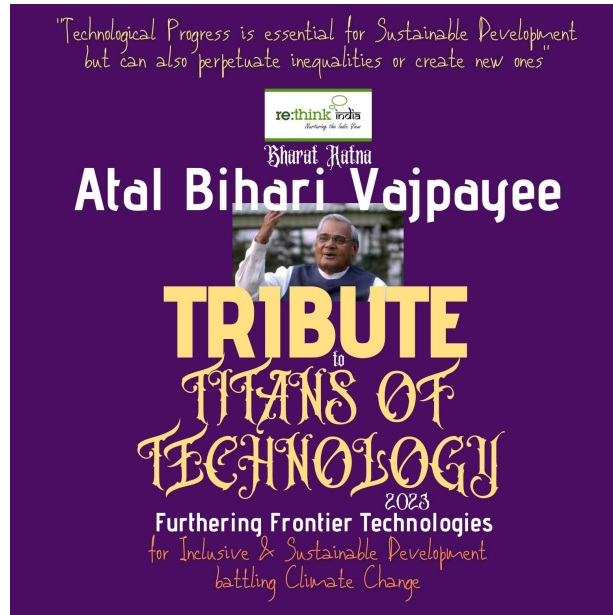


Atal Bihari Vajpayee Tribute to Titans of Technology 2023



You might be an Institution of any Genre from being a Pre-School to a K-12 School to a Skills Training Institute to a Higher Education Institution of any denomination, a Research Organization, Central Government Agency, State Government Agency, District Administrative Unit, Central Public Sector Enterprise, State Public Sector Enterprise, Indian Corporate, Small Scale Enterprise, Medium Scale Enterprise, Micro Scale Enterprise, Start-Up etc.

You might be engaging with one or the other Frontier Technologies at one or the other Stages of Engagement -

Utilitarian **USAGE** | Adroit **Adoption** | Appropriate **Adaptation** | All Round **Awareness** | Skills **Training** | Futuristic **Research** | Contextual **Innovation** | Sovereign **Development** | Strategic **Deployment** | Full Market **Offering**.

Do Entail the same in elaborate detail and win the Title of Being a **Titan of Technology 2023** in the name of India's Most Enigmatic of Leaders Bharat Ratna Atal Bihari Vajpayee Ji

*Frontier Technology(ies) to be Nominated For **

Artificial Intelligence	<input type="checkbox"/>
Internet of Things	<input type="checkbox"/>
Big Data	<input type="checkbox"/>
Block Chain	<input type="checkbox"/>

You may choose one or more of the Frontier Technology(ies) with which you engage at various stage(s)...You would have to present your Nomination Note for each of them separately....

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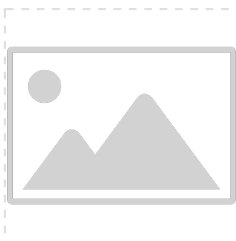
Nominee Category *

- Pre-School
- School
- Skill Training Institution
- Higher Education Institution
- Research Organization :: Private
- Research Organization :: Public Sector
- Central Government Agency
- State Government Agency
- District Administrative Unit
- Central Public Sector Enterprise
- State Public Sector Enterprise
- Indian Corporate
- Medium Enterprise
- Small Enterprise
- Micro Enterprise
- Start-Up
- Other

Check the Category You Belong To. ABV Tribute to Titans of Technology would be given away in respective Categories.

Institutional/Organizational Details

Upload Institutional/Organizational Logo



sample.png

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

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Physical Address for Communication *

Street Address

Address Line 2

City

State/Region/Province

Postal / Zip Code

Country

Official Website *

Facebook Page (If Any)

Twitter Handle (If Any)

LinkedIn Profile (If Any)

YouTube Channel (If Any)

Concerned Person

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Name *

First

Last

Designation *

Email ID *

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AI is normally defined as the capability of a machine to engage in cognitive activities typically performed by the human brain. AI implementations that focus on narrow tasks are widely available today, used for example, in recommending what to buy next online, for virtual assistants in smartphones, and for spotting spam or detecting credit card fraud. New implementations of AI are based on machine learning and harness big data.

The United States and China have traditionally driven research on AI. During the period of 2000-2021, 438,619 AI-related publications were issued. Of these, nearly half were published in three countries: the United States (90,202), China (81,857) and the United Kingdom (29,011). The top three affiliations were the Chinese Academy of Sciences (4,831/China), the Centre National de la Recherche Scientifique (3,295/France), and Carnegie Mellon University (2,887/United States). During this same time period (2000- 2021), 214,365 AI-related patents were granted, the three top assignee nationalities being China (70,847), the US (41,911), and the Republic of Korea (16,135). The top three current patent owners in 2021 were Samsung Group (3,066/Republic of Korea), Ping An Insurance Group (3,013/China), and LG Corp (3,240/Republic of Korea).

American and Chinese companies lead AI service provision. The top AI service providers commonly referred to include Alphabet, including their affiliates, Google and DeepMind, Amazon, Apple, IBM, Microsoft, Alibaba, and Tencent. The top AI service users measured by spending on AI are the retail, banking, and discrete manufacturing sectors. Prices of AI depend on applications and their requirements, but overall the trend is for increasing affordability.⁹ Developing AI-based tools takes increasingly fewer resources: between 2018 and 2022, the cost to train systems decreased by 64 per cent, while training times improved by 94 per cent. For instance, a basic video/speech analysis AI platform is estimated to cost \$36,000-\$56,000, an intelligent recommendation engine might cost \$20,000-\$35,000 and an AI-driven art generator might cost \$19,000-\$34,000.

The market for AI (\$65 billion in 2020) is growing rapidly. Private investment increased 103 per cent in 2021 compared to 2020 (from \$46 billion to \$96.5 billion). Supply-side market growth is driven by factors including growth in big data allowing for increased learning, improved productivity, distributed application areas, greater availability of government funding, and advances in image and voice recognition technologies. However, a shortage of AI technology experts represents a significant restraint on supply. Demand-side growth is primarily driven by the increasing adoption of cloud-based applications and services and solutions that use AI to increase efficiency. Commonly cited challenges that might limit the expansion of the AI market include cybersecurity, regulatory compliance, privacy concerns, and equity and fairness.

The AI labour market is thriving. One study using detailed data on online job vacancies found that demand for AI skills has risen sharply in the United States across industries and occupations. The number of positions seeking AI skills increased tenfold between 2010 and 2019, and four times as a proportion of all job postings. The highest demand for AI skills was in IT occupations, followed by architecture and engineering, scientific, and management occupations.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Stage of *ENGAGEMENT* with the Frontier Technology of Artificial Intelligence *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of Artificial Intelligence

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of Artificial Intelligence

PEOPLE ASSOCIATED with the Frontier Technology of Artificial Intelligence

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of Artificial Intelligence

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **Artificial Intelligence**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier Technology of **Artificial Intelligence**

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

IoT refers to myriad Internet-enabled physical devices that are collecting and sharing data. There is a vast number of potential applications. Typical fields include wearable devices, smart homes, healthcare, smart cities and industrial automation.

China and the United States also lead research on IoT. Between 2000 and 2021, 139,805 IoT-related publications were issued, led by China (28,461), India (21,188) and the United States (17,318). The three leading affiliations were the Chinese Academy of Sciences (1,420/China), Beijing University of Posts and Telecommunications (1,415/China) and the Chinese Ministry of Education (1,085/China). During the same period, 147,906 patents were assigned, with three top nationalities of recipients being China (100,958), the Republic of Korea (17,374), and the United States (13,406). The three current leading owners in 2021 were Samsung Group (9,035/Republic of Korea), Qualcomm (2,477/United States), and State Grid Corporation of China (1,552/China).

American companies are major IoT service providers. The top IoT service providers (IoT platformers) commonly referred to include Accenture, TCS, IBM, EY, Capgemini, HCL and Cognizant.¹⁶ The top sectors deploying IoT solutions include the manufacturing, home, health, and finance sectors.¹⁷ The price of an IoT system depends on the type of application, but costs are only decreasing: the average cost of an IoT sensor has dropped from \$ 1.40 in 2004 to \$ 0.38 in 2020.¹⁸ Currently, for instance, ECG monitors range between \$ 3,000 and \$ 4,000; environmental monitoring systems are priced from \$ 10,000, energy management systems cost \$ 27,000 and up, and building and home automation starts from \$ 50,000.

The IoT market is already large and is expanding at a fast pace: McKinsey estimates that it will enable \$ 5.5 trillion to \$ 12.6 trillion in value globally by 2030, up from \$ 1.6 trillion in 2020.²⁰ Supply-side growth is driven in particular by advances in semiconductor technology which enable the development of lower-cost, lightweight, and more efficient devices.²¹ On the demand side, growth is mainly driven by rising demand for advanced consumer electronics in growing economies, increasing adoption of smart devices and internet-enabled devices, the rise of tele-healthcare services, and the emergence of automation technology in various sectors. However, cybersecurity risks and privacy concerns could negatively affect market growth here as well.

The growth of the IoT market has led to skills shortages. According to one study, the number of online job advertisements that included "IoT" increased by 32 percent between July 2021 and April 2022.²⁴ In 2021, LinkedIn data suggests there were over 13,000 IoT-related job openings in the United States alone.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Stage of *ENGAGEMENT* with the Frontier Technology of Internet of Things *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of Internet of Things

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of Internet of Things

PEOPLE ASSOCIATED with the Frontier Technology of Internet of Things

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of Internet of Things

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **Internet of Things**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier Technology of **Internet of Things**

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Big data refers to datasets whose size or type is beyond the ability of traditional database structures to capture, manage and process. Computers can thus tap into data that has traditionally been inaccessible or unusable.

China and the United States are the front-runners of big data R&D. During the period spanning 2000- 2021, there were 119,555 publications related to big data with three top countries being China (39,484), the United States (23,821) and India (8,970). The three leading affiliations were the Chinese Academy of Sciences (2,339/China), Ministry of Education China (1,186/China) and Tsinghua University (1,149/China). Within the same period, there were 72,184 patents with top nationality of assignees being China (62,605), the Republic of Korea (5,302) and the United States (2,031). The top three current owners were State Grid Corp. of China (1,534/China), Ping An Insurance Group (1,189/China) and Baidu Inc. (468/China).

American companies lead the big data market. The leading providers of big-data-as-a-service measured in terms of revenue include Amazon, Microsoft, IBM, Google, Oracle, SAP and HP.²⁶ Top users of big data measured by spending on big data service are banking, discrete manufacturing, and professional services. The cost of a big data system varies depending on the objective. For example, the average cost of building a data warehouse with cloud storage has been estimated at \$359,951 per year, while the average cost of building one with on-premises storage is pegged at \$372,279 per year.

The big data market is already expanding quickly, particularly in developed economies, and will continue to add economic value as its uptake across industries drives impressive efficiency improvements. Supply-side growth is driven by factors including growing Internet user coverage, increasing adoption of cloud services and solutions, and continual major growth in data production. However, the lack of skilled workers represents a concurrent constraint to supply. Growth in demand is driven by an increasing awareness of the efficiency-related benefits and novel solutions that big data approaches can yield, particularly in finance, but also in other industries from electricity generation to as they use them for risk management, demand modelling, customer service, and real-time analytics.³² However, lack of awareness of the benefits of big data as well as privacy and security concerns continue to somewhat dampen market growth.

The big data industry has driven a boom in demand for data scientists. According to Glassdoor data, job openings for data scientists have increased by 480 per cent since 2016 and 650 per cent since 2012. In the United States, the Bureau of Labor Statistics predicts a growth rate of 36 per cent between 2021 and 2031. Globally, the job market for data scientists and analysts will number in the tens of millions.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Stage of *ENGAGEMENT* with the Frontier Technology of Big Data *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of Big Data

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of Big Data

PEOPLE ASSOCIATED with the Frontier Technology of Big Data

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of Big Data

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **Big Data**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier
Technology of **Big Data**

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

A blockchain refers to an immutable time-stamped series of data records supervised by a cluster of computers not owned by any single entity. Blockchain serves as the base technology for cryptocurrencies, enabling peer-to-peer transactions that are open, secure and fast.

As with most of these technologies, China and the United States lead research efforts into blockchain technology. During the 2000-2021 period, there were 27,964 publications related to blockchain, led by China (7,014), the United States (3,906), and India (3,069). The top three affiliations were Beijing University of Posts and Telecommunications (413/China), the Chinese Academy of Sciences (402/China) and the Chinese Ministry of Education (271/China). During this same period, 63,767 patents were granted, the top three assignee nationalities being China (29,088), the United States (10,591), and the Cayman Islands (5,408). The top current owners were Advanced New Technology Co. Ltd. (3,540/Cayman Islands), Alibaba Group Holdings (3,256/Cayman Islands) and Ant Group Co. Ltd. (2209/China).

Top providers of blockchain (blockchain-as-a-service providers) service include Alibaba (China), Amazon, IBM, Microsoft, Oracle (all United States) and SAP (Germany). American companies are thus the leading blockchain service providers. The top users of blockchain by industry, measured by spending on blockchain service, were banking, process manufacturing, and discrete manufacturing. Blockchain is a feature-dependent technology, so the final price depends on the specific project requirements. The development cost of an NFT marketplace is estimated between \$50,000 to \$130,000, that of a Decentralized Autonomous Organization (DAO) is between \$3,500 to \$20,000, while a cryptocurrency exchange app costs between \$50,000 to \$100,000.

The blockchain market has grown particularly rapidly in the past decade and projections suggest this will only accelerate, forecasting that the business value generated by blockchain will reach \$176 billion by 2025 and \$3.1 trillion by 2030.³⁹ On the supply side, the application fields of blockchain have expanded to include various financial transactions (online payments and credit and debit card payments) as well as IoT, health and supply chain management.⁴⁰ However, challenges relating to scalability and security, regulatory uncertainty, and difficulties with integrating the technology within existing applications act as potential market constraints. Demand-side growth is primarily driven by growth in online transactions, currency digitization, secure online payment gateways, and growing interest from the banking, financial services and insurance sector alongside businesses' increasing acceptance of cryptocurrencies as a means of payment.

The blockchain job market is growing rapidly. Global demand for blockchain developers is estimated to have increased by between 300 and 500 percent in 2021, driven by hiring from the five biggest blockchain employers: Deloitte, IBM, Accenture, Cisco, and Collins Aerospace.⁴² Blockchain developers continue to be well remunerated, with median annual incomes of \$136,000 in the US, \$87,500 in Asia, and \$73,300 in Europe.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Stage of *ENGAGEMENT* with the Frontier Technology of Blockchain *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of Blockchain

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of Blockchain

PEOPLE ASSOCIATED with the Frontier Technology of Blockchain

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of Blockchain

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **Blockchain**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier Technology of **Blockchain**

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

3D printing, also known as additive manufacturing, produces three-dimensional objects based on a digital file. 3D printing can create complex objects using less material than traditional manufacturing.

The story with 3D printing is similar, with the United States and China driving research. During the period 2000-2021 period, 36,367 publications related to 3D printing were made available, led by the United States (8,896), China (7,515), and the United Kingdom (2,586). The top affiliations were the Chinese Ministry of Education (631/China), the Chinese Academy of Sciences (571/China), and Nanyang Technological University (491/Singapore). Within the same period, there 70,799 new patents were assigned, with assignees' nationalities dominated by China (42,691), the United States (9,069), and Germany (4,705). The top patent owners in 2022 were Hewlett-Packard (1,632/United States), Xi'an Jiaotong University (563/China) and Beijing University of Technology (559/China).

The largest 3D printing companies include Stratasys, 3D Systems, Materialise NV, EOS GmbH and General Electric.⁵⁴ Top users by sector, measured by spending on 3D printing technology, were discrete manufacturing, healthcare and education.⁵⁵ The cost of 3D printing has dropped markedly in the recent years and are expected to continue to do so. Currently, an entry-level 3D printer can cost as low as \$ 100, while an industrial 3D printer starts at \$ 10,000.

The 3D printing market has been growing at a fast pace. Globally, it was valued at \$ 12 billion in 2020, expected to rise to \$ 51 billion by 2030. Supply-side growth is mainly driven by increasing variety in the materials that can be 3D printed (major shift from plastic to metal), increases in the production speed, increases in the size of printable objects, reduction of errors, decreases in development costs and time, the ability to build customized products, and government spending on 3D printing projects.⁵⁹ However, the still relatively high cost of 3D printing when compared to many products' traditional methods of production, combined with the scarcity of skilled labourers, may hamper the market growth. This has however not prevented demand-side growth, driven by an increase in applications in healthcare, consumer electronics, automotive, dental, food, fashion, and jewelry.

The 3D printing industry's demand for labour is increasing as its rapidly growing market requires more skilled professionals. It is estimated that the industry will create 1.7-2.8 million new jobs in 3D-printing-enabled manufacturing in the United States, and between 3 and 5 million new skilled jobs in total. Auxiliary jobs are also increasingly sought after, with the industry needing engineers, software developers, material scientists, and a wide range of business support functions including sales, marketing and other specialists.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Stage of *ENGAGEMENT* with the Frontier Technology of 3D Printing*

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of 3D Printing

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of 3D Printing

PEOPLE ASSOCIATED with the Frontier Technology of 3D Printing

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of 3D Printing

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **3D Printing**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier Technology of **3D Printing**

Robots are programmable machines that can carry out actions and interact with the environment via sensors and actuators either autonomously or semi-autonomously. They can take many forms: disaster response robots, consumer robots, industrial robots, military/security robots and autonomous vehicles.

Robotics research is led by the United States. Among the 276,027 publications related to robotics published in 2000-2021, the United States (69,909), China (38,494) and Japan (20,527) led the way. Top affiliations were the Chinese Academy of Sciences (3,676/China), Harbin Institute of Technology (2,568/China) and Carnegie Mellon University (2,484/United States). During the same period, 122,940 patents were granted, with most assignees coming from the United States (48,164), followed by China (27,502) and Germany (5,205). The top three patent owners as of 2022 are Johnson & Johnson (3,438/United States), Intuitive Surgical Inc. (3,383/United States) and Medtronic Inc. (1,834/United States).

Manufacturers from a diverse collection of countries are dominate robotics sales and production. The four largest industrial robotics manufacturers are ABB (Switzerland), Fanuc (Japan), KUKA (Germany) and Yaskawa (Japan), while the largest autonomous vehicle manufacturers include Alphabet/Waymo (United States), Aptiv (Ireland), GM (United States), and Tesla (United States).⁶² The top industry spenders on robotics were discrete manufacturing, process manufacturing and resource industries.⁶³ There are many types of robots and price depends on the type.

As the costs of production in robotics have decreased (e.g., through increasing production in lower-cost regions, lower R&D costs, and economies of scale) prices have followed: there has been a more than 50% drop in average robotics costs since 1990.⁶⁴ This increased affordability, combined with greater volumes of production, is in turn driving a democratising increase in market size.

The current estimate of job growth in robotics is modest in comparison to some of these other technologies, in part because in many economies it is already further developed than they are. In the United States, for instance, there were 167,100 active robotics engineers in 2022 with the robotics engineer job market is expected to grow by between 1 and 5 percent between 2020 and 2030. Robotics careers include robotics engineers, software developers, technicians, sales engineers, and operators.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Stage of *ENGAGEMENT* with the Frontier Technology of Robotics *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of Robotics

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of Robotics

PEOPLE ASSOCIATED with the Frontier Technology of Robotics

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of Robotics

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **Robotics**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier Technology of **Robotics**

A drone, also known as an unmanned aerial vehicle (UAV) or unmanned aircraft system (UAS), is a flying robot that can be remotely controlled or fly autonomously using software with sensors and GPS. Drones have often been used for military purposes, but they also have civilian uses such as in videography, agriculture and in delivery services.

The United States and Canada drive research into drone technology. During the period of 2000-2021, the biggest contributing countries to the 23,526 publications on drone technology were the United States (5,047), China (3,028), and the United Kingdom (1,411). The top affiliations were the Centre National de la Recherche Scientifique (CNRS) (220/France), the Chinese Academy of Sciences (220/China) and Beihang University (151/China). During the same period, there were 48,613 patents assigned worldwide, dominated by China (22,209), the United States (7,791), and the Republic of Korea (6,318). The top three current owners of patents in 2022 were SZ DJI Technology Co. Ltd. (1,705/China), Qualcomm (891/United States) and LG Corp. (704/Republic of Korea).

American manufacturers are dominant in the military drone space while the commercial drone space is more diverse, though Chinese companies play an outsized role. Companies commonly referred to as top manufacturers of commercial drones are 3D Robotics (United States), DJI Innovations (China), Parrot (France), and Yuneec (China), while military drone makers include Boeing (United States), Lockheed Martin (United States), and Northrop Grumman Corporation (United States).⁶⁷ Top industries measured by spending on drone technology were the utility, construction, and discrete manufacturing sectors.⁶⁸ The price of commercial (non-amateur) drones begins at \$2000 per unit, while military drones range in price from \$800,000 to \$400 million per unit.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

The commercial drone market, which has already experienced significant growth, is set to continue expanding. In the US market alone, the industry grew from around \$40 million in 2012 to around \$1 billion in 2017 and is expected to have an annual impact of \$31 to \$46 billion on the country's GDP.⁷⁰ The industry with the largest potential market for commercial applications of drone technology is infrastructure, with an estimated addressable market value of \$45.2 billion.⁷¹ Digitization and technological improvement in cameras, drone specifications, mapping software, multidimensional mapping, and sensory applications are driving growth. However, health and safety, privacy and national security regulations are expected to negatively affect the market while satellite imagery, though expensive, represents a competing industry that might impede market growth, particularly as satellite services do not share the same regulatory issues. On the demand side, increasing demand for GIS, LiDAR, and mapping services from sectors including agriculture, energy, tourism, construction, mapping and surveying, and emergency services are contributing to growth.

As the drone industry grows, so does its job market. In Australia, drones are expected to support 5,500 full-time job equivalents on average per annum between 2020-2040.⁷³ In 2020, a year marked by economic uncertainty and job losses, drone companies reversed the trend, increasing their labour force by an average of 15%.

Stage of ENGAGEMENT with the Frontier Technology of Drones *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of Drones

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of **Drones**

PEOPLE ASSOCIATED with the Frontier Technology of **Drones**

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of **Drones**

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **Drones**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier Technology of **Drones**

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Gene editing, also known as genome editing, is a genetic engineering tool to insert, delete or modify genomes in organisms. Potential applications include drought-tolerant crops or new antibiotics.

Gene editing research is, as is the trend, led by the United States and China. In 2000-2021, publications related to gene editing numbered 24,802, led by the United States (9,881), China (5,106), and the United Kingdom (2,099). The top affiliations were the Chinese Academy of Sciences (994/China), Harvard Medical School (696/United States), and the Chinese Ministry of Education (573/China). Within the same period, 13,970 patents were granted, with the most assignees coming from the United States (6,482), followed by China (3,834) and Switzerland (673). The three current owners were Massachusetts Institute of Technology (427/United States), the University of California (360/United States), and Harvard University (337/United States).

Companies commonly referred to as top gene editing service providers include CRISPR Therapeutics (Switzerland), Editas Medicine (United States), Horizon Discovery Group (United Kingdom), Intellia Therapeutics (United States), Precision BioSciences (United States), and Sangamo Therapeutics (United States).⁷⁵ Gene editing is used by pharmaceutical companies, academic institutes and research centres, agricultural genomic companies, and contract research organizations.⁷⁶ The price of gene editing varies by technology and application. The cost of human gene therapies addressing genetic medical conditions currently ranges from \$373,000 to \$2.1 million but can cost as much as \$5 billion to develop.

The gene editing market is growing but some concerns persist. Supply remains driven by large funding for research and development and technological improvement in genetic engineering technologies.⁷⁸ On the demand side, the market is driven by increasing cases of genetic and infectious diseases, the food industry's increasing focus on genetically modified technologies, and increasing demand for synthetic genes. However, ethical issues concerning the misuse of gene editing as well as its potential effect on human health may dampen growth.

Labour demand in gene editing is expected to soar with the gene editing market's expected growth from \$5.20 billion in 2020 to \$18.50 billion in 2028. In the United Kingdom, it has been estimated that 18,000 new jobs will be added between 2017-2035, while in the United States, 22,500 new medical scientist and biomedical engineer jobs are expected to be added between 2021 and 2031.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Stage of *ENGAGEMENT* with the Frontier Technology of Gene Editing *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of Gene Editing

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of Gene Editing

PEOPLE ASSOCIATED with the Frontier Technology of Gene Editing

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of Gene Editing

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **Gene Editing**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier
Technology of **Gene Editing**

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

5G networks are the next generation of mobile internet connectivity, offering download speeds of around 1-10 Gbps (4G is around 100 Mbps) as well as more reliable connections on smartphones and other devices.

China and the United States also lead 5G research. During the period 2000-2021, 13,045 publications related to 5G were issued, led by China (3,236), the United States (1,446) and India (1,224). The top affiliations were Beijing University of Posts and Telecommunications (402/China), Nokia Bell Labs (225/United States) and University of Electronic Science and Technology of China (179/China). During the same period, 32,412 patents were granted, with the top assignee nationalities being China (15,869), the Republic of Korea (12,646), and the United States (1,858). The top current owners are Samsung Group (11,920/Republic of Korea), Huawei (1000/China) and LG Corp. (744/Republic of Korea).

The leading vendors of end-to-end 5G network infrastructure include Ericsson, Huawei, Nokia, ZTE, Samsung, and NEC. Certain industries are expected to be particularly heavy users and major beneficiaries of the 5G rollout. These include mobile operators and network providers, machinery and industrial automation companies, component and module vendors, and manufacturing businesses. 5G mobile line prices vary depending on the carrier and features. However, costs remain high: the monthly cost of a single line of service with unlimited access to the 5G nationwide network in the US starts at \$70 for Verizon, \$65 for AT&T, and \$60 for T-Mobile. The leading early adopters of 5G technologies are China, Republic of Korea, the United Kingdom, Germany, the United States, Switzerland, and Finland.

PwC estimates 5G's economic impact in 2022 to be \$150bn and projects that it will reach \$1.3 trillion by 2030.

The rollout of 5G will take time, approximately five years to achieve broad coverage. It is already widespread though, with Ericsson predicting one billion subscriptions by the end of 2022 and 4.4 billion by 2027. Projections based on current trajectories predict that it will generate \$7 trillion of economic value by 2030. One constraint is introduced by the necessity of upgrading 5G infrastructure, notably microcell towers and base stations as the high costs associated with upgrades impede wide diffusion. In terms of demand, growth is mainly driven by rising demand for mobile broadband, the growing use of smartphones and smart wearable devices, surging demand for mobile video, rapid developments in IoT and an ever-growing number of connected devices, initiatives in multiple countries towards the development of smart cities, and the shift in consumer preference from premise-based to cloud-based solutions.

5G adoption is set to create large opportunities in the job market. It is estimated that in the US alone in 2034, 4.6 million 5G-related jobs will be created, driven largely by employment in the following sectors: agriculture, construction, utilities, manufacturing, transportation and warehousing, education, healthcare, and government. By 2035, the global 5G value chain is expected to support 22 million jobs globally.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Stage of *ENGAGEMENT* with the Frontier Technology of 5G *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of 5G

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of 5G

PEOPLE ASSOCIATED with the Frontier Technology of 5G

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of 5G

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **5G**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier Technology of **5G**

Nanotechnology is a field of applied science and technology dealing with the manufacturing of objects in scales smaller than 1 micrometre. Nanotechnology is used to produce a wide range of useful products such as pharmaceuticals, commercial polymers and protective coatings. It can also be used to design computer chip layouts.

Nanotechnology research is led by the United States and China. Between 2000 and 2021, 186,827 nanotechnology-related publications were issued, led by the United States (52,135), China (31,502), and India (13,448). The top affiliations were the Chinese Academy of Sciences (5,451/China), the Chinese Ministry of Education (3,581/China) and Centre National de la Recherche Scientifique (CNRS) (2,390/France). Within the same period, 6,175 patents were assigned, with the top nationalities of beneficiaries being China (1,395), the United States (1,253), and the Russian Federation (922). The three biggest owners were Aleksandr Aleksandrovich Krolevets (224/Russian Federation/Individual), Harvard University (90/United States) and PPG Industry Inc. (76/United States).

Top nanotechnology companies include BASF (Germany), Apeel Sciences (United States), Agilent (United States), Samsung Electronics (Republic of Korea), and Intel Corporation (United States). The major users of nanotechnology include medicine, manufacturing, and energy.

On the supply side, the market is driven by technological advancements, increasing government support, private sector funding for R&D, and strategic alliances between countries. In terms of demand, the market is driven by a general growing demand for device miniaturization. Concerns related to environmental, health, and safety risks, as well as nanotechnology commercialization risk constraining market growth.

The nanotechnology job market is expected to grow, but at a modest rate. In the United States, the nanotechnology engineer job market is set to grow by 6.4 percent between 2016 and 2026.84 Expected salaries in the United States range between \$ 35,000-\$ 50,000 for associates to \$ 75,000-\$ 100,000 for doctorate degrees.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Stage of *ENGAGEMENT* with the Frontier Technology of Nanotechnology*

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of Nanotechnology

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of Nanotechnology

PEOPLE ASSOCIATED with the Frontier Technology of Nanotechnology

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of Nanotechnology

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **Nanotechnology**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier Technology of **Nanotechnology**

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Solar photovoltaic (solar PV) technology transforms sunlight into direct current electricity using semiconductors within PV cells. In addition to being a renewable energy technology, solar PV can be used in off-grid energy systems, potentially reducing electricity costs and increasing access.

Solar PV research is led by India, the United States, and China. During the period 2000-2021, 19,875 publications related to solar PV were presented, led by India (6,169), the United States (2,850) and China (1,692). The top affiliations were the Indian Institute of Technology Delhi (817/India), Vellore Institute of Technology (219/India) and National Renewable Energy Laboratory (199/United States). Within the same period, 38,425 patents were granted, with the most assignees coming from China (31,361), the Republic of Korea (1,792), and the United States (1,578). The top three owners in 2022 are State Grid Corp. of China (290/China), Tianjin University (152/China), and Wuxi Tongchun New Energy Tech (139/China).

Top solar panel manufacturers include Jinko Solar (China), Canadian Solar (Canada), Trina Solar (China) First Solar (United States), SunPower (United States), and Hanwha Q CELLS (Republic of Korea). The biggest users of solar PV technology include the residential, commercial and utilities sectors.

The prices of solar PV panels have decreased significantly, the average upfront cost for commonly used residential PV systems (6kW) dropped from \$50,000 to the range of \$16,200-\$21,420 in ten years between 2008 and 2018, while the national average cost of a residential PV system in the United States is now estimated at \$2.94 per watt.

The concentrated solar power market size is set to continue expanding. The IEA recorded a negative impact of COVID-19 due to the pandemic hampering construction efforts. However, they project an overall increase in global implementation of the technology from 2023 to 2025 onwards, with a push for worldwide economic recovery encouraging increased installation of both private and commercial-purpose PV systems, with potential for an approximate 165 GW rise in per annum capacity overall.

Solar is widely acknowledged as key to efforts to combat climate change. Chinese estimates have projected that if solar photovoltaic energy was installed in the remaining construction area available for it in the country (estimated at approximately 6.4 billion metres squared), it would generate 1.55 times the territory's annual electricity usage per year.

Solar PV is the largest employer among the different renewable energy industries, already accounting for close to 4 million jobs worldwide. In the United States, the industry has experienced an average annual growth rate of 33% in the last decade alone. The International Renewable Energy Agency (IRENA) estimates that around 15.4 million people will be employed in solar PV under the 1.5° C Scenario.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Stage of *ENGAGEMENT* with the Frontier Technology of Solar PV *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of Solar PV

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of Solar PV

PEOPLE ASSOCIATED with the Frontier Technology of Solar PV

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of Solar PV

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **Solar PV**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier Technology of **Solar PV**

Concentrated solar power (CSP) plants use mirrors to concentrate the sun's rays and produce heat for electricity generation via a conventional thermodynamic cycle. Unlike solar photovoltaics (PV), CSP uses only the direct component of sunlight and can provide carbon-free heat and power only in regions with high direct normal irradiance (DNI).

Concentrated solar power research is led by the United States. Across 2000-2021, the 3,195 publications related to concentrated solar power came out of the United States (595), Spain (484), and China (389). The top affiliations were the German Aerospace Center (131/Germany), University of Seville (72/Spain), and the Centre National de la Recherche Scientifique (CNRS) (68/France). Within the same period, 1,101 patents were assigned, the most recipients of which came from the United States (454), Belgium (79), and Germany (79). The top three current patent owners are Cockerill Maintenance & Ingenierie SA (79/Belgium), Brilliant Light Power, Inc (59/United States), and General Electric (56/United States).

Companies considered to be leaders in the concentrated solar power space include Abengoa Solar, S.A. (Spain), Iberolica Group (Spain), ENGIE (France), NextEra Energy Resources (United States), and BrightSource Energy (United States). Concentrated solar power serves industrial, commercial and residential sectors. ***The global weighted-average cost of electricity for concentrated solar power was estimated at \$ 0.108/kWh in 2020.***

On the supply-side, growth in the market is driven by government support for the adoption of renewables, the integration of concentrated solar power into hybrid power plants, and advancements in heat transfer technologies such as proppants, high-temperature salts, and CO₂ along with a growing ability to minimize light reflection through new coatings for receivers.⁹⁶ On the demand-side, market expansion is driven by concentrated solar power plants' ability to supply power on-demand rather than being weather dependent. However, there remain concerns in terms of high capital costs, limited supply of land mass in high solar radiation zones, limited access to water resources, and challenges with the accessibility of transmission grids.

Worldwide, the concentrated solar power industry has created an estimated 32,000 jobs to-date. Jobs in the concentrated solar power space are set to grow with IRENA and the ILO predicting 1.6 million concentrated solar power jobs to have been created by 2050.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Stage of *ENGAGEMENT* with the Frontier Technology of Concentrated Solar Power *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of Concentrated Solar Power

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of Concentrated Solar Power

PEOPLE ASSOCIATED with the Frontier Technology of Concentrated Solar Power

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of Concentrated Solar Power

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **Concentrated Solar Power**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier Technology of **Concentrated Solar Power**

Biofuels are liquid fuels derived from biomass, and are used as an alternative to fossil fuel-based liquid transportation fuels such as gasoline, diesel and aviation fuels. In 2020, biofuels accounted for 3 per cent of transport fuel demand.

Biofuels research is led by the United States. During the period 2000-2021, biofuels publications numbered 74,801, originating in large part from the United States (18,386), China (10,085), and India (6,896). The top affiliations were the Chinese Academy of Sciences (1,626/China), the Chinese Ministry of Education (1,225/China), and the University of São Paulo (847/Brazil). Within the same period, 22,325 patents were granted, largely to beneficiaries from the United States (6,988), China (3,798), and France (1,083). The three largest patent owners were Royal Dutch Shell (560/United Kingdom), Bayer AG (470/Germany) and BASF SE (339/Germany).

Leading biofuel production companies include Cosan (Brazil), Verbio (Germany), ALTEN Group (France), Archer Daniels Midland Co. (United States), Argent Energy UK Ltd. (United Kingdom), REG (United States), Cargill Inc. (United States), Louis Dreyfus (France), and Wilmar International Ltd (Singapore). The main users of biofuels are the transportation, heating and electricity generation sectors.⁹⁹ The cost of biofuel production depends on methods used. In 2020, the average production cost of biofuels made using cellulosic ethanol was \$4 per gallon-gasoline equivalent (gge). Biofuels produced using the pyrolysis-biocrude-hydro treatment pathway had a cost estimate of \$3.25/gge, biofuels produced using biomass to liquid (BTL) had an average cost of \$3.80/gge, while hydrotreated esters and fatty acids (HEFA) biofuels were estimated to have an average cost of \$3.70/gge.

The global biofuels market is projected to expand rapidly; the IEA estimates that demand for biofuels will most likely grow by 41 billion litres, or 28 per cent, over the period 2021-2026. The market is currently driven by demand-side factors as national policies such as obligatory blending take effect and national ambitions for energy security increase, the latter having been amplified by the conflict in Ukraine and the 2022 global energy crisis. Growing demand for fuel in the transportation sector and moves to transition to a low-carbon economy also contribute significantly. On the supply-side, preferential taxes, subsidies and mandates have driven biofuel prices lower and helped increase production. However, the key challenge to biofuels is their continued low cost-competitiveness relative to fossil fuels. Furthermore, biofuel feedstock production may cause changes to land use patterns, place strain on water supply, generate air and water pollution, and increase food costs.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Worldwide, the liquid biofuel market employs an estimated 2,411,000 people. Although biofuel jobs declined between 4 and 5 per cent in the United States in 2020 due to knock-on effects from the Covid-19 pandemic, declines in biofuel employment were less severe than those in the job markets for other kinds of fuels. Biofuel employment is projected to rebound, accompanying the gradual recovery from the pandemic.

Stage of *ENGAGEMENT* with the Frontier Technology of BioFuels *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of BioFuels

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of BioFuels

PEOPLE ASSOCIATED with the Frontier Technology of BioFuels

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of **BioFuels**

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **BioFuels**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier Technology of **BioFuels**

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Biogas is a mixture of methane, CO₂ and small quantities of other gases produced by anaerobic digestion of organic matter in an oxygen-free environment. Biomass is renewable organic material that comes from trees, plants, and agricultural and urban waste. It can be used for heating, electricity generation, and transport fuels.

Biogas and biomass research is led by China and the United States. Between 2000 and 2021, 400,062 biofuel-related publications were put out, led by China (79,658), the United States (77,614), and India (27,183). The top affiliations were the Chinese Academy of Sciences (17,175/China), the Chinese Ministry of Education (8,554/China), and the University of the Chinese Academy of Sciences (6,245/China). Within the same period, the 251,251 registered patents were assigned primarily to residents of China (99,328), the United States (38,856), and France (13,713). The three top patent owners in 2022 were Xyleco (3,808/ United States), BAS F SE (2,694/Germany), and Evonik Industry AG (1,694/Germany).

Major biogas and biomass producers include Future Biogas (United Kingdom), Air Liquide (France), PlanET Biogas Global (Germany), Ameresco (United States), Quantum Green (India), Envitech Biogas (Germany), and Weltec Biopower (Germany). The main users of biogas and biomass are the industrial, transportation, residential and electric power generation sectors.¹⁰⁶ The cost of producing biogas varies between \$2/MBtu to \$20/MBtu.¹⁰⁷ Biomass power plants generate electricity that generally costs around \$0.030 and \$0.140/kWh; but certain projects can cost up to \$0.250/kWh.

The global biogas markets is projected to grow rapidly, while the biomass market is expected to undergo transformation as it transitions from traditional to sustainable methods. While biomass constitutes 9 per cent of the world's energy production, biogas represents only a 0.3 per cent share of total primary energy. Despite this, the IEA projects significant growth for sustainable forms of both, driven by their flexibility, simplicity, and ecological necessity. The transition towards a low-carbon economy, growing demand from power generation companies, and the adoption of biomass in fuel cell technology. On the supply-side, biomass costs are dropping due to favorable government policies including loans for the establishment of biomass power plants while the availability of sustainable feedstocks for biogas purposes is set to grow by 40 per cent over the period to 2040. However, the market is limited by challenges which include scarce land areas for energy-growing crops and technical hurdles that limit the commercial feasibility of biomass as a replacement for fossil fuels at higher blending rates when compared to coal.

The biomass and biogas job markets are anticipated to keep growing. Solid biomass employs an estimated 765,000 individuals worldwide, while biogas employs approximate 339,000 people. It is estimated that biomass production creates 73 permanent full-time direct jobs per 100MW of installation capacity.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Stage of *ENGAGEMENT* with the Frontier Technology of BioGas & BioMass *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of BioGas & BioMass

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of BioGas & BioMass

PEOPLE ASSOCIATED with the Frontier Technology of BioGas & BioMass

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of BioGas & BioMass

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **BioGas & BioMass**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier Technology of **BioGas & BioMass**

Wind energy is used to produce electricity using the kinetic energy created by air in motion. This is transformed into electrical energy using wind turbines. Many parts of the world have strong wind speeds, but the best locations for generating wind power are sometimes remote and offshore ones.

Wind energy research is again led by China and the United States. 2000-2021 saw 37,514 publications related to wind energy, led by China (5,376), the United States (5,359) and India (4,254). The top affiliations were the Technical University of Denmark (545/Denmark), North China Electric Power University (364/China), and Delft University of Technology (359/Netherlands). Within the same period, 58,134 patents were assigned, mainly to applicants from China (32,991), Germany (11,630), and the US (2927). The top three current owners are Wobben Properties GMBH (3062/Germany), Wobben Aloys (1966/Germany), and Senvion SE (1884/Germany).

The companies frequently cited as leading in the wind energy space include Vestas (Denmark), Siemens Gamesa (Spain), Goldwind (China), GE (United States), and Envision (China) (BizVibe, 2022). The major users of wind energy include the agricultural, residential, utility and industrial sectors (Hartman, 2021). The global weighted-average cost of electricity of new onshore and offshore wind farms was \$ 0.053/kWh and \$ 0.115/kWh respectively in 2019.

The global wind energy market continues to grow as installation and maintenance costs decrease. In 2021, wind electricity generation increased by a record 273 TWh (up 17 per cent compared to 2020), making it the fastest growing of all power generation technologies. Given the increasing affordability and profitability of wind and the large number of high-wind areas that have not yet been exploited for it, potential for growth is strong. Demand-side drivers of growth in the wind energy market include increasing demand for renewable energy sources and continually growing energy consumption globally.

With energy prices increasing significantly, demand for increasingly cost-effective renewable energy is growing. On the supply-side, offshore wind farms have circumvented challenges related to sea depth while benefitting from high wind speeds. Barriers in the wind energy sector include technological ones related to grid connection and integration and the lack of supporting infrastructure. There are also economic challenges, notably the high initial cost of capital and long payback periods, shortages in financing channels, immature offshore supply chains, and outdated regulatory frameworks.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

The wind energy job market, already significant, currently employing 1.25 million people worldwide, is expected to experience rapid growth. 117.33 million new jobs are expected to be created as a result of the additional 470GW of wind capacity expected to be installed by 2025.118

Stage of *ENGAGEMENT* with the Frontier Technology of Wind Energy *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of Wind Energy

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of Wind Energy

PEOPLE ASSOCIATED with the Frontier Technology of Wind Energy

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of **Wind Energy**

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **Wind Energy**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier Technology of **Wind Energy**

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Green hydrogen is hydrogen generated entirely by renewable energy or from low-carbon power. The most established technology for producing green hydrogen is water electrolysis fuelled by renewable electricity. Compared to electricity, green hydrogen can be stored more easily. The idea is to use excess renewable capacity from solar and wind to power electrolyzers which would utilize this energy to create hydrogen, which can be stored as fuel in tanks.

Green hydrogen research is led by China. Across 2000-2021, 802 green hydrogen publications were issued, led by China (140), Germany (100), and the United States (74). The top affiliations were the Chinese Academy of Sciences (22/China), the University of Birmingham (13/United Kingdom), and the Chinese Ministry of Education (12/China). Within the same period, 58 patents were assigned, predominantly to applicants from China (30), the United Kingdom (5), the US (4) and Australia (4). The three top current owners are Anglo-American Corp. (4/UK), Xi'an Thermal Power Research Institute (4/China), and Johnson Matthey (3/UK).

Major green hydrogen companies include Air Liquide (France), Air Products and Chemicals, Inc (United States), Engie (France), Green Hydrogen Systems (Denmark), Siemens Energy Global GmbH (Germany), Toshiba (Japan), and Tianjin Mainland Hydrogen Equipment Co. Ltd (China). The largest users of green hydrogen include heavy industry and the transportation, heating and power generation sectors. Green hydrogen costs remain high, currently estimated at around 2.5-6 USD/kg H₂.

Demand in the global hydrogen market is growing because of the need for increased flexibility and dispatchability of renewable power systems, green hydrogen's broad potential use across the entire economy, and several countries with large renewable resources seeking to become net exporters. On the supply-side, the market is flourishing courtesy of technological improvement and market-readiness of several items in the hydrogen value chain.

However, several barriers remain significant. Green hydrogen has higher production costs relative to grey hydrogen even when carbon pricing increases the costs of competing fossil fuels. Significantly, there remains a shortage of dedicated infrastructure for the transport and storage of green hydrogen, a still-small market for it, and difficulties in drawing clear distinctions between grey and green hydrogen in national energy statistics. Challenges also remain concerning the measurement of its sustainability.

Green hydrogen is estimated to create as many as 2 million jobs between 2030 to 2050 as investments in electrolyzers and other green hydrogen infrastructure increase and as it becomes increasingly widely adopted as a fuel source.

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

Stage of *ENGAGEMENT* with the Frontier Technology of Green Hydrogen *

- Utilitarian USAGE
- Adroit ADOPTION
- Appropriate ADAPTATION
- All Round AWARENESS
- Skills TRAINING
- Futuristic RESEARCH
- Contextual INNOVATION
- Sovereign DEVELOPMENT
- Strategic DEPLOYMENT
- Full MARKET OFFERING

Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

Institutional/Organizational PERSPECTIVES, PLANS & PROJECTIONS about the Frontier Technology of Green Hydrogen

OVERALL COMMENTARY of the Stage of Engagement with the Frontier Technology of Green Hydrogen

PEOPLE ASSOCIATED with the Frontier Technology of Green Hydrogen

Give the Details of all the Key Personnel in the <Name, Designation, Contact Number, Email ID, LinkedIn Profile, Role> Format

PUBLICITY MATERIAL, PUBLICATIONS & PATENTS (if any) associated with any Stage of the Frontier Technology Engagement Value Chain of Green Hydrogen

Atal Bihari Vajpayee Tribute to Titans of Technology 2023

PROCESS & PROTOCOL of Engagement with the Frontier Technology of **Green Hydrogen**

PARTNERSHIPS & ALLIANCES struck to bolster the Stage of Engagement with the Frontier
Technology of **Green Hydrogen**

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Electric vehicles (EVs) use one or more electric motors for propulsion. They can be powered by a collector system, with electricity from extravehicular sources, or autonomously by a battery. As energy-consuming technologies, EVs create new demand for electricity that can be supplied by renewables. In addition to the benefits of this shift, such as reducing CO2 emissions and air pollution, electric mobility also creates significant efficiency gains and could emerge as an important source of storage for variable sources of renewable electricity.

Electric vehicle research is led by China, the United States, Germany, and South Korea. From 2000 to 2021, of the 79,732 publications related to electric vehicles, most came from China (22,375), followed by the United States (13,108), and Germany (5,408). The top affiliations were the Beijing Institute of Technology (1,814/China), Tsinghua University (1,685), and Tongji University (900/China). Within the same period, of the 206,049 patents assigned, most went to China (94,124), the Republic of Korea (23,193), and the US (19,059). The top three current owners are LG Corp (7181/Republic of Korea), Toyota Group (6945/Japan), and Hyundai Motor Group (6817/Republic of Korea).

Leading electric vehicle manufacturers include Tesla (United States), Renault–Nissan–Mitsubishi Alliance (France/Japan), Volkswagen (Germany), BYD (China), Kia and Hyundai (Republic of Korea). The major users of electric vehicles include the transportation, e-commerce and delivery industries.¹²⁶ Between 2021 and 2022, supply chain problems and component shortages have in fact raised the average cost of a new electric car in the United States by 22 percent, to \$54,000 (compared to a 14 percent increase for internal combustion engine cars).

Nearly 10 percent of global car sales were electric in 2021, four times the market share in 2019. This rate of growth is projected to continue or accelerate. Demand is being driven by supportive government policy in the form of fuel economy and emission targets, city access restrictions, and financial incentives, along with growing corporate and consumer interest in purchasing electric vehicles to meet sustainability objectives. On the supply-side, technological innovations have improved the driving range, cost competitiveness, and time required to charge for many electric vehicles. Crucially, charging infrastructure is becoming more widespread and accessible, and automotive manufacturers have made ambitious strategic commitments to promote electric vehicle production and consumption. Further impetus comes from the growing success of Chinese manufacturers' focus on producing small EVs at much lower price points: in 2021, the sales-weighted median price of EVs in China was only 10% more than that of conventional offerings, compared with 45-50% on average in other major markets.

However, barriers remain including concerns about electric vehicles' range, high battery prices, a shortage of charging infrastructure in certain countries, and concerns about the environmental harms of electric vehicle charging and battery production.

Electrifying the transportation industry is expected to support job growth. It is estimated that nearly 200,000 additional permanent jobs will be created in Europe by 2030 as result of employment in ten sectors: battery manufacturing, charger manufacturing, wholesales, installation of the chargers, grid connection, grid reinforcement, civil and road work, charge point operation, charge point maintenance and electricity generation. It is likewise expected that more than the transition to electric transport will lead to a net global net global increase of 2 million jobs despite losses the combustion engine sector. While there might be job losses in the auto repair and maintenance industries, these would be offset by gains in economy-wide induced jobs and increased power sector jobs.

Stage of *ENGAGEMENT* with the Frontier Technology of Electric Vehicles *

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Usage | Adoption | Adaptation | Awareness | Training | Research | Innovation | Development | Deployment | Market Offering

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