Growth Opportunities & Emerging Trends in Corrosion Resistant Pipe Market

Lucintel Brief

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Executive Summary

- **Global pipe market was estimated at ~$200 billion in 2013**
  - Steel pipes are the most dominant in the global pipe market. Other dominant pipes are concrete and plastic pipes, especially the PVC pipes
- **In the global pipe industry, corrosion is a serious issue across industries such as oil and gas exploration, oil and gas transmission, industrial and chemical, sewage, marine, water and waste water, etc.**
  - Key piping system applications include chlorine/caustics handling, water lines, vent lines, sludge and slurry lines, brine slurry, floor drains, etc.
  - High cost of corrosion has led to increased usage of corrosion control mechanisms such as protective coatings, corrosion resistant materials, cathodic protection, and corrosion inhibitors
- **Corrosion resistant pipes are gaining traction as a means of corrosion control and mitigation.**
  - Key corrosion resistant pipes include metallic pipes made of stainless steel, carbon steel, nickel and it's alloys, titanium and it's alloys, etc. and non-metallic pipes made of such as fiber reinforced plastics (FRP), polypropylene (PP), fluoropolymers, etc.
  - Titanium and nickel pipes are most suitable in extreme conditions, but there use is limited due to high cost
  - PVC/CPVC, FRP, PP, and other plastics are preferred in medium temperature conditions and offer high cost benefit advantage as compared to titanium and nickel
- **Demand for corrosion resistant pipes is likely to surge in emerging applications such as flue gas desulfurization, hydraulic fracking, mineral extraction, etc.**
- **Increasing usage of FRP pipes, increasing trenchless piping leading to increased usage of multi-layered pipes, and increased usage of titanium, nickel & FRP pipes due to shale gas revolution are the key emerging trends in corrosion resistant pipe market**

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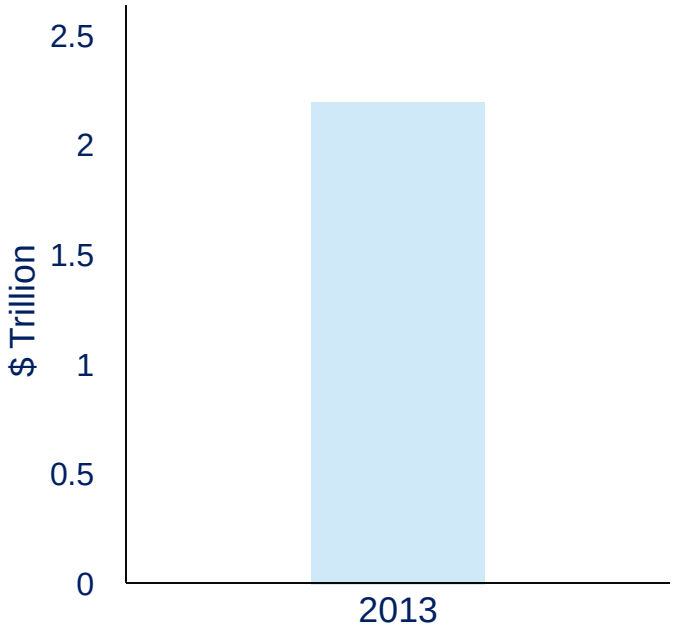
Global Cost of Corrosion Accounts for ~3% of the Global GDP Annually

Annual Global Cost of Corrosion: ~$2.2 Trillion



Source: World Corrosion Organization

Key Insights

- Corrosion is a naturally occurring phenomenon which happens when metal reacts with the environment, such as water or soil.
- Corrosion has been the predominant cause of failure in pipeline
- The annual cost of corrosion worldwide is estimated at $2.2 trillion, more than 3 percent of the world's gross domestic product (GDP)

In Piping Industry, Corrosion is a Big Problem which Decreases the Life of the Infrastructure

Key Types of Corrosion		Insights
	Uniform or General Corrosion	The surface effect produced by most direct chemical attacks (e.g., as by an acid) is a uniform etching of the metal.
	Pitting Corrosion	It's a localized corrosion that occurs at microscopic defects on a metal surface. The pits are often found underneath surface deposits caused by corrosion product accumulation.
	Galvanic Corrosion	An electrochemical action of two dissimilar metals in the presence of an electrolyte and an electron conductive path. It occurs when dissimilar metals are in contact.
	Crevice Corrosion	The corrosion is produced at the region of contact of metals with metals or metals with non-metals.
	Erosion Corrosion	It's a combined process, which is partly the mechanical impact of a moving medium over a metal surface, and partly electrochemical processes
	Environment-induced Cracking	It results from the combined action of mechanical stresses and corrosion. Stress Corrosion Cracking (SCC) falls within this group

Corrosion in Pipes is Caused by a Multitude of Factors Including both the Internal as well as the External Environment

Key Reasons of Corrosion in Pipes

- Type of the Fluid
- Composition of the Fluid (Presence of Pollutants, etc.)
- Temperature: Internal & External
- Pressure: Internal & External
- Velocity of the Fluid
- Degree of Harshness in External Conditions
- Other Environmental Factors such as Pollution, Changes in Temperature, etc.

All the Industries Need Suitable Corrosion Resistant Materials in order to Minimize the Losses & Increase the Life of Infrastructure

Oil & Gas and Retail Fuel

- Crude oil transmission
- Flow lines
- Injection lines
- Marine vessel piping
- Refinery / offshore platform piping
- Sub-sea piping
- Transportation of fuel at retail outlet

Water & Waste Water/Marine

- Cross country transmission
- Irrigation
- Municipal distribution
- Potable water

Sewage

- Sewers
- Storm and surface drainage
- Urban fire-water networks
- Pipe rehabilitation & slip lining
- Irrigation networks

Chemical/ Industrial

- Process piping
- Industrial sewers
- Fire mains
- Brine disposal piping
- Industrial manufacturing applications

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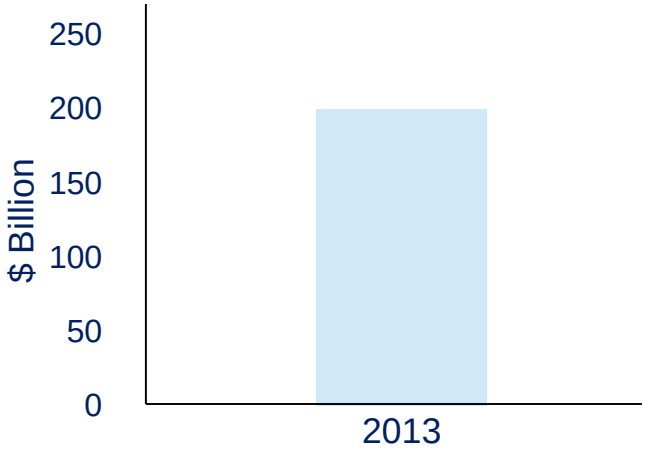
Pipe Market Overview

- Apart from household and municipal pipes, various industrial manufacturing processes use aggressive fluids in the production of the desired end product. Conveyance of these fluids require a proper piping system.
- **Key Requirements in Material Characteristics:** High Corrosion and chemical resistance and thermal stability are the most important characteristics required for materials in piping industry
- **Types of Materials**
  - Metallic piping include materials such as steel, nickel, copper, etc. and non-metallic piping include plastics, FRP, concrete, etc.
  - Steel is the most widely used metal in chemical processing piping applications
- **Key Applications:** Oil & gas, sewage, chemical, retail fuel, water & waste water, etc.

Steel is the Most Dominant Material in the Global Pipe Market

Global Pipe Market 2013: ~$200 Billion



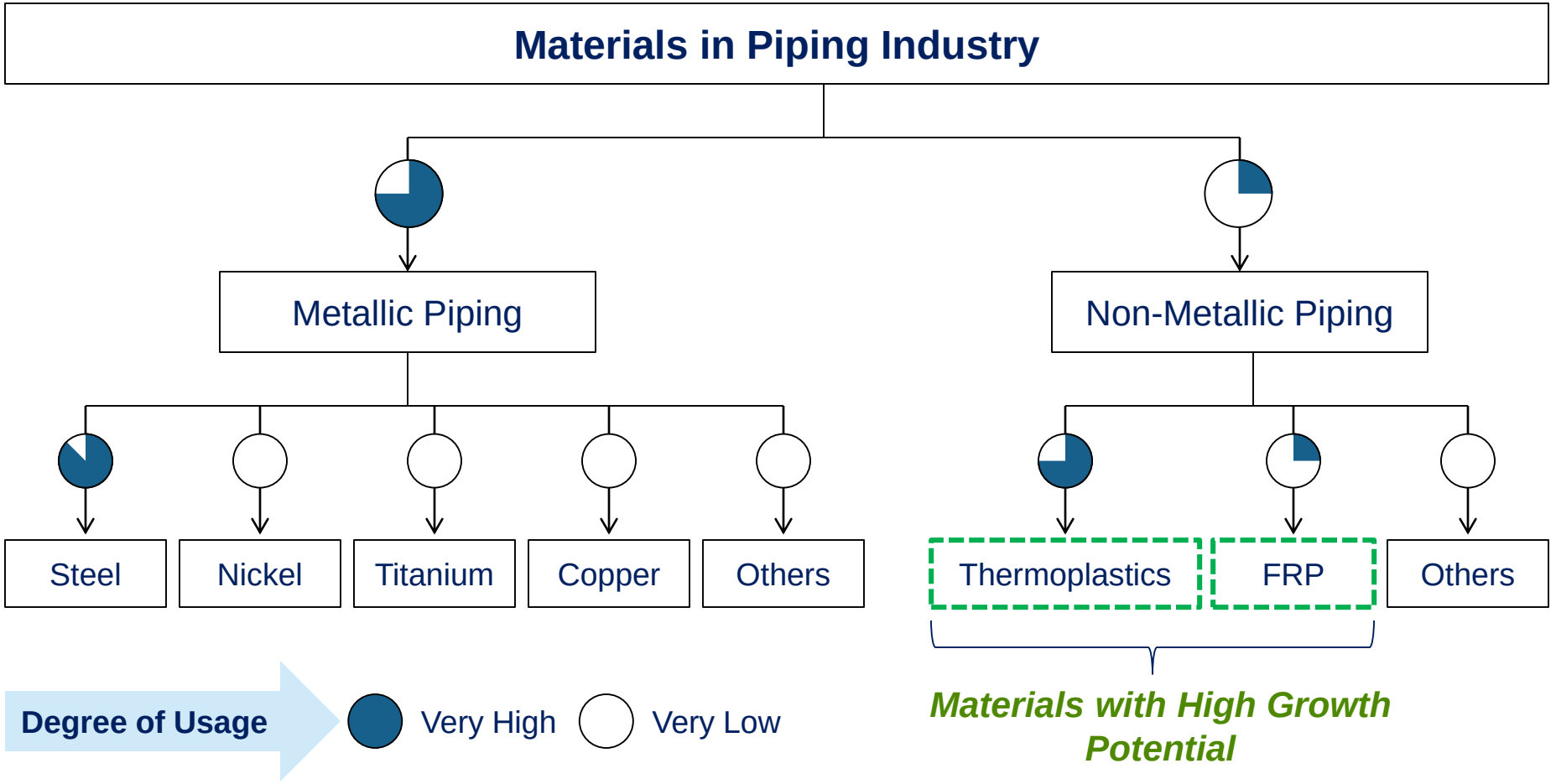
Key Raw Materials in Global Pipe Market

Steel	Concrete	Plastic	FRP	Others
				

Key Insights

- Global pipe market was estimated at ~200 B in 2013
- Global pipe market is mainly driven by growth in applications such as oil and gas, chemicals, sewage, water and wastewater, retail fuel, etc.
- Steel, concrete and plastic (PVC, HDPE etc.) are the most widely used materials in global pipe market.
- Corrosion resistance, chemical resistance, high tensile strength, low maintenance cost, etc. are some of the key success factors for the raw materials in piping industry

Metallic Pipe, Specifically Steel is the Most Dominant Material in Piping Industry



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Corrosion Control Techniques: Corrosion Resistant Material Selection for Pipes is Very Important for Effective Corrosion Management

Protective Coatings

- Protective coatings or layers are applied on the material to avoid the direct contact with the process media which enhances the material life
- The coatings can be paint, linings, metallic linings and sheets and non-metallic linings
- Ex: Fusion-bonded epoxy (FBE) and a three-layer polyolefin (3LPO), fiber glass, epoxy, nickel, zinc, etc.

Corrosion Resistant Materials

- Corrosion resistant materials are increasingly used these days in order to reduce the corrosion rate and increase the service life of the pipes.
- These include both metallic as well as non-metallic materials.
- Metallic materials include stainless steel alloys (304,316), carbon steel, nickel and it's alloys, titanium and it's alloys, fiber reinforced plastics (FRP), polypropelyne (PP), pvc/cpvc, fluoropolymers, dual laminates

Corrosion Control Techniques: Corrosion Resistant Material Selection for Pipes is Very Important for Effective Corrosion Management….. Cont'd

Corrosion Inhibitors

- Corrosion inhibitors are chemical compounds which are added to the flowing medium to reduce the corrosion of pipes
- They protect the surface of metals either by merging with them or by reacting with the impurities in the environment that may cause pollution
- Examples: Hexamine, phenylenediamine, dimethylethanolamine and their derivatives, dibenzylidene acetone, 6-benzylaminopurine etc.

Cathodic and Anodic Protection

- Cathodic protection is a method to reduce corrosion by minimizing the difference in potential between anode and cathode.
- It is achieved by applying current to the pipe. When enough current is applied, the whole structure will be at one potential; thus anode and cathode sites will not exist
- It is normally used jointly with coatings and can be considered as a secondary corrosion control technique
- The two methods of applying cathodic protection include
  - Sacrificial (or galvanic) anode cathodic protection (SACP)
  - Impressed current cathodic protection (ICCP)

Corrosion Resistant Pipes

Key Types of Corrosion Resistant Pipes Used in the Industry

Types of Corrosion Resistant Pipes

Metallic

- Titanium Pipes
- High Ni Alloy Pipes
- Nickel Pipes
- Stainless Steel (316, 304) Pipes
- Carbon Steel Pipes

Non-metallic

- FRP (Fiberglass Reinforced Plastic) Pipes
- PP (Polypropylene) Pipes
- PVC / CPVC (Chlorinated Polyvinyl Chloride) Pipes
- Fluoropolymer (PVDF, FEP, ECTFE) Pipes
- Dual Laminate/Multilayer Pipes

- Preferred material of choice for extreme conditions such as high pressure, high temperature and high corrosiveness.
- High cost is the limiting factor for applicability in easy conditions

- Stainless steel is the most dominant material among corrosion resistant materials
- Low cost of these materials in comparison to nickel and titanium

All the Industries Need Suitable Corrosion Resistant Pipe Systems in order to Minimize the Losses & Increase the Life of Infrastructure

Oil & Gas

Chemical/Industrial

Sewage

Marine/Offshore

Retail Fuel

Water & Waste Water

Others

Dominant Materials

Metallic, majorly Stainless Steel

Non-metallic, majorly Thermoplastic

Key Essential Properties for High Corrosion Resistance of Pipe Systems

Key Property Requirements for Corrosion Resistant Pipes

- Chemical Resistance
- Tensile Strength
- Thermal Stability
- Pressure Resistance
- Durability
- Temperature Resistance

Key Corrosion Resistant Pipes Used in the Industry

Titanium Pipes

- While grades 1, 2, 3, 7, 9, 11 and others are all usable, grade 2 is the one that is employed for most situations
- In situations that require greater corrosion resistance, then the pipe can be fabricated from grades 7, 12, 16, or 26
- Key Applications: High pressure, high temperature applications such as chemical processing, oil & gas, aerospace, power generation

Nickel Pipes

- Nickel has a very high resistance to corrosion. Adding chrome, molybdenum, copper and other elements to the nickel alloys gives them even higher resistance to corrosion
- Few nickel alloys are Nickel 20/200/201/205, Monel K-500, Inconel 600/601, etc. Nickel 200 is normally limited to service at temperatures below 600°F (315°C). For service above 600°F (315°C), Nickel 201 is preferred.
- Key Applications: High pressure, high temperature applications such as chemical processing, oil & gas, marine, food processing, power generation, etc.

Key Corrosion Resistant Pipes Used in the Industry

Steel Pipes

- Carbon and stainless steel is a low-maintenance, oxidation resistant, and doesn't affect other metals it comes in contact with. It is used in a large array of applications, especially in piping and tubing.
- Low carbon (304L) is the recommended alloy and provides increased resistance to intergranular corrosion. The addtion of 2% molybdenum makes 316 considerably more resistant to corrosion and oxidation than the 304 family of alloys. Type 316 is considerably more resistant to solutions of sulfuric acid, chlorides, bromides, iodides and fatty acids at high temperature
- Operating temperature ranges from -20°C to +400 °C

FRP Pipes

- FRP pipe weigh only 25% as much as similar steel pipe and 10% as much as similar concrete product
- It is longer as compared to other materials. Hence eliminates upto 75% of the joints compare to any other materials. It is easy to install due to its light weight
- It has a minimum life of 50 years as compared to 30 years life of steel and iron pipes
- Operating temperature ranges from -30°C to +150 °C

Key Corrosion Resistant Pipes Used in the Industry

Polypropylene Pipes

- Polypropylene (PP) pipes are widely used in industrial processing. PP is suitable for working temperatures up to 90ºC, and withstand short term use at a maximum 110ºC
- PP is resistant to aqueous solutions of acids, alkalis and salts, and to a large number of organic solvents

Fluoropolymers(PVDF, FEP, ECTFE) Pipes

- It has excellent chemical and physical properties, even at low temperatures, and has considerable resistance to abrasion. It is resistant to most of the inorganic acids and bases, and to aliphatic and aromatic hydrocarbons, organic acids, alcohols and halogenated solvents.
- Economical and useful alternative to metallic alloy piping in many applications such as corrosive solvents in chloroalkali plants, pesticides, pharmaceuticals and paper & pulp
- The working temperature from -20°C to +100 °C

Key Corrosion Resistant Pipes Used in the Industry

PVC/CPVC Pipes

- Maximum service temperature upto +90 °C
- CPVC has excellent chemical resistance to wide range of corrosive fluids. It's chemical resistance is almost identical to that of PVC. The additional chlorine in CPVC polymer extends its maximum service temperature from 140°F to 210°F.
- CPVC is used for hot water distribution systems, hot corrosive fluids where PVC cannot be used due to its low strength at higher temperatures.

Dual Laminate Pipes

- Dual laminate bonded pipe is one where the fibreglass reinforced plastic (FRP) has been bonded to the thermoplastic liner to overcome factors of thermal expansion
- Dual-Laminate provides a cost effective alternative for high cost alloys such as hastelloy, nickel, titanium, etc.
- Liner Materials: Polyvinylchloride (PVC), chlorinated polyvinylchloride (CPVC), polypropylene (PP), high density polyethylene (HDPE), polyvinylidene fluoride (PVDF), etc.
- Maximum service temperature upto +100 **°C**

Property Performance Comparison of Various Corrosion Resistant Pipes

Corrosion Resistant Pipes	Cost	Chemical Resistance	Tensile Strength	Thermal Stability	Pressure Resistance	Temperature Resistance	Durability
Carbon Steel	Low						
Stainless Steel	Low						
Titanium	High						
Nickel	High						
FRP	Medium						
PP	Low						
PVC/CPVC	Low						
Fluoropolymers	Medium						
Dual Laminate Pipes	Medium						

Low Medium High

Performance of Different Corrosion Resistance Pipes in Different Flowing Media

Corrosion Resistant Pipes	Maximum Operating Temperature	Corrosion Resistance to Different Flowing Media				
		Water	Hydrochloric Acid	Sulfuric Acid	Phosphoric Acid	Nitric Acid
Carbon Steel	+400 °C	Medium	Low	Low	Low	Low
Stainless Steel	+400 °C	Medium	Low	Low	High	High
Titanium	+600 °C	High	High	Medium	Medium	High
Nickel	+600 °C	High	Medium	High	High	High
FRP	+150 °C	High	High	High	High	High
PP	+90 °C	High	High	High	High	Medium
PVC/CPVC	+90 °C	High	High	High	High	High
Fluoropolymers	+100 °C	High	High	High	High	High
Dual Laminate Pipes	+100 °C	High	High	High	High	High

Low Medium High

Key Companies Present in Corrosion Resistant Pipe Market

Steel Pipes

- Nippon Steel
- Arcelor Mittal
- AMERICAN
- NOV (Ameron)
- FlexSteel
- Europipe
- Evraz Inc NA
- US Steel Corp
- Sumitomo Corp
- Tenaris
- ATI
- Titanium Fabrication Corporation
- SCHULZ
- Ezeflow Group

Titanium Pipes

- ATI
- Titanium Industries
- Titanium Fabrication Corporation
- Sandvik Materials Technology
- Titanium Engineers
- VSMPO-AVISMA
- Ezeflow Group
- Timet

Nickel Pipes

- ATI
- Titanium Fabrication Corporation
- Sandvik Materials Technology
- SCHULZ
- Ezeflow Group
- Timet

FRP Pipes

- Amiantit
- Future Pipe Industry
- NOV Fibre Glass
- Hobas
- Ershings
- Flex Pipe Systems
- Sarplast
- Sekisui
- Farassan
- Hengrun Group
- China Klinfare Group
- AC Plastiques

Key Companies Present in Corrosion Resistant Pipe Market

PVC/CPVC Pipes

- JM Eagle
- Mexichem
- Sekisui
- Formosa Plastics
- Shin-Etsu Chemical
- INEOS
- Pipelife
- Solvay S.A.
- AXIALL Corporation
- North American Pipe Corp.
- Aliaxis
- China Liansu

Fluoro Polymer Pipes

- Aliaxis
- Simon AG
- Arkema
- NIBCO
- Altaflo
- Crist Group
- Adtech
- Saint Gobain
- B & D Plastics

Dual Laminates & Multi-layered Pipes

- Sekisui
- ZCL Dualam
- Enduro Composites
- AC Plastiques
- Vancouver
- Belco Manufacturing
- Plasticon Composites
- Abtrex Industries
- Uponor
- Henco
- Hewing
- Fondital Group
- Simon AG

Polypropylene Pipes

- Advanced Drainage Systems
- Formosa Plastics
- Fondital Group
- Pipelife
- Simon AG
- Tessenderlo
- KWH Pipe
- NIBCO
- Polypipe
- Rehau AG
- Crist Group

Emerging Corrosion Resistant Pipes in Different Industries

	Temperature Resistance	Pressure Resistance	Existing Dominant Types of Pipes	Emerging Materials
 **Oil & Gas**	Medium to High	High	Stainless Steel	FRP, Titanium, Nickel, etc.
 **Water & Waste Water/Marine**	Low to Medium	Medium to High	Stainless Steel	FRP, CPVC, PP, etc.
 **Sewage**	Low	Low to Medium	Concrete, PVC	FRP, CPVC, PP, etc.
 **Chemical/ Industrial**	Medium to High	High	Stainless Steel	FRP, Titanium, Nickel, Fluoropolymers, etc.

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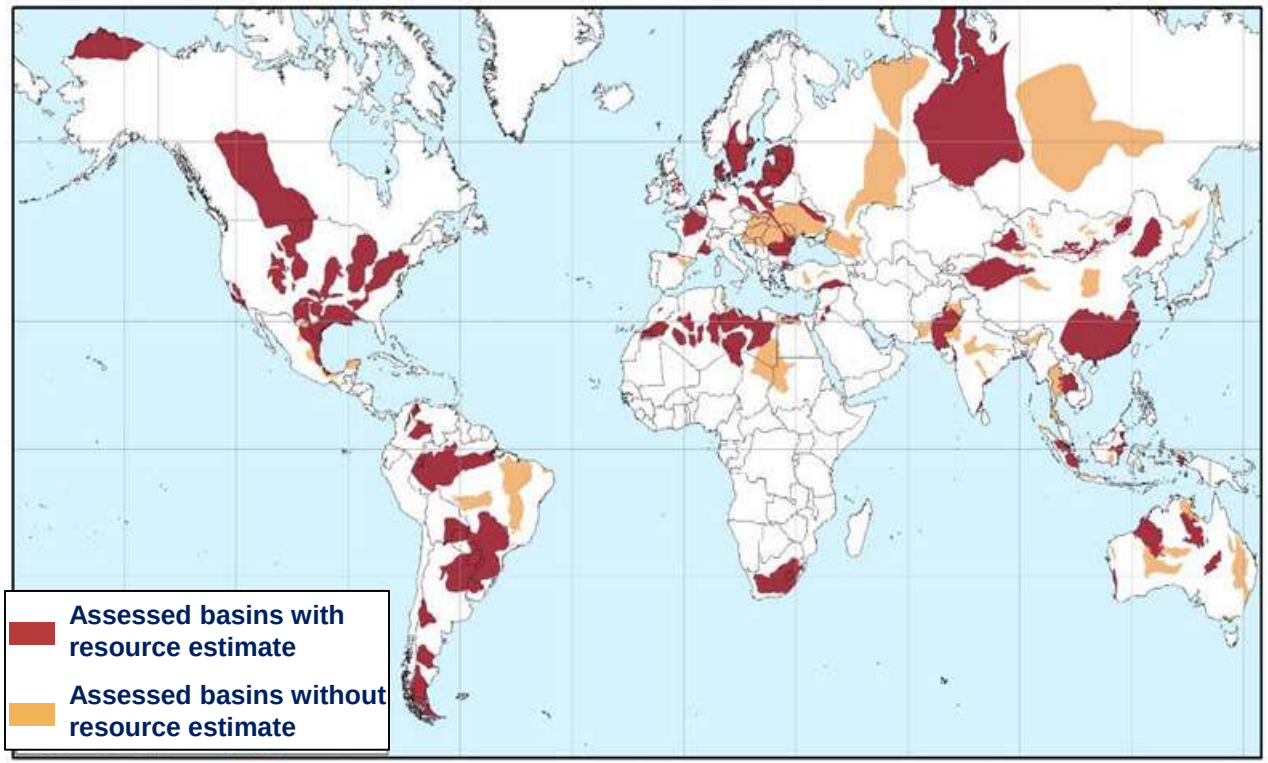
Hydraulic Fracking has Emerged as One of the Biggest Opportunity Areas, which has Lead to the Surge in Demand for Corrosion Resistance Pipes in Shale Oil & Gas Basins

Global Shale Oil & Gas Basins



Source: EIA

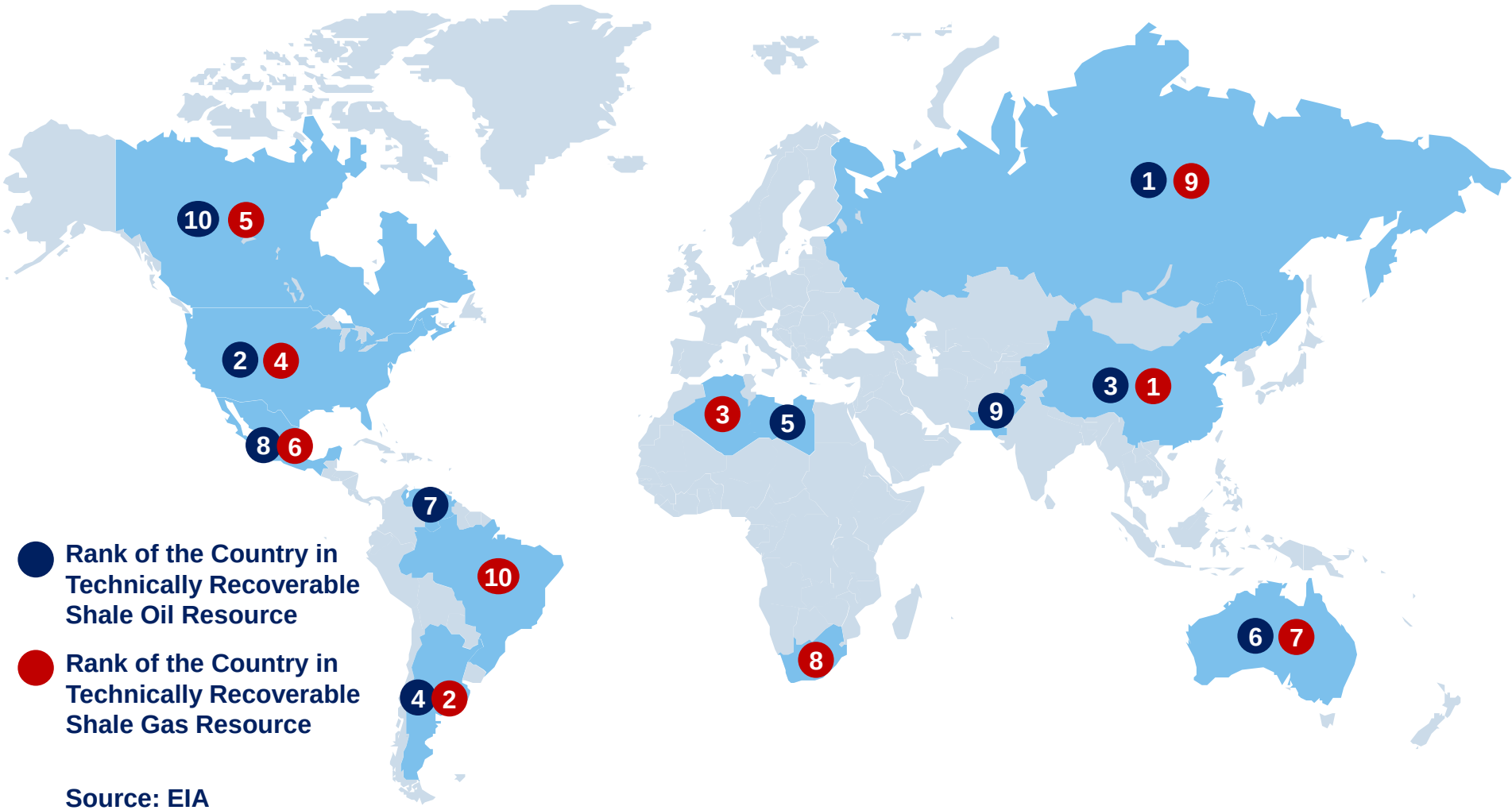
Shale Gas Revolution in US and Oil Sands in Canada

Use of Hydraulic Fracking & Horizontal Drilling

Increase in Use of Hydrochloric Acid & Prevalence of Harsh Conditions

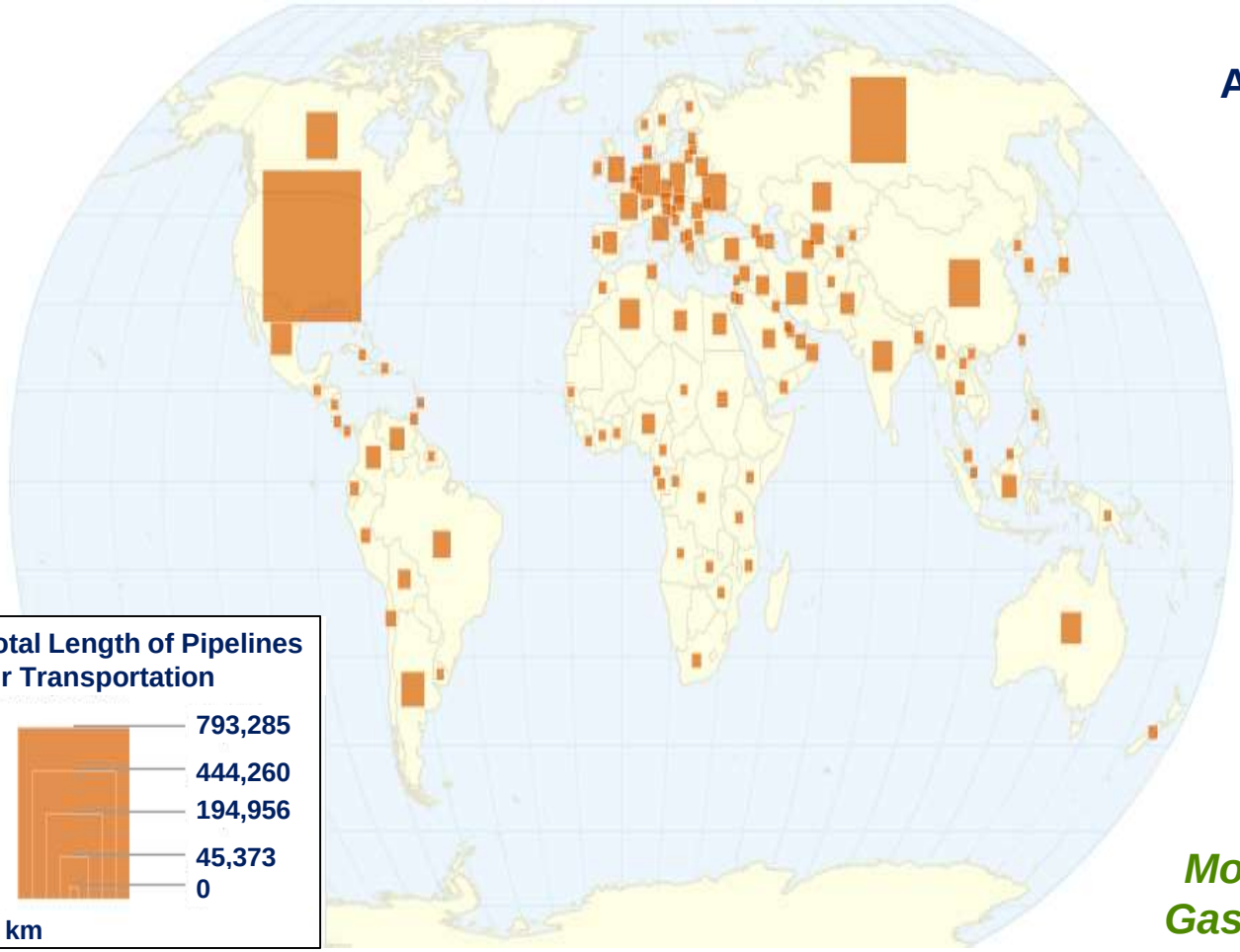
Increasing Demand for Corrosion Resistant Pipes

Global Top 10 Technically Recoverable Shale Oil & Gas Resources



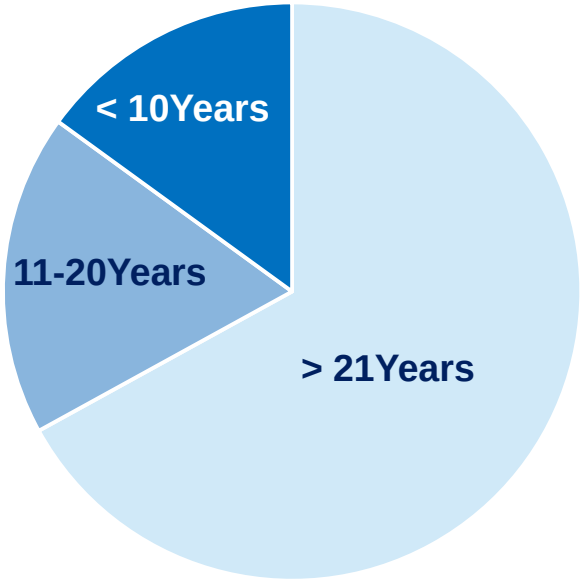
Source: EIA

Ageing Infrastructure in Oil & Gas Pipelines is Likely to Create a Demand for Up-gradation to Corrosion Resistant Pipes Across the Globe



Source: Shawcor

Ageing Pipeline Infrastructure



More than Two-Third's of Oil & Gas Pipelines are > 21 Years Old

Other Emerging High Opportunity Areas for Corrosion Resistant Pipes

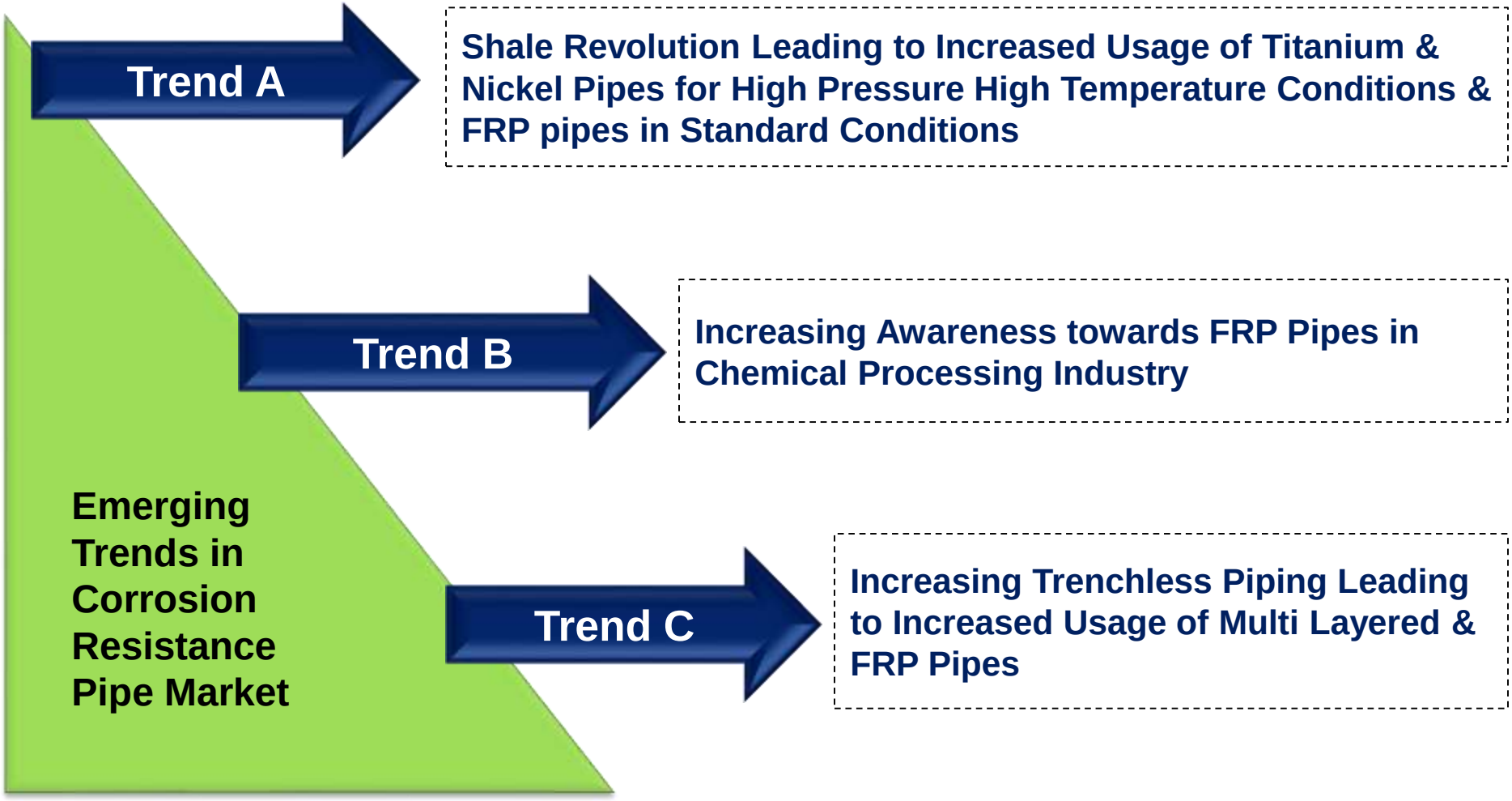
Flue Gas Desulphurization in Electric Power Plants, especially China

- Pollution control for coal furnace for reducing sulfur dioxide (SO2) & nitrogen oxide (NOx)
- Huge investments in flue gas desulfurization systems by coal-fired electric power industries in **China** and emerging industrial nations, such as **India and South Africa**
- China using five times as much of coal as the US

Mineral Processing

- Many minerals, such as copper, nickel and rare-earth elements, are extracted from their ores using strong acids
- **Few examples of mines using corrosion resistant pipes**: Long Harbour project in Newfoundland, Canada; the El Boleo project in Mexico; Ambatovy mine, the world's largest nickel mine in the African island nation of Madagascar

Major Emerging Trends in Corrosion Resistant Pipe Market



Growth Strategies for Corrosion Resistant Pipe Manufacturers

1. Identify Growth Applications based on Synergy

- *Identify new opportunities with good synergy and profitability. Example: Flue gas desulfurization, shale basins, etc.*
- *Identify growing regions such as China & India*

2. Educate the Market

- *Educate the market about cost of corrosion and benefits of corrosion control and management techniques*
- *Educate the market about the benefits of corrosion resistant materials*

3. Strategic Alliances

- *Enter into strategic alliances with inspection & corrosion management service providers*
- *Provide complimentary services such as inspection, material selection and design, etc., which will create long term relation with customers and ensure repair and replacement orders*

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About Lucintel

About Lucintel

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- To provide accurate data, insights, strategy and innovation which empowers companies to make better informed decisions.

History

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- Team of over 120 analysts / consultants - USA / Europe / India

Industry Leadership

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- 15 years of proven global strategic management consulting & market research experience
- Panelists and key note speakers at leading conferences

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- Over 500 published market reports – 65 covering composites industry

Consulting Services:

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Lucintel Ensures Strategic Insights for the Right Market Entry

"*Lucintel has its finger on the pulse of the market and drives deep Strategic Insight*"

- Andy Schmidt, MacQuarie Partners, Managing Partner

- Lucintel has performed hundreds of consulting projects in the area of M & A, market entry strategy, opportunity screening, competitive benchmarking, value chain analysis, unmet needs analysis and others in a variety of markets for last 14 years.

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Construction


Renewable Energy

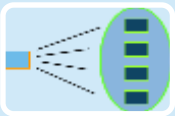

Recreational

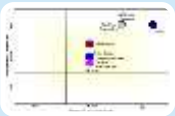

Composite Materials

Consulting


Strategic Growth Consulting

Benchmarking


Opportunity Screening


Partner Search and Evaluation


Due Diligence and M&A


Market Entry Strategy

Thank You