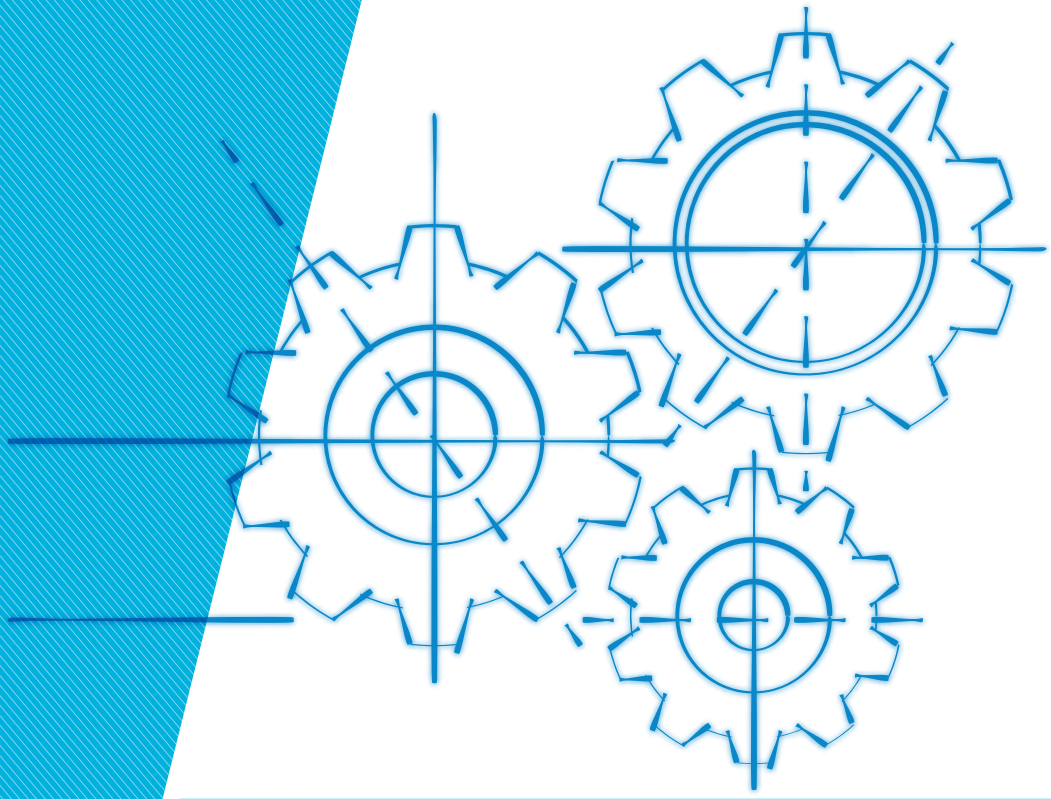
TIFAC

TECHNOLOGY VISION 2035
MANUFACTURING



EXECUTIVE SUMMARY

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TECHNOLOGY VISION 2035

MANUFACTURING
EXECUTIVE SUMMARY

This document is dedicated to

Dr. A P J Abdul Kalam

(Former President of India)

TIFAC

TECHNOLOGY INFORMATION,
FORECASTING AND ASSESSMENT COUNCIL

VISION

Technology Vision 2035 for the manufacturing sector analyses the current Indian and Global Scenario in manufacturing, leading to the identification of technology gaps, drivers for change and its possible contribution to the GDP of India.

2035

Strengthening the manufacturing base of India through innovation-driven clean, green and lean processes.

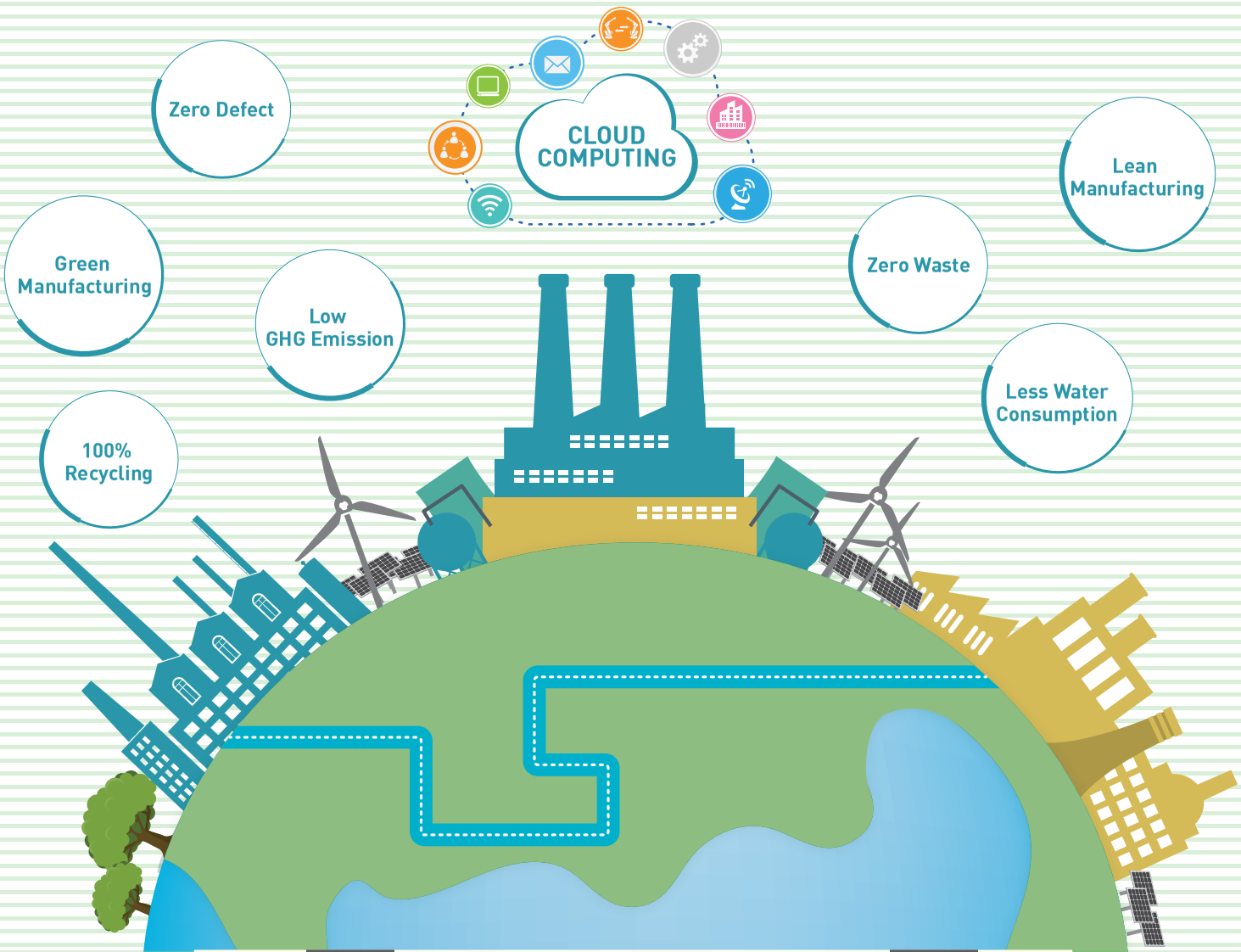
SEGMENTS ANALYSED

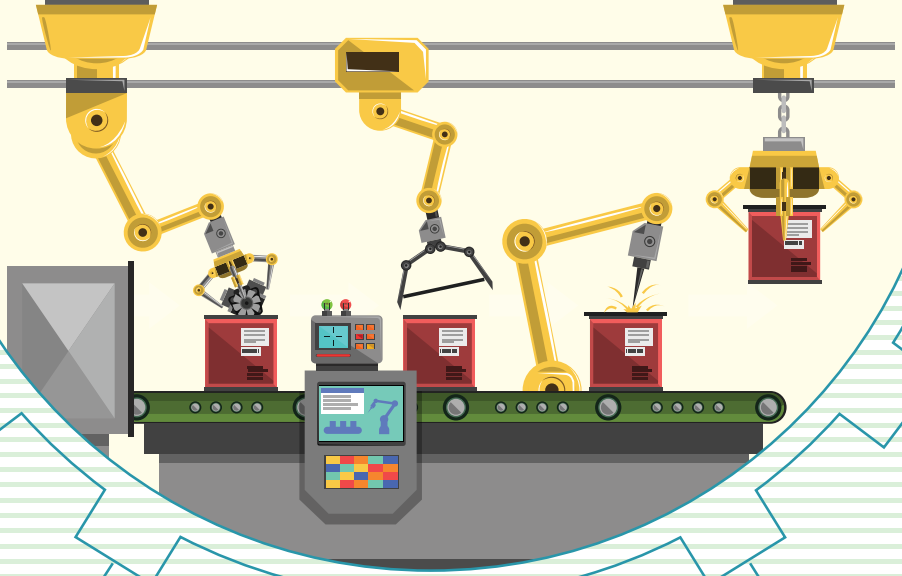
The Vision document provides an insight into 8 segments. Traditional segments such as food processing, textile, leather, chemicals and metal fabrication have been analyzed along side upcoming areas such as composites, micro and nano manufacturing, and electronics and ICT

READERSHIP

Researchers, academicians, funding agencies, policy makers, manufacturers and entrepreneurs with specific interest in the manufacturing sector of India would find this document interesting.

MANUFACTURING 2035





Innovation - receptive Manufacturing

Human Centred Manufacturing

Modularity / Flexible Manufacturing

Process Intensification

Micro Nano Manufacturing

Smart/ Intelligent Machines

Self Healing / Mending Machines

Machine to machine communication

Multiscale Manufacturing

Product Customisation

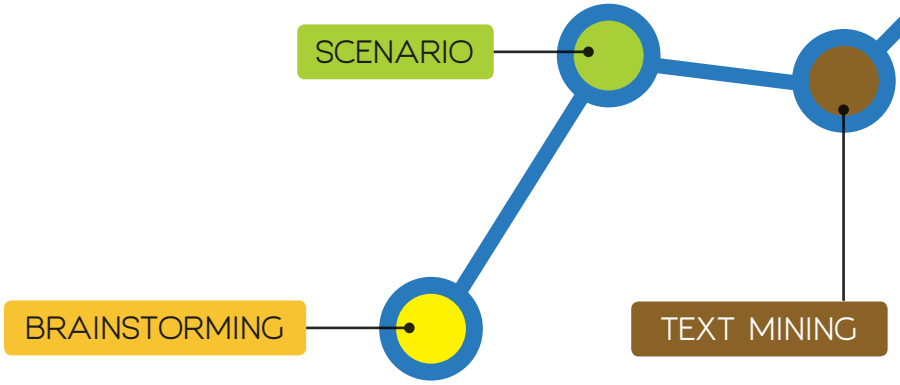
Distributed Manufacturing

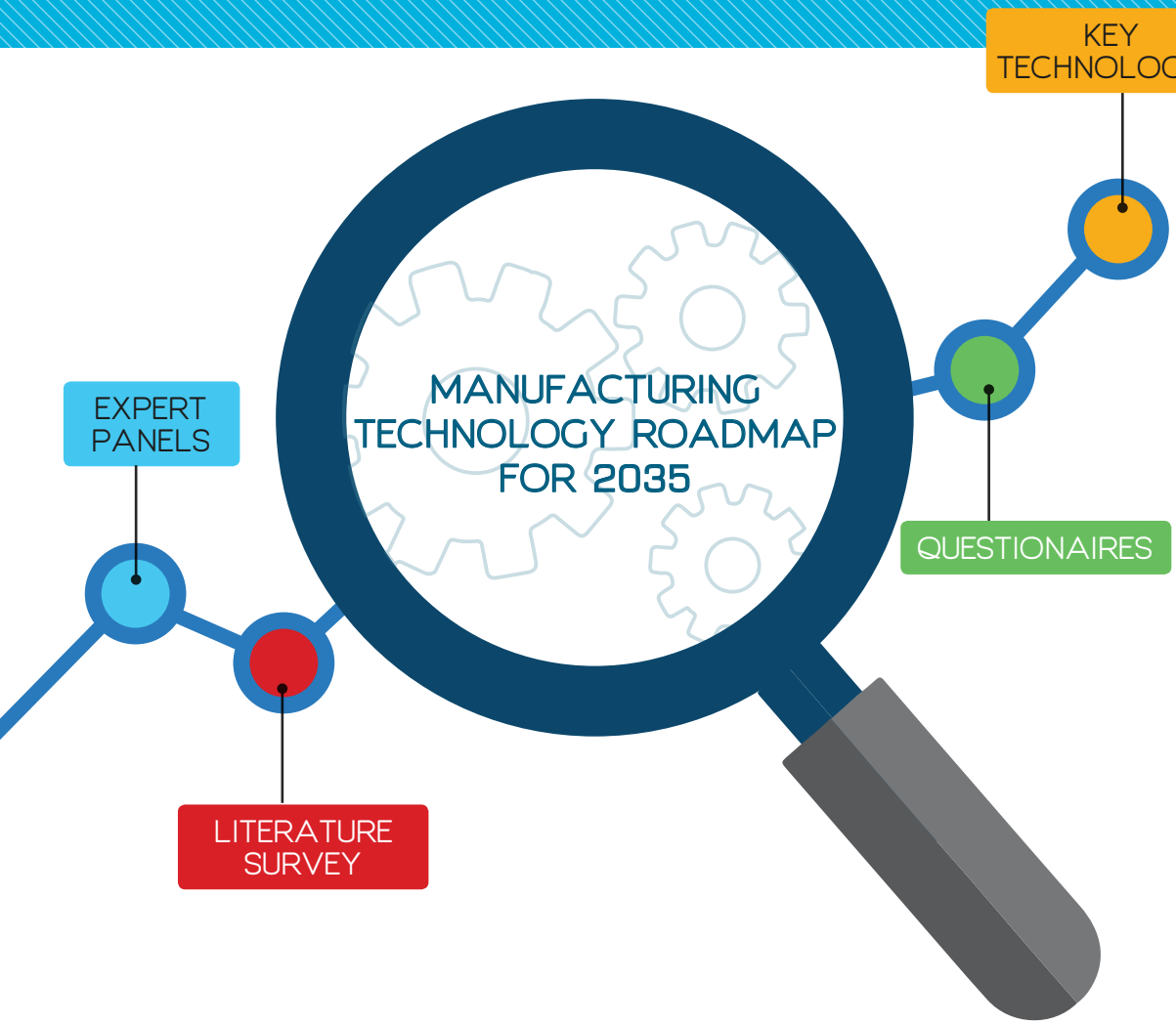
Reconfigurable Manufacturing

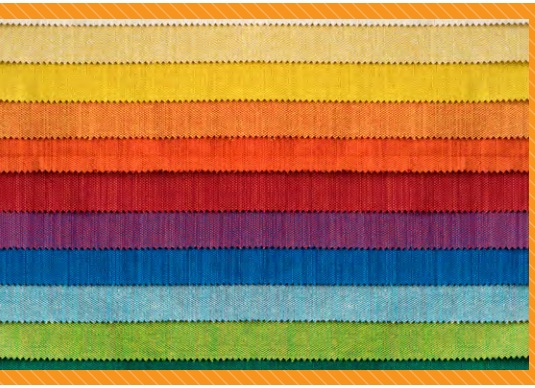
METHODOLOGY

The team had brainstorming sessions with topic specific experts and also amongst themselves. The experts were posed with specific questions regarding the way they expect the industry and business would move in the area of R&D, new technology initiatives, environmental management, adopting to consumer preferences and so on.

A technology road map was constructed based on available literature and also based on reports, road maps and scenario / trend analysis carried out by Government agencies and those published on the world wide web.




KEY TECHNOLOGIES
MANUFACTURING TECHNOLOGY ROADMAP FOR 2035
EXPERT PANELS
QUESTIONAIRES
LITERATURE SURVEY

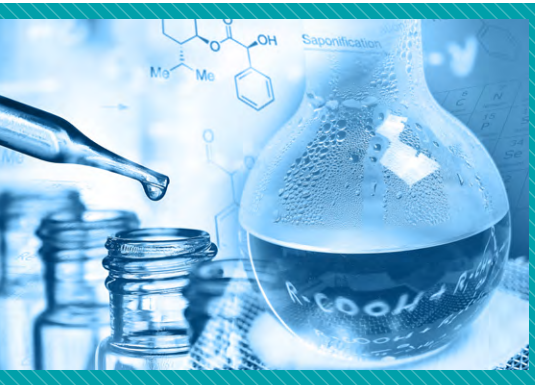


TEXTILE & APPAREL

Industry characterized by largest employment potential, vertically integrated growth and decentralized processing and weaving. Technology needs to meet increasing export and domestic demands, production of colored cotton, customized apparels, embedded electronics, technical textiles, zero effluent discharge, moving away from decentralized processing in weaving, processing and finishing for absorption of technology to reduce cost and improve quality is highlighted.

LEATHER

Tradition bound activity driven mostly by market forces and consumer preferences. S&T, innovation etc. have remained in isolation. Chapter perceives development of technology for economical utilization of raw material and leather and thus a technology led growth path – an innovation driven manufacturing and leather remaining a consumer preference oriented fashion statement.

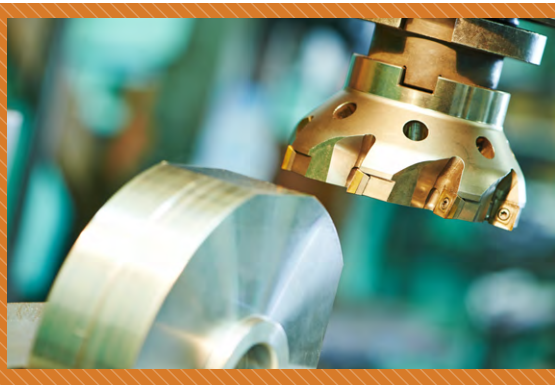


CHEMICALS

Technology has always played a decisive role in most subsectors of chemical industry to enhance competitiveness and improve life cycle of processes and products. Classified as basic, specialty and knowledge intensive, the chapter traces the history of these industries and links it to the future, providing inputs on technology drivers, infrastructure needs, technologies to meet environmental issues etc.

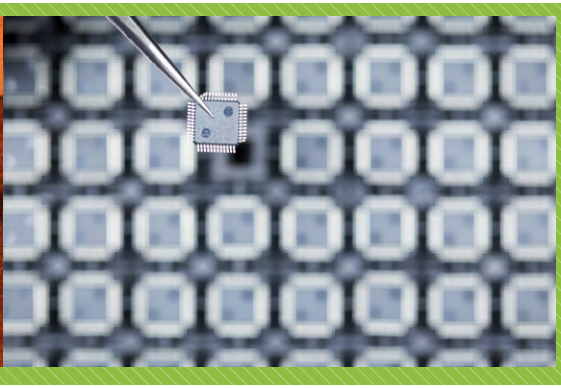
METAL FABRICATION

Covers a wide range of activities – general welding, forming, casting, cutting and high-specialized additive manufacturing. The processes involve both demand for raw materials and intermediate components and services. Contributors through interactions with various experts predict future as of 2035 and provide insight into actions needed, including automation for increasing quality levels, precision and productivity.



FOOD PROCESSING

Composed of food preservation, processing, nutritional needs and socio-economic factors in addition to health factors. Chapter points out that scope exists to improve quality attributes of food along with simultaneous decrease of spoilage with innovative application of technology, improvisation in supply chain and focus to traditional and health foods.

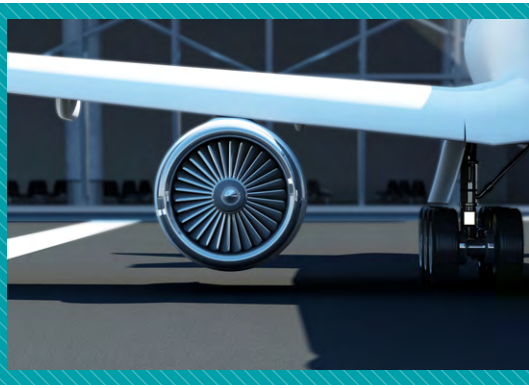


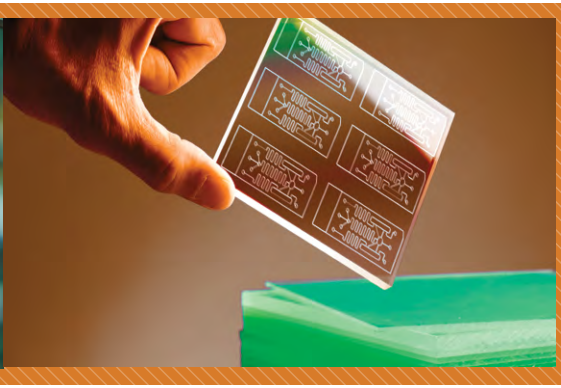
ELECTRONIC APPLIANCES AND ICT

An integral part of any engineering and science application this is a potential and dominant player in the GDP of a country. Chapter correlates the industrial growth with the economics of investment and risks of business, alongside a roadmap for semiconductor industry in terms of More Moore, More than Moore and Beyond CMOS. It is envisioned that the growth of this sector as an independent as well as supporting technology for product development – a mainstay for manufacturing sector as a whole.

COMPOSITE FABRICATION

Modern composite materials constitute a significant proportion of engineering material market ranging from everyday products to sophisticated niche applications. Chapter highlights current and future demands within key application areas, specific requirements for different applications, technologies for repair, machining and processing, drivers of growth, methods for production, gaps in technologies and recommendations for industries.





MICRO NANO MANUFACTURING

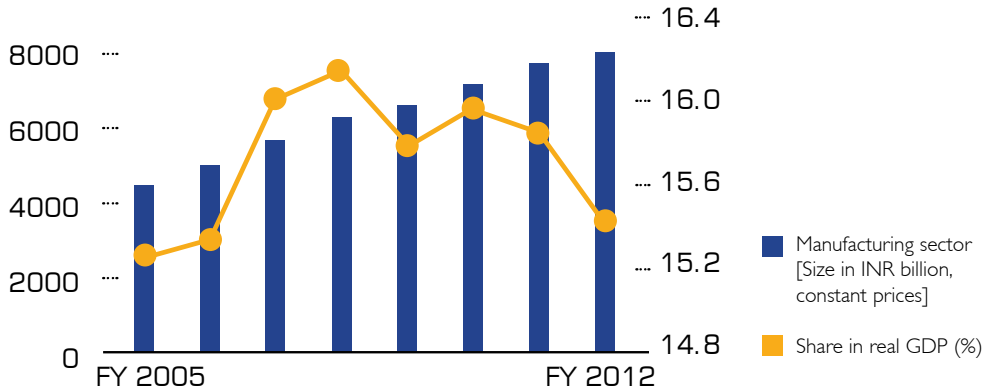
This is an emerging field that enables production of several innovative products in a wide spectrum of functionalities and low cost. Chapter predicts significant impact in improving energy harvesting, healthcare, water purification, environmental remediation etc. It is envisioned that by 2035 India would be global leader in micro nano manufacturing tools for medicine, self-assembly and new material synthesis with frugal investment for development of simulation tools.

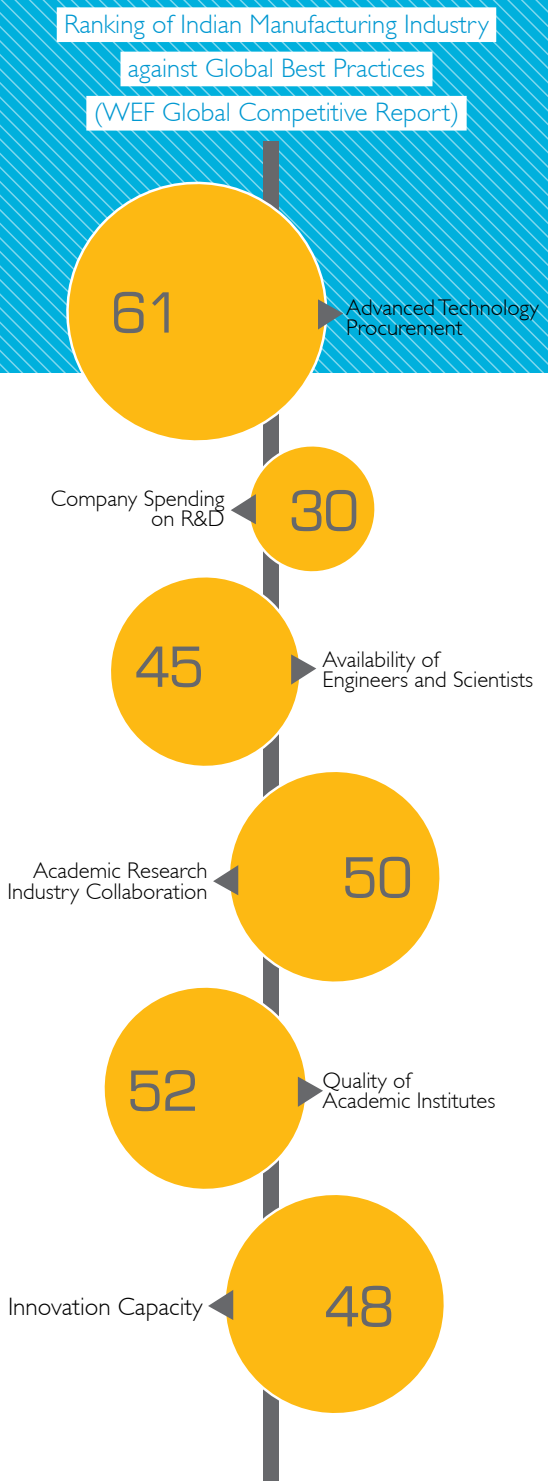
CONTRIBUTION TO INDIAN GDP

PRESENT INDIAN SCENARIO

Manufacturing, the engine of growth of a country and the provider of a stable economy is a unique sector, which sells goods to other sectors and in turn buys materials and services from them. Growth of manufacturing sector also ensures growth of agriculture and services sectors through its contribution to better machinery, appliances and communication systems. Indian manufacturing has been contributing just about 16% to the total GDP of the Nation for over two decades now as can be seen from Plate 1.

The contribution of the industry segment (comprising mining and quarrying, manufacturing, electricity/water/gas supply and construction) has been predicted to be around 27.1% as against 63.2% by services for FY 19-20. Among the contributors of the industry segment, manufacturing alone accounts for a weight of 79.4% in the Index of industrial production.





Indian share in the overall trade from manufacturing is at a low of 1.7%, mostly through exports of goods. Last two decades has seen several developments in the global manufacturing sectors across the globe. In addition to changes in the economic trade barriers, technology revolution, which has impacted productivity and lowered the cost of production has been playing a significant role. Ranking of Indian manufacturing segment vis-à-vis other global players showed interesting results (Plate 2)

Manufacturing sector in India enjoys several advantageous factors such as young work force, large pool of scientists, engineers and managers, abundant natural resources and an increasing relevance in the domestic market. For the purpose of analysis and planning, the Government of India has included 17 industrial groups under the manufacturing sector. Between 2008 and 2011 in spite of these advantages, the growth of the sector has been fluctuating. After a good growth of 11.3 and 9.7% in 2009-10 and 2010-11, sluggish growth has been reported (2.7 and

1.9%) for 2011-12 and 2012-13. Of the 22 sub-groups considered under manufacturing, during 2012-13, 4 sub groups (weighted contribution of 14.5% in IIP) contributed to a growth in excess of 5%, 7 sub groups had a positive growth (weighted contribution of 37% in IIP) and 11 sub groups (weighted contribution of 24% in IIP) recorded negative growth rate. Labor-intensive industries such as textiles, leather and food products, were prominent industries in the group demonstrating positive growth. For the technology and mechanization intensive industries, factors such as low growth of investments, squeezed margin of corporates, deceleration of rate of growth of credit flows and a fragile global economic recovery has been suggested to contribute to this sluggishness.

Manufacturing sector in India, predominantly those like textiles, food, leather, chemicals and electronics also need to look at the growing domestic demands. With United Nations indicating that Indian population would be between 1.41 and 1.64 billion by 2035, Indian manufacturing sector could look forward to a large domestic market as well.

In addition to the growing population, the income levels of India are also on the rise. It has been projected that the number of households with annual incomes between 3 to 15 lakh Rupees would be around 127 million in 2014-15. The demand for processed food, electronics etc. is bound to increase owing to the increase in expendable income as well as the younger age profile of its population.

The Indian **food-processing sector** is currently facing the challenge of enabling the process of bringing down the undernourished people from current 21% to significantly low figure by 2035, in addition to providing solutions to the increasing food related problems such as diabetes, over-weight and obesity. The sector also provides for 1.6 million jobs (19% of total industrial labor force), with 14% of industrial output and 5.5% of GDP, with a CAGR of 13%.

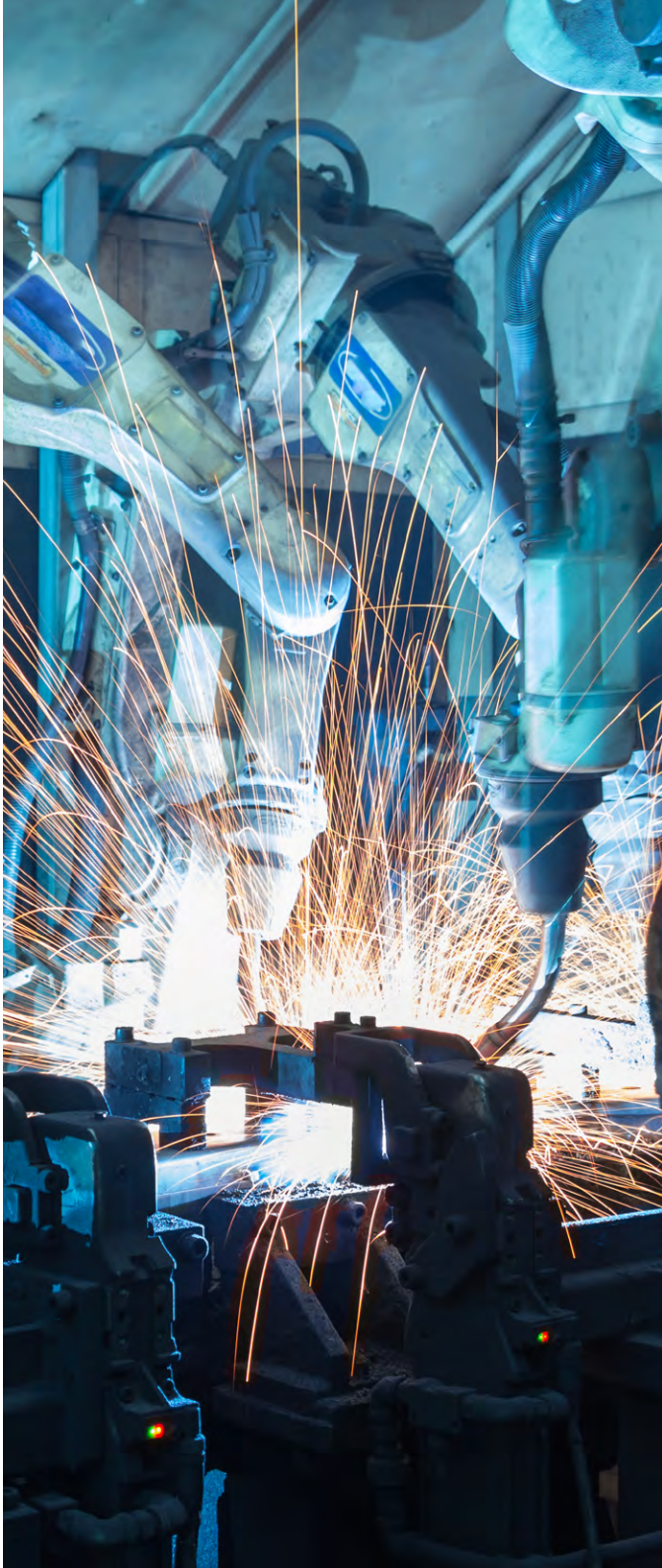
A fundamentally strong production base for a wide range of fibres and yarn, the Indian **textile sector** is benefited by large domestic consumption (2/3 of world per capita consumption) in addition to a strong export base. A predominantly decentralized sector, this sector provides for 45 million direct and 60 million indirect jobs. The value of this sector was pegged at USD 58 billion for 2011-12, with a 11% industrial output and 4% of GDP, with a CAGR of 11%.

Indian **leather sector**, supported by a large raw material base produces about 2100 mil. Sq.ft of leather from about 1600 tanneries located predominantly

in clusters in Tamil Nadu, Uttar Pradesh, West Bengal and Punjab. The sector contributes to 2.5 million direct and indirect jobs, mostly to women and weaker sectors of society. The value of this sector was pegged at USD 10 billion for 2012-13, with 0.5% of GDP, with a CAGR of 8.54%.

Indian **Chemical Manufacturing industries** are likely to reach USD 250 billion turnover by 2035 from the 2009 level of USD 64 billion. Of this the contribution of knowledge intensive sector would be 40% - in par with basic chemicals. **The metal fabrication** sector is expected to have a CAGR of 6% by 2020, leading to a market share of INR 6.7 lakh crore. In terms of applications, automotives, auto ancillary and general engineering would consume 61% of the production. **Electronics industry** in India has a market value of USD 400-800 billion, of which consumer durables alone contribute to around USD 340 billion. Though in the chip market Indian contribution is by way of design, there is enormous potential for the country to contribute to value addition. Infusion of technology and investment is likely to move the market share from USD 2 billion to 60 billion.

The **micro nano manufacturing industry** is relatively new to India, more so as an offshoot of precision fabrication requirements of strategic industries. Currently market size and trends of this industry is not available. **Composites manufacturing** industry has a production level of 320,000 metric tons per annum with a market size of INR 8000 crore, with a CAGR of 22%.



MANUFACTURING: GLOBAL IMPACT

PRESENT INDIAN SCENARIO

Competitive Industrial Performance (CIP) Index for India has been 0.0747 as against 0.5409 for Japan. This places India at a dismal position of 43 amongst 133 countries analyzed by UNIDO. However, India has a high World Manufacturing Value Added (WMVA) index but lowest Manufacturing Value Added per capita (MVApc) and Manufactured Exports per capita (MXpc) (arising from its high population). A comparison to a similarly populated country, China indicates that the MVApc and MXpc values for India are 7 times lesser. Further, the manufacturing value added share in total GDP for India is 18%, indicating the relevance of the service sector in the country. The industry in India is also too complex and this has resulted in a poor share of medium and high tech manufacturing value added (MHVAsh) value of 37%. The export basket of India comprises only 28% of high-tech products. Amongst the six factors that define the three dimensions of competitiveness, viz., the capacity to produce and export, technology deepening and creating a world impact, India figures amongst top 20 countries only in the case of world impact, indicating that Indian manufacturing industries are considered to be relevant globally.

INDUSTRIAL COMPETITIVENESS

Capacity of countries to increase their presence in international and domestic markets while developing industrial sectors and activities with high value added and technology content – reported as the CIP Index. Some of the factors, which go into the computation of this index includes MVApc (manufacturing value added per capita), MVA (manufacturing value added), MXpc (manufactured exports per capita), MVAsh (manufacturing value

added share in total GDP) MHVAsh is the share of medium- and high-tech manufacturing value added in total manufacturing value added and WMVA (world manufacturing value added).

WORLD IMPACT

A factor calculated based on impact of a country on world manufacturing value added (ImWMVA – relative performance and impact in manufacturing) and impact of a country on world manufactures trade (ImWMT – country's competitive position relative to others in international markets).

An opportunity and ideal S&T / policy environment to convert this global impact into parameters that define its technological relevance and export capacities needs to be created. On the policy front, India has made some progress. One of this includes the creation of BRIC nations, of which India is a part. The growth rate of gross domestic product in BRIC countries is overwhelmingly larger than in traditionally strong economies like US and Germany.

From the technology point of view, the inclusion of technologically complex chemicals in the export basket of India is considered as providing favorable environment for growth, leading to it gaining a position in the CIP index. Further enhancement of the technological strength of India would strongly depend on enhancement of its technical capabilities and available skilled manpower. Lall (1992) indicates the existence of a national technological capabilities index arising out of interplay between capabilities, incentives and institutions. While capabilities indicate best of achievable, incentives guide use of capabilities and stimulate expansion, renewal or disappearance.

Perhaps the most assuring factor for India is its position in the Global

Manufacturing Competitiveness Index, a figure derived from the rating provided by manufacturing executives for 26 countries selected by Council on competitiveness, Deloitte and Clemson University. According to this index, a new world order of manufacturing competitiveness consisting of China, India and Korea has emerged. India is positioned at number two and is set to gain a stronger foothold on that position for the next five years as well.

Rich pool of talented scientists, researchers and engineers as well as a large English speaking workforce and government support for global giants to invest is considered as the reasons behind this position.

Interestingly, India, according to the survey has gone beyond low-cost manufacturing into areas such as quality improvement, adopting the Japanese principles of quality management etc. India is also viewed as a destination for design, develop and manufacture innovative products for sale in local and global markets. There has been a tendency to look at the China model for growth of Indian industry. Current advantages for China include its better infrastructure and an authoritarian government. However, as China's strength as manufacturing powerhouse fades owing to lesser relevance to heavy industry, privatization and increase in wages, India could occupy the space vacated by China as well.

Monthly wages in manufacturing sector of India is still far less than Chinese. Other advantages for India includes efficient bank assets and credit systems, lower internal funding for private investment, ambitious reform programs involving shift from controlled to open market economy etc.

Moving specifically into industries under the manufacturing sector, the food and beverage industry is worth USD 7 trillion, with a CAGR of 3.5%. The industry is expected to grow by 25 – 35% by 2025. Industrial growth in this segment is determined by multiple factors such as changes in consumer demands (convenience, health, age/gender complexities, income, connectivity etc.), globalization of manufacturing and sales processes etc. With USA and EU continuing to be the major consumers for textiles, countries with resource based advantages such as China and India for cotton and silk; Australia, China, New Zealand and India for wool; India, China, Indonesia etc. for man-made fibres; are likely to determine the market trends.

The chemical manufacturing industries, divided predominantly as basic, specialty and knowledge intensive is expected to cross USD 5 trillion by 2020 in terms of turnover. Of this, Asia-Pacific countries are likely to contribute to 60% of the total production.

DEMAND PROJECTIONS 2035

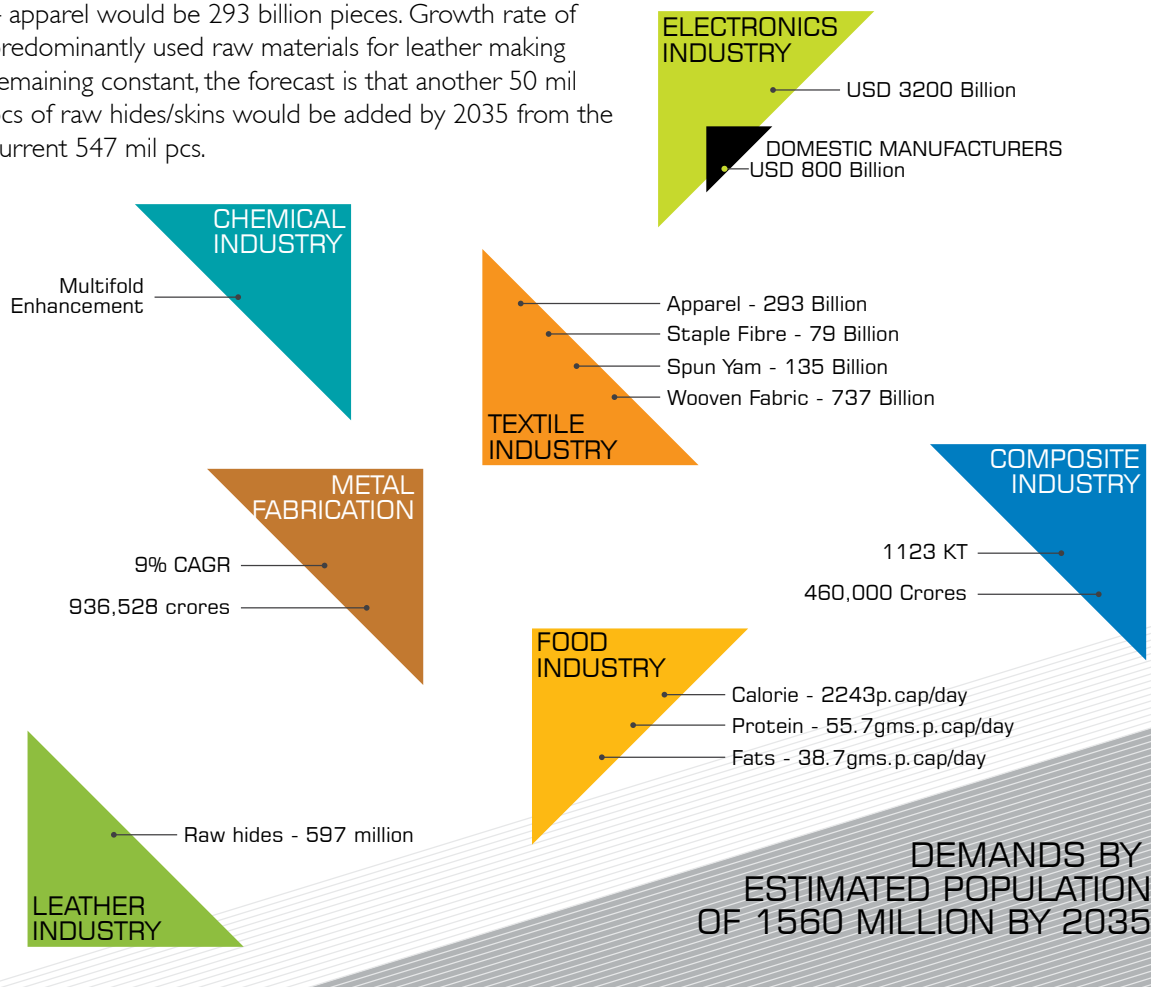
TECHNOLOGY SCENARIO

Major developed nations suggest that global competitive environment would be determined by three factors, viz., changes in competition, value networks moving east, and increasing economic volatility. Key end markets such as automotive, construction and pulp production are all set to surge in Asia and this in turn is likely to drive the demand for products of the manufacturing sector.

Based on the current trends, and assuming a population of 1560 million in 2035, the predicted value for food items like cereals, coarse grains etc. have been worked out for India. These projections presented in the Chapter on Food Processing are based on the assumption that the current norms of per capita consumption food, i.e. 2243 p.cap/day calories; 55.7 gms.p.cap/day proteins and 38.7 gms.p.cap/day fats. Multifold enhancement in production and turnover has also been predicted for basic, specialty and knowledge intensive Indian chemical industries. A 9% CAGR as against 6% in 2013 has been predicted for the metal fabrication sector, leading to a value of INR 936528 crores. An aggressive growth has been predicted for the composite industry to reach value of INR 46000 crores by 2035, this probably would accelerated by the penetration of composites into various manufacturing segments. Interestingly, the demand for composite materials is expected to go from 360 KT in 2013 to 1123 KT in 2035. Demand for electronics in Indian market has been predicted at USD 3200 billion by 2035, of which a likely target for domestic manufacturing could be in the region of USD 800 billion.

As India is and would continue to be a major supplier for global textile and leather demands, the predictions for the same have been worked out at the global rather than Indian level. Global demand for staple fibre and spun yarn has been predicted to 79 and 135 million tonnes, while that for woven fabric

would 737 billion sq.mts and the value added product – apparel would be 293 billion pieces. Growth rate of predominantly used raw materials for leather making remaining constant, the forecast is that another 50 mil pcs of raw hides/skins would be added by 2035 from the current 547 mil pcs.



DEMANDS BY ESTIMATED POPULATION OF 1560 MILLION BY 2035

TECHNOLOGY TRENDS

Technology can be described as one that provides the manufacturing sector the "edge" in a globally competitive environment. Though productivity increase, environmental management, energy conservation, use of benign resources have been in vogue for over two decades in manufacturing sector, the future will hold substantial differences.

Changes from the vertical structure to becoming part of a global complex integrated system will be more pronounced in the future. Innovations would come from the need to meet the requirements. Manufacturing process innovation could include technologies like additive manufacturing (3D printing) and maskless lithography. Technologies to produce new materials or to enable multi-scale manufacturing, including those which would turn manufacturing more sustainable would be the next important trend as we get closer to 2035. Manufacturing systems would also adopt improved test and measurement methods including non-destructive testing protocols. Other technology trends that are likely to happen would include increasing degree of automation and improvements in precision manufacturing – combination of robotics, automation and human and innovations in supply chain management.

All these efforts will keep environmental and economic sustainability as its prime motive through more efficient consumption of energy and increased use of recycled and composite materials. Technology trends across platforms could be grouped under

a. nano-engineering of materials and surfaces
b. additive and precision manufacturing
c. adaptive automation
d. next generation electronics

e. continuous/bio-manufacturing and
f. sustainable manufacturing

In addition to existing technologies, technologies that are true enables of a new class of products are also likely.

Technology usage in food processing industry can be classified as conventional and advanced. It is likely that the advanced technologies such as electron beam irradiation, micronization, use of radiowaves, ultrasonics etc. would be employed for drying. Food processing would see use of technologies such as high pressure processing, ozone, pulsed electric fields, ohmic heating etc. It is also likely that technology for enhancing the shelf life, quality standardization, packaging etc. would be developed for traditional Indian foods. Owing to several long-term health effects such as obesity associated with current day life style foods technologies to create new products based on cereals, pulses, fruits and vegetables, beverage products, dairy products etc. would be forth coming. Concept of intelligent packing is also likely to be adopted.

Technology for providing clothing to the growing population by way of modulating the textile machinery would be one of the major trends in the future. This would include increase in spindle speeds, automated controls for cotton processing, technologies to boost the production of man-made fibres, employing nanotech outputs for enhancing performance of apparels, technical textiles etc. Innovations in apparel industry to introduce smart features, wear comfort for user will also be a trend to look for.

Technology trends for chemical industry would include non-Si based semiconductors, natural gas substitution, ethylene from bio ethylene, bio substitutes for traditional plastics, biopolymers, controlled release solid

formulations for fertilizers, dry rather than steam reforming for ammonia synthesis, modified urea production systems, fuel cells in the electrolytic cells systems for chloroalkali manufacture, changes to age old methods of acid manufacture, precipitated silica as replacement for carbon black in automotive tyres, bio refinery platforms etc.

Replacement of harmful and difficult to treat solvents with more benign and recyclable solvents would be a priority for several industries. Interestingly, the zero emission norms for textile or leather industry would lead to even replacement of water with solvents, which are more easily manageable. Leather industry is likely to go more biobased than chemical and also work towards better integration with material science – so as to be able to manufacture customer desired products.

Being the largest contributor to the GDP of all goods producing sectors, technology trends in metal fabrication sector is governed by a host of parameters involving production capabilities, marketing strategies, finance, HR potential and environment. Likely trends in this sector are towards enhanced utilization of CAD/CAM in fabrication, waste minimization, adoption of green raw materials etc. Interest shown by automotive and aerospace OEMs in carbon fiber applications, adoption of technologies for semi-automated molding, etc. would be the driving force for composite manufacturing globally. In India, sectors such as energy, transportation, construction, civic bodies etc. are likely to drive the technology forward. Associated technology drivers are likely to be in areas such as reduction in weight, emissions, multifunctional materials, steel replacers etc.

Technology trends for micro and nanotechnology would be based on the enablers, which are the existing and emerging markets. The enablers for the technology development are likely to be automation of processes, micro/nano robots, photonic equipment, additive manufacturing and multiple integration systems such as nano-bio-info technologies. In India, the need for the precision manufacturing industries is likely to enable new technologies for micro/nano manufacturing.

The core of the electronic end equipment – the CMOS integrated circuits would grow for a decade or so, with their operation speeds on the rise. The manufacturing eco-system is likely to move to fabrication-less companies who would design their products and outsource the same to third party non-competitive manufacturers. Reaching the basic physical limits to CMOS scaling would mean the

development of technologies for improving chip performance via increased system-level functionality (system-on-chip concept). FINFET (nonplanar, double-gate transistor built on an silicon-on-insulator substrate) will also be looked at as a new option for replacing CMOS.

Enabling the manufacturing sector to be faster, responsive and adopting to customer desires would be the central role of technology. Technology trends for Indian industry needs to be one of one-upmanship rather than that of an adopter or follower

TECHNOLOGY GAP ANALYSIS

Significant gap exists between the technology available with several developed and developing nations and India. According to the World Bank Indicators, this gap could be attributed to the low amounts of FDI as percent of the GDP and also to the presence of relatively small export sector as a percentage of GDP. While the small presence has the advantage of protection against economic meltdown, it also prevents the nation from reaping the gains of economy at better times. The contribution of high technology service exports to the overall exports from India lies at just around 5%. Even though India has a large bank of higher education institutions and graduates, it apparently has only 160 researchers for every million people (as of 2010). The expenditure on R&D is at about 0.8% of GDP. All these have led to Indian manufacturing sector resorting to import of technology for manufacture of goods in India.

In the case of food sector, Indian presence in the areas of technologies for food processing in the niche areas such as extension of shelf life, flavoring and coating, fortification etc. is low. Technologies employed for such activities may have to be imported and remodeled to suit products for Indian people. The attitude of the developed world, which in earlier times had shifted their manufacturing needs to developing world owing to higher costs of labor and waste management is changing. Use of technology to contain labor costs and environmental impact is likely to signal a trend towards reestablishment of manufacturing sectors in these countries, signs of which are perceptible in textiles and leather. To meet such challenges, Indian textile and leather sectors would have to automate the labor-intensive processes.

Technology to replace ring spinning, overcome restrictions in operational speed of cotton yarn looms and modulating the traditional sewing methods to meet needs of production of value added garments have been identified as some of the gaps in the textile sector. For the leather sector, developing technology to produce leathers with customer-desired properties from available rather than the present trend of ideal raw material is one of the major challenges. Technological gaps also exist for translation of existing markets to niche segments such

as personalized footcare products, intelligent upholstery and garments and also for exploring new product segments such as aviation upholstery. Biggest challenge for Indian leather sector would be to meet societal commitments and gain environmental acceptability and yet enhance the cost-benefit ratio through adoption of appropriate technology. As the disposable income of Indian population increases, Indian leather sector would find a need for constant modulation of technology to meet challenges of synthetics, cost of production and time of production.

In comparison to the raw material intensive processes such as food, textile or leather, the metal fabrication sector is highly technology dependent. Innovation presents opportunities to produce new components to replace existing or obsolete components, meet price pressures and consumer needs of strength, reliability, durability and functionality. Technology gaps related to manufacturing sector include energy intensive operations, low levels of customization, automation, flexibility and agility, poor product design and life cycle management, and limited use of simulation tools.

Technology gaps in the composite industry are very high as it is currently only for FRP and GFRP based systems. Technology for manufacture of carbon fibres, cutting down manufacturing costs, design of composite based products and automation of production lines is called for. In the case of semiconductor industry, the predominant gap has been the absence of wafer fabrication units. Cost intensive technological facilities are required to enhance production in India. In the case of micro nano manufacturing, a large gap exists in technology between India and rest of the world. Technology and facilities for multi-tasking machine tool manufacture, nano fabrication etc. are not adequate today.

In essence, the predominant gap that exists in manufacturing sector of India is the absence of cost intensive technologies associated with the manufacturing sector. Indian technology leaders and institutions need to make a compromise between technology sourcing and development as required.

TECHNOLOGY DRIVERS FOR 2035

Technologies for 2035 have been analyzed by adopting three scenarios, viz., when disposable income in 2035 remains same as 2013, increases by 25% from present and increases by 50% from present. Technologies for the manufacturing sector in India would strongly depend on the consumer demands, which would change with disposable income. One of the characteristic changes likely is the shift from the economies of scale to that of economies of scope.

Food processing sector, for instance, would look forward to technologies for convenience foods, customized food for elderly, infants, children, sports persons, paramilitary, lactating mothers etc. Manufacturing sector like leather would, depending on increase in disposable income, move from manufacturing common products like traditional footwear to customized personal foot care products, leaving the traditional footwear markets to non-leather synthetic materials. Accordingly, technologies for 2035 would have to be able to couple smart features to meet customer needs. Similarly in textiles, the global demand for woven fabrics is expected to be 737 billion sq. mts. High performance fabrics would find applications in automotive textiles, healthcare, personnel protective garments etc.

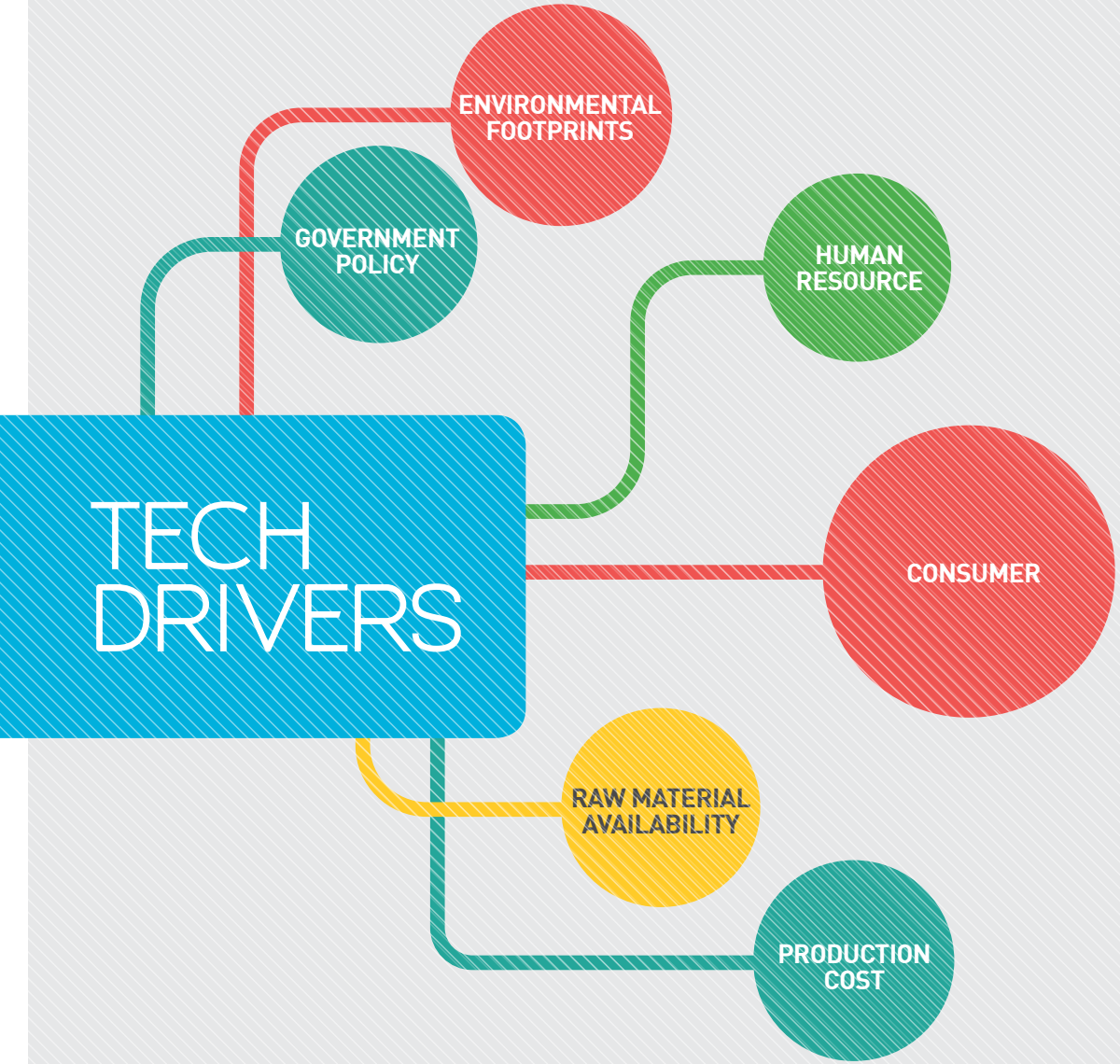
In the case of electronics, meeting the demands of the consumer electronics as well as needs of industry will be two different but requisite needs. For instance improved device technology and new system structures are needed for improving the overall performance of electronic systems. The semiconductor industry will itself go through various stages such as system-on-chip, additive technologies for the existing CMOS, NEMS switches etc. Metal fabrication industries would look forward to technologies ranging from that for overcoming post weld heat treat to cryogenic joining, adaptive welding to welding without

HAZ, disposable moulds, ultrasonic plastic assembly etc.

Developing state-of-art composite technologies from engineering to operational level through use of modeling, systematic process selection and procedure development so as to employ composites in niche areas such as automotive, aerospace and marine industries is considered a future need. The nascent micro and nano manufacturing industry should create adequate capability in nano structuring, coating, replication and characterization at affordable cost.

Common technological goals for the manufacturing sector of India could be summarized as

- reducing environmental footprints
- adopting non-destructing testing methods
- adopting to changing labor / HR scenarios
- developing product recyclability methodologies
- adopting to global accelerated technological changes, so as to be in tune with intensified global competition
- exploring niche market areas such aerospace, alternative energy production industries and life style products
- meeting the increasing consumer/ customer demand based on their disposable income
- reducing cost of production, energy consumption, specific raw material dependability


ENVIRONMENTAL FOOTPRINTS
GOVERNMENT POLICY
HUMAN RESOURCE
TECH DRIVERS
CONSUMER
RAW MATERIAL AVAILABILITY
PRODUCTION COST


Taking Indian manufacturing to global best in terms of material, energy and water consumption leading to reduced environmental footprint
Guaranteeing requisite material and energy for the growing manufacturing industry needs at globally competitive costs
Transforming Indian food processing to meet quantity and quality requirements through zero waste methods
Making India a globally competitive producer of textiles and apparels through adoption of superior technologies
I
II
III
IV
GRAND CHALLENGES
V
VI
VII
VIII
Ensuring sustainable manufacturing technologies to turn all available raw material into value added consumer desired leather products
Building indigenous cost effective nano structuring, coating, replication and metrological capabilities
Ensuring skilled manpower, appropriate level of automation, precision and productive fabrication equipment, design capabilities, globally acceptable testing facilities and standards
Providing state of art fabs and infrastructure to promote large scale ICT and electronic appliances manufacture in India

- Strengthening institutional architecture to promote innovation and creativity
- Reframing and refocussing industry
- Building coalitions, relationships etc. with stake holders with emphasis on economy of scale / scope and R&D investment

RECOMMENDATIONS

- Investment inducement through clusters
- Skill development support with appropriate certification to ensure productivity
- Promoting industrial value and needs
- Govt. support for technology transfer / modernisation / technology acquisition / design know how
- Benchmarking against global best

Growth of any manufacturing sector would depend on a favorable policy atmosphere that assures the industry of a long-term sustained investment climate

Industry would require an ecosystem that promotes high technology, productivity improvement, cheap raw material base and power

Innovation would be the key to success. Kindling innovation through new education models and promoting out of box thinking right from schools is needed

Technology is only a pathway. Bringing in corporate accountability and new methods of marketing are required to promote technology

POINTS TO EMPHASIZE

Indian S&T has in it to make bigger strides. Manufacturing sector could lead the upward movement of India as a technology superpower. Appropriate linkage of education, technology incubation, entrepreneurship, industrial policy and external relationships could provide the right atmosphere for manufacturing sector to take India forward by way of contributing towards 30-35% of GDP by 2035

BLUE SKY RESEARCH

Common to all manufacturing sector industries some of the areas for blue sky research are

Mass production of multifunctional products

Custom designed and self assembled materials

Reducing the time of processing

For natural product dependent processes, modulating raw material quality through genetic modulations

Biologically inspired nano scale process / fabrication

Zero emission processes

Noise and odour free production

TIFAC, India's think tank has recently brought out the Technology Vision 2035 document, which was unveiled by the Honorable Prime Minister of India, Shri. Narendra Modi on 3rd January, 2016. This document outlines the aspirations of Indians in 2035, the different prerogatives they would be assured of and also the technologies that would enable them to be achieved.

To turn the vision into reality, TIFAC is supplementing the Vision document with comprehensive technology roadmaps on 12 sectors it deals with. The technology roadmaps would provide insights on future technology trends, R&D directives, pointers for research, business opportunities, anticipated challenges, policy imperatives pertaining to each sector. Manufacturing is one of the sectors, for which technology roadmap has been evolved.

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