TECHNOLOGY VISION 2035

TECHNOSCAPE

Technology Roadmaps — a snapshot

TECHNOLOGY INFORMATION, FORECASTING AND ASSESSMENT COUNCIL (TIFAC)
“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**

### 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**

### 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
Medical Sciences & Health Care

**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 healthcare 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

**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.

**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

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

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 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 MT (2013-14) and estimated **16.87 MT (2035)**
- **Egg production** (in billion numbers): 69.7 (2012-13) and estimated **132.8 (2035)**

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 C3 to C4 crop plants
- E-sensing (e-nose & e-tongue)
- Remote sensing and GIS applications
- Perennial cereal crops
- Rapid diagnostic tools for detection of zoonotic diseases
- Apomixis for fixing hybrid vigour
- Molecular manufacturing of food
**Water Security for all: More from less for more**

- Augmenting water availability
- Challenges of water quality
- More crop per drop in agriculture
- Managing wastewater
- Desalination
- Mitigating uncertainties and impact of calamities
- Monitoring and surveillance of water quality

**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 Gm3/annum of domestic sewage, of which ca. 30% is from Class I & II cities.
- 19 states are affected by fluoride, 7 states by arsenic, 16 states by nitrate, 8 states by salinity ingress, 4 states by inland salinity

**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 (graphene, 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
- 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

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

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

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

Future Research Areas

- RENEWABLES: Pyrolysis, gasification, Yeast / enzyme based conversion to high quality hydrocarbon 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.

Vision

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

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FUTURE RESEARCH AREAS

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Environment

Sustainable, clean and healthy environment

ENVIRONMENT

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 $\text{H}_2\text{O}$ electrolysis

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

Human habitat

Industrial environment

Climate change

Green house gases & air pollution

Natural Resources Management
**Habitat**

“Sustainable Habitat – 2035: Affordable decent habitat for all

**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

**Blue Sky Research Ideas**

- 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
- 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

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.

VISION

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

SECTORS COVERED

- Railways
- Roadways
- Airways
- Waterways

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

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

VISION

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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

**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 US$ 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.

**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

**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
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

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

Electronic & Energy Materials
Metallc Materials
Biomaterials
Glass & Ceramics
Polymers & Composites

FACTS AND FIGURES

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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

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 US$ **1.9 billion** by 2018 (USD 638 million in 2014)

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

TECHNOLOGY AREAS

- Solid State display and Photovoltaic
- Photonics
- VLSI design
- Processors and Computers

BLUE SKY RESEARCH IDEAS

- 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

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