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A Next Generation Material:

PEF is the Future of PET Bottles

PEF is the next generation polyester with superior barrier properties, mechanical as well as chemical properties. It can reduce the carbon footprint and the use of non-renewable energy by approximately 65% and greenhouse gas emissions by approximately 70% as compared to PET.

Bio-based plastics have found its usage in a broad array of applications, and still constitute only about 1% share in the overall plastic production. The bio-based plastic production is expected to rise at an exponential rate in the coming years due to several reasons such as strict government regulation and initiative to use bio-based plastics, increasing environmental and health concern among the consumers, and its performance benefits.

Polyethylene Furanoate (PEF) is 100% bio-based and is derived from plants. It has the ability to replace the most widely-used petroleum-based polyethylene terephthalate (PET) polymer in bottle manufacturing. PEF is the next generation material and does have several performance advantages compared to PET. It has superior gas barrier properties (O_2 barrier is 10 times greater than PET, CO_2 barrier is 4 times greater than PET, and H_2O barrier is 2 times greater than PET), better tensile strength, light weight in nature, and superior thermal stability without heat-setting. PEF is a sustainable alternative as it is 100% bio-based, requires less additives than PET, and has more attractive thermal properties with a higher glass transition temperature of 86°C (Avantium, 2013). The bottle manufacturers do not need a new equipment to replace PET with PEF as it can be processed in the same way and in the same machinery.

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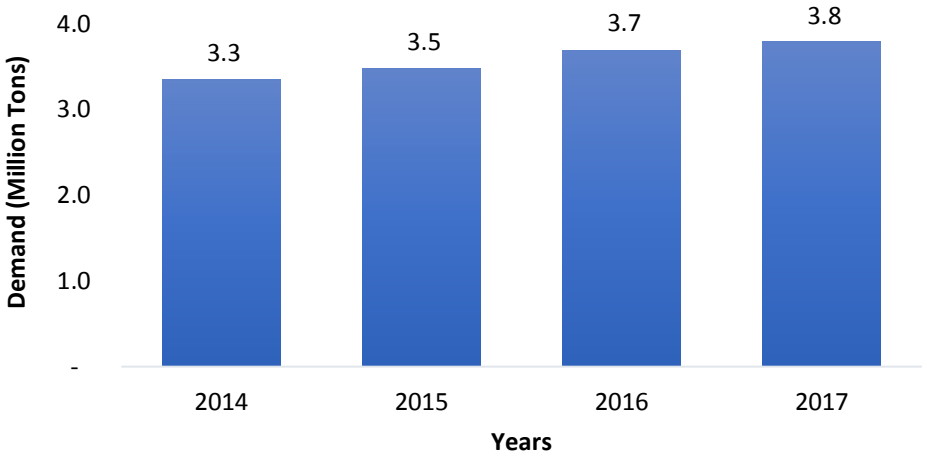
Figure 1: Why PEF can Pose a Challenge to PET?

PEF is the superior alternative as it offers various performance benefits than PET. Due to its low melting temperature, it is easier to handle and higher glass transition temperature makes it better for use. And last but not the least, in large quantities it is even cheaper, when compared to Bio-PET.

Figure 2: Pet Bottles Demand In Europe In Million Tons, 2014–2017



Source: PlasticsEurope

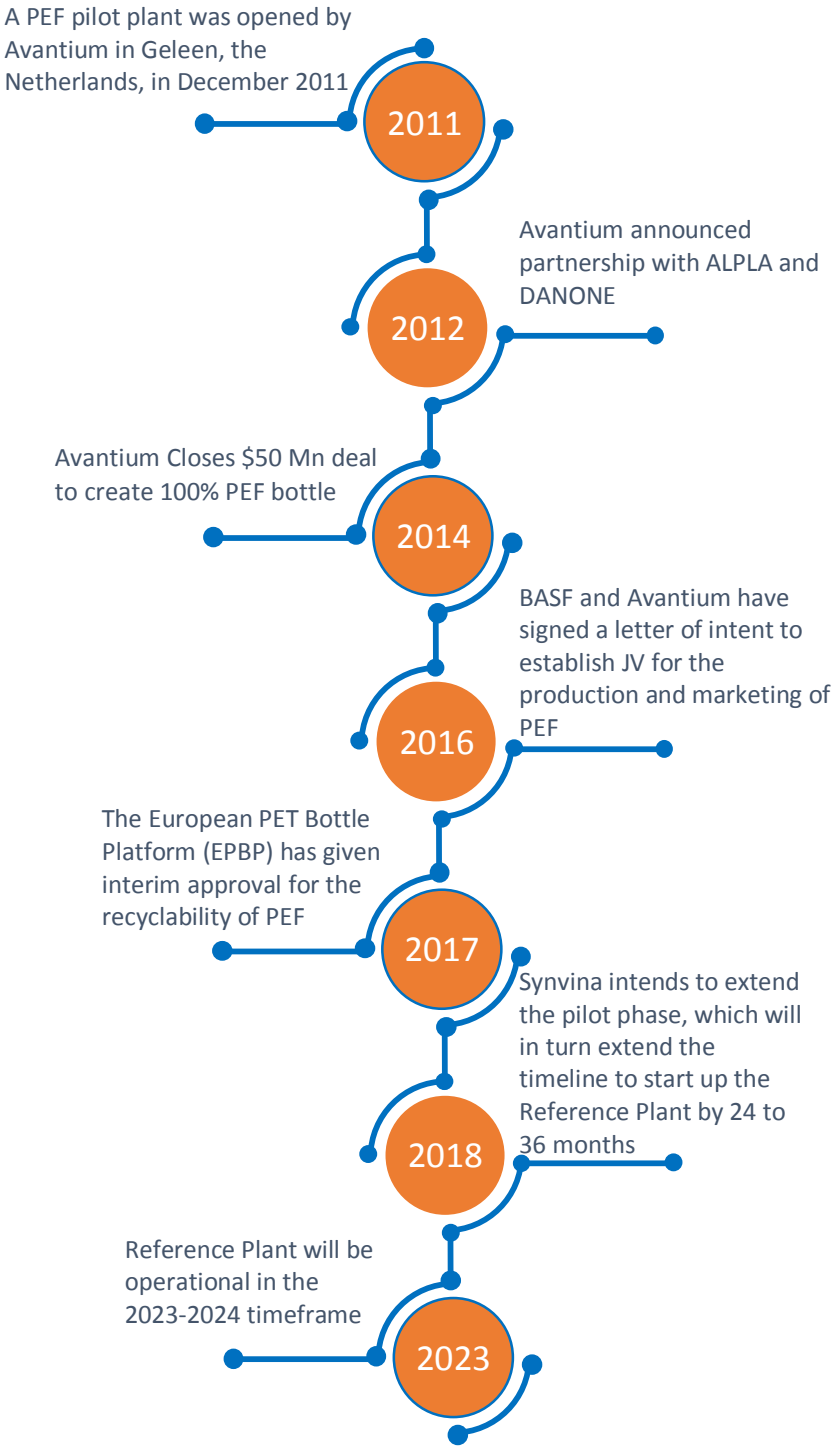
A group of researchers have found that the production of PEF can reduce non-renewable energy use and greenhouse gas emissions by approximately 65% and 70% respectively, as compared to PET. These reductions are higher as compared to other bio-based plastics available in the market such as polylactic acid (PLA) or bioPE. The global annual production of PET bottles is approximately 18 million tons and the substitution by PEF could save 440–520 petajoules (PJ) of non-renewable energy use and reduce greenhouse gases by 20–35 tons of carbon dioxide equivalents.

The above figure depicts the key initiatives taken by Avantium and other industry players for the development and market of PEF bottles. BASF and Avantium have signed a letter of intent to establish a joint venture (JV).

The JV will use the YXY process developed by Avantium in its laboratories and pilot plant in Geleen. Avantium has also collaborated with the Coca-Cola Company, Danone, ALPLA, and Wifag//Polytype to launch the first PEF packaging in the market in 2018. Currently, the concept of PEF bottles is in the commercial launch phase and PEF bottles will be rolled out through the beverage market by 2020.

Across the globe, developed countries are diverting their investments to 100% bio-based PEF, a sustainable alternative of PET. Europe and the U.S. lead the innovation in the field of bio-chemistry. Though PEF is one of the best alternatives of PET, it will take time to replace PET at the global level. Government regulations regarding the use of bio-based materials and involvement by providing subsidies to the manufacturers will help in the replacement of PET bottles. Other factor that is pushing the manufacturers towards the development of PEF bottles, is the growing consumer behavior, as consumers are now more health conscious and concerned about the environment. Hence, 100% bio-based PEF is the future of PET bottles.

Figure 3: Key Developments Related to PEF



Smart Materials:

The Future of Construction

Keywords: Smart Material, Construction, Construction Material, Infrastructure, Self-healing, Corrosion Resistance, Compressive Strength, Smart Concrete, Self-Healing, Smart Cities, Self-Healing Coatings.

Smart materials, also called responsive or intelligent materials, are materials that respond to the environment in a timely manner. These materials are capable of receiving, transmitting, or processing a stimulus and reacting by producing a convenient effect that may include a signal that the materials are acting upon.

Smartness can be used to describe the self-adaptability, self-sensing, memory and multiple functionalities of the materials or structures. These properties offer various applications for these materials and structures in civil infrastructure systems, manufacturing, aerospace, environment, and biomechanics. One or more properties of these materials can be considerably transformed in a controlled manner by an external stimuli such as stress, temperature, and moisture. A smart material comprises built-in sensors, actuators and a control mechanism by which it is capable of detecting a stimulus, reacting to it in a scheduled manner and in a short time and returning to its original state when the stimulus is removed. There are various smart construction materials among which a few are smart concrete, smart glass, and self-healing coatings.

Smart Concrete

Concrete is a critical component of any residential, industrial, or commercial building. Smart concrete is a recent development by Dr. Deborah D.L. Chung from the State University of New York, Buffalo. The unique benefit of smart concrete is that it is stimulated by carbon fibre, which constitutes 0.2% to 0.5% of the volume.

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It is stronger than traditional concrete, and can also be monitored wirelessly for strain, stress, and damage before the concrete structure fails. With smart concrete, there is no need for manual assessment and expensive implanted sensors. The composition of smart concrete can help in detecting areas where damage is likely to occur by using voltage monitors. These monitors allow for timely repairs, and are ultimately safer and more cost effective.

There are various recent developments to create a version of this smart concrete that can selfheal when it comes into contact with water. Smart concrete could be exploited to make concrete reflective to radio waves; and thus, suitable for use in electro-magnetic shielding. A room built with smart concrete would shield everything. In addition, the radio reflective concrete could also be used to lay smart highways to guide self-steering cars, which now follow tracks of buried magnets.

Innovations in Smart Concrete Construction in 2018:

Electronically Conductive	•Electronically conductive concrete can deliver great benefits on roads and other surfaces during times of snow and ice. The Des Moines International Airport is testing two slabs of this heated concrete to see how it improves runway conditions during the winter. •The concrete is managed through a smartphone app, which monitors and captures its performance and quality in various settings. If successful, this type of concrete can be used on roads, bridges, and airports, primarily in cold-weather conditions, to increase safety.
Ultra-High Performance Concrete (UHPC)	•UHPC is a new class of concrete that is extremely strong and durable. It is similar to traditional concrete, but roughly 25% of its composition is composed of a variety pf fibers and mineral/ chemical additives that create a significantly stronger end product. •UHPC has an estimated lifespan of 75--100 years. It also has a compressive strength of 30,000 pounds per square inch (psi), with some mixtures achieving 100,000 psi. Other benefits of UHPC include flexibility, ductility, and extraordinary resistance to salt, moisture, and chemicals
Green Concrete	•Cement production is responsible for approximately 5% of global man-made CO2 emissions. Steps are being taken by many concrete producers during the mix process to make a product that lasts longer and requires less maintenance in order to conserve energy and reduce these emissions. •Net-zero emissions for all new construction will require a rapid scale-up in the deployment of novel cements. Some can achieve emissions reductions of more than 90%. Others can sequester carbon, theoretically capturing more carbon than is emitted in their production, rendering them carbon-negative.

Smart Glass

Smart glass is a new technology that allows glass panels to change their transmission properties based on either light, heat, or voltage. On infusing high amount of light, smart glasses dim themselves and switch from transparent to translucent. Smart glass can be used to substitute static building coverings due to its capability to respond to climate and adjust consequently. It also saves the costs of air-conditioning and heating, and of buying and maintaining outdated curtains and blinds. There are various types of smart glasses available such as clear glass, safety/laminated glass, insulated glass, and tampered glass. Insulated glass accounted for 37% share of the market in 2017, and is projected to grow at a CAGR of 4.15% through 2023. The popularity of insulating glass can be attributed to the combination of two or more panes of glass sealed with air or inert gas within the panes. This helps reflect heat outside and maintain the temperature inside. Insulated glass is constructed of two sheets, making it unbreakable. When these glasses are used in conjunction with Low-Emissivity (Low-E), reflective coatings, they perform even better for conserving energy. Low-E glass, which allows only certain waves to penetrate through the pane of glass, is designed to reflect radiant heat and can be used to reflect heat outside in cold climatic conditions or reflect heat inside in hot climatic conditions.

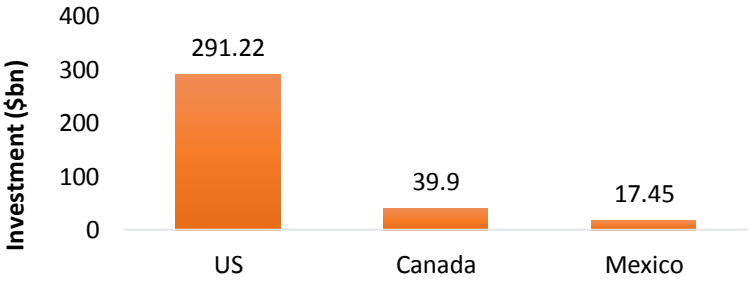
Types of Low-E Insulated Glass

Hard Coat Low-E glass	•Manufactured by pouring a minuet layer of molten tin onto a sheet of glass while the glass remains slightly molten. The tin becomes welded to the glass. This process makes it hard to remove the tin. Frequently, this glass has a blue tint to it.
Soft coat Low-E Glass	•Manufatured by adding several metals such as silver, zinc, or tin glass to glass in a vacuum. The glass enters a vacuum chamber filled with an inert glass which is electrically charged. The electricity combined with the vacuum permits molecules of metal to sputter onto glass. The coating is delicate as compared with hard coat Low-E glass

Self-Healing Coatings

Self-healing coatings are innovative products that are set to significantly influence building structures of all types. These are polymer-based products that can be used directly to a variety of materials, and tend to repair themselves when subjected to light, heat, and water. These coatings create self-healing properties for materials such as metal, ceramic, paint, glass, and even concrete. These coatings can be used to essentially correct damages like scratches, cracks. The application of coatings can potentially save hundreds of thousands in repair and maintenance costs for property owners. Reversible polymers are the most common type of self-healing material. They heal through a process similar to that of a biological organism. The reversible polymers segment leads the self-healing materials market, and is expected to account for 37% of the market share by 2022.

Figure 1 North America Infrastructural Investment, 2017

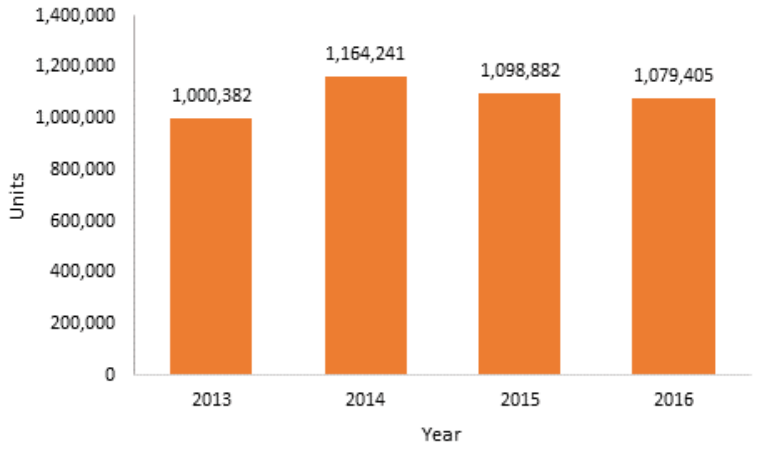


The U.S. Department of Transportation (USDOT) has embarked on the Infrastructure for Rebuilding America (INFRA) program, formerly the FASTLANE Grant Program, which entails10 bridge and highway projects, two transportation logistics projects, three railways infrastructure projects, and three port projects. The Infrastructure segment is expected to remain stable with 3% growth in 2019. In the meantime, new products such as truss and divider board frameworks, portable roll forming, Joist and stud frameworks with extensive solidified openings, embellished individuals, thermally effective studs, and boxed segments are being produced. The increased investment in R&D is propelling the growth of the smart materials market in the U.S. In a latest investment, Soft Bank has invested $1.1 billion on smart windows.

View Dynamic Glass, a Silicon Valley company, has also signed a number of high-profile projects such as the Dallas/Fort Worth International Airport, the San Francisco Levi's Stadium, and various hospitals run by Kaiser Permanente to power the Japanese investor.

According to industrial experts, the U.S. will experience a moderate growth rate with competitive market environments restraining margin upside. Residential construction should grow at a moderate pace driven by low interest rates, and low debt ratios. Inventory shortages will limit the upside. Non-residential construction should continue its gradual recovery, but growth could accelerate supported by the $305 billion in transportation funding and additional state and local government infrastructure investments.

Figure 2 New Building Construction in India, 2013–2016 (Units)



India ranks second in terms of population and is one of the fastest growing economies in the world. With increasing demand for improved living conditions, India has become a hub for the construction industry. India's growing economy coupled with the emerging middle class population continues to contribute to the growth of the construction market. The construction sector accounts for about 8% of the country's GDP. The demand for construction services is expected to rise due to several factors such as massive expansion of the infrastructure sector; rapid industrialization and urbanization; and rise in disposable incomes. The government's efforts to improve residential and transport infrastructure will also support growth. The construction industry will also be supported by the government's 100 Smart Cities Mission.

According to Moody's, the 2019 global construction outlook is stable due to the rising construction and infrastructural development in the U.S. and APAC, mainly due to low interest rates which will fuel infrastructure spending and private investment, boosting sector-wide revenues by around 5%. Rapid urbanization and economic development in regions such as Southeast Asia and sub-Saharan Africa will increase demand for new buildings; and thus, for concrete and cement. With as many as 3 billion people potentially living in slums by 2050, new rapidly deployable housing solutions are needed urgently. Moreover, the infrastructure demands of development and urbanization are not limited to housing. Providing clean water, sanitation and energy services typically relies on concrete, whether for transport infrastructure, wind farms, or hydro-electric dams. In this context, continuing efforts to meet the UN Sustainable Development Goals (SDGs) would trigger $60 trillion in infrastructural investments in developing countries by 2030.

Carbon Fiber:

The Go-To Material for the Aerospace Industry

Keywords: Aerospace and Defense, Carbon fibre, Passenger Jets, Aerospace Components

Global aerospace and defense (A&D) industry is anticipated to grow at a high growth rate in 2019, majorly due to growing commercial aircraft production and increasing defense spending. The industry accounted for 35.2% of the overall carbon material consumption in 2017.

Carbon fiber, due to its lightweight and durability properties, is increasingly being adopted by companies in the aerospace industry. Due to its light weight property, carbon fiber significantly decreases fuel consumption of aircraft. For instance, carbon fiber bearings are used in the Airbus A340's horizontal tail to reduce its weight by 50% and cost by 30%. The U.S. market for carbon fiber is forecast to exhibit a relatively higher CAGR of 7.45% through 2021, driven by the growing A&D industry. Carbon fiber reinforced plastic (CFRP) is primarily utilized in Blackhawk helicopters, body armor, helmets, holsters and many other military applications such as rocket motor casing, satellites, and missiles.

According to Boeing, the utilization of carbon fiber in aircraft reduces the fuel consumption by nearly 20%. The high tensile strength and lightweight nature of this material also allows high utilization in this high standard based industry. Carbon materials constitute almost 50% of the Boeing 787, offering average weight savings of 20%. Owing to its excellent strength to weight ratio, carbon is also used in helicopters to maximize payloads and performance in general.

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Figure 1 Structural Components of 787 Body

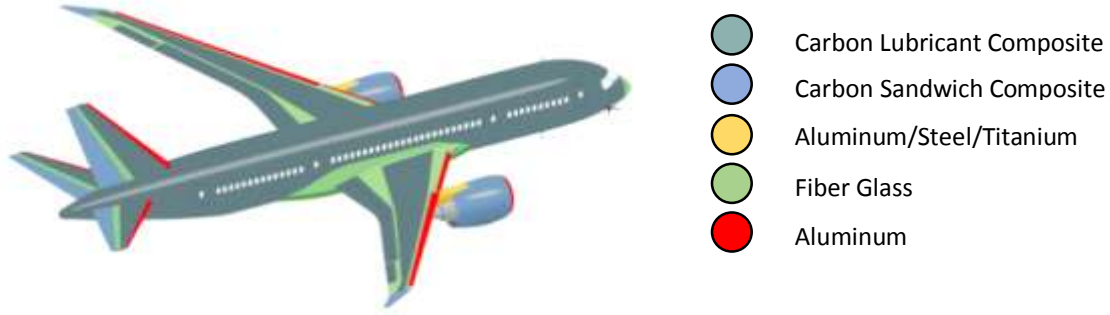
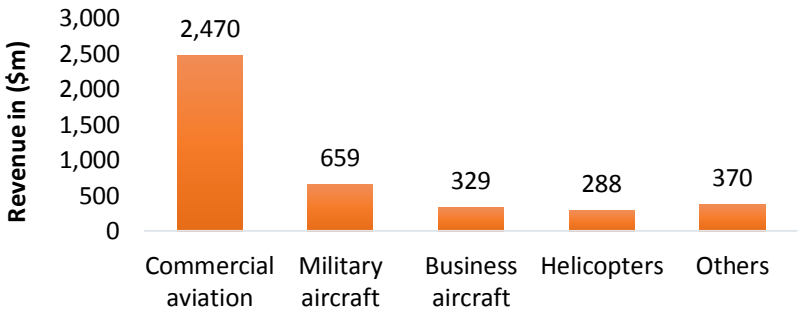


Figure 2 Global Carbon Composite Revenue in the Aerospace and Defense Market in 2017, By Sub-Segment (in $m)

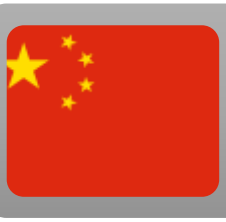


The global revenue generated from carbon composites within the A&D market in 2017 was $659m for military aircraft and $2,470m for commercial aircraft. The global demand for carbon composites is expected to increase in the next few years as these have the potential to replacing aluminum in the aerospace industry. Research is underway to integrate nanotechnology with CFRP manufacturing, which would strengthen these materials more and make them lighter. Some of the planes that use CFRP in primary and secondary structures include Boeing 777, Boeing 787, Airbus A320, and Airbus A380. Furthermore, Airbus, Boeing and Bombardier have been involved in development of carbon fiber wings. CFRPs are also being employed increasingly for efficient satellite communication and higher data transmission by antennas.

A Few Recent Developments in the Industry:

- In early 2018, Toho Tenax launched a high-tensile, highly shock resistant hybrid pre-preg, combining carbon fiber and carbon nanotubes (CNT) technology.
- In mid-2016, Solar Impulse 2 successfully completed its world tour. The zero fuel aircraft use photovoltaic panels to exploit solar energy, and provide necessary drive to the engines. It incorporates nano-carbon fiber reinforced structural components to reduce the overall weight of the body. It has created a huge pressure on the global aerospace industry to create a long-term development strategy for zero-fuel aircraft, which will ultimately drive the carbon material market.
- On the aerospace materials front, in early 2018, the world's largest supplier of carbon fiber, Toray, acquired thermoplastic composites specialist TenCate Advanced Composites for $1.1 billion.

Figure 3 Aerospace and Defense Trends by Major Countries



According to Boeing, China require 7,690 new commercial aircraft valued at $1.2 trillion over the next two decades.

The country is the second largest defense spending nation after the US;

China's 2018 defense budget grew 8.1% Y-O-Y to $175 billion.

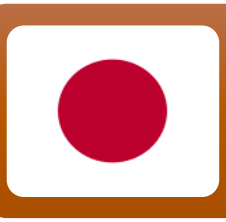
The country's defense expenditure is likely to grow by 10% from 2018 to 2025.

France plans to grow its defense spending by 40% from 2018 to 2025 as it aims to meet the NATO target of 2% of GDP spent on defense by 2025.

The defense ministry is aming to increase defense spending by $2 billion per year between 2019 and 2022 and $3.5 billion every year from 2023 to 2025.

The 2019 defense budget is expected to be nearly $42.2 billion, up 5% Y-O-Y. Military spending in France is likely to grow by 5% each year till 2022.

By 2025, India's aviation industry is expected to be the third largest. Demand can be of more than 2,000 new aircraft in India till 2025, which would be laregly lead by by single aisle aircraft. The 2018–2019 defense budget stood at $43.8 billion, a 7.7% increase compared to the 2017–2018 budget.



Japan's passenger traffic growth from 2018 to 2025 is projected to grow at over 3.2%, below the APAC passenger growth of 5.3%. Japanese airlines are mainly focussing to increase traffic from the high growth APAC region by collaboration with other airlines. Japan's defense budget for 2018–2019 was up by 2.1%, the seventh straight annual increase; though, it is below 1% of GDP.

Passenger traffic in the Middle East is likely to grow at 5.2%, with a demand for 2,990 new aircraft valued $660 billion from 2018 to 2023. In the Middle East, large body aircraft are projected to account for more than 40% of total aircraft demand from 2018 to 2023.

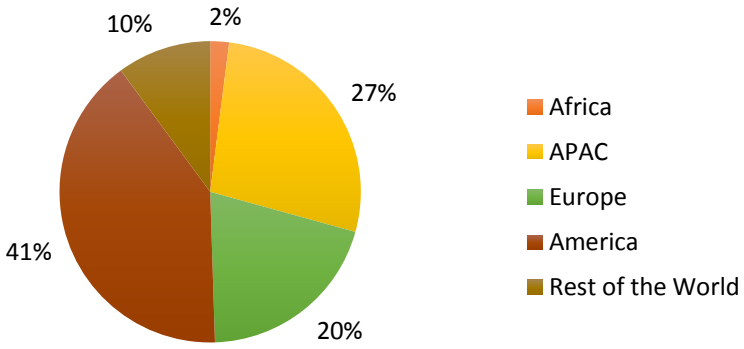
In the Middle East, Oman, Jordan, Saudi Arabia, Israel, Kuwait, Bahrain, and Lebanon have the highest military expenditure as a percentage of GDP.

The U.K.'s defense budget of about $52 billion is around 2% of the GDP. This budget could increase as a recent defense committee report recommended increasing the budget to 3% of GDP to strengthen the country's armed forces.

BREXIT has created uncertainty for the UK A&D industry, and has created disruption in supply chains and new trade barriers as the country could renegotiate trade agreements with the European Union and other major trading nations.

India and China are expected to drive growth in both commercial aerospace and defense sectors. Japan is expected to be a major market primarily for the defense sector. Defense expenditure in France is also likely to expand as the U.S. encourages NATO countries to increase military spending to 2% of GDP. In the Middle East, defense spending is expected to recover as oil prices stabilize at much higher levels compared to the 2015-2017. With respect to the U.K, there is uncertainty around the impact of BREXIT on the country's A&D industry, as a hard application of BREXIT might lead companies to revisit their industrial strategies.

Figure 4 Global Defense Spending by Region, 2017



The U.S., which makes the largest spending in the defense sector compared to other countries, had reduced its defense expenditure by an average of 4% every year from 2012 to 2017, primarily due to sequestration, while Russia and China had increased their defense expenditure at a CAGR of 8% from 2012 to 2017. Decreasing defense spending in the Americas and European regions were largely counterbalanced by the increasing defense expenditures by APAC countries.

The market share of carbon fiber is increasing in the A&D industry, primarily due to the increasing consumption of carbon fiber in commercial aircraft. Growing production of U.S. Boeing 787 and 777 and the Europe Airbus A350XWP is anticipated to boost the market growth. The demand for fuel efficient and long haul aircrafts is the major driving factor for the carbon fiber composite industry. Carbon fiber composites help reduce aircraft weight and enable better fuel economy, thus lowering the operating costs.

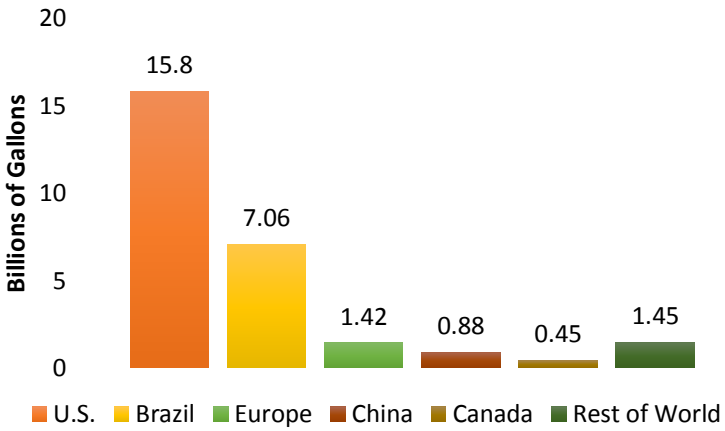
Ethanol: The Biofuel Additive for Gasoline

Ethanol is blended with gasoline to produce a fuel in various blends, which has environmental advantages when compared with gasoline, and can be used in gasoline-powered vehicles. The production method of ethanol is based on the type of feedstock used.

Ethanol or anhydrous ethyl alcohol derived from plant material is known as bio-ethanol. It is used as a blend stock for gasoline such as petrol and alternative source of fuel in many countries. Ethanol molecules contain oxygen, which helps in initializing the complete combustion of the fuel, resulting in low emission, and thereby reducing the environmental pollution.

In the U.S., 70% of gasoline at the pump contains ethanol. Most of the ethanol is sold in a gasoline blend of 10% ethanol and 90% gasoline known as E10 gasoline. Further, ethanol is blended with gasoline in various amounts for use in vehicles such as E15 and E85. The E15 is a low-level blend composed of 15% of ethanol in gasoline, whereas E85 is a high-level blend with 85% of ethanol in gasoline. The E85 in the U.S. is used in small proportions to make gasoline for flexible fuel vehicles.

Global Ethanol Production, By Country or Region, 2017 (Billions of Gallons)



Source: Renewable Fuels Association

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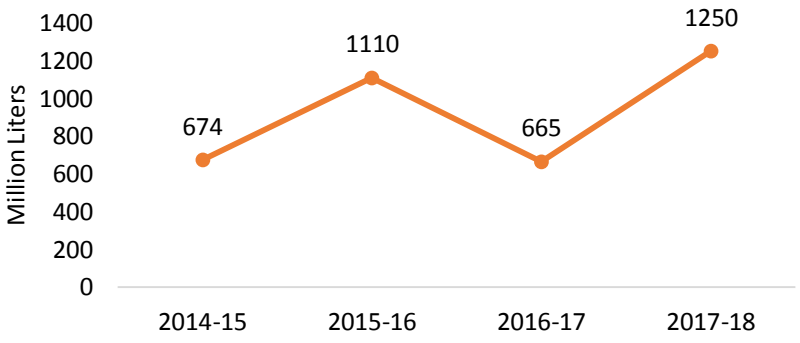
The U.S. Energy Information Administration (EIA) estimates that 142.85 billion gallons of finished motor gasoline was consumed in the U.S. in 2017, which contained about 14.39 billion gallons of fuel ethanol. The fuel ethanol contains a denaturant, which is added to ethanol making it unfit for human consumption. In the U.S., the gasoline contains ethanol composed of ethanol-gasoline blends such as E10, E15, and E85 to meet the requirement of the 1990 Clean Air Act and the Renewable Fuel Standard set forth in the Energy Independence and Security Act of 2007. Further, the U.S. EIA states that fuel ethanol production in the U. S. has reached more than 16 billion gallons per year at the beginning of 2018. Most of the ethanol consumed in the U.S. is corn-based ethanol, which is produced domestically, and about 7% is sugarcane-based ethanol.

In Canada, ethanol is presently made from corn and wheat. The Government of Canada and some provincial governments have supported the development and use of ethanol fuel in R&D programs. As Canada has the forest resources and cropland needed to support the production of ethanol feedstock's, it will contribute to the region's economic growth, mainly to the rural communities and towards the development of substantial ethanol industry.

The two population giants, India and China, extensively need fuel to meet their energy requirements. The rise in population has led to an increase in consumption of many goods and services, from automobile to electronic component, leading to environmental imbalance in terms of pollution. Hence, both the countries are on the lookout for alternative sources of energy to restore the environmental condition back to its original form. In 2003, the Government of India launched Ethanol Blended Petrol (EBP) to promote the use of alternative and environment-friendly fuels. In 2016, the Ministry of Petroleum and Natural Gas, Government of India, permitted oil and marketing companies to sell ethanol blended petrol with the percentage of ethanol up to 10% as per the Bureau of Indian Standards (BIS) specification.

Furthermore, to boost the domestic production of ethanol, the Union Food Ministry, Government of India, has amended the Sugar Control Order, 1966, to allow sugar mills to manufacture ethanol directly from sugarcane juice. These steps will reduce dependency on import, generate employment, facilitate infrastructural investment in rural areas and be the source of additional income for farmers, as well as improve the environmental condition.

Ethanol Supplied Under Ethanol Blended Programme (EBP), India, 2014–2018 (Million Liters)

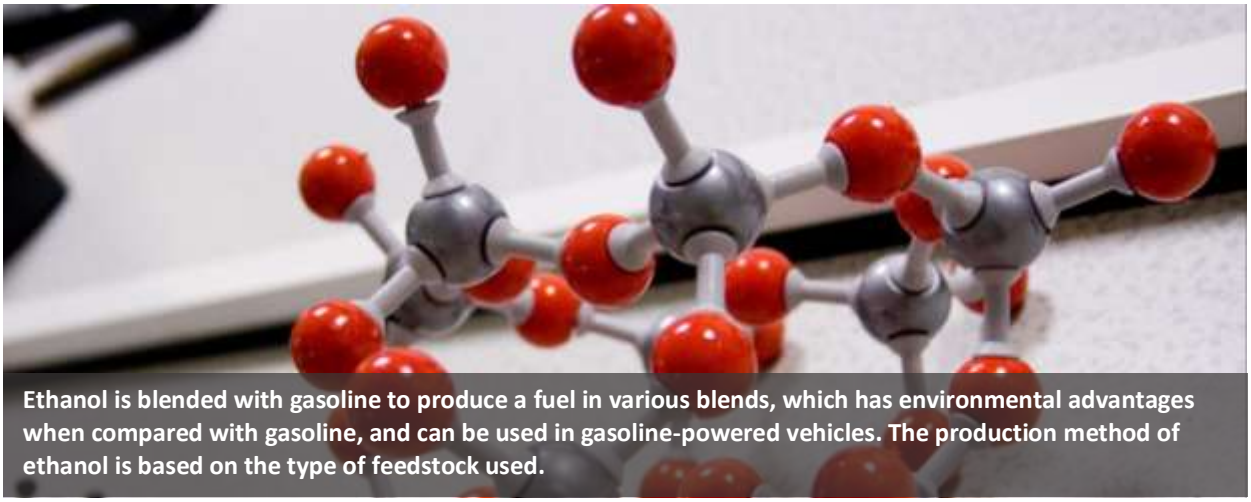


Source: European Union

In 2000, China implemented fuel ethanol programs but switched its course in 2010 due to increased concerns over food for fuel. The grain-based ethanol is banned due to food security concerns. China is looking into second generation biomass and biofuel production, including cellulosic and algae-based biofuels. The restrictions on grain-based ethanol and challenges in producing commercial cellulosic biofuel has resulted in supporting a type of biofuel called "Generation 1.5". The Generation 1.5 biofuel is produced by non-grain based feedstock's, such as sweet sorghum and cassava. These crops can be grown on marginal land and require fewer inputs; however, supply is insufficient for large scale production of ethanol.

Ethanol reduces greenhouse gas emission as the grain used to produce ethanol absorbs carbon dioxide as it grows. Greenhouse gas emission is reduced by 3% to 4% during the production of low blend ethanol from corn. This results in reducing the environmental pollution as countries are seeking alternate source to counter the emission impact through investment in R&D. The U.S. Department of Energy's (DOE) Bioenergy Technologies Office funded a project to assess the potential of High Octane Fuel (HOF) to reduce energy consumption and greenhouse gas emission. The Ministry of Petroleum and Natural Gas, Government of India, has come up with a National Policy on Biofuels in 2018. The policy focuses on biofuels generated from feedstock and on advanced biofuels, such as 2G ethanol and Bio-CNG, drop in fuel, and increase in R&D investments. The Government of Canada in partnership with private firms plans to invest a huge capital in R&D to convert biomass fibers to ethanol using the enzyme technology.

Effective Use of Innovative Polymers in Controlled Release Applications



Ethanol is blended with gasoline to produce a fuel in various blends, which has environmental advantages when compared with gasoline, and can be used in gasoline-powered vehicles. The production method of ethanol is based on the type of feedstock used.

The healthcare sector exhibits tremendous growth as compared to other sectors, with the innovation and technologies of healthcare equipment and machines aiming to reduce life-threatening diseases and curing various ailments in a short period of time. Many companies are developing different kind of chemicals that are less toxic for humans. Likewise in the pharmaceutical industry, the use of innovative polymers for drug delivery has come into existence.

Pharmaceuticals are now adopting innovative polymers such as poly (ethylene glycol), polyesters, polycarbonates, and polypeptides for control release applications. Controlled drug delivery refers to the process of prudently combining an innovative polymer, either natural or synthetic, with a drug or other agents in such a manner that the active agent is released from the material in a planned manner. The release of the active agent can be constant or cyclic over a long period. It can be triggered either by the environment or by any external event.

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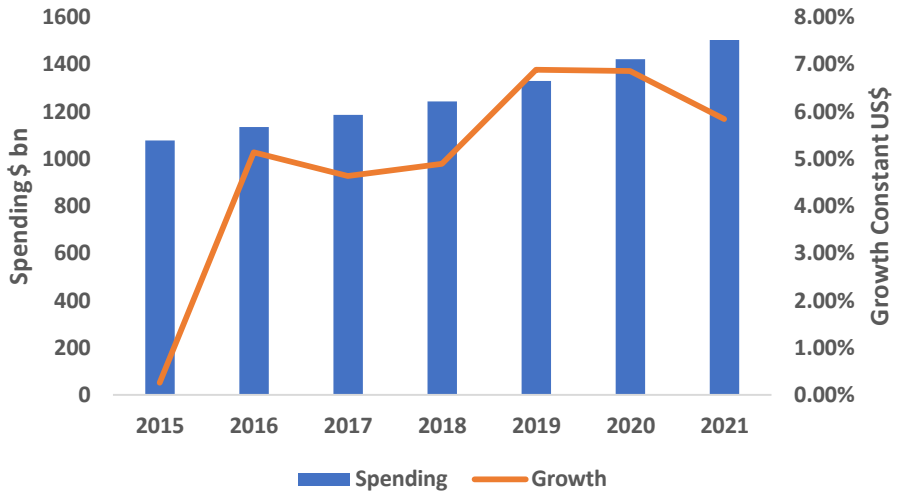
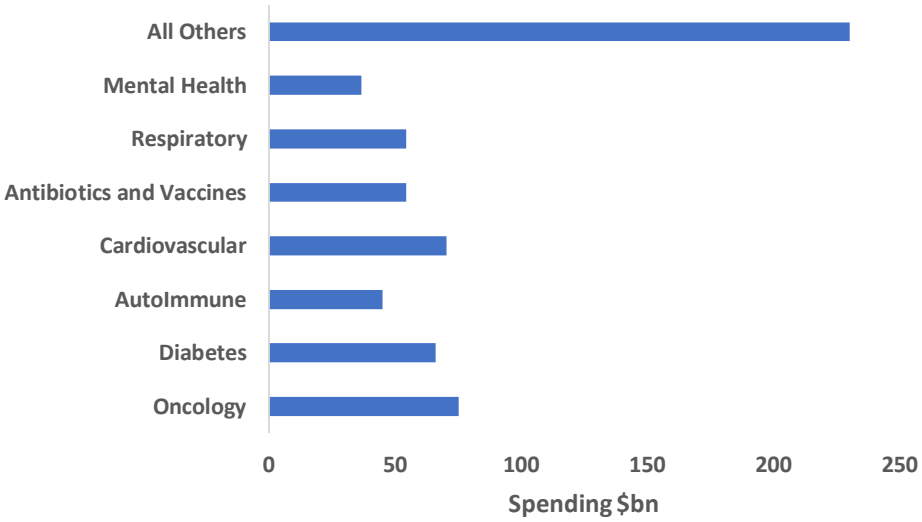
Figure 1: Global Medicine Market Spending and Growth, 2015–2021 ($)



Source: QuitilesIMS Institute

With the advent of new technologies in healthcare industries, the medicine market exhibits tremendous and steady growth. The above graph shows the investment in medicines and drugs as well as the growth rate of the medicine market globally. In 2015, the global spending on medicines was about $1073–$1080 billion with the growth rate of 5% to 5.3%. The new system of drug delivery has revolutionized the healthcare industry, and therapies for oncology, diabetes, cardiovascular, respiratory, antivirals, and others can take place without any hassle using the controlled drug delivery system.

Figure 2: Spending Cost on Leading Therapy Areas, 2016 ($)

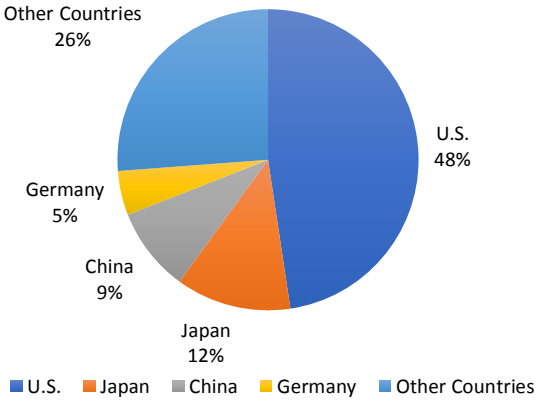


Source: QuitilesIMS Institute

The graph above compares the spending cost on therapies in 2016, which shows the impact of controlled release applications in the healthcare sector. The graph shows effective use of controlled release drug delivery for oncology where there is minimal spending.

Currently, the application of biodegradable innovative polymers are considered for drug delivery applications in therapies. A resorbable polymer might also play the role of a drug depot, to provide long-term supply of drug at constant rate to the blood stream.

Figure 3: Top Countries Ranking By Control Release Applications in Healthcare, 2016 ($)



Source: QuitilesIMS Institute

New technologies in the pharmaceutical industry has resulted in huge growth globally. The U.S. dominates the world of healthcare. New innovations in medicines and upcoming technologies have created a new way to deal with harmful diseases. In an effort to create better and smarter dosage, the control release technology helps in maintaining the desired plasma concentrations for extended periods to meet the therapeutic index. It also helps in avoiding drug toxicity as well as in making patient compliance less burdensome. To control the dosage of the drug, the use of innovative polymers shows much better results, and hence, control release technology is being widely adopted and polymers are the most widely used excipients in this technology. Chemical industries are investing heavily in R&D to bring a new polymer with 0% or less toxicity level so that the healthcare industry can easily adopt these innovative polymers for their control release applications.

Brexit: Impact on U.K.'s Chemical Industry

At the core of every successful economy is a strong chemical manufacturing sector. As an integral part of the economic and social environment, the chemical industry in the U.K., provides products that are critical building blocks for other sectors in the economy.

The U.K.'s chemical industry accounts for 9% of the total goods exports and is an important manufacturing segment. Furthermore, chemical products help in sustaining other manufacturing sectors. The U.K.'s chemical trade is largely entangled with the EU; 61% of the exports in 2017 were to EU member countries, and 74% of the imports are from the EU.

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There is plenty of complexity in the supply chains of various manufacturing sectors. Employment in the U.K.'s chemical industry stands at 88,000 people.

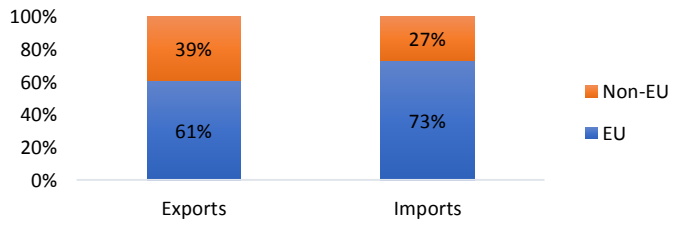
The European and global chemical industry value chains are highly integrated, of which, U.K.'s industrial customers and suppliers are a part. The complex supply chains often cross borders on many occasions both inside the EU and across the external EU border. Chemicals in the form of integrated in (intermediate) products made with chemicals (e.g. car parts) or final chemical products may cross the U.K. and EU27 borders several times. A major challenge that the U.K. chemical industry is facing is Brexit. However, CAPEX plans will be impacted more than the production levels. The industry as a whole, for 2018, remained relatively buoyant. Plans for large scale new CAPEX have slowed since 2017, with more focus now being placed on R&D and improvement to preserve the U.K.'s competitive edge in chemical production.

A lot of uncertainty still prevails about the future trade and investment relations between the U.K. and the EU-27. Whatever form it takes, it might fall short of the current singular market, with significant consequences for the chemical businesses and its employees. Even the most advanced Free Trade Agreement (FTA) falls short of the conditions prevailing in a single market.

Chemicals Manufacturing Industry, U.K., 2017		
		% of U.K.
Economic Contribution	$16.88 billion	0.7%
Employment	88,000	0.3%
Businesses	2,735	0.1%
Exports	$39.89 billion	8.8%
Imports	$43.35 billion	6.5%

Industrial clusters are also concerned about the cost that companies will bear for having to comply with two regulatory structures or systems, should the U.K. no longer be part of REACH after Brexit. The Chief Executive of the Chemicals Industry Association explained that a no deal scenario where registrations are no longer recognized under REACH would "seriously bring into question 10 years of investment". REACH is the main EU legislation for the regulation of chemicals in the EU (formally the Registration, Evaluation, Authorization and Restriction of Chemicals Regulation, No 1907/2006). There is also a specific EU legislation for certain types of chemicals (such as biocides and cosmetics) and for the labeling and packaging of chemicals.

Figure: TRADE IN CHEMICAL PRODUCTS, U.K., 2017(%)



In conclusion, Brexit uncertainty could have severe consequences for businesses in general. A slowing economy may impact the demand directly. It might also impact the government spending and investment into new plants; companies may restructure or relocate. With changes to the U.K.'s access to the single market, contracts may have to be restructured. Restrictions on the movement of goods will impact provider/supplier relationships, bringing the production and trade to a halt.

Increasing Uptake of Renewable Energy

The global energy demand rose by 2.1% in 2017, which is more than twice that of 2016, because of the strong global economic growth. Approximately 70% of the global energy demand was met by conventional fuels in the same year, resulting in increase in carbon dioxide emissions.

The renewable energy sector has experienced remarkable growth over the past decade. The production and usage of clean energy has grown exponentially across the globe. Most of the installed renewable energy capacity now comes from the developing and emerging countries. The policy makers are focusing on generating surplus energy to meet the demands through uptake of modern energy technologies.

The increased adoption of renewable energy would act as a catalyst for developing countries to topple the developed countries in terms of clean energy production.

Generating electricity and heat from renewable energy also helps diversify national energy mixes and reduces the dependency on energy imports, which in turn increases a country's security of energy supply. The establishment of renewable energy corridors helps in stimulating the economy, and generating employment, especially in rural areas.

The year 2017 recorded substantial investments in new renewable energy, characterized by the largest ever increase in renewable power capacity and advances in enabling technologies. Several renewable energy sources such as hydropower, bioenergy, and geothermal power and heat have long been established as mainstream and cost-competitive sources of energy.

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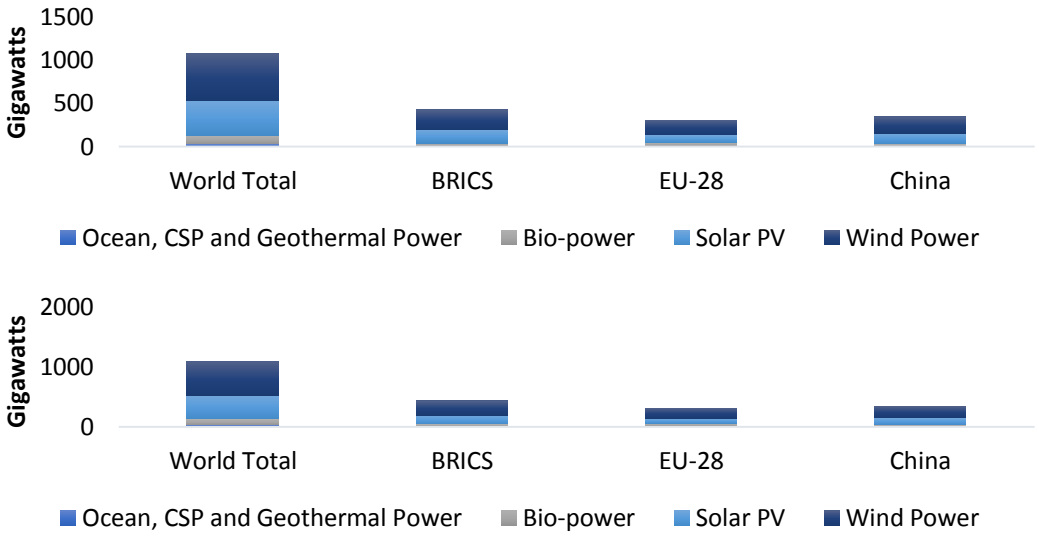
Renewable Power Capacities in the World, EU-28 and Top 6 Countries, 2017



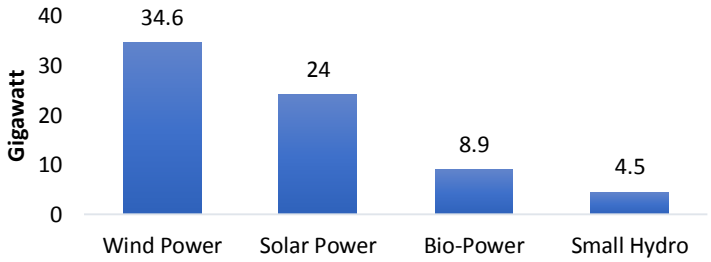
Source: REN21

The power sector led the results with 9% growth in overall generating capacity, out of which 55%came from new solar. The other energy-consuming sectors such as heating, cooling, and transportation saw marginal gains in clean energy uptake. Renewable energy represents on 20% of the final energy demand. Heating and cooling accounts for half of the total global energy consumption, whereas transport accounts for almost one-third. According to Renewable Energy Policy Network for 21 Century (REN21), the penetration of renewable energy was just 3.1% in transport in 2017 and 10.3% in heating.

According to the International Energy Agency, the demand for electricity across the world will increase by 70% by 2040. It will be driven by the emerging economies such as India, China, and certain countries in the African, Middle East, and South East regions. The international community is backing the usage of renewable energy through the Paris Accord signed at the World Climate Summit in 2015. The agreement will come into force in 2020, and under this agreement, the signatory countries have pledged to reduce their emissions. The overall investment in renewable energy reached $279.8 billion in 2017 compared to $274 billion in 2016. According to REN21, developing and emerging economies grew their investment by 20% to $177 billion compared to developed countries whose investment fell by 19%, adding up to $103 billion.

The maximum investment in the developing and emerging category was led by China. China accounted for a record 45% of global investment in 2017. According to India Brand Equity Foundation, the electricity consumption in India is projected to reach 15,280 Terawatt hours (TWh) in 2040. The renewable sector in India has become quite attractive and is expected to attract up to $80 billion in investments in the next four years.

Installed Capacity for Different Renewable Energy System (RES) in India, 2018 (GW)



Source: India Brand Equity Foundation

In March 2019, The World Bank has approved $185m credit to add 310 Megawatt renewable energy generation capacity in Bangladesh. The investment will increase the installed capacity of renewables by piloting and expanding investments in key market segments.

According to the International Renewable Energy Agency (IREA), the OECD Americas region saw investment rise from $40 billion in 2013 to $52 billion in 2015 and remained strong in 2016 at $51 billion because of the solar PV and wind markets. The Western Europe market also saw high investment in 2015 with $73 billion but fell to $53 billion in 2016 because of falling investment in the U.K. The partnerships and various project announcements by governing bodies can have important impacts on the renewable energy sector. Sustainability Mobility for All (SuM4ALL), a new strategic global alliance of 50 organizations and agencies, was formed in 2017. It aims to implement the Sustainable Development Goals (SDGs) set by the United Nations in the transport sector, and reduce the sector's environmental footprint to combat climate change and pollution. Also, the European Commission, R20, and the Global Covenant of Mayors have entered into a joint venture to support sub-national authorities in Africa in identifying, structuring, and developing bankable low-carbon and climate-resilient infrastructure projects. Renewable energy programs are continuously gaining ground globally and many developing countries in Africa and Asia are focusing on harnessing renewable energy to meet the rising demand for energy.

Surfactants role in Enhanced Oil Recovery (EOR)

As the discovery of new oil fields has become difficult with the passing time, multiple companies have made it their holy grail to reach the maximum recovery along with parallel maintenance of economic oil rate. In this regard, Enhanced oil recovery (EOR) methods based on polymer flooding, surfactant-polymer flooding, and alkali-surfactant-polymer flooding are well established.

Chemical methods for EOR involve injecting fluid into oil reservoirs to mobilize crude oil trapped in porous rocks. Generally, the displacing fluid is a water solution containing various additives. Typically, the displacing fluid mixture contains a water soluble polymer alone or in combination with a surfactant. The role of surfactant in EOR is to improve the mobility ratio of the oil by using the displacing fluid and increasing the capillary number.

Basically, the mobility ratio is defined as the mobility of displacing fluid (surfactant enhanced water) divided by the mobility of the displaced fluid.

$$M = \frac{\kappa_{rw}}{\mu_w} \frac{\mu_o}{\kappa_{ro}}$$

Where, κrw and μw are the relative permeability and phase viscosity respectively. It is quite evident by the above equation that it is better to take mobility ratio < 1. Then, the efficiency of the displacing fluid will not be higher than the displaced fluid and pure crude oil can be extracted from the rig.

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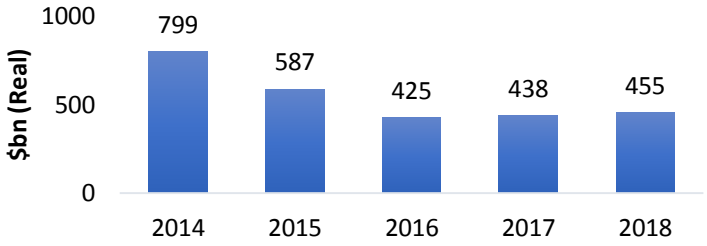
With global demand steadily rising, supply - side response is crucial. The recovery from the historic drop-off in upstream oil investments by 25 percent in both 2015 and 2016 has hardly begun. Upstream oil investment was stagnant in 2017, however, 2018 saw a modest increase. The rise in upstream oil investments has a positive impact on surfactants. With the depletion of oil reserves, the need for deeper and horizontal drilling in challenging terrains is increasing. This is expected to influence the market players to undertake EOR techniques, leading to increased surfactant demand.

From 2014 to 2016, a drastic fall in spending can be observed in oil and gas globally due to the lack of technologies as well as reduction in establishment of new oilfields. Earlier surfactant technique was less effective on rock formations with short permeability. Modern day advancement in R&D and surfactant product expertise have lowered chemical concentrations which in turn has reduced the quantity of surfactant required for EOR.

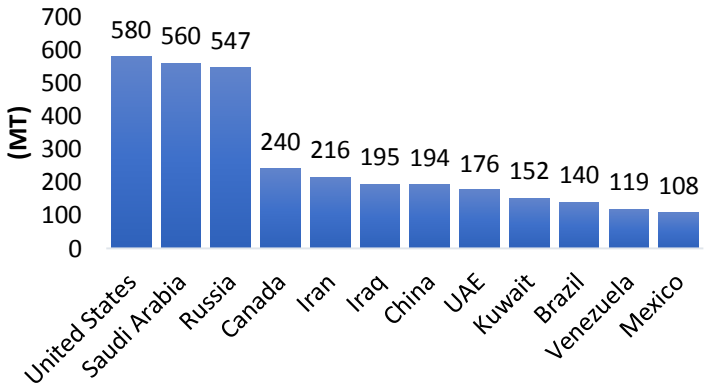
Figure 1: Global Oil and Gas Upstream Capital Spending, 2014–2018 ($Bn)



Source: - International Energy Agency

In 2018, the highest production of crude oil was seen in the United States due to the discovery of new oilfields in certain regions and increased production from New Mexico Permian Basin has brought the U.S. on top in oil production sector. This is because the OPEC society is now focusing more on non-oil production regions which has high economic growth.

Figure 2: Global Crude Oil Production, 2018 (MT)



Source: - Global Energy Statistical Yearbook 2018

EOR techniques contribute highly to the sustainable oil production sector. It also helps to ensure the long-term energy demands globally are met. Surfactant injection is a promising technique, which is executed on large scale and it also demonstrated remarkable success when a proper and thorough evaluation was conducted while producing crude oil.

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