TECHNOLOGY VISION 2035

TECHNOSCAPE

Technology Roadmaps — *a snapshot*

TIFAC

TECHNOLOGY INFORMATION, FORECASTING AND ASSESSMENT COUNCIL (TIFAC)
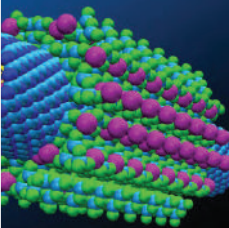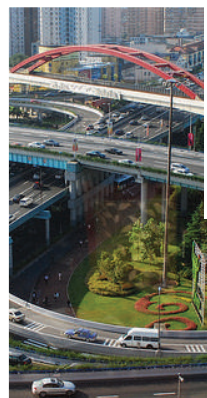
TECHNOSCAPE

"The future has already happened.
Technology is just the echo bouncing back at humanity"
says Gray Scott, the noted futurist and techno-philosopher. Alive
to its mandate to keep a watch on the technology horizon for the
country, TIFAC has made an attempt to trap these echoes and
script the Technology Vision 2035 for India. The vision is anchored
in the aspirations of the Indians today and hooks
on to the needs of Indians in 2035.

With a view to turn the vision into reality, meet the aspirations of
people, assure delivery on expectations with full force, TIFAC is
supplementing its Technology Vision 2035 with roadmaps on 12
sectors, it has specially focussed upon. Each document provides in-
depth insights in the sector it deals besides providing a
future perspective and technology. This booklet provides a
snapshot of broad coverage, key facts and an indicative
list of future technologies.

Education

*Realizing the full potential
of every Indian*

ISSUES ADDRESSED

- Literacy, Creativity & Skills
- Culture, Recreation and the Good Life
- Access: Anyone, Anywhere, Anytime
- Lifelong Learning
- Testing, Evaluation & Certification,
- Integration, Aggregation & Flexibility
- Technology in Education

EMERGING TRENDS AND CONCEPTS

- **Adaptive Learning** programmed for desired learning output
- **Adaptive Testing** replacing *one-size-fits-all* assessment of academic proficiency
- **Collaborative & Social Learning** that allows construction of knowledge with peers or in social groups
- Lectures and home assignments get swapped in **Flipped Classroom**
- Game play with defined learning outcomes through **Game based learning**
- **Hybrid or Blended Learning**, a combination of classroom and online learning
- **Learning Analytics** which decipher trends and patterns from educational big data
- **Massive Open Online Course** (MOOC) aimed at unlimited participation and open access *via* web
- **Remote/ Internet Labs**

- **Reputation metrics** as a substitute to institutional certifications like degrees
- **Virtual Learning Environment** for delivering learning materials to learners *via* the web and includes assessment, collaboration and communication tools

FUTURE TECHNOLOGIES

- 3D Printing
- 4G/5G Communication Technology
- Artificial Intelligence
- Brain Computer Interface
- Cloud Computing
- Gesture Recognition
- Holography
- Internet of Things
- Machine Vision
- Machine Augmented Cognition
- Photonics
- Quantum Computing
- Real Time Translation
- Volumetric Screens
- Wearable Technology

Medical Sciences & Health Care

VISION

Ensuring affordable and accessible health care to every Indian through prophylactic, promotive, curative and rehabilitative aspects of technologies

MISSIONS

- Enhance longevity and health span.
- Encourage nutritional intervention for better health
- Expand health awareness especially hygiene & public health
- Eliminate preventable infant & maternal mortality, improve mother and child health care
- Eradicate natural outbreaks and control infectious diseases
- Evolve novel therapeutic approaches
- Ensure minimization of all forms of disabilities
- Ensure synergy & quality of indigenous and modern system of healthcare
- Efficient networking of rural and urban healthcare delivery system
- Encourage and implement indigenous biomedical technologies

FACTS AND FIGURES

- India's Life expectancy will reach **72 years by 2035** from 66 years in 2013

- Maternal mortality rate will reduce to **15/100,000 by 2035** from the current 190 deaths/100,000 live births (2013)

- Under-5 mortality rate will reduce to **6/1000 by 2035** from the current 53 deaths/1000 live births (2013)

- Total health spending will be **5.7% of country's GDP by 2035,** up from the current 4.0% (2013)

- Out-of-pocket **health spending** will come down from the current 58.2% in 2013 of the total health-care to **30% by 2035**

- **Health worker density** per 1000 population (doctors- allopathy, nurses and midwives) will reach **4.66% by 2035** from 1.29% in 2011

FUTURE TECHNOLOGIES

- Personalized medicine
- Digital Health delivery
- Brain Computer Interface
- Synthetic Biology
- Next generation genomics
- Wearable devices
- Bio-printing and regenerative medicine
- Optogenetics
- Robotic surgical system
- Controlled drug delivery
- Smart Assistive devices

BLUE SKY RESEARCH

- Gene manipulation to delay ageing process and increase health span
- Neo-eugenics to reduce or eliminate rare genetic disorders
- Regeneration of organs
- Biological scanner to indicate multiple pathogenic load of an individual

Food and Agriculture

VISION

State-of-the-art technologies to ensure adequate, nutritious, healthy and safe food for growing population

BROAD COVERAGE

⋏ Status of Indian agriculture and projection for 2035

⋏ Issues and challenges

⋏ Farmers and their needs in 2035

⋏ Strategies to overcome the challenges

⋏ Inter relationship of agriculture and other important sectors

⋏ Technology perspectives and policy issues for future

FACTS AND FIGURES

⋏ **Food grain** production: 265.5 MT (2013-14) and estimated **392 MT (2035)**

⋏ Per capita **net availability of food** grains: 510.8[P] gm/day (2013) and estimated **456.8 gm/day (2035)**

⋏ **Milk production:** 137.7 MT (2012-13) and estimated **230.5 MT (2035)**

⋏ Per capita **availability of Milk:** 299 gm/day (2012-13) and estimated **454 gm/day (2035)**

⋏ **Meat production:** 5.9 MT (2012-13) and estimated **15.5 MT (2035)**

⋏ **Fish production** (both marine and inland): 9.58[P] MT (2013-14) and estimated **16.87 MT (2035)**

⋏ **Egg production** (in billion numbers): 69.7 (2012-13) and estimated **132.8 (2035)**

[P] Provisional

FUTURE TECHNOLOGIES

⋏ Advanced Genomics and Phenomics

⋏ Precision Agriculture and Robotic farming

⋏ Hydroponics/Aquaphonics and vertical farming

⋏ ICT application in agriculture particularly sensor technologies

⋏ Nanotechnology applications

⋏ Multipurpose crops (sucrose, fodder, fuel etc.)

⋏ Biofortification

⋏ Conversion of C_3 to C_4 crop plants

⋏ E-sensing (e-nose & e-tongue)

⋏ Remote sensing and GIS applications

⋏ Perennial cereal crops

⋏ Rapid diagnostic tools for detection of zoonotic diseases

⋏ Apomyxis for fixing hybrid vigour

⋏ Molecular manufacturing of food

Water

●○○ VISION

Water security for all: More from less for more

●○ BROAD COVERAGE

○ Augmenting water availability

○ Challenges of water quality

○ More crop per drop in agriculture

○ Managing wastwater

○ Desalination

○ Mitigating uncertainties and impact of calamities

○ Monitoring and surveillance of water quality

●○○ FUTURE TECHNOLOGIES

○ Smart leak detection system

○ Smart monitoring, energy storage and technologies to increase efficiency of cooling towers & boilers

○ Water purification technologies based on in-situ treatment, biomimetic, novel materials (gra-

phene, CNT, FO) and ultra-sound

○ Recycling and reuse technologies for zero discharge

○ Harnessing atmospheric moisture to meet fresh water shortages

○ Seismic tomography for investigating rigidity of rocks

and understanding litho-logical characteristics for construction of dams, reservoirs and tunnels

○ Ground penetration radar to detect ground water surface and water contamination

○ Climate resilient cropping system

○ Geo-synthetic & poly-fibre for canal lining

○ Trenchless technologies for water infrastructure

○ Immersion vibratory roller compactor concrete

●○ FACTS AND FIGURES

○ More than **80 percent of fresh water** resource is consumed in agriculture.

○ The cumulative demand for water — from ca. **650 BCM** in 2010 to ca. **1100 BCM** in 2050

○ The estimated annual loss of **live storage** capacity is 1.3 BCM

○ The Country generates ca. 400 Gm^3/annum of **domestic sewage**, of which ca. 30% is from Class I & II cities.

○ **19 states** are affected by fluo-

ride, 7 states by arsenic, 16 states by nitrate, 8 states by salinity ingress, 4 states by inland salinity

●○ FUTURE RESEARCH AREAS

○ Non-contact sensors to measure water level anywhere across the depth and width of the river

○ Robust, tamper-proof and reliable water meters that can be clamped without any plumbing

○ Agriculture in the sea to grow plants, like sea weeds to yield edible components which can source micronutrients

○ Microbial Fuel Cell that generates electricity through the metabolic activity of electrochemically active bacteria using wastewater as substrate

○ Development of net water positive materials for water purification

○ New generation of RO membranes, like Graphene that work on the basis of chemical engineering and rely less on energy to push water molecules across them

○ Hydro-fracturing during floods to maximise the water recharge

Energy

◑◔ VISION

To provide affordable access to energy services for all Indians enabling an improved quality of life

◐◔ BROAD COVERAGE

- ⩗ Upcoming challenges with current and future projections
- ⩗ Different energy supply & efficiency scenarios
- ⩗ Sectors covered:
  - ▪ Buildings & Communities

- ▪ Fossil fuels (Coal, Oil & Gases)
- ▪ Industry
- ▪ Renewables
- ▪ Transport
- ▪ Nuclear
- ▪ Rural Energy
- ▪ Smart Grid
- ▪ Energy Storage

◐◔ FACTS AND FIGURES

- ⩗ **40%** of the population have **no access** to electricity & commercial energy sources (2013)

- ⩗ **Fossil fuels** account for about **80%** of the electricity supply (2013)

- ⩗ Electricity usage in 2035 would be in range of **2746-5554 Billion kWh** (1807-3654kWh/Capita/Year), considering constant efficiency of conversion (25% as in 2010)

◐◔ FUTURE TECHNOLOGIES

- ⩗ **COAL:** Pulverised Coal Super Critical (PC-SC), Pulverised Coal Ultra Super Critical (PC-USC), Atmospheric Circulating Fluidised Bed Combustion (AC-FBC), Pressurised Circulating Fluidised Bed Combustion Super Critical Combine Cycle (PCFBC – SC- CC), Integrated (Coal) Gasifier Combined Cycle Technology

- ⩗ **OIL & GAS:** Technological developments on oxidative, bio catalytic, adsorption, and membrane technologies, Hydrogen production from heavier fossil fuels and hydrocarbon waste

- ⩗ **RENEWABLES:** Pyrolysis, gasification, Yeast / enzyme based conversion to high qualityhydrocarbon fuels

- ⩗ **NUCLEAR ENERGY:** Thorium based power reactor

- ⩗ **RURAL ENERGY TECHNOLOGIES:** Micro wind turbines, hybrid renewable energy sources, micro grids for energy distribution

- ⩗ **ENERGY STORAGE TECHNOLOGIES:** Super capacitor, Nickel battery & fuel cell etc.

◐◔ FUTURE RESEARCH AREAS

- ⩗ **BUILDINGS:** Carbon absorbing concrete, cooling and conditioning through lifestyle products

- ⩗ **FOSSIL FUEL:** Zero emission, sustainable coal power generation

- ⩗ **RURAL ENERGY:** Micro turbines to run on bio fuels, bio gas and bio mass

- ⩗ **INDUSTRIAL ENERGY:** Process technologies that will enable to operate at closer to thermodynamic limits, bio mass boiler with supplier efficient grate combustors, advanced insulating materials for thermal systems

- ⩗ **NUCLEAR ENERGY:** Utilizing the large Thorium reserves by converting it to fissile U-233

Environment

VISION

*Sustainable, clean
and healthy environment*

BROAD COVERAGE

⌃ Human habitat

⌃ Industrial environment

⌃ Climate change

⌃ Green house gases & air pollution

⌃ Natural Resources Management

FUTURE TECHNOLOGIES

⌃ Cost effective recovery of **precious metal**

⌃ Re-designing of **biomedical equipments** to facilitate segregation and reuse

⌃ **Space conditioning** technology

⌃ **Low cost** treatment at source to make it a resource material

⌃ **Immobilization technology** (biological and chemical for leachable solid waste)

⌃ Remediation through **nano material** for both bio and non bio components

⌃ Biomass boilers / gasification using rice and straw husk waste with high **silicon** content

⌃ Pathways for conversion of **cellulosic biomass** in combustible (liquid fuel) form

⌃ **Thorium route** for power generation

⌃ **Carbon capture** by using algae from fuel gas

⌃ Direct use of renewable energy for H_2O electrolysis

FUTURE RESEARCH AREAS

⌃ Plasma technology for waste management

⌃ Development of more efficient biological processes for industrial & municipal solid waste treatment and management

⌃ Development of cereals/ crop variety with nitrogen fixation properties

⌃ Faster biodegradation of pesticides

⌃ Lowering /shortening half life of pesticides

⌃ Development of pest and disease resistant crop varieties

⌃ Biological control of pests & diseases

⌃ Development of high power to weight ratio systems for energy efficiency

⌃ Storage battery with fast recharge and long life time

⌃ Technology for mitigating forest fire

⌃ High yielding rice, varieties that grow under non flooded conditions in unsaturated (aerobic) soil

⌃ Transgenic crop plants resistant to biotic and abiotic stresses

⌃ Microbial mining

Habitat

○○○ VISION

"Sustainable Habitat – 2035: Affordable decent habitat for all

○○○ BROAD COVERAGE

- Possible future scenarios
- Trends, concerns and issues in the area of planning, materials and technologies
- Challenges in the building sector and its implementation strategies
- Future technologies including blue sky research ideas

○○○ FACTS AND FIGURES

- **Building stock** demand: 411 million sq. m (2012) to **690 million sq. m** (2035)
- **Cities with population** of 1 million plus is expected to increase from 53 in 2011 to **68** by 2030
- By 2030, **40%** of Indian population would live in **urban areas** against 32% in 2014
- Demand for **affordable houses** will increase from 25 million in 2010 to **40 million** by 2035
- The urban and rural housing shortage is at **18.8 Million** and **47.4 million** in 2012-13

○○○ TRENDS IN HOUSING

- Energy efficiency and cost effective
- Faster and efficient construction
- Safe and environment friendly
- Disaster resistant buildings
- Net zero energy buildings
- Inbuilt intelligent features

- Prefabricated technology combined with appropriate connecting devices
- Sensor technologies for smart and intelligent building systems
- Embedded technology to enhance the quality of construction
- Alternative sources of energy for sustainable habitat: Solar, Building Integrated Photo Voltaic (BIPV), Wind, Thermal etc.
- Material alternatives to aggregates
- Additive manufacturing (3D Printing)
- Local and recyclable materials

○○○ BLUE SKY RESEARCH IDEAS

- Housing to adapt to unexpected situations such as, changing climates, earthquakes, cyclones, fire etc.
- Habitation on the Moon and under the sea
- Building as living organisms
- Interactive building interiors —change of colours, lights, temperature by just touching the walls just like touch screen
- City underneath a city or a desert
- Cement free / water free concept

Transportation

⬤◯◯ VISION

Sustainable, clean, safe, inclusive, smart and integrated mobility system

⬤◯◯ SECTORS COVERED

- Railways
- Roadways
- Airways
- Waterways

⬤⬤◯ FACTS AND FIGURES

- Second largest road network (4.7 Million km) in the world carries **85%** of Passenger traffic and more than **60%** of freight traffic

- **13-fold** growth in passenger **cars** in India by 2035 as against 2005

- Total **freight traffic** (Road & Rail) will be **13,000 BTKM** in 2031-32 (Billion Tonnes Kilometers) as against 2000 BTKM in 2011-12

- **Average trip length** of road will increase from 2.5-10.3 Km in 2007 to **4-14.8 Km** in 2031

- India will become the **5th largest** in domestic **air travel** by 2031

⬤⬤◯ FUTURE TECHNOLOGIES

- Advanced propulsion technologies
- Fuel cell drive train
- Flying cars
- Alternative fuel based transportation

- Active aerodynamics
- Intelligent vehicles- Autonomous power train and vehicle control
- Super high efficiency electric machines - superconductors
- Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communications
- Magnetic levitation
- Tilting train technologies
- Fuel cell technology or renewable sources of energy for all
- Fog vision systems
- Next generation avionics and flight control systems
- Biomimetics design for ship
- Flexible and foldable vehicles
- Automotive Paints to help charge the vehicle
- JPod , Hyper loop, high-speed pressure tubes for transportation
- Evacuated tube transport, non-stop trains

Infrastructure

◐ VISION

To build integrated, robust, technology-driven, cutting-edge infrastructure for inclusive growth, sustainable development and a strong economy

◐ AREAS COVERED

- Urban Infrastructure
- Pipelines (Oil and Gas)
- Roads and Bridges
- Power
- Railways
- Water and Sanitation
- Ports, Shipping and Waterways
- Civil Aviation
- Irrigation Infrastructure
- Human Resource & Capacity Building

●● FACTS AND FIGURES

- Urban population in India to be around **600 Million** by 2030

- Cities with population of 1 million plus is expected to increase from **53** (2011) to **68** (2030)

- Total Road length **4.87 Million KM** (2012) and projected to be **15 Million KM** (2035)

- Total passenger traffic by road and rail is expected to reach **168,875 bpkm** in 2031-32 from **10,375 bpkm** in 2011-12.

- Estimated air traffic for passenger and cargo by 2031-32 is **696.5 Million** and **2.57 MMT** in 2013-14.

- Total cargo traffic and cargo capacity at ports (both major and minor ports) by 2031-32 is estimated to be **3,154** and **4,100 MT** respectively as against **914 MT and 1142 MT** in 2012.

- The demand for unskilled, semi-skilled, support staff and professionals for construction industry is expected to be **92 Million** people by 2022.

●● FUTURE TECHNOLOGIES

- Smart self-healing materials for faster construction

- Increased durability and improved performance of infrastructure, especially roads and bridges

- Geo-synthetics for roads and solar roadways

- Segmented and pre-cast construction in bridges

- Wireless connectivity for safer, quicker transportation—both vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I)

- High Speed Rail corridors of speed above 250 kmph with advanced track technology, automated signalling and train control

- Ultra high performance concrete and tunnelling technologies for railway construction

- Magnetic levitation

- Wireless sensor networks

- Adsorbed Natural Gas (ANG)

- GIS applications for long-range water supply facilities

- Additive manufacturing

Manufacturing
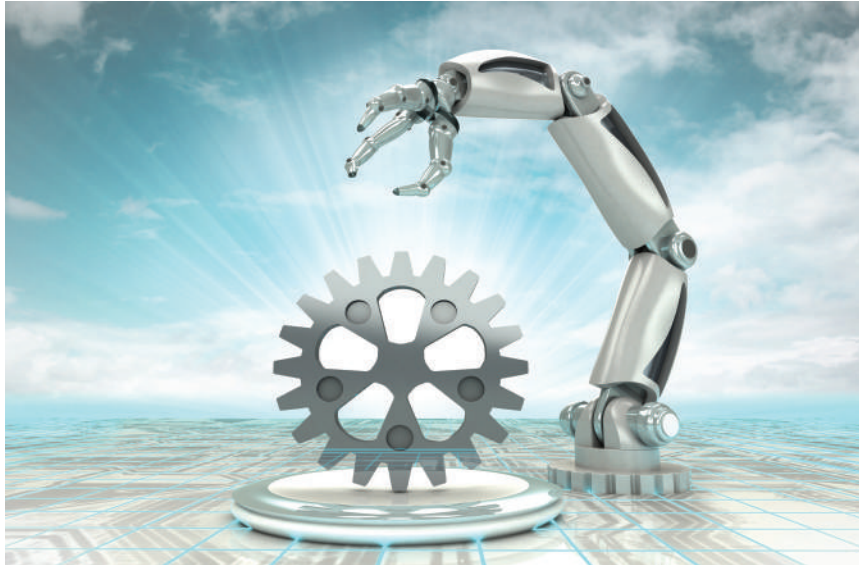
VISION

Strengthening manufacturing base through innovation driven clean, green and lean processes

SECTORS COVERED

- Leather
- Micro Nano Manufacturing
- Textile and Apparel Manufacturing
- Metal Fabrication
- Composite Manufacturing
- Electronic Appliances & ICT products
- Food Processing
- Chemical Manufacturing

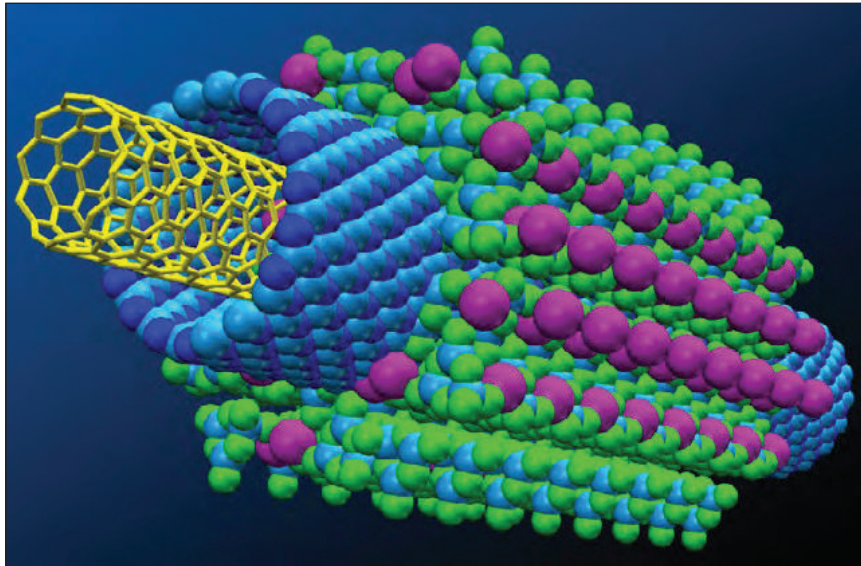## FACTS AND FIGURES

- **Metal fabrication** sector in India expected to generate revenue of **152 billion USD** by 2035

- Value of **textile** and apparel industry likely to reach **USD 140 billion** by 2020 and around **USD 385 billion** by 2035

- Indian **chemical** industry turnover is expected to reach **USD 250 billion** by 2035. Chemical production will reach **260 MMTPA** by 2035

- Demand for **electronics** in the Indian market is expected to grow from US$ 45 billion to USD 400 billion by 2020 and **USD 3200 billion** by 2035 at a growth rate of 15%. The export market is likely to grow from USD 4 billion to **80 billion** by 2020

- Indian **composites** industry is expected to grow steadily and reach approximately **7 billion USD** in 2035

- **Leather garment** would become a high value product with a low volume production. By 2035, main market for leather garments would be the **fashion industry**

FUTURE CONCEPTS & TECHNOLOGIES

- Additive manufacturing (3D printing)
- De-materialisation
- Precision manufacturing
- Process intensification
- Multi material construction
- Lean manufacturing
- Embedded flexible electronics
- Adaptive automation
- Micro-nano manufacturing
- Modularity
- Mass production of multifunctional products
- Nano Photonics
- Water-less processes
- Noise and odour free production
- Zero emission processes
- Biologically inspired nano scale process/fabrication
- Modulating raw material quality through genetic modulations
- Biodegradable/recyclable products
- Big data in bioactive molecule discovery

Materials

VISION

India to be a global leader in niche materials and its processing technologies by 2035

BROAD COVERAGE

- Electronic & Energy Materials
- Metallic Materials
- Biomaterials
- Glass & Ceramics
- Polymers & Composites

FACTS AND FIGURES

- India to emerge as world's second largest **steel** producer **300 Mtpa** by 2025

- Annual consumption of **Aluminium** is expected to touch **10 Mt** by 2020

- India is expected to be the **2nd largest copper** market by 2025, with a size of 2.7 MT

- Recycleability of **Zinc** makes it a preferred metal today and the figure of **~30% recycling** in India is estimated to reach >80% by 2035

- 5% of total world production of **Silicon** during next five years. By 2035, India should aim to target **30%** of total electricity production through Silicon

- In future, **glass** consumption in India to grow at **9 %** in construction, **20%** in automotive, **10-12 %** in consumer goods and **12-15 %** in pharmaceutical sectors

NEXT-GENERATION MATERIALS

- Super-strong Graphene
- Smart Materials and Sensors
- Environment friendly & Bio-degradable
- 100% recyclable ⌃ Sports Material
- Light-weight high strength alloys
- Shape- memory ⌃ Energy saving
- Meta- materials
- Programmable Matter
- Biomimetic materials

FUTURE TECHNOLOGIES

- Functionalised Magnetically directed Ceramic Nanoparticle (MNP) technology for advanced drug delivery
- Perovskite material based solar cells
- Battery made of Self healing polymers
- Technologies for growing large area high quality Graphene
- Injectable scaffolds
- Transparent polymers with a 10-fold reduction in permeability via additives

Information and Communication Technologies

VISION

Paperless activities and services in every form with no physical computer by 2035

APPLICATION AREAS

- Electronics for inclusive society
- Healthcare in India
- Banking
- Telecom
- Energy and Smart Grids
- Government
- Transport

- Industry
- Education
- Commerce
- Agriculture
- Cyber Security
- Disaster Management

FACTS AND FIGURES

- **Second largest** telecom industry in the world with **969 million** subscribers
- **100%** Tele-density by 2020
- **6100 million** smart phone users by 2020
- **550 million** internet users by 2018 (160 million)
- More than **300** million 3G subscribers by 2020
- **Electronics** hardware demand to reach **USD400 billion** by 2020
- Machine to Machine communication (M2M) /Internet of Things will grow to **26 billion units** by 2020
- Cloud Services Market is estimated to reach USD **1.9** billion by 2018 (USD 638 million in 2014)

TECHNOLOGY AREAS

- Solid State display and Photovoltaic
- Photonics
- VLSI design
- Processors and Computers
- Quantum computing, and IC manufacturing
- Speech Technologies
- Robotics
- Cloud Computing Technologies
- Image processing and computing, media and entertainment
- Artificial Intelligence
- Decision, Control and Security systems
- Solar power (PV) battery

BLUE SKY RESEARCH IDEAS

- **Machines /robots to connect all personal and emotional needs**
- **Inter-planetary communications systems**
- **3D telepresence**
- **Sensing devices to be able to feel the product on internet before buying it**
- **Intelligent vehicles to detect emergency situations and take over the control**
- **Virtual Courts and Digital Evidence**
- **Complex real time dynamic disaster management response systems**
- **3D holographic displays with foldable screens**

VISION FOR 2035

"Technology in the service of India: ensuring the security, enhancing the prosperity and strengthening the identity of every Indian."