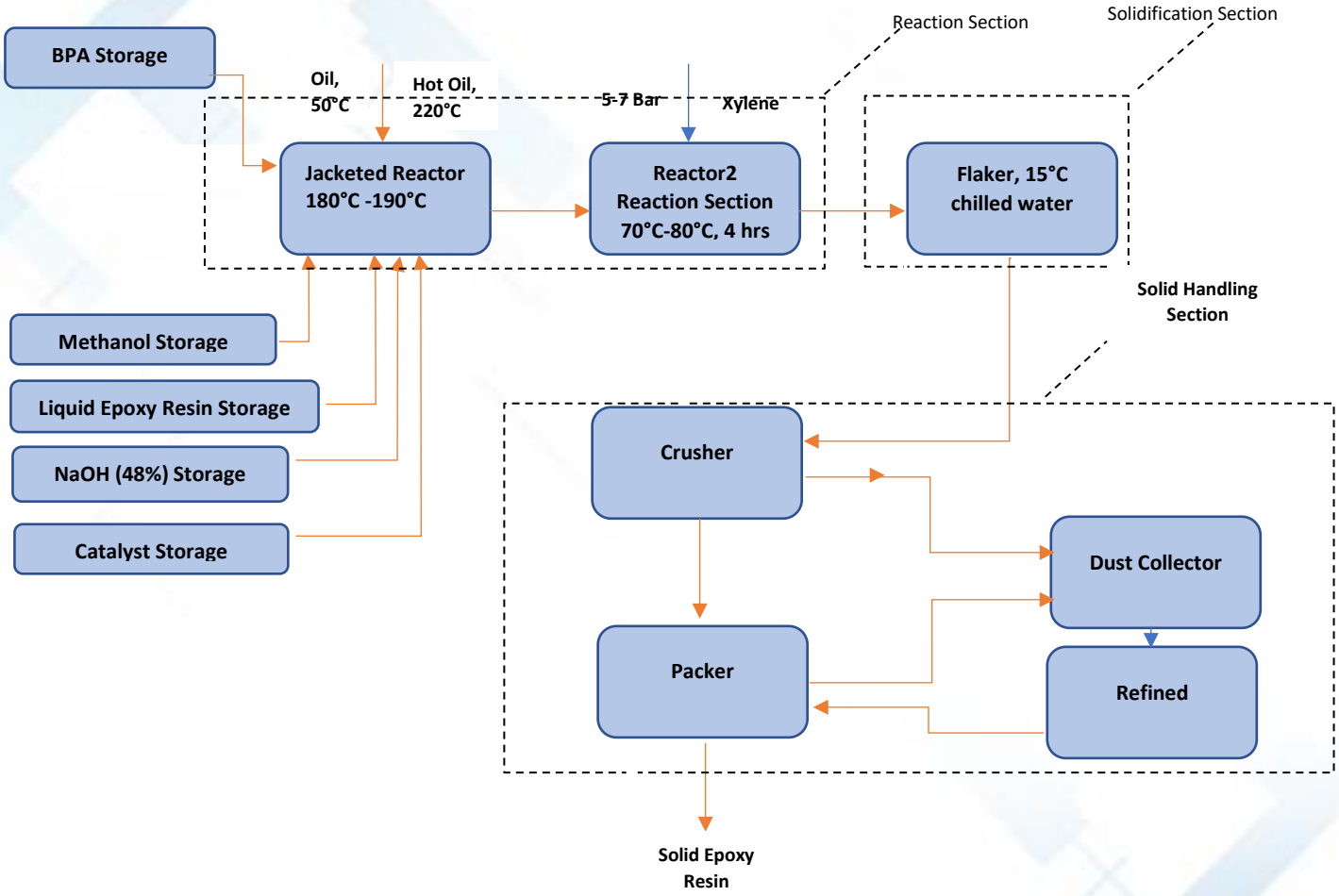
Evaporator: In this section, dissolvent is done to remove the solvent, toluene from the resin by passing through evaporator (falling film thin evaporator & Rotary film thin Evaporator can be used for better efficient solvent recovery) under vacuum. Around 95% toluene can be recovered which will further be used in the next batch once production process gets developed.

6. Product Finishing Section

Filtration: Epoxy resin is finally filtered to remove the traces of salt / impurities via sparkler filter or cartridge filter. Final product Liquid Epoxy Resin is produced and send to the packer section for drum packaging.

Solid Epoxy Resin:

Process Flow Diagram:



1. Reaction Section

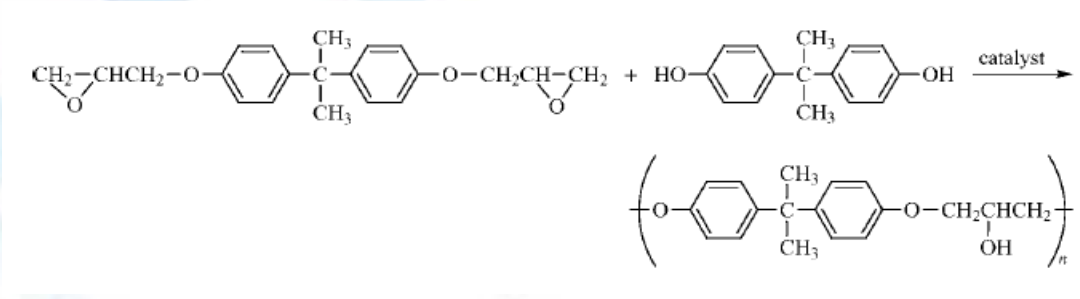
Reactor 1: In this section, Liquid Epoxy Resin, Bisphenol A & Catalyst is added into the jacketed reactor (BPA & Catalyst is added in 2 Stages i.e. With progress of the reaction, 2nd lot of BPA &

catalyst is added to avoid side reactions and unwanted products, also reactants are added in lots to improve yield.)

For the suppression of catalytic reaction, a small quantity of Methanol is also added in reactor

Reactor 2: Here reaction mixture from the pre reaction section is added with a solvent in control range of pressure (5-7 Bar) & temp (70-75^0 C) approximately with continuous stirring.

Note: The reaction can be carried out with or without solvents



2. Solidification Section

Flaker: Here Epoxy Resin (i.e., formed in reaction section) is passed through the flaker (with required utilities (chilled water & steam)).

3. Solid Handling Section

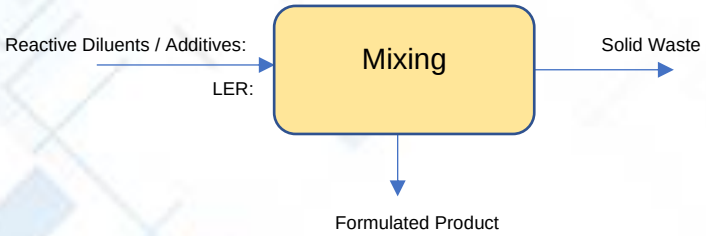
Crusher: After flaker, product is further passed through the crusher to collect the final mesh size solid product.

Dust collector: It is installed with crusher & packer to collect the product dust. Which is refined and send to the for packer

Packer: Product is finally sent to the packer for the packaging in respective size Bag (20 Kg, 25 Kg, 50 Kg, 100 Kg etc.) i.e., as per the requirement.

Formulated Resins:

Mixing: Different grade Liquid Epoxy Resin is mixed with various types of additives or Reactive Diluents to meet customer specific applications or other special Resin.



Example: Amine cured epoxy coating is an epoxy coating where an anime-based hardener was used in the curation process.

Hardeners: Hardeners are required to make an epoxy resin useful for its intended purpose. The correct type of hardener must be selected to ensure the epoxy mixture will meet the requirements of the application. Mixing epoxy resin and hardener begins a chemical reaction that transforms the combined liquid ingredients to a solid. The time it takes for this chemical transformation from liquid to solid is called cure time. As it cures, the epoxy passes from the liquid state, through a gel state, before it reaches a solid state. Common examples of epoxy hardeners are anhydride-based, amine-based, polyamide, aliphatic and cycloaliphatic.

Diluents or Diluting Agent: Diluents are low-molecular-weight, low-viscosity compounds that are used to reduce the viscosity or enhance the solubility of a resin and/or hardener, Diluents may be either reactive or non-reactive. However, the reactive types are more desirable since they combine chemically with the main resin during cure and are not free to outgas or leach. Examples of diluents for epoxy resins include: phenylglycidyl ether, butylglycidyl ether, allylglycidyl ether, butanediol diglycidyl ether and glycerol-based epoxy resin.

Additives: Epoxy resin additives are often used for multiple purposes. They can enhance the appearance of given resin and can even strengthen the resin. resin additives include metallic powders, liquid epoxy dye, spray paints, and glitter adhesives.

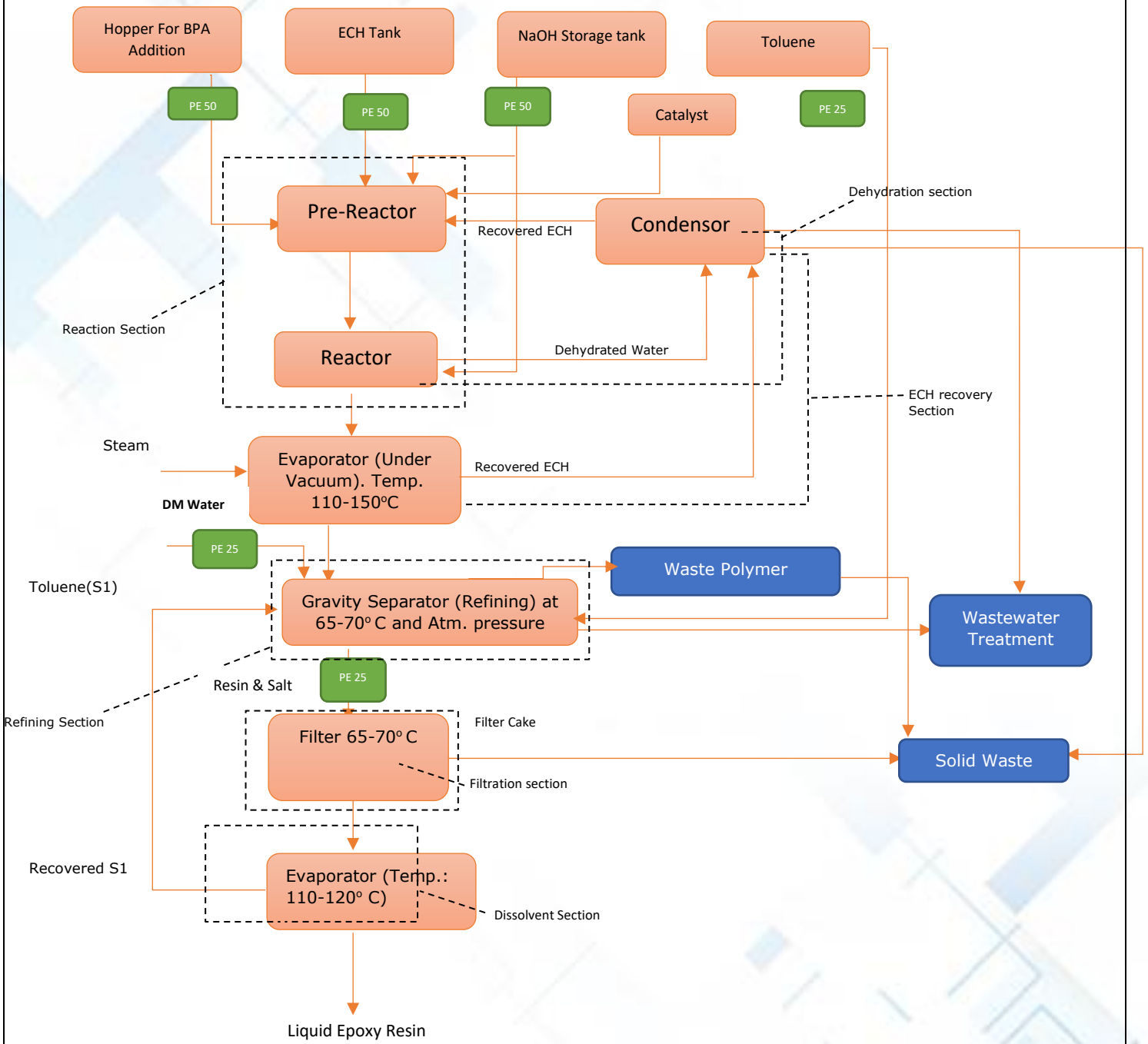
Fillers: Major fillers include Graphene, Poly(2-butylaniline) functionalized Graphene & Waste Tire Rubber Particles. Fillers are used to affect the tensile strength, compressive strength impact resistance, viscosity, and shrinkage.

Fillers	Dispersion technique
Graphene	Epoxy Resin + graphene is dispersed by mechanical blending for 10 min + ultrasonic dispersion for 30 min.
Poly(2-butylaniline) functionalized Graphene	Poly(2-butylaniline) + Tetrahydrofuran (THF) sonicated for 30 min. Addition of epoxy with 10 min stirring. Removal of THF by rotary evaporation; addition of curing agent followed by blending at 4000 rpm for 5 min; room temperature degassing in vacuum oven.
Waste Tire Rubber Particles	Epoxy Resin + (1–20 wt%) Micronized Tire Rubber Manual Stirring for 10 min; Addition of curing agent followed by manual stirring for 5 min.

Technology- 2: Tohto Kesai

Process Flow Diagram: Tohto Kesai

Tohto Kasei (Japan) (Now known as Nippon Steel & Simikin Chemical Co Ltd.), leader in resin producer, have its own epoxy licensing technology arrangements with numerous resin manufacturers in Asia.



Tohto Kesai Process Details:

1. **Reaction Section:**

Pre-reactor

Reaction starts with adding excessive quantity of Epichlorohydrin (fresh & recovered) with prescribed quantity of Bisphenol-A by using NaOH as catalyst at 65^{o} C. In this section one more catalyst* is also added along with NaOH. As result of this reaction, Bisphenol-A chlorohydrin intermediate is formed.

*Catalyst can be lithium salts, quaternary ammonium salts or any other catalyst.

Reactor

Bisphenol-A chlorohydrin intermediate formed from the pre-reaction section is further changed to liquid epoxy resin by reaction with NaOH. Optimum process conditions are maintained in the reactor which minimize hydrolysis of ECH and formation of by-product waste polymer and enables the production of high-quality epoxy resin of the required viscosity at high yields.

Note*: it is advisable to add optimum ratio of BPA to ECH, which will form less side product / oligomers / Impurities etc. In India, Grasim Industries Ltd having Tohto Kesai Process, uses 1:6 BPA to ECH ratio (2 moles of fresh ECH & 4 Mole of recovered ECH).

2. **Dehydration Section**

Condenser: Water evaporated during reaction contains ECH and water. Same is passed through condenser, it forms two layers of ECH & water. ECH is separated out & reused and water sent to the ETP section.

3. **ECH Detachment Section**

Evaporator: After the reaction process is done, excessive quantities of unreacted ECH are separated from the product by increasing the temperature to 110-150^{0} C through a vaporizer (Evaporator), same is returned via condenser for reuse. The crude epoxy is then sent to the next refining section. In order to protect the epoxy resin from thermal effect, vaporization of ECH is done under vacuum conditions, at the lowest possible temperature and in the shortest possible time. Around 95% toluene can be recovered which will further be used in the next batch once production process gets developed.

4. **Refining**

Gravity Separator: In this section washing & separation takes place at atmospheric pressure. Toluene and water are added to dissolve resin in it and the salt solution is separated from the resin manually by adding demineralised water. Three layers are formed; the resin and toluene stay in the upper layer (called organic layer) & NaCl-water in the lower layer & centre one is the unreacted BPA, it is called emulsion layer. Again, Demineralised (DM) water is added to wash the resin and remove the traces of salt from it.

The recovered unreacted BPA with impurities can be further purified and reused in the next batch once production process gets developed.

5. **Product Finishing Section**

Filtration: Finally, Epoxy resin is filtered to remove suspended particle via filter and is sent to the next section for solvent recovery. Filter Cake removed from the filter is sent to the waste management section.

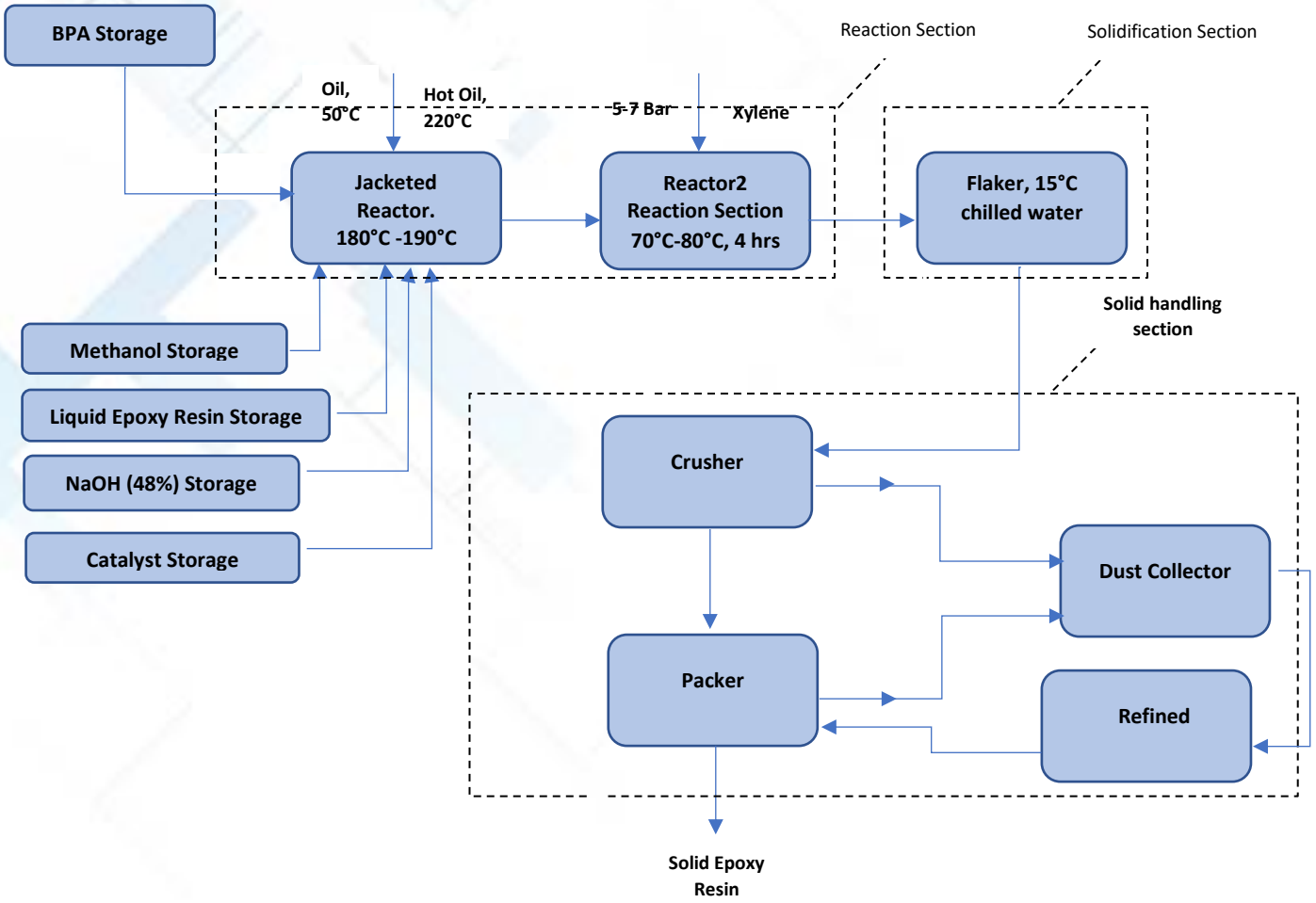
Filter used can be sparkler filter or cartridge filter. Final product Liquid Epoxy Resin is produced and send to the packer section for drum packaging.

6. **Dissolvent**

Solvent Recovery: In this section solvent is removed from the resin by passing through evaporator (falling film thin evaporator & rotary film thin evaporator) under vacuum and product then packed through packer).

Solid Epoxy Resin:

Process Flow Diagram:



1. Reaction Section

Reactor 1: In this section, Liquid Epoxy Resin, Bisphenol A & Catalyst is added in to the jacketed reactor (BPA & Catalyst is added in 2 Stages i.e. With progress of the reaction, 2nd lot of BPA & catalyst is added to avoid side reactions and unwanted products, also reactants are added in lots to improve yield.)

*For the suppression of catalytic reaction, small quantity of Methanol is also added in reactor.

Reactor 2: Here reaction mixture from the pre reaction section is added with a solvent in control range of pressure (5-7 Bar) & temp (70-75^0 C) approximately with continuous stirring.

Note*: The reaction can be carried out with or without solvents

2. Solidification Section:

Flaker: Here Epoxy Resin (i.e., formed in reaction section) is passed through the flaker (with required utilities (chilled water & steam)).

3. Solid Handling Section

Crusher: After flaker, product is further pass through the crusher to collect the final mesh size solid product.

Dust collector: It is installed with crusher & packer to collect the product dust, which is refined and send to the packer.

Packer: Product is finally sent to the packer for the packaging in respective size Bag (20 Kg, 25 Kg, 50 Kg, 100 Kg etc.) i.e., as per the requirement.

Observations:

1. In Ciba Technology, only one reactor is used for the catalytic reaction as well as dehydrohalogenation of the chlorohydrin intermediate using NaOH as Catalytic and dehydrohalogenation agent. While in Tohto Kesai Technology, reaction take place in two reactors (Pre-Reactor & Reactor), using NaOH and ammonium salt as catalyst & NaOH as Dechlorinating agent.
2. Major difference between two technology is process parameter (Pressure, Temperature, Retention time etc.), Solvent, Catalyst, Additives, Hardeners, fillers used etc.
3. In Tohto Kesai, filtration is done first, then after distillation is done to recover solvent used. While in Technology 2 (CIBA), First Distillation (under Vacuum) is done to recover solvent and then filtration is done.

According to the key opinion leaders, the technology employed by Ciba-Geigy AG process is less complex than the Tohto Kasei Co. Ltd. technology. Other than this, few variations in process parameters (like Reaction time, flow rate of Solvent, Catalyst used, BPA to ECH ratio) are the only observable differences.

CIBA is also characterized by the following strengths:

- Well established and mature Technology.
- High-quality and low-cost production facilities
- Well-invested plants across the Globe (e.g. Nanya Plastic (China), Huntsman, Atul ltd (India), Hindusthan Specialty chemicals (India) etc.)
- Economies of scale
- Leading market positions for licensing
- Operating diversity – Plant process route, Grades Availability

4.1.6. Utilities Overview (Cooling Water System, DM Water Plant, Compressed Air System, power, steam & effluent processing details): For 84 KTPA capacity in two phases)

Fresh water requirement will be 923 KLD. 710 KLD treated water after UF/RO system will be reused/recycled back in process. Water will be sourced from the near water supply system.

Water Consumption:

Description		Fresh/ Permeate	Recycled water	Remark
1	Primary RO	908		
	RO Permeate	678		RO permeate water will be used in utility & domestic
	Domestic	15		
	Cooling Tower	528	530	528 KLD Fresh + 530 KLD recycled water after UF/RO system
	Boiler	130	-	
	Plant Washing	5		
2	Process	230	180	180 KLD recycled water after UF/RO system
3	Gardening	15		
4	Water Required	923	710	
	Total (fresh and recycled)	1633		923 KLD Fresh water from GIDC and 710 KLD recycled water after UF/RO System

Detail of Wastewater Generation

S. No.	Description	Wastewater Generation in KLD	Remark
1	RO Reject	230	To ETP
2	Domestic	15	
3	Cooling Tower	200	
4	Boiler	117	
5	Plant Washing	5	
6	Process	243	304 KLD process effluent will be sent to MEE. From that 61 KLD will convert to Salt and 243 KLD MEE condensate will sent to ETP for further treatment
	Total Wastewater Generation	**810**	
	Recycled Water	710	After treatment in recycling UF and RO system

	Treated Wastewater going to nearest drain/ CETP	**100**	**RO reject will be disposed off into deep sea via nearest drain/CETP**

Nitrogen: The reaction is carried out in reactor under 'nitrogen blanket'.

Power Requirement

Nearest State Electricity Board will supply power through grid in that area. The peak demand of power would be approx. 5500 kVA. DG sets will be installed as a backup arrangement.

4.1.7. Waste generation, Management, and disposal:

Wastewater generation from capacity of 84 KT which includes processes like Badge, Taffy, Advancement and manufacturing of standard and specialized epoxy resin, wastewater generation will be around 700 KLD. From that, 615 KLD will be recycled and 85 KLD will be discharged to CETP after achieving desired norms. Unit will provide 750 KLD capacity of ETP followed by RO & UF. High TDS (Total Dissolved Solids) stream will be treated in MEE/MVR (Multi Effect Evaporator/ Mechanical Vapor Re-compressor).

Hazardous wastes like resin sludge with polymers, resin-soaked cotton waste / gloves & chemical contaminated saw dust, office garbage, filter material, waste glycerine, spent solvent, spent oil, activated carbon, ETP (Effluent Treatment Plant) sludge, and waste barrel will be generated during the production. MEE/MVR salts (i.e., NaCl Salt) need to be send to authorized vendors & to managed as per the Hazardous Wastes (Management, Transport and Transboundary) Rules 2016 as amended till date.

S No	Type of Waste	Source	Quantity per Year (MT)	Method of collection	Treatment/Disposal
1	ETP Sludge + Evaporation residue	Process	2.1	Bag	Collection, storage and Disposal at Approved TSDF Site
2	Resin-Soaked Cotton Waste/ Gloves, Chemical, Contaminated Saw dust, Office Garbage	Process	0	Bag	Incineration
3	Filter Material	Process	1.46	Bag	Incineration
4	Waste Glycerine	Maintenance	10.95	Drum	Incineration

5	Spent Solvent	Process	87.6	Drum	Collection, storage and Disposal at Approved TSDF Site
6	Spent Oil	Maintenance	0	Drum	Via Register Recycler
7	Activated Carbon	Process	0.43	Bag	Via Register Recycler
8	ETP Sludge	ETP	0	Bag	Via TSDF
9	Discarded Container	Process	534.6	Drum	Via Authorised Vendor
10	Process Residue	Process	0	Drum	Via CHWIF
11	Salt (NaCl)	Process	15149.2	Bag	Sell to Authorised Vendor

TSDF: Treatment, Storage, & Disposal Facility.

CHWIF: Common Hazardous waste Incineration facility.

CETP: Common Effluent Treatment Plant

4.1.8. Raw Material Required (Detail list of all raw major raw material used for the manufacturing of Epoxy Resin):

Chemical Name	Molecular Weight	Flash Pt.(°C)	Boiling Pt (°C)	Melting pt. (°C)	Density (g/cm³)	Autoignition temp. (°C)	Solubility in water
Epichlorohydrin	92.5	31	117.9	-25.6	1.1812	385	Insoluble
Isopropyl alcohol	60.1	11.7/13	82.5	-89	0.786		Soluble
Bisphenol-F	200.24	177.1	362.5 °C at 1 atm		1.208g/cm³		Low
Bisphenol-A	228.9	227	360	158	1.2	600	Insoluble
Caustic soda lye	40		1390	318	2.1 (Solid)		Soluble
Toluene	92.14	4.4/16	110.6	-95	0.8636	1.53	Insoluble
Phenol	94.11	79		40.5	1.07		8.3g/100ml
o-cresol	108.14	81	191	29.8	1.05(solid) 1.03(liq.)		2.5g/100ml
1,4-Butanediol	90.12	121	235	20.1	1.0171 at	350	Soluble
					20° C		
Cardanol	300			57-65	1 at 25° C		Less than 1g/L at 25° C
Polypropylene glycol	76.09	99	188.2	-59	1.036 at 20° C	371	
Hexahydropthalic anhydride	154.2	152	296	37.5	1.18	395	7g/L at 20° C

5. Economic Evaluation

Estimated cost analysis for the suggested capacity of 84 KPTA.

5.1 Fixed Cost & Variable Cost Analysis (CAPEX):

In particular, the total capital investment was based on the percentage of the delivered equipment cost method for a solids and liquids processing plant,

The total cost of the process equipment (including auxiliary equipment) as the 100% value, the total capital investment for the base case is estimated at USD 34.1 million.

	ITEM	[USD Million]
A	**TOTAL FIXED-CAPITAL INVESTMENT ***	33.4
A1	TOTAL DIRECT PLANT COST	23.7
1	Delivered main equipment (includes auxiliary equipment)	7.7
2	Purchased-equipment installation	3.0
3	Instrumentation and controls (installed)	2.0
4	Piping (installed)	2.4
5	Electrical (installed)	0.8
6	Buildings (including services)	2.2
7	Yard improvements	0.9
8	Service facilities (installed)	4.2
9	Land (purchase is required)	0.5
A2	**TOTAL INDIRECT PLANT COST**	9.7
10	Engineering and supervision	2.5
11	Construction expenses	2.6
12	Legal expenses	0.3
13	Contractor's fee	1.5
14	Contingency	2.8
B	**WORKING CAPITAL**	0.8
16	Safety and hazard analyses	0.8
	TOTAL CAPITAL INVESTMENT	34.1

Note: All calculation is based on the prevailing prices of equipment during Q2 and Q3 of 2021. As per the market participants, the prices may get revised upwards in next 2-3 years due rising commodity prices.

PARAMETERS		COST OF PRODUCTION: Technology 1 CIBA)			COST OF PRODUCTION: Technology 2 (Tohto Kesai)		
		Quantity	Unit Rate	Amount	Quantity	Unit Rate	Amount
		Tonne	USD/Tonne	USD	Tonne	USD/Tonne	USD
A	VARIABLE COST						
1	Raw Materials						
	Bisphenol A	0.7	1350.0	945.0	0.7	1350.0	945.0
	Epichlorohydrin	0.6	1470.0	823.2	0.6	1470.0	837.9
	Caustic Soda	0.5	150.0	75.0	0.5	150.0	75.0
	Sub-Total (1)			1843.2			1857.9
2	Utility, Catalyst, Solvent, Labour, Packaging, R & D and Selling & Transportation			340.5			390.2
	TOTAL VARIABLE COST			**2183.7**			**2248.1**
B	FIXED COST						
1	Maintenance and repairs			10.2			10.8
2	Plant-Overhead Costs			45.4			47.8
3	Administrative costs			3.7			4.2
	Total Fixed Cost			69.5			74.7
C	**Total Production Cost**			**2243.0**			**2311.8**

Assumptions and Findings

1. Solvent recovery in CIBA Technology is quite better than that of Tohto Kesai
2. Catalyst & Chemical cost is higher in Tohto Kesai.
3. Prices of raw material and catalyst for both licensors are moving monthly average of ApReliance Industries Ltd 2019-March 2021 and for liquid epoxy resin.
4. The cost of power used by the plant considered as INR5.50 per kWh. Further, the companies interviewed were grid connected for their power requirements. Tariff of electricity was derived from public documents of manufacturers and power distribution companies.
5. The other utilities mainly include raw water, and its cost has been taken as INR1.25 per m3
6. Per kg costs for the fixed items are calculated based on primary research. Further, Repair and maintenance cost is 2.5% of plant & machinery cost. Interest on working capital is around 10% and depreciation has been calculated based on 10 years.

5.2. Machinery & Equipment Cost Analysis:

The total cost of the equipment is approximately USD 7.7 million (Ciba Process) including the auxiliary equipment. Considering the reactor and flaker as a complex part of the epoxy resin manufacturing, hence are considered as auxiliary equipment and the construction material is SS 304. The client is preferred to outsource the complex equipment (reactor and flaker) from the technology provider itself or under their recommendation. The equipment cost might vary for different manufacturers depending on the complexity and the material of construction. Construction and Installation of large size equipment (volume more than 100m^3) like LER Storage Tanks is done on-site as the transportation of such equipment is not feasible.

This analysis is provided for uninterrupted production process:

CIBA						
	MAIN PROCESS EQUIPMENTS	**CAPACITY & MOC**	**Qty**	**Unit Rate [USD Million]**	**Category**	Remarks
1	Caustic Preparation Solution Tank (48% Caustic)	m3,PP	1	0.098	Indigenous	
2	Caustic transfer pump	m3/hr,PP	2	0.033	Indigenous	1 Standby & 1 working
3	BPA Hopper (if Solid)	m3, SS304	1	0.033	Indigenous	
5	ECH Storage Tank	m3, SS304	1	0.164	Indigenous	
6	ECH Transfer Pump	m3/hr, SS304	2	0.033	Indigenous	1 Standby & 1 working
7	Pre-Reactor	Not Required				
8	Reaction solution Transfer pump					
9	Reactor	m3, SS304	1	0.491	Auxiliary	For more no of grade, Reactor will be increased accordingly
10	Reaction solution Transfer pump 2	m3/hr, SS304	2	0.033	Indigenous	1 Standby & 1 working
12	Distillation Tower for ECH	m3, SS304	1	0.131	Indigenous	
13	Solvent Storage Tank (Toluene)	m3, SS304	1	0.164	Indigenous	
14	Solvent transfer pump	m3/hr, SS304	2	0.016	Indigenous	1 Standby & 1 working
15	Washing Tower	m3, SS304	1	0.098	Indigenous	
16	Gravity Separator	m3, SS304	1	0.164	Indigenous	
17	Soln Transfer pump	m3/hr, SS304	2	0.016	Indigenous	1 Standby & 1 working

18	Ditillation Tower for Toluene Recovery	m3, SS304	1	0.131	Indigenous	
19	Soln Transfer pump 2	m3/hr, SS304	2	0.033	Indigenous	1 Standby & 1 working
20	Filter	m3, SS304	2	0.164	Indigenous	
21	Mixing Tank	m3, SS304	1	0.196	Indigenous	
22	Feed Pump	m3/hr, SS304	2	0.033		1 Standby & 1 working
23	Product Tank	m3, SS304	1	0.246	Indigenous	
24	UF/RO System	m3/hr, SS304	1	0.164	Indigenous	
25	Evaporator (Thin Evaporator & Rotary film thin evaporator)	m3, SS304	1	0.049	Indigenous	
26	Cooling Tower	m2, SS304	1	0.098	Indigenous	
27	DG's, Generator's	400 KV	2	0.131	Indigenous	
28	DCS System (Instrumentation Item)		1	0.491	Indigenous	
	Total			3.21		
1.2	Equipment list for SER					
1	LER Storage tank	375m3, SS304	2	0.327	Indigenous	
2	Xylene Storage Tank	110m3, SS304	1	0.147	Indigenous	
3	Condenser	7m2, SS304	1	0.041	Indigenous	
4	Feed Pump	18m3/hr, SS304	4	0.02	Indigenous	2 Process pump & 2 Standby
5	Weighing Tank	14m3, SS304	1	0.041	Indigenous	
6	Hoist	3-4 Ton/hr, SS304	1	0.025	Indigenous	
7	BPA Hopper	08-12m3, SS304	1	0.02	Indigenous	
8	Reactor	15 m3, SS304/CS	1	0.491	Indigenous	
9	Resin Hopper	1.2m3, SS304	1	0.02	Indigenous	
10	Condenser	7.5m2, SS304	1	0.033	Indigenous	
11	Reactor	15m3, SS304	1	0.491	Auxiliary	
12	Condenser	7.5m2, SS304	1	0.049	Indigenous	
13	Raw material Hopper	0.2m3, SS304	1	0.003	Indigenous	
14	BPA Dust Collector	25m3, CS	1	0.016	Indigenous	
15	Reactor	16m3, SS304	1	0.491	Auxiliary	
16	Resin hopper	1.2m3, SS304	1	0.005	Indigenous	
17	Condenser	7.5m2, SS304	1	0.049	Indigenous	
18	Dust Collector	25m3, CS	1	0.016	Indigenous	
19	Cut Tank	17m3, SS304	1	0.327	Auxiliary	
20	Condenser	25m2, SS304	1	0.065	Indigenous	
21	Product filter	15m3/hr, SS304	1	0.016	Indigenous	
23	Flaker hopper	4,000kg/hr, SS 304	1	0.033	Indigenous	
24	Circle Feeder	7.5 ton/hr, SS 304	1	0.065	Indigenous	
25	Crusher	4500kg/hr, SS304	1	0.131	Indigenous	
26	Packer	**(25 Kg, 100 Kg, 200Kg, 500 Kg /bag,)** SS 304	4	0.098	Indigenous	

27	Product Dust Collector	40m3/hr, SS314	1	0.025	Indigenous	
28	Product Tank	150m3, SS304	4	0.698	Indigenous	
29	Vent Condenser	6m2, SS304	4	0.098	Indigenous	
30	Product Filter	15m3/hr, SS304	4	0.079	Indigenous	
	Feed Pump	18m3/hr, SS304	5	0.082	Indigenous	
	Total			4.002		
1.3	ETP Plant	800 KD		0.477		
	Final Total			**7.689**		

Tohto Kesai						
	MAIN PROCESS EQUIPMENTS	**CAPACITY & MOC**	**Qty**	**Unit Rate [USD Million]**	**Category**	Remarks
1	Caustic Preparation Solution Tank (48% Caustic)	m3,PP	1	0.098	Indigenous	
2	Caustic transfer pump	m3/hr,PP	2	0.033	Indigenous	1 Standby & 1 working
3	BPA Hopper (if Solid)	m3, SS304	1	0.033	Indigenous	
5	ECH Storage Tank	m3, SS304	1	0.164	Indigenous	
6	ECH Transfer Pump	m3/hr, SS304	2	0.033	Indigenous	1 Standby & 1 working
7	Pre-Reactor	m3, SS304	1	0.491	Auxiliary	
8	Reaction solution Transfer pump	m3/hr, SS304	2	0.033	Indigenous	1 Standby & 1 working
9	Reactor	m3, SS304	1	0.491	Auxiliary	For more no of grade, Reactor will be increased accordingly
10	Reaction solution Transfer pump 2	m3/hr, SS304	2	0.033	Indigenous	1 Standby & 1 working
12	Distillation Tower for ECH	m3, SS304	1	0.131	Indigenous	
13	Solvent Storage Tank (Toluene)	m3, SS304	1	0.164	Indigenous	
14	Solvent transfer pump	m3/hr, SS304	2	0.016	Indigenous	1 Standby & 1 working
15	Washing Tower	m3, SS304	1	0.098	Indigenous	
16	Gravity Separator	m3, SS304	1	0.164	Indigenous	
17	Soln Transfer pump	m3/hr, SS304	2	0.016	Indigenous	1 Standby & 1 working
18	Ditillation Tower for Toluene Recovery	m3, SS304	1	0.131	Indigenous	
19	Soln Transfer pump 2	m3/hr, SS304	2	0.033	Indigenous	1 Standby & 1 working

20	Filter	m3, SS304	2	0.164	Indigenous	
21	Mixing Tank	m3, SS304	1	0.196	Indigenous	
22	Feed Pump	m3/hr, SS304	2	0.033		1 Standby & 1 working
23	Product Tank	m3, SS304	1	0.246	Indigenous	
24	UF/RO System	m3/hr, SS304	1	0.164	Indigenous	
25	Evaporator (Thin Evaporator & Rotary film thin evaporator)	m3, SS304	1	0.049	Indigenous	
26	Cooling Tower	m2, SS304	1	0.098	Indigenous	
27	DG's, Generator's	400 KV	2	0.131	Indigenous	
28	DCS System (Instrumentation Item)		1	0.491	Indigenous	
	Total			3.733		
1.2	Equipment list for SER					
1	LER Storage tank	375m3, SS304	2	0.327	Indigenous	
2	Xylene Storage Tank	110m3, SS304	1	0.147	Indigenous	
3	Condenser	7m2, SS304	1	0.041	Indigenous	
4	Feed Pump	18m3/hr, SS304	4	0.02	Indigenous	2 Process pump & 2 Standby
5	Weighing Tank	14m3, SS304	1	0.041	Indigenous	
6	Hoist	3-4 Ton/hr, SS304	1	0.025	Indigenous	
7	BPA Hopper	08-12m3, SS304	1	0.02	Indigenous	
8	Reactor	15 m3, SS304/CS	1	0.491	Indigenous	
9	Resin Hopper	1.2m3, SS304	1	0.02	Indigenous	
10	Condenser	7.5m2, SS304	1	0.033	Indigenous	
11	Reactor	15m3, SS304	1	0.491	Auxiliary	
12	Condenser	7.5m2, SS304	1	0.049	Indigenous	
13	Raw material Hopper	0.2m3, SS304	1	0.003	Indigenous	
14	BPA Dust Collector	25m3, CS	1	0.016	Indigenous	
15	Reactor	16m3, SS304	1	0.491	Auxiliary	
16	Resin hopper	1.2m3, SS304	1	0.005	Indigenous	
17	Condenser	7.5m2, SS304	1	0.049	Indigenous	
18	Dust Collector	25m3, CS	1	0.016	Indigenous	
19	Cut Tank	17m3, SS304	1	0.327	Auxiliary	
20	Condenser	25m2, SS304	1	0.065	Indigenous	
21	Product filter	15m3/hr, SS304	1	0.016	Indigenous	
23	Flaker hopper	4,000kg/hr, SS 304	1	0.033	Indigenous	
24	Circle Feeder	7.5 ton/hr, SS 304	1	0.065	Indigenous	
25	Crusher	4500kg/hr, SS304	1	0.131	Indigenous	
26	Packer	(25 Kg, 100 Kg, 200Kg, 500 Kg /bag,), SS 304	4	0.098	Indigenous	

27	Product Dust Collector	40m3/hr, SS314	1	0.025	Indigenous	
28	Product Tank	150m3, SS304	4	0.698	Indigenous	
29	Vent Condenser	6m2, SS304	4	0.098	Indigenous	
30	Product Filter	15m3/hr, SS304	4	0.079	Indigenous	
	Feed Pump	18m3/hr, SS304	5	0.082	Indigenous	
	Total			4.002		
1.3	ETP Plant	800 KD		0.477		
	Final Total			**8.212**		

5.3. Operating Cost of Production

	ITEM	[USD Million on 100% Percent Capacity Utilization i.e. 84 KTPA]
C	**MANUFACTURING COST**	181.9
C1	**Raw materials**	166.3
1	Raw materials	163.8
2	Catalyst & Chemicals	2.5
C2	**Labour**	2.0
3	Salaries & Wages (calculated)	2.0
C3	**Variable Overheads**	8.8
4	Packaging Cost (calculated)	2.3
5	Utilities (calculated)	6.5
C4	**Fixed Overheads**	4.9
6	Maintenance and repairs (2.5% of fixed-capital investment)	0.9
7	Plant Overhead Costs (45% of 2 + 3 + 5)	3.8
8	Administrative costs (10% of 2 + 3 + 5)	0.3
D	**Selling Overheads**	21.8
9	Distribution and selling costs (10% of manufacturing cost)	18.2
10	Research and development costs (2% of manufacturing cost)	3.6
	Total Production Cost	203.8

5.4. Payback Period:

PROFITABILITY PARAMETER	
	Value (USD Million)
NPV @ 10%	144.96
Internal Rate Of Return (%) ***On Total Capital - Before Taxes***	54.9%
Payback Period, Years	
Simple	2.4
Discounted @ 12%	2.9

5.5. Project Sensitivity Analysis:

					NPV in USD Million
	BASE CASE	90.00%	95.00%	105.00%	110.00%
	CAPITAL COST				
IRR%	54.89%	54.37%	54.63%	55.15%	55.42%
NPV	145.0	143.5	144.2	145.7	146.4
	REVENUE				
IRR%	54.89%	35.82%	45.74%	63.58%	71.96%
NPV	145.0	72.5	108.7	181.2	217.4
	RAW MATERIALS COST				
IRR%	54.89%	66.11%	60.56%	49.10%	43.00%
NPV	145.0	190.5	167.8	122.2	99.4

1. IRR is highly attractive
2. Project is moderately sensitive to variations in Investment and highly sensitive to Selling Price as also the Feedstock prices. Relative sensitivity, in decreasing order is:

a) Selling Price (i.e., Revenue)
b) Feedstock Prices (i.e., Raw Material Costs)
c) Investment (i.e., Capital Cost)

6. Project Schedule:

PROJECT IMPLEMENTATION SCHEDULE FOR EPOXY RESIN PLANT																								
Activity		**Month**																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	18	16	18	22	24	26	28	29	30
1. Kick Off Meeting, Detailed Engineering and Licensing																								
1. Civil Work																								
Company Registration																								
Land Acquisition																								
Finalisation 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																								
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																								

7. Project and Business Risk on setting up Vinyl Ester resin plant in West Region of India

- **Cost Escalation-** There may be cost escalation and time overrun due to Covid-19 pandemic-related challenges, unusual rise in commodity prices and land conversion issues. It may also face cost overrun due to increase in foreign exchange component, increase in cost towards storage and preservation of equipment and interest during construction (IDC). As commodity prices like crude oil, steel, natural gas, coal & electricity are increasing which will be impacting the overall cost of the project. As per industry experts, the bullish market for the next few months will be noticing the upward trend in the commodity prices.
- **Domestic/ Geo-Political scenario-** In western India, Gujarat, Maharashtra, and Madhya Pradesh are three major states, where setting up of plant can be considered. The political scenario will not be much impact on the project and businesses as any incumbent government majorly focuses on industrial development. Moreover, Reliance as a brand is considered as the major contributor for the socio-economic growth in Western region.
- **International/ Geo-Political Scenario-** India is not immune to geo-political scenario prevailing all over the global. In recent years, the following points have impacted the geopolitical scenario of India-
    - The conflict among GCC (Gulf Cooperation Council) nations have impacted the prices of commodities (crude oil, natural gas).
    - In past, the trade war between US – China, have impacted the global foreign trade from and to India.
    - The natural calamities like hurricanes, floods etc. are prevalent in the North America and Europe which hampers the export market.
- **Trade Barriers and Free Trade Agreement -** Many countries impose trade barriers / anti-dumping duties to protect their domestic industry. For initial period of operation, Reliance needs to explore export market. If any country imposes any safeguard duty from India's import, then it may impact realization/revenue.

  India has agreement with ASEAN nations for trade which attracts zero or lesser custom duties which has resulted in increased import from South Korea and Thailand in recent years.

- **Social Economic Factor:** All major social economic factor are favorable for the project in western region. Social economic factor include infrastructural facilities, provisions for public health, education, communication and banking facilities etc. Development of social sector along with technology absorption could be considered as the primary objective of any economic developmental effort. Many developmental programs have been taken up in western region in a planned way with the main objective of enhancing the quality of life of people by providing the necessities as well as effecting improvement of economic wellbeing. When it comes to social indicators (like Female literacy rate & Empowerment, Education quality, Low conviction rates for crimes against scheduled castes, tribes), there has been seen lot of development in past few years & same is continuously developing under current government new policies & regulations.

  Gujarat and Maharashtra economy are largely supported by industries located in districts near the coastline. The districts away from the coast are agrarian economy.

8. Abbreviations

FY	Financial Year
EEW	Epoxy Equivalent weight
SEAC	State Expert Appraisal Committee
FDI	Foreign Direct Investment
GDP	Growth Domestic Product
BPA	Bisphenol A
ECH	Epichlorohydrin
BADGE	Bisphenol A DiGlycidyl Ether
TGPAP	Triglycidyl para-aminophenol
TGAPP)	triglycidyl of 4-(4-aminophenoxy) phenol
MW	Molecular Weight
CPA	Centi Pascal
EPN	Epoxy phenol/cresol Novolac
LMW	Lower Molecular Weight
NMR	Nuclear Magnetic Resonance
FRP	Fibre-Reinforced Plastic
mPa.s	millipascal second
OSHA	Occupational Safety and Health Administration
THF	Tetrahydrofuran
UF/RO	Ultra-Filtration/Reverse Osmosis
MEE/MVR	Multi Effect Evaporator/ Mechanical Vapor Re-compressor
TSDF	Treatment, Storage, & Disposal Facility
CHWIF	Common Hazardous waste Incineration facility.
CETP	Common Effluent Treatment Plant
NPV	Net Present Value
FOB	Free on board
SPSS	Statistical Package for the Social Sciences,
SIR	Special Investigation Region
SEZ	Special Economic Zone
PCPIRs	Petrochemical Investment Region and manufacturing as well as logistic park
INS	Indian Nava; Ship
VER	Vinyl Ester Resin
NZE	Net Zero Emissions
GW	Diesel Generator
DG	Giga Watt
GW	
PE	Polyethylene
SDS	Sustainable Development Scenario
PP	Polypropylene
PVC	Polyvinyl Chloride
MT	Metric Tonne
FDI	Foreign Direct Investment
FRP	Fiberglass Reinforced Plastics
CAGR	Compound Annual Growth Rate
BPA	Bisphenol A
KTPA	Kilotonne per annum
MTPA	Metrictonne per annum
GCC	Gulf Cooperation Council
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
CCL	Copper Clad laminates

IoT	Internet of Things
KT	Kilotonne
Kg	Kilograms
LCD	Liquid Crystal Displays
2025 F	2025 Forecast
NAOH	Sodium Hydroxide
APAC	Asia Pacific
TRAI	Telecom Regulatory Authority of India
Inc.	Incorporated
EPA	Environmental protection Agency
EW	Equivalent Weight
KW	Kilo watt
Lit/Hr	Litre/Hour
KL/day	Kilolitre/day
ETP	Effluent Treatment Plant
LER	Liquid Epoxy Resin
NPV	Net Present Value
IRR	Internal Rate of Return
UPR	Unsaturated Polyester Resin
IDC	Interest during construction