NAVIGATING INDIA'S TECHNOLOGICAL LANDSCAPE

KEY FINDINGS OF A2K+ STUDIES
"ACCESS TO KNOWLEDGE FOR TECHNOLOGY DEVELOPMENT AND DISSEMINATION"

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH
MINISTRY OF SCIENCE AND TECHNOLOGY
GOVERNMENT OF INDIA

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Secretary
Government of India
Department of Scientific & Industrial Research

Azadi Ka Amrit Mahotsav

वैज्ञानिक और औद्योगिक अनुसंधान विभाग
विज्ञान और प्रौद्योगिकी मंत्रालय
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Message

The Access to Knowledge for Technology Development and Dissemination Studies [A2K+ (studies)] programme of Department of Scientific & Industrial Research (DSIR) analyses current status of Science, Technology and Innovation (STI) landscape in India. By engaging a diverse range of stakeholders across the Indian science sector like industry, MSMEs and grassroots-level participants, the programme has gathered invaluable data and insights.

I am extremely happy to note that the A2K+ (Studies) programme has supported over 45 studies across various technology domains, aligning with our National Socio-economic vision. These A2K+ (Studies) serve as an evidence base for S&T assessment, which is crucial for informed decision-making, policy formulation and fostering responsible innovation that benefits both Industry and Science.

This compendium brings together the breakthrough findings and recommendations under the A2K+ (Studies) programme. It is hoped that this publication will serve as a valuable resource for disseminating knowledge within the Indian Science Sector.

Congratulations to the team for their dedication and hard work in bringing out this compendium.

18 June, 2024
New Delhi

N. Kalaiselvi
(N. Kalaiselvi)

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सत्यमेव जयते

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GOVERNMENT OF INDIA
MINISTRY OF SCIENCE AND TECHNOLOGY
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FOREWORD

The country would celebrate 100 years of independence in 2047. By the year 2047, India aims to be a global powerhouse with the size of economy around USD 30 trillion, with a per-capita income of USD 18,000-20,000, with strong public finances and a robust financial sector. India is well placed on the path to becoming the second largest economy in the world by 2047 with country's demographic dividend, prospering middle class, expanding digital economy and sustainability-focused economy which are going to act as pillars of strength in successfully attaining the vision for 2047.

In order to achieve the above, it is important to have good study reports on emerging areas of technology which provide useful information and knowledge base to industry, academia, research institutions, consultants, entrepreneurs and policy makers. Status reports on technologies from public funded institutions, that are ready for commercialization with a view to catalyse the translation of research output from institutions to market are of immense importance. Such reports also provide precious data that can be used in decision-making by academia, industry and the government and hold immense importance due to its role in disseminating significant recent developments and best practices in the country, as well as across the globe.

The "Studies" programme under Access to Knowledge for Technology Development and Dissemination (A2K+) scheme of Department of Scientific & Industrial Research (DSIR) has been supporting studies on topics relevant to current Science, Technology and

Innovation (STI) landscape in India. Over the years, the programme has gathered invaluable data and insights from these reports. It is time to consolidate the outcomes of the reports prepared under the "Studies" programme, to outline the findings of the systematic research and identify the gaps which need immediate attention.

The current Compendium **"Navigating India's Technological Landscape"** is an effort to document the findings, learnings and outcomes of the study reports supported by the "Studies" programme under Access to Knowledge for Technology Development and Dissemination (A2K+) scheme of Department of Scientific & Industrial Research.

18th June, 2024
New Delhi

Dr. Sujata Chaklanobis
Scientist-G and Head A2K+

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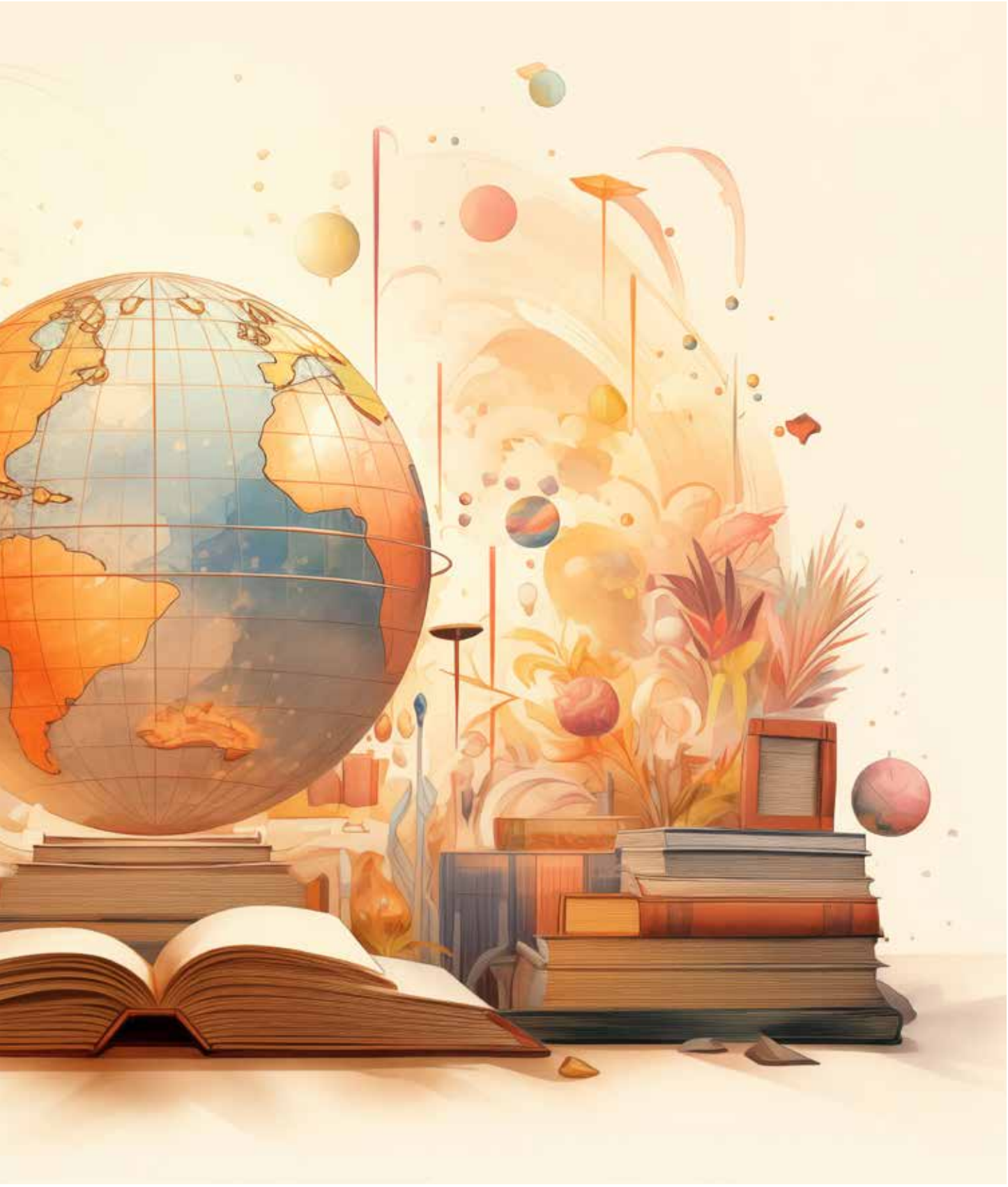
Introduction



The "Studies" programme, under the Access to Knowledge for Technology Development and Dissemination (A2K+) scheme of the Department of Scientific and Industrial Research (DSIR), Ministry of Science and Technology, Government of India, is dedicated to the study and analysis of developments in emerging technology areas. The programme meticulously documents the STI findings, learnings, and outcomes, ensuring their wider dissemination. The programme aims to provide a valuable knowledge base and useful information to industry, industry associations, academia, research institutions, consultants, entrepreneurs, research students, and policymakers, aiding them in their further work in these domains. Additionally, the A2K+ (Studies) programme supports the preparation of status reports on technologies developed by publicly funded institutions that are ready for commercialization. This effort catalyzes the translation of research outputs from institutions to the market, fostering partnerships between key stakeholders. The programme's impact extends beyond insights, encompassing the formulation of predictive models based on machine learning (ML) and artificial intelligence (AI) technologies to support businesses and research, as well as the development of technology platforms that serve as access points for information for all stakeholders.

The Studies programme plays a crucial role in policy development. Policymakers can leverage the programme's comprehensive insights to formulate adaptive policies that align with the rapid pace of technological advancement. This ensures that regulatory frameworks remain agile, supportive of innovation, and equipped to address potential challenges and risks.

The A2K+ (Studies) programme as launched in 2014, however in last 4 years the programme has undergone many empirical changes, diversifying to provide collaboration opportunities among stakeholders in the technology domain. It has initiated dialogues among industry, academia, and policymakers to foster a cohesive ecosystem for technological advancement.

The methodology followed in these studies is heterogeneous, exhaustive, and comprehensive. Each study involves qualitative research and quantitative surveys with various stakeholders. The primary survey instrument is a structured questionnaire prepared by the implementing agency in consultation with experts and the DSIR team. The sampling framework is designed to ensure equitable representation of all sectors and stakeholders involved in the research domain of the topic of interest. Data collection is conducted through personal visits, seminars, workshops, telephonic discussions, and rigorous desk research.

At its essence the Studies programme is a proactive response to the rapidly shifting technological landscape, to yield a wealth of meticulously crafted informative insights and establish a comprehensive knowledge repository. The programme is uniquely designed to cater to a diverse audience, encompassing Industry professionals, associations, academic Institutions, Research Bodies, consultants, entrepreneurs and policy makers.

This publication seeks to showcase the findings and outcomes of the studies supported by the A2K+ (Studies) programme, particularly those conducted in the last four years. This compendium aims to contribute to the collective efforts of advancing technology and policy decisions responsibly and also facilitating access to knowledge and dissemination of information.

Importance of study reports in Technology Development and Dissemination

Future Research and Commercialization Strategy
The studies serve as a go-to solution for stakeholders, providing strategies based on current national and global scenarios.

Status Reports and Analysis
The studies prepare status reports and thoroughly review and analyze various developments in emerging technology domains.

Assessment of current trends
Study reports provide a comprehensive overview of current national and international technological trends highlighting emerging areas of STI.

Policy Formulation and Regulation
The A2K+ Studies program extends to informing policy and regulations, empowering decision-makers with data-driven insights.

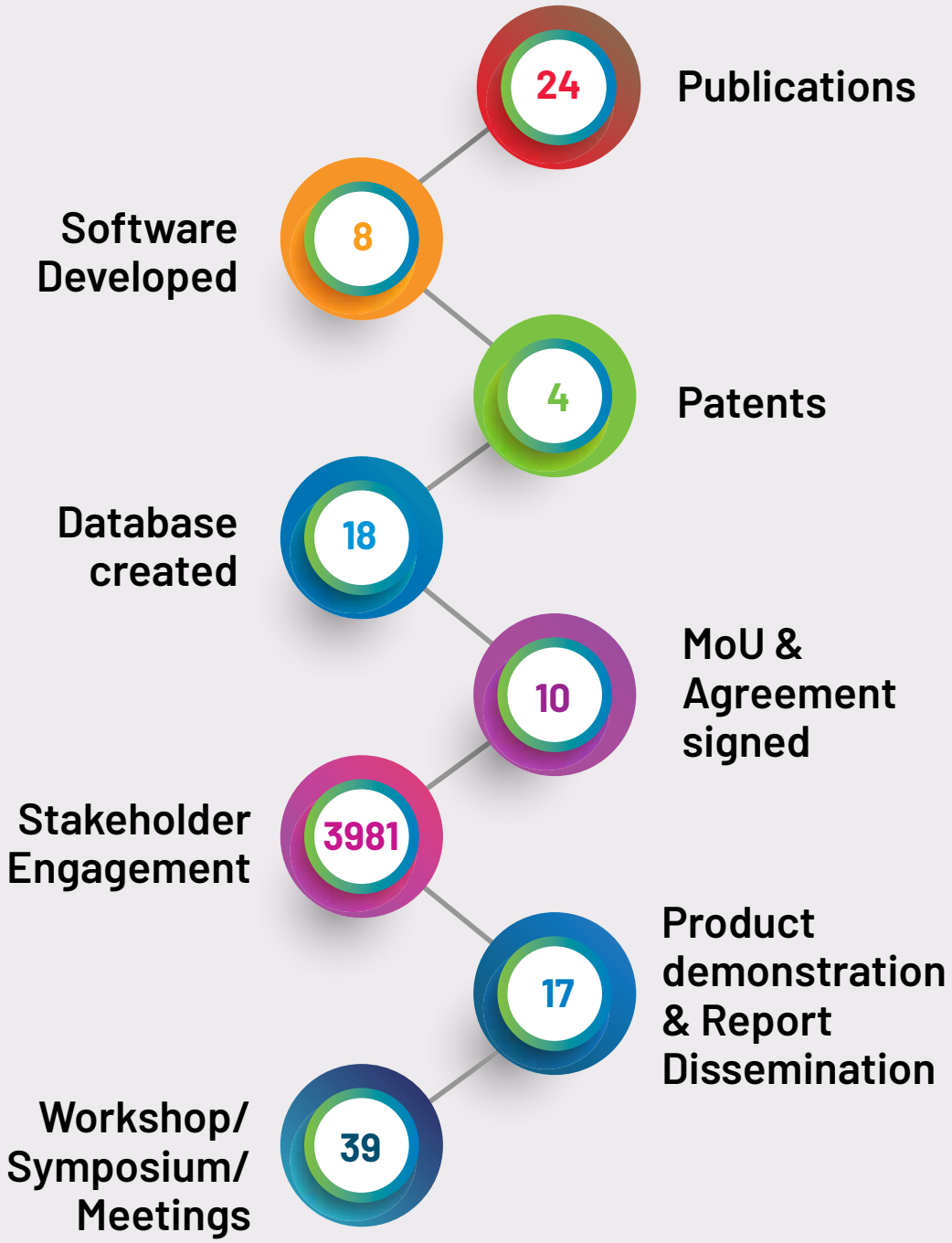
Supporting MSMEs
The A2K+ Studies program offers tailored solutions, leveraging insights to enhance competitiveness and sustainability in the evolving tech landscape.

Best Practices and case studies
Through showcasing best practices and compelling case studies, the program equips stakeholders with actionable strategies, fostering innovation and growth across industries.

Technology Assessment and evaluation
Conducting rigorous technology assessments and evaluations, the A2K+ Studies program ensures informed decision-making, guiding stakeholders towards optimal technology adoption and implementation.

Methodology adopted for carrying out the studies

A2K+ Studies Output



New Initiatives under A2K+ Studies programme

The A2K+ (Studies) programme is adopting a range of new initiatives to broaden its influence and effectiveness. A primary aim of the A2K+ programme is knowledge dissemination and bringing out recommendations for a wide range of stakeholders, encompassing MSMEs, industry, academia, researchers, social organizations, associations, government, and regulatory bodies. These initiatives include innovative methodologies and strategic efforts, underscoring the programme's dedication to remaining at the forefront of research and industry needs.

Empirical changes have expanded the scope and impact of each study, addressing diverse technological challenges and fostering collaboration among stakeholders. Through ongoing developments and forward-looking measures, the A2K+ (Studies) programme supports more robust methodologies and seamless e-governance processes. The forthcoming projects highlight the programme's commitment to continuous enhancement and its aspiration to make significant contributions to the industrial and research sectors, ultimately broadening its areas of functionality and impact.

Themes supported under A2K+ (Studies) programme

The A2K+ (Studies) programme of the Department of Scientific and Industrial Research (DSIR), supports a diverse range of studies aligned with the emerging technological needs of Indian businesses and the research sector. The thematic areas are meticulously selected based on ongoing dialogues with various line ministries and their associated departments, ensuring that the studies address real-world problems faced by key stakeholders and are aligned to SDG goals.

The current supported studies under the programme can be broadly categorized into five key themes namely technology commercialization/technology readiness levels (TRLs), ICT & Education, Adoption & future of Digital Technologies, Smart Cities & Waste Management, Industry & MSMEs.

THEME I: Technology Commercialization

The commercialization of technology plays a pivotal role in ensuring that innovations reach the end-user, driving economic growth and fostering a culture of innovation and creativity. In line with India's "National Intellectual Property Rights (IPR) Policy," which aims to create an ecosystem conducive to innovation, technology commercialization emerges as a key component of this framework.

Technology Readiness Levels (TRLs) serve as a crucial metric for assessing the maturity of technological developments across various stages of product development. Ranging from ideation (TRL 1) to commercialization (TRL 9), these levels provide a standardized framework for evaluating the readiness of technologies for market deployment.

Under the A2K+ Studies programme, the Department has undertaken 13 studies focused on identifying barriers to technology commercialization and developing strategies to facilitate the process. Of particular significance are the six studies centered on the theme of "Technology Readiness Assessment of TRL-6 and Above Technologies," aimed at assessing technologies developed in academia, research labs, and industry.

These studies employed a systematic approach, including scouting, identification, and assessment of TRL 6 level technologies across six technology sectors. A nationwide survey was conducted to gather technological data from various stakeholders, including academia, research labs, incubation centers, and industries. Through workshops, webinars, interviews, and surveys, technology stakeholders were actively engaged to gain insights into the challenges of commercialization.

Under this theme, the A2K+ Studies programme has contributed significantly to advancing the agenda of technology commercialization in India. By identifying key challenges and proposing actionable strategies towards technology commercialization, these studies pave the way for harnessing the full potential of innovative technologies, thereby fostering economic growth and societal development.

The studies culminated in six compendiums featuring over 500 TRL 6 and above level technologies developed across India's Science, Technology, and Innovation (STI) landscape. Moreover, they identified specific barriers to commercialization faced by technology inventors and proposed strategies to successfully deploy these technologies in the market. These insights have informed the development of a roadmap for policymakers, providing a framework with a responsibility assignment matrix based on stakeholder inputs.

Six Compendium of TRL 6 and above level technologies prepared under A2K+ Studies program of DSIR:

Study Theme	Organization	Number of technologies assessed and reported in the compendium
Food Processing and Agriculture	IIT, Dhanbad	278
Materials and Manufacturing	IIT Jammu, Jammu	102
Electronics, telecommunication and Manufacturing	IIT Roorkee	104
Clean Energy & Transportation	FITT, New Delhi	116
Healthcare, Chemical and Pharmaceutical	TIFAC, New Delhi	100
Water Purification Technology	ICCW, Chennai	100

Another significant project under this theme was' Inventorization of microbe based technologies developed in National Agricultural Research System (NARD) for catalyzing their effective translation from lab to land'. The study collated a list of 246 companies dealing in the area of biofertilizers and biocontrol agents. A web based database has been developed (www.agrimicrotech.com) through which information on available microbe based technologies can be obtained by the industries ; The technology readiness levels (TRL) evaluated under AICRP have also been included for ready reference for the industries.

Meanwhile a **CSIR-CSIO, Chandigarh** study examined commercializing technologies at Public funded research organizations (PFROs). They found government policy, Industry hurdles and collaboration as key factors. Recommendations suggested focus on better Industry engagement through dedicated units. Additionally, incubation centres and flexible licensing were also suggested to improve technology commercialization ecosystem. A study by **CSIR-IHBT,** further explored the academia-Industry linkages across the country and bringing out challenges and recommendations fostering collaborative projects.

The combined quantitative and qualitative output indicators under theme **Technology Commercialization/ Technology Readiness Levels (TRL)** from the supported studies is shown below

Theme II- ICT and Education

The landscape of education in India has undergone significant transformation in recent years, with a steadfast commitment to providing equitable access to quality schooling nationwide. Integral to this evolution is the strategic integration of technology, which plays a pivotal role in fostering inclusive, dynamic, and student-centric learning environments. The advent of digital technologies has opened up a realm of possibilities, offering innovative pedagogical approaches aimed at empowering students

and nurturing their confidence throughout their educational journey.

Aligned with the vision of the Ministry of Education, the Department of Scientific and Industrial Research (DSIR) has embarked on the A2K+ programme, a collaborative initiative aimed at advancing research, development, adoption, and implementation of Information and Communication Technology (ICT) tools in school education. Information and Communication Technology (ICT) plays a transformative role in education, known as e-learning or digital learning, offering benefits across various dimensions. Online learning platforms and Open Educational Resources (OER) improve access by overcoming geographical barriers and reducing costs. Personalized learning is enhanced through adaptive learning systems and interactive software, tailoring education to individual needs. Teacher professional development benefits from online training and resource sharing, fostering collaboration. Enhanced learning resources leverage multimedia content, Virtual Reality (VR), and Augmented Reality (AR). Global collaboration is facilitated through online tools, connecting students and educators worldwide. Remote and blended learning models provide flexibility, while data analytics and learning analytics monitor student performance and predict needs. Educational gamification makes learning engaging, and digital literacy skills are developed through ICT integration. The integration of ICT democratizes education, improves teaching and learning, and equips students for the digital era, but challenges like the digital divide must be addressed for equitable access.

Within this framework, DSIR has provided support for a series of studies focused on exploring the Pan India landscape of ICT tools in education, with a particular emphasis on fostering inclusivity and addressing the diverse needs of learners. The studies have achieved Mapping of ICT Technologies and Tools for Addressing the Special Needs of Visually Impaired Students with a Comprehensive Inventory of Assistive Technology Tools with manufacturer details and an information booklet for special educators, compiling top-rated ICT tools and resources sourced from academia, research organizations, government institutes/bodies, and EdTech companies. The integration of ICT democratizes education, improves teaching and learning, and equips students for the digital era, but challenges like the digital divide must be addressed for equitable access.

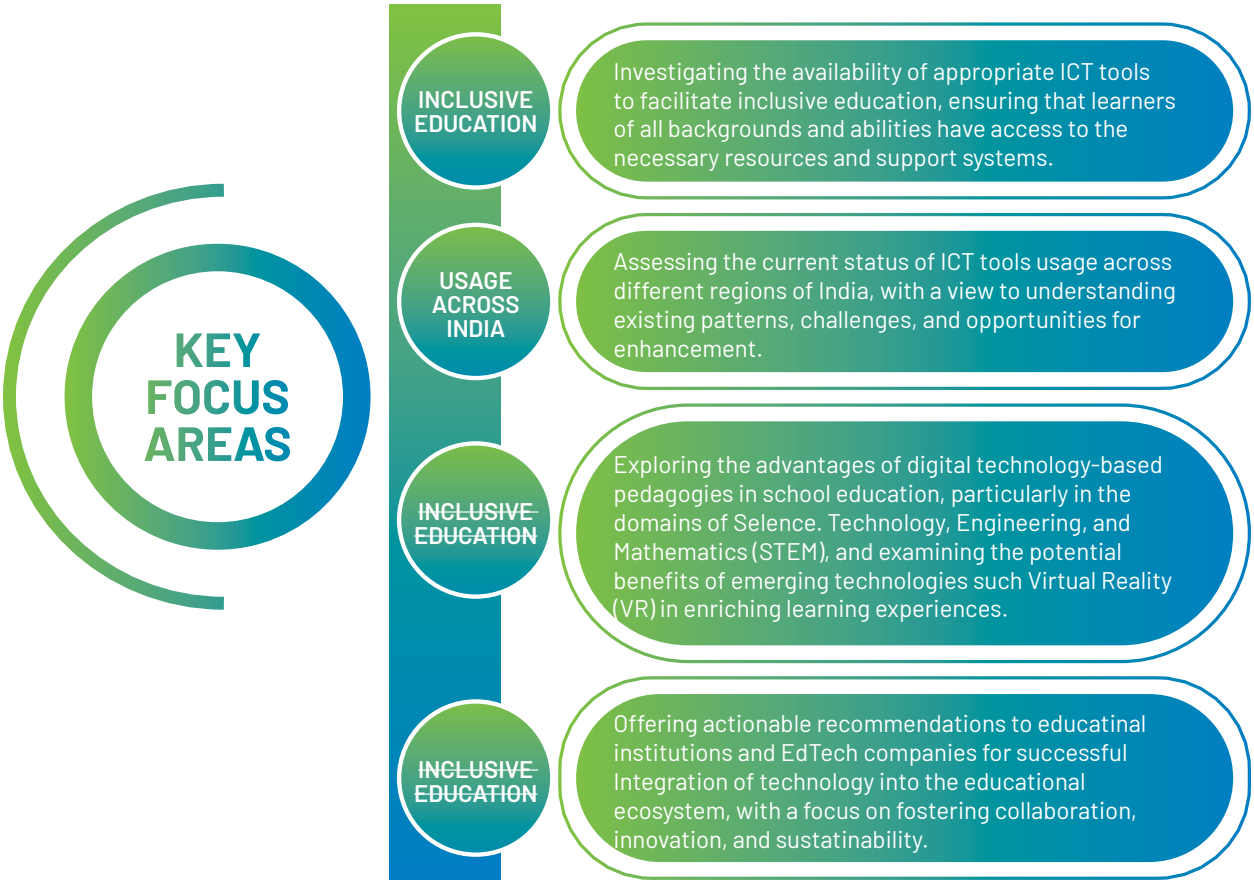
One such study awarded to **IIT, Hyderabad** examined the feasibility and impact of Virtual Reality (VR) on learning by creating AR/VR educational content, evaluating its impact and assessing school readiness for VR based teachings.

Three studies supported to **CUSAT, Kochi, SIMS, Pune** and **MNIT, Jaipur** under this theme conducted a comprehensive analysis on awareness, availability, accessibility, affordability and extent of use of various ICT tools by all learners, including those with special needs, aligned with India's NEP 2020 goals. These studies recommended clear ICT guidelines, continuous teacher training, community engagement, collaboration with tech providers, and CSR funding for assistive technologies to enhance inclusivity in special education in India. One of these studies emphasized the ICT revolution for inclusive education for visually impaired (VI) students in India, promoting their integration into mainstream schools per the 2016 Rights of Persons with Disabilities Act. These studies

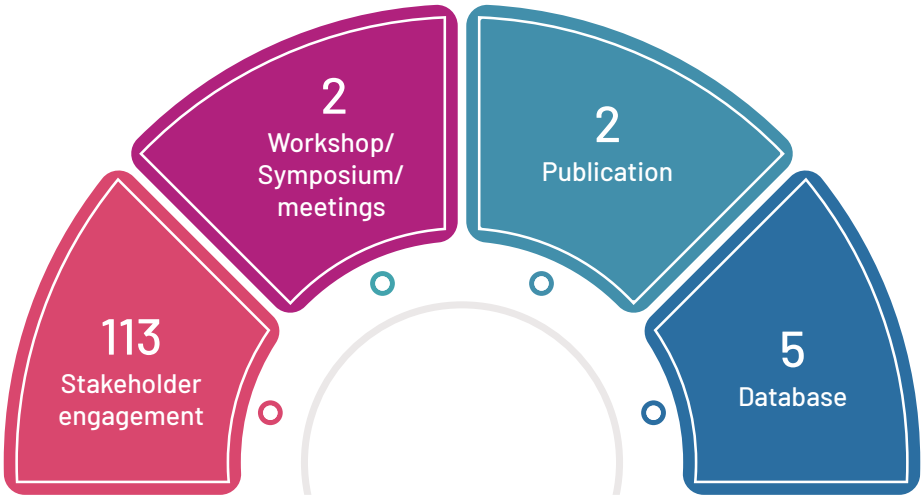
achieved mapping of ICT Technologies and Tools for Addressing the Special Needs of Students and a comprehensive Inventory of indigenous and imported Assistive Technology Tools available in the Country.

The studies collectively highlighted the importance of collaboration among educators, administrators, social organizations and technology developers (including EdTech companies) in realizing the full potential of ICT for improved learning outcomes. Key recommendations include developing inclusive policies, financial support, and enhancing assistive technology infrastructure. Cross-ministry collaboration is essential for successful implementation.

Through these studies, DSIR under its A2K+ (Studies) programme aims to contribute to the ongoing discourse on leveraging technology to enhance the quality, accessibility, and inclusivity of education in India, thereby empowering learners and preparing them for success in an increasingly digital world.



The combined quantitative and qualitative output indicators under theme ICT and Education from the supported studies is shown below:



Theme III: Adoption and Future of Digital Technologies

Artificial intelligence (AI) is rapidly becoming a cornerstone of technological advancement across the globe, with the global AI market projected to grow at a compound annual growth rate (CAGR) of 37.3% from 2023 to 2030. This transformative technology is reshaping industries by enhancing efficiency, reducing costs, and providing robust data analytics for strategic decision-making.

The integration of Digital, Internet of Things (IoT), Artificial Intelligence (AI), and Machine Learning (ML) in Science, Technology, and Innovation (STI) has revolutionized both public and private sectors. In the public sector, AI and ML enhance R&D with advanced analytics and high-performance computing. In healthcare, precision medicine and IoT contribute to personalized treatment, while environmental monitoring employs IoT sensors and AI for climate research. Smart cities invest in IoT infrastructure and use AI for data-driven decision-making. In education, digital platforms and AI-driven adaptive learning are prevalent. In the private sector, Industry 4.0 adopts IoT and AI-driven automation for smart manufacturing. Health tech relies on telemedicine and IoT medical devices, while financial services employ AI in algorithmic trading and digital banking. Retail benefits from personalized marketing and supply chain optimization using IoT and AI. Energy and utilities optimize with smart grids and predictive maintenance through IoT and ML. Future trends include increased interconnectivity of technologies, ethical considerations in AI, edge computing, AI for scientific discovery, quantum computing integration, digital

twins, enhanced cybersecurity, and the application of augmented and virtual reality in various domains. Continuous innovation and collaboration between sectors are anticipated to profoundly impact scientific research, technological advancements, and societal challenges.

In India, the adoption of AI and Machine Learning (ML) solutions is accelerating, driving significant changes in organizational operations. The A2K+ (Studies) programme of the Department of Scientific and Industrial Research (DSIR) has supported various studies to explore and facilitate the adoption of AI technologies across different industrial sectors. These studies not only propose AI adoption frameworks at the firm level but also develop numerous ML-based tools to support businesses.

One notable study conducted by the **Centre for Development of Advanced Computing (CDAC)** focuses on the status of AI in the Indian healthcare sector. It highlights the benefits of government initiatives and policies promoting AI in healthcare and identifies startups currently leveraging AI technologies. The report underscores the transformative potential of deep learning (DL) methods in converting vast health data into improved health outcomes. It also addresses the challenges and suggests strategies for researchers and policymakers to overcome these hurdles.

Another significant research effort, supported by the A2K+ (Studies) programme and conducted by the **All India Management Association (AIMA), New Delhi** examines the framework for AI and ML adoption at the firm level using the Technology-Organization-Environment (TOE) framework and the Diffusion of Innovation (DOI) theory. This study reveals that AI/ML technologies are increasingly accessible to small and medium-sized enterprises (SMEs), with 41% of MSMEs at various stages of implementation. The report also introduces a Maturity Assessment Framework for AI implementation in SMEs, illustrating the growing interest and readiness among these enterprises.

The **Rajiv Gandhi Institute of Petroleum Technology (RGIPT), Amethi** has focused on the readiness and interest of Indian refineries in adopting AI/ML technologies for their operations. The programme has successfully funded development of several ML-based tools catering to different industrial needs. For instance, an ML-based predictive forecast model for 37 leather commodities has been developed by **CSIR-CLR**I for the year 2030-31 to support business and research. Study by **IIT Delhi** focused on post –COVID air filteration in central AC units using AI and ML. The study evaluated existing filtration tech. Additionally, a Gaussian process-regression (GPR) based model was created to predict filtration efficiency and pressure drop of high-efficiency HVAC filters using Matlab by IIT Delhi.

Further, a study by the **Indian Institute of Technology (IIT) Indore** highlights the growing demand for real-time Transient Stability Assessment (TSA) in power grid operations. Utilizing the Long Short-Term Memory – Autoencoder (LSTM-AE) technique, the study aims to enhance the efficiency and reliability of power distribution, generation, and transmission. **The Symbiosis Institute of Digital and Telecom Management (SIDTM), Pune** has also developed an efficient long-term load forecasting model for Load Dispatch Centers in India using AI techniques.

Study supported to **Indian Institute of Information Technology and Management (IIITM), Gwalior** explored innovation readiness, research intensity, and technology resilience in Indian manufacturing firms

and their influence on production system excellence. These studies and many other supported under A2K+ (Studies) programme of DSIR collectively showcase the significant strides being made in AI/ML adoption across various sectors in India. They provide a comprehensive overview of the current landscape, the benefits realized, the challenges faced, and the strategic frameworks and tools developed to support further adoption and integration of AI technologies in industrial growth. Under the A2K+ Study programme,

The combined quantitative and qualitative output indicators under theme **Adoption and future of Digital technologies** from the supported studies is shown below.

Theme IV: Empowering the Industrial Sector and MSMEs

The Industrial Sector stands as a cornerstone of economic progress, encompassing a spectrum of manufacturing and production activities vital for growth and development. Within India's industrial landscape, the Micro, Small, and Medium Enterprises (MSME) sector emerges as a pivotal force, contributing significantly to economic expansion. With approximately 46 million establishments, it fosters employment for about 110 million individuals directly and indirectly. Moreover, MSMEs stimulate an entrepreneurial culture, driving innovation across various sectors of the economy.

Recognizing the significance of both large industries and MSMEs, governments and policymakers worldwide advocate for fostering a balanced and resilient industrial ecosystem. Under the A2K+ Studies programme, the Department has championed 13 studies addressing the technological challenges encountered by industries and MSMEs. Ranging from examining branding strategies adopted by MSMEs to delving into the emerging demands of Ultra Precision Machining Technology, these studies provide invaluable insights into the gaps and hurdles hindering indigenous technological development in the Indian market.

These studies extend from broad-spectrum analyses to niche market investigations, offering recommendations for capacity building within the Indian industry and guiding policymakers in formulating effective strategies. Moreover, they have yielded machine learning-based models aimed at leveraging technology to tackle industry challenges, alongside compiling and disseminating databases accessible through common open web platforms. By establishing a central repository and information support facility, these studies serve as a beacon for industries across India.

Key Contributions of the Studies Include:

01 A study by **ICAR-Central Institute of Agricultural Engineering (CIAE),** forecasted the demand for farm implements up to 2030 across five states, while evaluating the technological capabilities of agricultural machinery manufacturers.

02 Another study by **Indian Council for Research on International Economic Relations (ICRIER)** explored the role of standard-setting organizations and industries in fostering an IoT environment within MSMEs, incorporating the potential of AR, MR, and VR technologies.

03 Additionally a study conducted by **CMTI, Bangalore** on Ultra Precision Machining (UPM) technology and nano coatings in India. UPM study highlighted motivations, challenges like cost and skilled workforce shortage and existing applications

04

A Study by **All India Management Association (AIMA), New Delhi** analyzed the Role of Branding in enhancing the competitive growth of MSME sector. The study emphasized that MSMEs need to discover better approaches including long term branding strategy to adapt for developing marketing needs. Recommendations focused on capacity Building Effort, Provisions for International and National level of training to be made for MSMEs dealing with marketing and branding so that they are exposed to the dynamic market environment and inculcate the best practices prevailing globally.

ABV IIITM, Gwalior

Development of a novel framework for assessing innovation readiness, research intensity, technology resilience, and production system excellence, providing managers with a valuable toolkit for organizational assessment

CMTI, Bangalore

List of nano coating material developed by Industry/academia intended to coat on the products & Identification of requirements and challenges faced by MSMEs in various sectors related to Nano coatings

National Institute of Technology, Srinagar

Creation of a fault diagnostic model enhancing the performance evaluation of Advanced Dielectric Materials in Transformers, addressing the ambiguity in traditional fault detection methods

PDPM-IIITDM, Jabalpur

Design and development of a small-scale prototype integrating IT technology and metering solutions like overload Monitoring System (OMS) and software to address high failure rates in distribution transformers

These studies not only underscore the critical role of technological innovation in propelling industrial growth but also exemplify the transformative impact of collaborative research and strategic policymaking in driving economic prosperity.

The combined quantitative and qualitative output indicators under theme **Empowering the Industrial Sector and MSMEs** from the supported studies is shown here:

Theme V: Smart Cities and Waste Management

India's urbanization journey is marked by rapid expansion fueled by rural-to-urban migration and economic concentration. Amidst this surge, sustainability emerges as a pressing concern, especially with India's ambitious goal of achieving carbon neutrality by 2070. As a part of A2K+ (Studies) program stands efforts were made to address these challenges, emphasizing the pivotal role of modern construction techniques, innovative building materials, and waste management practices in enhancing the quality, safety, and sustainability of urbanization.

Smart waste management is a cornerstone of efficient and sustainable smart cities, utilizing technology to optimize waste collection and enhance environmental sustainability. The integration of IoT sensors in waste bins enables real-time monitoring and automatic alerts for optimized collection routes. RFID technology facilitates waste tracking, sorting, and recycling. Smart fleet management utilizes GPS and sensor technologies for real-time vehicle monitoring and predictive maintenance. Some smart cities invest in waste-to-energy technologies, reducing landfill dependence and generating renewable energy. Public awareness is heightened through mobile apps and incentive programs. Centralized control systems and automated sorting facilities enhance efficiency, while big data analytics inform data-driven decision-making and policy planning. Blockchain ensures secure waste tracking, and sensors detect hazardous materials for safe disposal. Community collaboration platforms facilitate communication between stakeholders, fostering a holistic approach to waste management in smart cities.

The studies awarded under the theme of Smart Cities and Waste Management not only aims to tackle environmental concerns but also align with India's sustainable development goals, offering enhanced value for stakeholders and society at large.

One such study, undertaken by **TERI, New Delhi,** focuses on catalyzing informed decision-making and promoting the widespread adoption of cutting-edge practices in advanced building materials and energy-efficient design strategies. Through the development of a dynamic web-based knowledge portal and an interactive online discussion forum, this study facilitates communication between stakeholders, fostering a holistic approach towards data-driven smart cities. By curating a compendium comprising best practices, illuminative case studies, and a wide array of pertinent literature, including government policies and research papers, this initiative aims to provide free access to invaluable knowledge, thereby driving sustainable urban development forward.

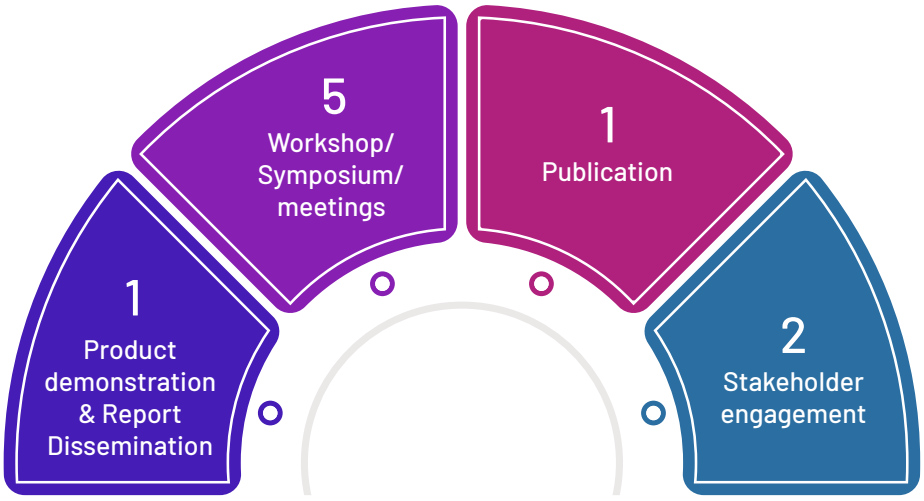
Smart waste management emerges as a cornerstone of efficient and sustainable smart cities, leveraging technology to optimize waste collection and enhance environmental sustainability. An awarded project to **Rajiv Gandhi University of Knowledge Technologies, Basar,** focuses on mitigating environmental pollution caused by plastic waste by converting it into valuable construction materials. Through the reuse of shredded plastic waste to enhance the quality of concrete, this study explores various composites, offering innovative solutions to address the plastic waste crisis. The study suggested cost-effective alternatives and recommending

further research and collaboration for wider adoption.

Additionally, another project awarded to **Academy of Technology, Hoogly** within this theme develops an innovative, sustainable, technology-driven solution for collecting, monitoring, and facilitating the transfer of household waste from residential complexes for subsequent recycling and toxicity neutralization. These initiatives not only contribute to environmental sustainability but also foster community engagement and empowerment.

Another study undertaken by TERI, New Delhi, focused available membrane technologies for wastewater treatment, identifying gaps and opportunities for research and commercialization. By focusing on membrane manufacturing status and the current wastewater treatment practices in Indian cities, these studies shed light on the potential of advanced treatment systems to yield high-quality treated wastewater for water reuse, thus contributing to water conservation efforts.

Under the A2K+ Study programme, Department has **supported 5 nos. of studies.** The combined quantitative and qualitative output indicators under theme **Smart Cities and waste management** from the supported studies is shown below.



Theme I: Technology Commercialization

Study Title:

Developing a framework for commercialization of technologies developed at public funded Research Institution

Organization:

Central Scientific Instruments Organisation (CSIR-CSIO), Chandigarh

1. Overview

India aims to become a 5 trillion-dollar economy and shift its image from a vast market to a manufacturing hub. This transformation requires strong policy, strategic, and tactical support for the manufacturing sector. The COVID-19 pandemic, despite its challenges, has also presented new opportunities for

growth. The government is leveraging this crisis to enhance capabilities and drive the country toward self-sufficiency and export strength. Significant policy changes in Science & Technology are underway, identifying technological needs and engaging stakeholders to provide solutions. A robust R&D sector is essential for supporting manufacturing and disruptive technologies, with organizations like Council of Scientific and Industrial Research (CSIR) and public funded research organizations (PFROs) needing to refocus their strategies.

Although PFROs have taken various initiatives to push the technologies developed by them but this has left minimal impact on the Indian economy and the industrial cluster growth around these PFROs. In the last 40 years the Ambala Industries Cluster has not got any major breakthrough.

2. Objectives

1: Finding the status of commercialization of technologies developed at public funded research institutions 2: Identification of lacuna in the commercialization process 3: Developing a framework to strengthen commercialization process

3. Key Findings

Government Policy and Support

Fast-Track Initiatives
Governments recognize the importance of policy support. Initiatives like fast-track translation and commercialization projects for technologies with sufficient maturity levels aim to overcome the "valley of death" (high-risk phase) and accelerate market entry.

National Policies and Patent Laws
Supportive national policies and patent laws create a favorable environment for technology commercialization across various sectors.

PFRO-Industry Relationship

Knowledge Dissemination and Innovation
PFROs play a vital role in generating and disseminating knowledge to industries. This enhances their economic and innovation capabilities, leading to broader socio-economic benefits.

Challenges for Technology Transferees (Industries)

Marketing and Demand Creation
New product technologies require significant investment in marketing and demand creation. Decisions like shelf life and customer acceptance testing become crucial.

Customer Training and Failure Rates
Customers need training on testing methods for newly adopted technologies. The high failure rate (95%) necessitates careful selection of transferees with relevant experience and a willingness to handle technological challenges.

In-House Research Capabilities
Strong in-house research capabilities enable transferees to assess the licensed technology for flaws, obsolescence, or incompleteness. These capabilities also build confidence in the technology.

Prior Experience with the PFRO
Positive experiences with technology licensing and interactions with PFRO scientists foster trust, encouraging repeat collaborations.

Recommendations for Transferors (PFROs)

Streamlined Licensing Agreements
Engaging legal experts to expedite Non-Disclosure and Licensing Agreements minimizes delays associated with centralized legal review processes. This also fosters a more flexible work culture within PFROs.

Comprehensive Support Services
Beyond technology transfer, PFROs should provide adequate support services to licensees, including quality assurance, certification assistance, and testing support (handholding).

Industry Infrastructure and Support Ecosystem

Market Competitiveness:
Robust industrial infrastructure is essential for successful technology commercialization, enhancing market competitiveness.

Entrepreneurship and Innovation Boosters:
Incubators, accelerators, and other stakeholders play a critical role in supporting technology commercialization by fostering entrepreneurship through mentorship, networking, business plan development, and patenting. Proximity to PFROs allows startups and spin-offs to leverage their facilities and equipment.

Communication, Trust, and Commitment

Addressing Legal Issues:
Lack of proper communication, trust, and commitment among stakeholders can lead to technology commercialization failures. The licensing agreement should address potential legal issues arising from such situations.

Technology Appropriateness and Firm Innovation

Market Risk Assessment:
Technology selection requires careful consideration of market risks. Small enterprises, for instance, should conduct thorough market surveys before adopting new technologies, especially when competing with established players.

Importance of Firm Innovativeness:
Existing in-house R&D capabilities allow firms to modify licensed technologies by incorporating features from existing technologies to enhance performance or market acceptance.

Study Title:

Accessing the Techno-commercial Status of TRL-6 and above Technologies in the field of Food Processing and Agriculture

Organization:

Indian Institute of Technology, Dhanbad

1. Overview

To realize the benefits of innovation, it is necessary that they reach the end-user, and the commercialization of the technologies serves that purpose. Commercialization ensures the availability of the technology to the people and acts as an important contributor to economic growth. Thus, it becomes very crucial to know and assess the techno-commercial status of technologies developed in academia, research labs and industry in India. The status study will help the country to commercialize the high-end innovations that will benefit the society. Moreover, the "National Intellectual Property Rights (NIPR) Policy of India is also set to establish an ecosystem in the country conducive to innovation and creativity not only in terms of IP awareness and creation,

but also commercialization and enforcement" (NIPR Report, 2016). Thus, we need to create an ecosystem for the academia and research labs to facilitate and encourage them to commercialize their technologies. This study assessed the technology readiness level (TRL) and identified the challenges in the commercialization of technologies, particularly for high-end technologies, with due consultation from technology developers and prepared the roadmap to policymakers for translation of research output from institutions to the market.

2. Objectives

(i) To access the techno-commercial status of at least 100 or more TRL 6 & above technologies are developed in academic institutes, research labs and MSME sector in India. (ii) To prepare the status report on the techno-commercial status of at least 100 or more identified TRL 6 & above technologies. (iii) To identify the challenges faced by academic institutes, research labs and industry in the commercialization of technologies. (iv) To prepare/create the roadmap for policy makers, technology developers and commercializing agencies for translation of research output from institutions to the market.

4. Key Findings

Technology Readiness Levels and Commercialization Challenges

The study accessed the technology readiness level (TRL) and identified the challenges in the commercialization of technologies in the field of food processing and agriculture, particularly for high-end technologies, with due consultation from technology developers and prepared the road-map to policymakers for translation of research output from institutions to the market.

Distribution of Technologies by TRL

TRL wise classification of promising technologies are like, 68 technologies (25%) belong to TRL 6, and 87 technologies (31%) belong to TRL 7

Technologies Ready for Commercialization

The contribution of ready to commercialize technologies is 40 (15%), belong to TRL 8

Fully Commercialized Technologies

The fully commercialized technologies are TRL 9, total 83 technologies (30%) belong to TRL 9

Overcoming Barriers to Commercialization

The study also identified the specific barriers of commercialization faced by technology inventors and developed strategies to successfully deploy technology in the market.

Policymaker Roadmap

The study has prepared the road map for the policymakers, which will give the framework with a responsibility assignment matrix based on the inputs from stakeholders.

5. Output

01

Developed the exhaustive compendium of 278 technologies in the field of Food Processing and Agriculture.

02

Identified the challenges faced by academic institutes, research labs, and industry in the commercialization of technologies.

03

Proposed strategies to increase the possibilities of commercialization of technologies based on important challenges and relationships.

04

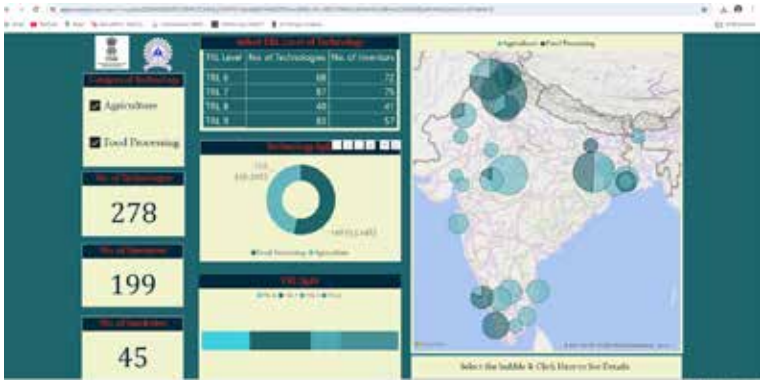
Developed the interactive web portal that highlights the TRL level of technologies in a user friendly manner.

05

Two brainstorming sessions were conducted in which experts from 30 research institutes, academia, and MSMEs participated. During these sessions, the experts engaged in discussions about the challenges they encounter when trying to commercialize these technologies.

6. Dashboard For TRL 6 and Above Technology Visualization

The dashboard designed to visualize technology readiness level (TRL 6) and above serves as a comprehensive platform that not only showcases cutting-edge technologies but also provides users with valuable insights and detailed information to foster a deeper understanding of TRL 6 and above technologies.



Dashboard Link:
https://app.powerbi.com/view?r=eyJrIjoiODJhOGQ5NTEtODRhZC00MjJjLTliNTEtYjMxMjNjY-WQ2OTI5IiwidCI6ImRmODY3OWNkLWE4MGUtNDVkOC05OWFjLWM4M2VkN2ZmOTVhMCJ9

Study Title:

Technology readiness assessment of TRL-6 and above technologies in materials and manufacturing developed in India by academia, research labs and industries

Organization:

Indian Institute of Technology Jammu

1. Overview

Technology Readiness Assessment (TRA), is a process flow for choosing novel technologies to meet the system requirements. This report is intended to provide a detailed outline of technology readiness in an Indian context, present the development of technology readiness levels (TRLs) specific to the material and manufacturing domain, describe the technology readiness analyses approach used in our research, and conclude by discussing the challenges and recommendations. To understand the system design and operation method of TRA in India, the Team circulated a TRL questionnaire to around 500 Stakeholders working in the material and manufacturing sector. The team further Interviewed researchers/Scientists across various labs/industries, successfully scouted Data from 55 Organizations, and collected 203 technologies for TRL Assessment, of which 102 technologies were considered for compendium as they were qualifying TRL level 6 Criteria and above.

2. Objectives

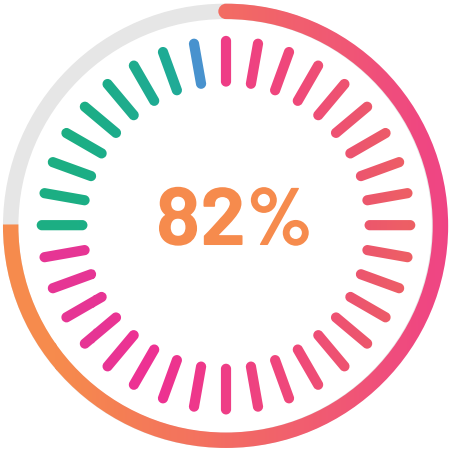
(i) Scouting and tracking of TRL6 level technologies (in the material and manufacturing sector, at least 100 in number) Indian Institutes, Universities, startups and Industries in the field of Materials and Manufacturing Domain. (ii) o identify and assess technologies demonstrated successfully and unproven ideas, and amplify the transparency of decisions in the development of new technologies, (iii) Establish the methodology of technology readiness assessment that can be used for evaluating technology maturity. (iv) Connecting stakeholders with technology developers for successful awareness implementation. (v) Delivering and documenting the importance of technology translation and addressing the complications and challenges encountered in Technology translations.

3. Key Findings

a. Database created

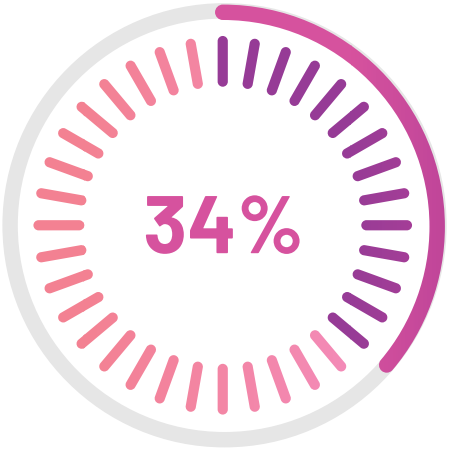
The database of 500 Stakeholders working in the material and manufacturing sector. The team further Interviewed researchers/Scientists across various labs/industries, successfully scouted Data from 55 Organizations, and collected 203 technologies for TRL Assessment, of which 102 technologies were considered for compendium as they were qualifying TRL level 6 Criteria and above.

Technology Scouted From R&D Labs

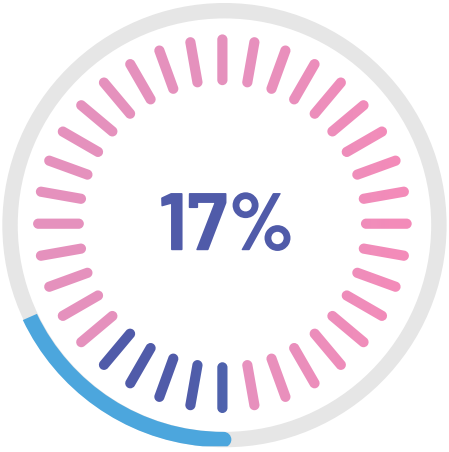


Technology Scouted From IITs

Technology Scouted From Pvt. Universities

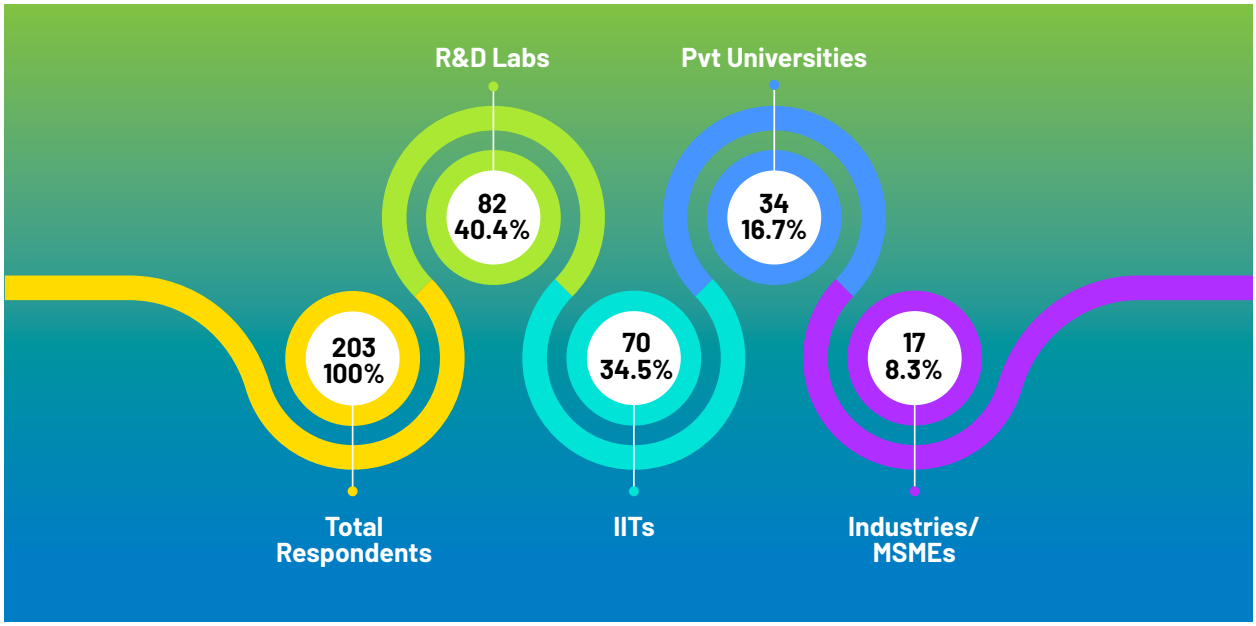


Technology Scouted From Industries/MSMEs



Summary of technologies scouted which includes 82 technologies scouted from the R &D labs, 70 technologies scouted from IITs, 34 technologies scouted from Pvt Universities and 17 technologies scouted from Industry/MSMEs.

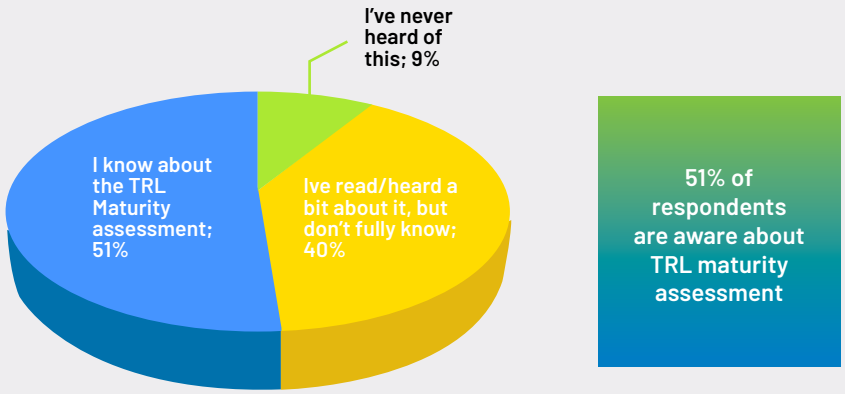
b. Summary of Respondents



Summary of respondents who participated which includes 40.4% respondents from the R &D labs, 34.5% respondents from IITs, 16.7% respondents from Pvt Universities and 8.3% respondents from Industry/MSMEs.

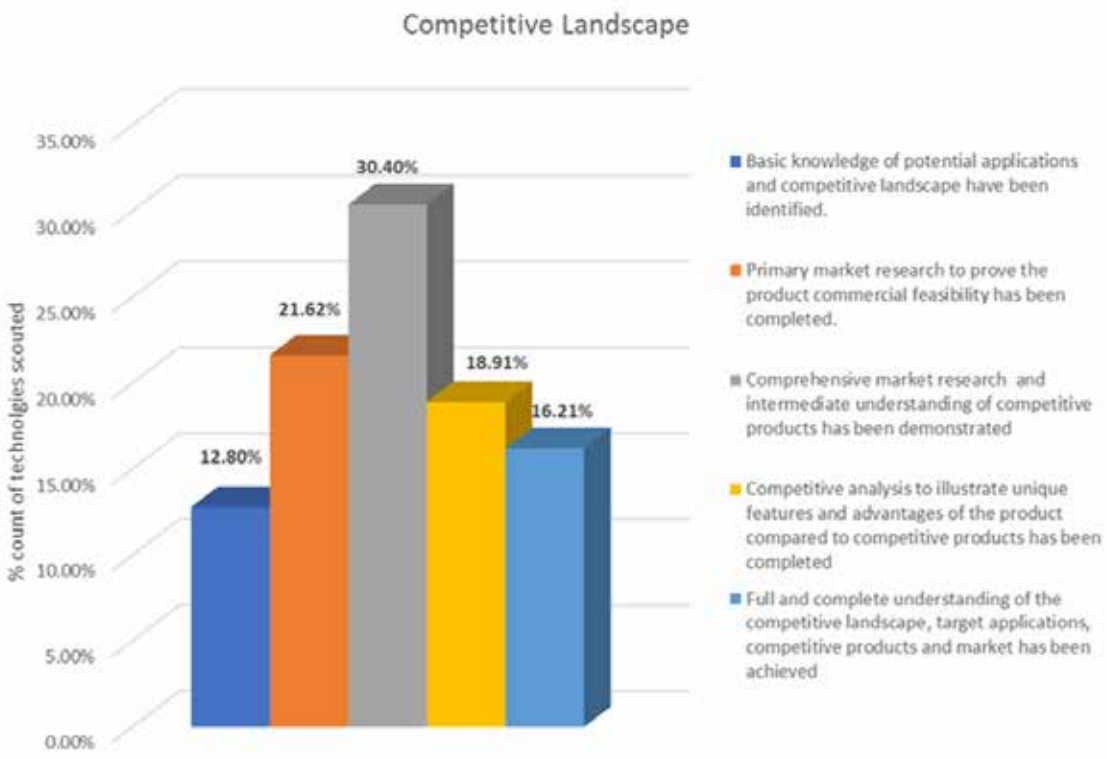
c. The team discovered that most TRL and TRA applications are appropriate and valuable. The team throughout TRA Studies listed eight challenges in commercialization and also provided recommendations for policymakers.

d. TRL Awareness:



TRL Awareness among Respondents who participated in survey. 68% of respondents have TRL assessment awareness, followed by 27% of respondents who have heard of TRL but do not have a complete insight.

e. Competitive Landscape of Technology Scouted:



Overview of Competitive Landscape of Technologies Scouted

16.2%
of technologies scouted have achieved competitive and market goals.

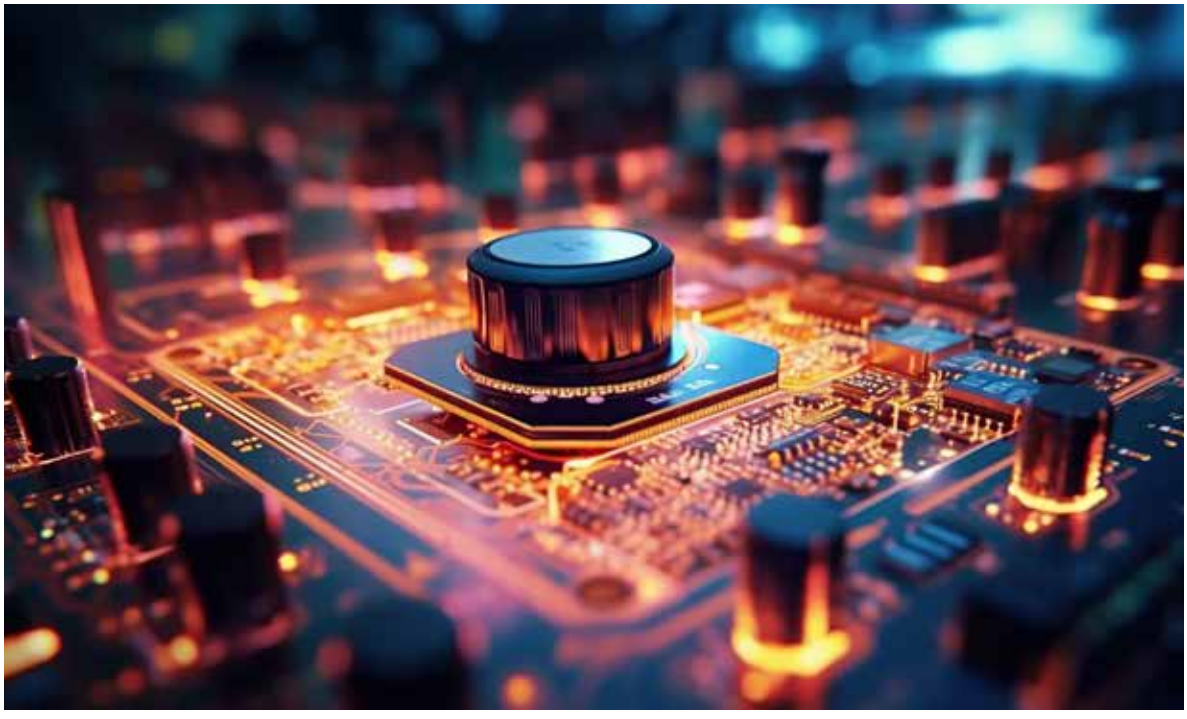
30.4%
of technologies scouted have completed the comprehensive market research.

Study Title:

Techno-commercial assessment of TRL 6 and above technologies developed in India by academia, research labs and industries in the domains of electronics telecommunication and manufacturing

Organization:

Indian Institute of Technology Roorkee, Uttarakhand



1. Overview

Projects with low Technology Readiness Levels (TRLs) carry heightened risks stemming from uncertainty, potential failure, and resource constraints. Managers must discern suitable technologies to align with business objectives. Consequently, familiarity with TRLs pertaining to existing technologies proves invaluable in mitigating project risks by leveraging established and extensively tested alternatives. Moreover,

this knowledge facilitates understanding the constraints of such alternatives and devising tailored solutions for specific use cases.

Identifying proven technologies greatly benefits researchers, offering insights into enhancement possibilities. Industries and burgeoning startups can creatively integrate these technologies into their operational challenges, fostering disruptive solutions that spur growth, job creation, and heightened customer satisfaction.

Exploring the hurdles of commercialization also aids technology developers and startups during the intermediate stages of product development. This process enables them to adapt their business models and refine their technologies while enhancing customer outreach and conducting thorough market research. Additionally, understanding factors like resource scarcity, product feature deficiencies, and competitor advantages is paramount.

2. Objectives

(i) To conduct the case studies on success stories of the technologies(projects) which are in the TRL-6 and above in academia, research labs; (ii) To study the challenges in the commercialisation of technologies developed in academia and research labs; (iii) To develop an Artificial Intelligence-based approach for predicting and evaluating TRL-level of technologies; (iv) To develop a database of technologies developed by academia and research labs using Govt funding and mapping them on the TRL scale; (v) To identify already existing successful epitome of TRL6 level or above technologies at least 100 in number) in Indian Institutes, Universities, startups and Industries; and (vi) To provide recommendations for policymakers.

3. Key Findings

Enhancing R&D Environment

Case studies of successful technologies at TRL-6 and beyond shed light on effective practices within research labs and academic institutions. This knowledge empowers researchers to focus their efforts on areas with higher success potential.

Promoting Technology Transfer

Examining the challenges in commercializing university innovations aids in refining technology transfer processes. Understanding these hurdles facilitates the development of more efficient pathways for translating academic discoveries into practical industrial applications.

Utilizing AI in Technology Evaluation:	Automating and streamlining Technology Readiness Level (TRL) assessments through AI-based methods offers impartial evaluations, saving time and resources.
Establishing Databases:	Creating transparent databases of government- funded technologies and their TRL mappings enhances accountability. Policymakers can assess the impact of government support on technology development.
Identification of Exemplary Technologies	Identifying successful technologies at TRL-6 or higher within Indian universities, startups, institutes, and corporations sets benchmarks and inspires innovation across academia and industry.
Business Innovation and Growth Opportunities	Industries and startups can benefit by implementing the identified successful technologies into their business strategies. This may result in the creation of novel solutions, encouraging expansion, generating job opportunities, and raising consumer satisfaction.
Barriers Ranking Results	A fuzzy-AHP framework ranks barriers in technology development, highlighting the significance of criteria such as the existence of similar successful projects for commercialization. Criteria like project indigenousness and system complexity rank lower in importance according to experts. Developing this framework involves literature review, expert input, pairwise comparisons, and criteria evaluation.
Promote Industry-Academia Partnerships	Establish regulations encouraging cooperation between academic institutions and business sectors. Fostering a culture of information exchange and collaboration can be achieved through various means, such as tax incentives, research grants, and faster approval processes for cooperative initiatives.
Technology Evaluation and Comparison	Established a methodical process for evaluating and comparing technologies across various TRL levels. This can help decision-makers make well-informed choices about financing priorities, resource distribution, and the possible effects of new technology on different industries.

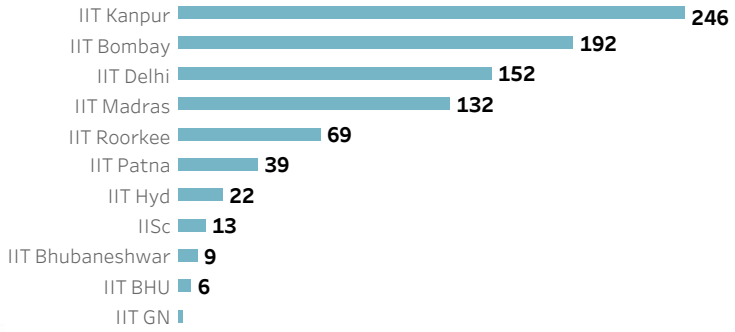
4. Dashboard

Summary of Technology Readiness Levels

Number of Technologies	Technologies greater than TRL6	Number of Institutes
927	469	11

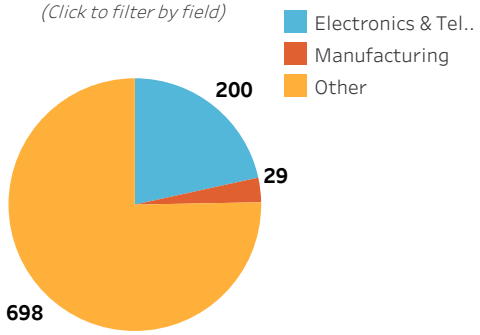
Number of Technologies across institutes

(Click bar to filter by institute)



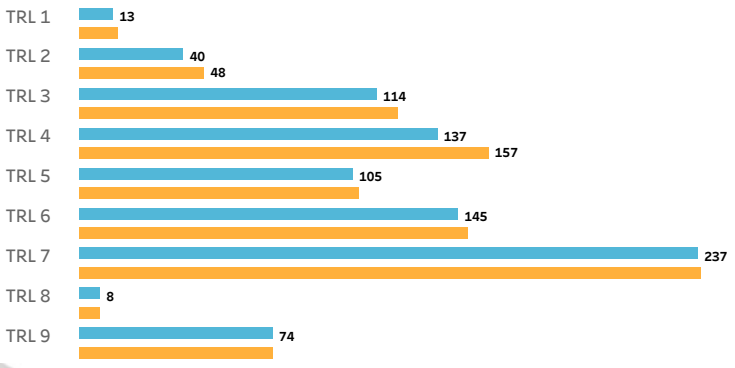
Application Domain

(Click to filter by field)



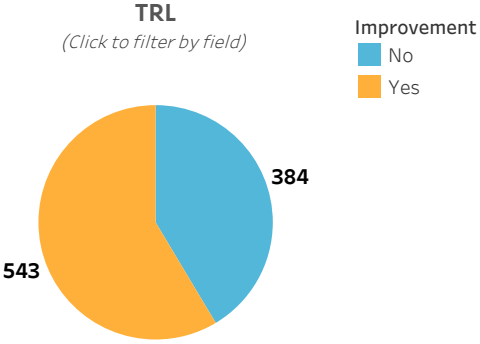
Change in TRL & Number of technologies

(Click bar to filter by TRL)



Technologies with Improvement in TRL

(Click to filter by field)



Source: https://akshitkg.github.io/trl/

Study Title:

Techno-commercial assessment of TRL 6 and above technologies developed in India by academia, research labs and industries in the domains of chemicals, pharmaceuticals, medical sciences and healthcare

Organization:

Technology Information, Forecasting and Accessment Council (TIFAC), New Delhi

1. Overview

India is a hub of prestigious academic institutions, national research laboratories, industries including MSMEs and startups. Despite this, India relies heavily on imported technologies, largely due to challenges in translating researches / innovations from the laboratory or pilot stage to commercial scale projects. The commercialization of technology is identified as a pivotal driver of economic development, but the process

is hindered by various challenges / issues. These challenges include issues related to technology readiness level, economic viability, resource availability, market potential, regulatory / statutory approvals, intellectual property awareness, and disconnect between technology providers and industries. The study has been aimed at capturing 100 technologies in the identified domains of chemicals, pharmaceuticals, medical sciences and healthcare which are developed indigenously by various academia, labs and industries particularly start-ups and are at quite advanced TRL levels but not yet explored towards full scale commercialization by industries. The study would also highlight the issues / barriers / challenges being faced in translating these technologies into commercial scale products and would recommend / suggest possible solutions towards establishing a comprehensive innovation ecosystem for fostering commercialization of technologies in the domains, which is a national priority for emerging economies.

2. Objectives

(i) To identify and assess the readiness level of technologies developed in identified sectors e.g. Chemicals, Pharmaceuticals, Healthcare, and Medical Sciences and to categorize these technologies based on their Technology Readiness Levels (TRLs).

(ii) To identify the barriers, issues and challenges being faced towards transfer / licensing for commercialization and to suggest optimum solutions towards formulating policy for robust innovation ecosystem.

4. Key Findings

01 Technologies were identified from four domains, viz. chemical, pharmaceuticals, medical sciences and healthcare. The TRL of each technology was assessed based on the assessments made by domain experts and categorized into threebrackets: TRL 3, TRL 4 to TRL 5 & TRL 6 to TRL 9.

02 SOURCES OF TECHNOLOGIES Among 110 technologies received under the study, 16 (14.5%) technologies are from research labs, 10 (9.1%) are from start-ups/industry, and 84 (76.4%) are from academia. (Figure at Page 23)

03 DOMAIN-WISE DISTRIBUTION OF IDENTIFIED TECHNOLOGIES Out of the total technologies identified for the study, 52 were from the healthcare domain, 30 were from pharmaceuticals, 7 were from medical sciences, and 21 were from the chemical domain

04 More than 100 technologies were identified through workshops, and visits to academic institutions. TRL of all the technologies were assessed and finalized based on the opinion of experts in each sector. Out of 110 technologies, 48 (43.64%) are at TRL 4 to 5, 52 (47.27%) technologies are at TRL 6 to 9, and 10 (9.09%) are at TRL 3.

05 A compendium of technologies in the identified domains featured about 130 technologies at various technology maturity level in identified domains

This work has highlighted challenges involved in the progression of technologies specifically in chemical, pharmaceuticals, medicine, and healthcare sectors. One prevalent gap identified in the technology transfer context is the non-alignment between industrial needs and academic orientation. Almost all institutions and start-ups face challenges due to inadequate infrastructure and resources for research and development. Limited access to state-of-the-art laboratories, equipment, and funding impedes technology development. Financial constraints is another challenge for innovators since money is required for crossing various steps involved in transferring technologies from the lab to the market. Lack of apt marketing strategies and business plan for scaling up innovative products and lack of knowledge among researchers in market dynamics pose more challenges in lab-to-pilot-scale demonstrations before transitioning to commercial-scale production. To sum up, not-so-effective industry academia collaboration, not-so-robust intellectual property rights management practices, regulations, policies, and market intelligence, low TRLs of indigenously developed technologies, not-so-efficient technology transfer mechanisms, and inadequate investments particularly from industries are some of the hurdles that impede the smooth transition of academic inventions into commercial deployments.

Study Title:

To Study the Extent of Linkages between Industry and Academia/ R&D Institutes in the state of Himachal Pradesh

Organization:

CSIR- Institute of Himalayan Bioresource Technology (CSIR- IHBT), Palampur

1. Overview

Education, schooling, research, technology, information, and training have all become essential components of individual and state productivity since the beginning of the twentieth century. Education is often regarded as the most significant ingredient in boosting the efficiency of human resources, and human capital has long been considered a key component of a country's economic growth and development.

As a result, education is essential in a country's social and economic development. The correlation between universities and industries is essential to develop

relationship between education and economic development. Although large number of studies focuses on the need of strong academia industrial research, but the policies and regulation to promote the same are still unstructured. There is utmost need for filling this gap to ensure growth and development of different sectors of the society.

As a matter of fact, knowledge and technological progress are becoming more widely recognised as drivers of global competition and economic progress. The role of university-industry collaborations in higher education policy-making has been very important at both the national and international levels. Despite the increasing interest in this issue, there is a scarcity of research in Himachal Pradesh to help policymakers. As a result, this research is being carried out in Himachal Pradesh to fill the knowledge gap in academia/R&D institutes and industry relations.

The study's basic aim is to assess the current state of university/R&D institutes and industry interactions and provide recommendations for developing long-term relationships.

2. Objectives

(i) To study the extent of linkages (collaboration, sponsored, consultancy, transfer of technology, incubation etc.) amongst academia, R&D and Industry; (ii) To study the innovation policies of various academia, R&D institutes and Industry of the region and its mechanism for industrial research, IPRs and transfer of technology; (iii) To study the R&D needs of Industry and the extent of in-house R&D and Technology outsourcing; and (iv) Two case studies (success/failure) for linkages amongst academia, R&D and Industry

3. Key Findings

Qualitative Analysis for Academia:

Dominant Informal Collaboration
The analysis reveals a surprising trend: most academia-industry collaboration is informal. This means collaborations often lack formal agreements or structured processes.

Missing Academia-Industry Policies
A major reason for informality is the absence of established policies within academic institutions. These policies would guide and promote formal collaboration with industry partners, leading to more structured interactions.

Government's Gradual Approach
The government is making progress in establishing regulations and measures to encourage collaboration. However, the pace may be slow, and these efforts might not yet meet global standards for effective partnerships.

Qualitative Analysis for Industry:

Predominance of Informal Collaboration

The analysis reveals that most industry-academia collaborations are informal. These collaborations often involve activities like personal networking, seminars, conferences, workshops, and symposiums.

Formal Collaboration for Innovation and Problem-Solving: Formal collaborations involve activities like training programs, student internships, information exchange, and consultancy engagements. These structured interactions typically focus on Creating an Innovative Environment where large industries leverage on formal collaboration to foster innovation and stay competitive in the global market and conduct science-based research to address production-related challenges and develop solutions.

Limited Engagement by Smaller Industries: Micro, small, and medium enterprises (MSMEs) primarily engage in informal collaborations with academia. Reasons for limited formal collaboration in MSMEs includes:

- **Lower R&D Investment:** MSMEs often have smaller budgets and may not invest heavily in research and development (R&D).
- **Internal Needs Focus:** Their primary focus might be on fulfilling their internal operational needs rather than pursuing cutting-edge research.
- **Limited Awareness:** MSMEs may be less aware of the potential benefits and available programs for formal collaboration with academic institutions.

Barriers to Academia-Industry Collaboration:

Despite growing recognition of the importance of collaboration between academia (universities, research institutions) and industry, several key challenges are hindering its full potential and these can be assessed under two perspectives:

Academia's Perspective:

Focus on Pure Research: Some academics may prioritize fundamental research over applied research with direct industry application. This can lead to a disconnect between academic pursuits and industry needs.

Lack of Industry Awareness
Academia may be unaware of critical industry and national needs, hindering the effective contribution of academic expertise.

Disincentivization of Collaboration
Faculty members may lack sufficient incentives or recognition for engaging in collaborative research with industry partners.

Infrastructure and Support
Limited access to specialized technical infrastructure or bureaucratic hurdles in utilizing funds allocated for collaboration can further hinder progress.

Missing Industry Interaction Channels
The absence of dedicated university-industry interaction cells can make it difficult for both sides to connect and initiate collaborations.

Industry's Perspective:

Short-Term Focus
Industries often prioritize short-term, targeted development with immediate results. This can clash with the longer timelines often associated with academic research.

Reluctance to Invest in Uncertainties
Industry may be hesitant to invest in collaborative projects with unclear or future-oriented outcomes.

Underestimating Academia's Resources
Industries may overlook the potential value of academia's resources and expertise due to a lack of awareness.

Overreliance on External Solutions
Companies may rely heavily on readily available foreign knowledge or expensive consultants, neglecting the potential of collaborating with local academia.

Theme II:
ICT and Education

Study Title:

A report on ICT tools catering to a wide range of learners, including Children with Special Needs

Organization:

Cochin University of Science and Technology, Kochi

1. Overview

New technological advancements like digital books, multi-sensory classrooms, remote learning, virtual and augmented reality, and artificial intelligence are transforming education. ICTs are crucial in creating knowledge societies by integrating technology into schools and overhauling educational processes. The Indian education sector has seen significant changes, driven by policymakers, educators, and learners. Both central and state governments have launched Edtech initiatives to address issues of access, quality, equity, and cost. The NEP 2020 emphasizes inclusive education, particularly

for individuals with disabilities, in line with the Rights of Persons with Disabilities Act (RPWD 2016), and proposes establishing a National Assessment Centre, PARAKH. Assistive technologies like JAWS, SAFA, and Audio Books will be provided to students in grades VI-XII and teacher education institutes, ensuring an inclusive experience on the Diksha platform.

2. Objectives

(i) Strategies and guidelines available currently for driving the adoption and usage of aligned ICT tools for children with special needs; (ii) To identify the various ICT tools available across the country for children with special needs and to understand the purpose of these tools; (iii) Assess the extent to which these ICT tools are integrated with the existing curriculum for children with special needs; (iv) To report the level of organizational support provided to facilitate the use of such tools; and (v) To gauge the extent of usage of these tools real-time by special school teachers.

4. Key Findings

Policy and Initiatives:

NEP 2020 and DIKSHA Platform: The NEP 2020 proposes a dedicated section on DIKSHA, a national repository by NCERT, to offer high-quality educational resources based on Universal Design of Learning (UDL) principles. This aims to improve accessibility for students with disabilities.

Samagra Shiksha Abhiyan: This government initiative emphasizes technology integration in teacher education institutions and mandates states to develop disability-inclusive e-content.

Challenges and Gaps:

Declining Enrollment: Despite policy support, the enrollment rate of students with disabilities remains low (29.47% in 2018-19).

Ambiguity in Special Schools: A lack of clarity exists regarding the nature, purpose, and regulation of special schools in India.

Limited Funding: The budget allocation for inclusive education under Samagra Shiksha Abhiyan has seen a concerning decline.

Existing ICT Infrastructure:

NCERT Initiatives
NCERT offers various digital resources like e-Pathshala (audiobooks, videos), DIKSHA platform, and NROER (open educational resources).

Satellite Education Programs
Educational content is broadcasted through satellite TV and radio programs (e.g., EDUSAT).

Assistive Technologies (AT) by Private Vendors
Tools like JAWS, Sonic Labeler, Seeing AI, Speechify, Be My Eyes, and Samsung Good Vibes are available, some free and some paid.

ICT Use in Special Schools:

Common Resources
Phones, tablets, laptops, desktops, smart TVs, smart boards, printers, and therapy tools like vHAB (Virtual Rehabilitation) are commonly used.

Access Methods
Laptops (44.2%), smart TVs (35.8%), smart boards (39.8%), and mobiles/tabs (25.2%) are used to access digital resources.

Level of ICT Integration

Curriculumm Content
76.3% of special educators reported moderate skill in using ICTs to access specific curriculum content.

Sharing Content with Parents
96.5% of teachers reported high usage and skill in using ICTs for this purpose.

Classroom Teaching
Only 44% of teachers reported using ICTs for displaying teaching content, and 54% reported low usage for classroom activities.

Course Content Creation`
Only 38.6% of teachers used ICTs for creating new course content, with very low reported skills and training.

Collaboration and Reporting
83.3% and 65.8% of teachers reported high usage of ICTs for collaboration with colleagues and preparing reports, respectively.

Teacher Training
All respondents reported low levels of institutional training on using ICTs for teaching and learning.

Skill Development for Students
Low usage and skill levels were reported in using ICTs for training students in language skills (51.8%), environment awareness (29%), math (26.3%), life skills (48.2%), social skills (33.3%), physical well-being (25.9%), extracurricular activities (18.6%), and computer skills (49.6%)

Parental Awareness and Usage:

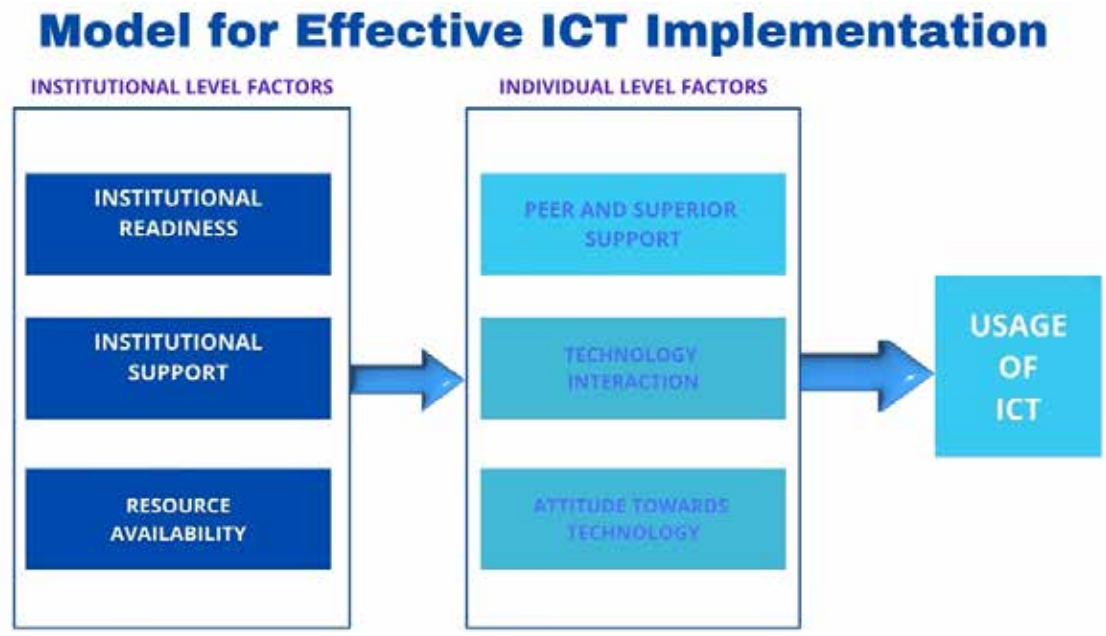
Parents reported low awareness and use of ICT tools for supporting their children's learning at home.

When choosing a special school, parents prioritized teachers, location, and infrastructure/specialist assistance over ICT facilities.

Integrated Model for ICT Integration:

The study proposes an integrated model for ICT integration in special education, adapting a pre-tested model by Kurian & Ramanathan (2018). This model emphasizes four key components:

- Institutional factors (e.g., ICT plan, accessibility support)
- Individual factors (e.g., teacher attitudes, technology interaction)
- Teacher competence in using ICTs
- Usage of ICTs in teaching and learning



Teacher Perceptions:

While teachers perceived moderate peer and superior support and positive attitudes towards technology, they reported low technology interaction skills.

The overall perceived teacher competence and usage of ICTs were found to be moderate and low, respectively.

Increased investment in ICT infrastructure and resources for special schools.

Enhanced training for teachers on using ICTs effectively in inclusive classrooms.

Improved parental awareness and support for using ICTs at home.

Addressing the decline in enrollment rates and ensuring clear guidelines for special schools.

A database of ICT tools catering the two categories of Disability, Viz., category one (Locomotor, Visual Impaired and Hearing impaired) and category two (Intellectual Disability and Autism Spectrum Disorder) was generated as part of this study.

Database pertaining to 226 Special Educators (Institutional Heads and Teachers), of four states including Kerala, Goa, Delhi & Haryana regarding the ICT usage generated as part of this study.

Database pertaining to 113 Parents of children with disabilities in the four states Kerala, Goa, Delhi & Haryana regarding ICT usage at home is generated as part of this study.

Study Title:

A Report on ICT Tools Catering to Wide Range of Learners, Including Children with Special Needs - Visually Impaired Children

Organization:

Symbiosis International (Deemed University), Pune

1. Overview

ICT has revolutionized inclusive education, offering equal learning opportunities for marginalized groups, including visually impaired (VI) students. In India, millions of VI children stand to benefit from ICT tools tailored to their needs, aligning with UN Sustainable Development Goals. The Rights of Persons with Disabilities Act, 2016 mandates equal educational opportunities, urging the integration of VI students into mainstream education for their future participation in professional settings. This study focuses on integrating VI students into higher secondary schools, particularly in

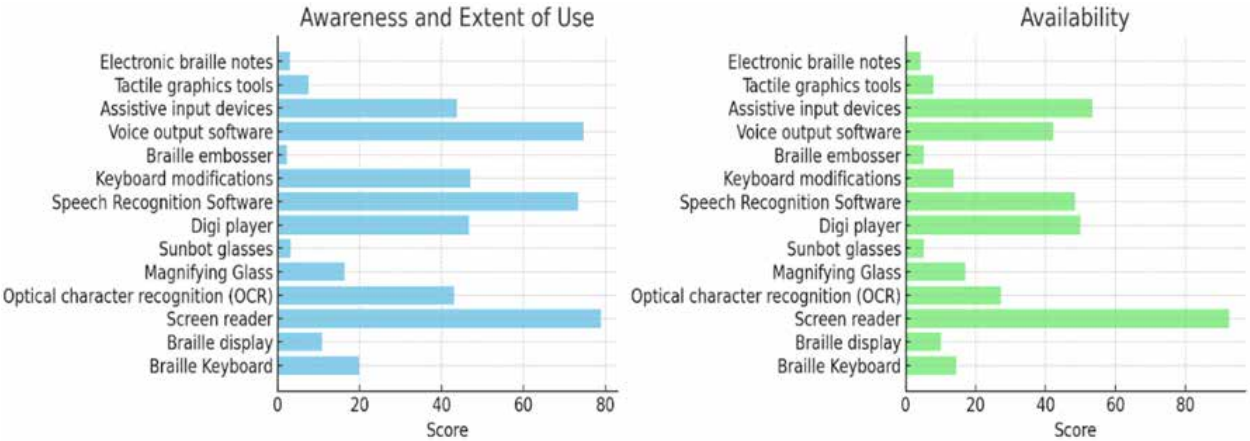
Maharashtra, Gujarat, Goa, and neighbouring regions. Despite research on VI students in specialized schools, little attention has been given to their integration into regular higher secondary schools. Conducted from January to December 2023, the study assessed awareness and challenges surrounding ICT tool usage in government, aided, and private schools to integrate VI students. Through mixed methods, including interviews and focus groups, it evaluated the accessibility, affordability, and effectiveness of ICT tools such as Braille keyboards and screen readers. Findings reveal positive attitudes toward ICT tools among VI students, but obstacles like cost and lack of training hinder their integration into higher education. Collaborative efforts and policy recommendations are necessary to enhance ICT tool adoption and integrate VI students into mainstream schools, promoting full societal inclusion as per UN goals.

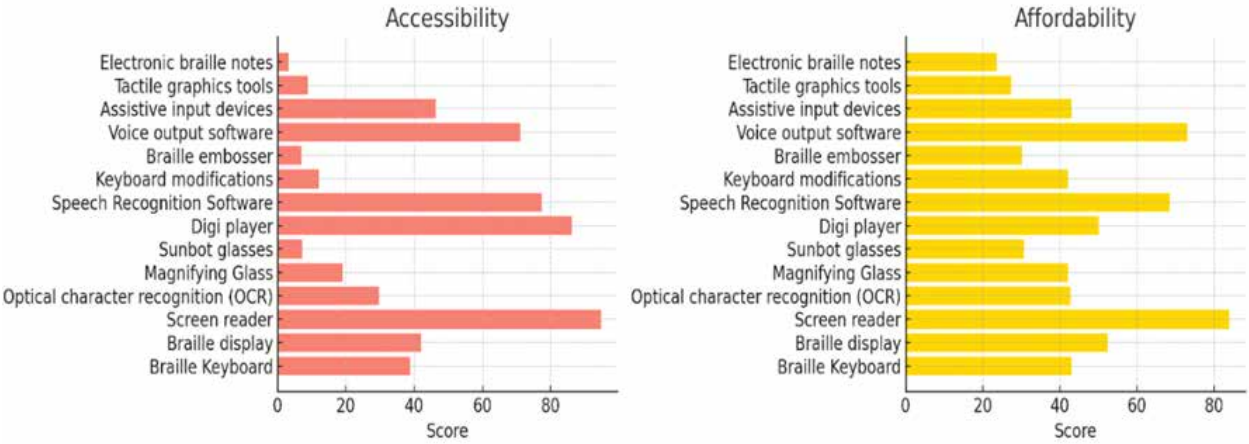
2. Objectives

(i) To explore the level of awareness of select ICT tools for visually impaired children among government, government-aided, and private higher secondary schools (HSS). (ii) To identify the challenges in the adoption of ICT tools, including stakeholders' approaches and policy implementation gaps, for visually impaired children in government, government-aided, and private higher secondary schools (HSS). (iii) To find commercially viable opportunities for integrating visually impaired children into government, government-aided, and private higher secondary schools alongside normally sighted children using ICT tools.

3. Key Findings

Status of awareness, availability, accessibility, and affordability of ICT tools by visually impaired students





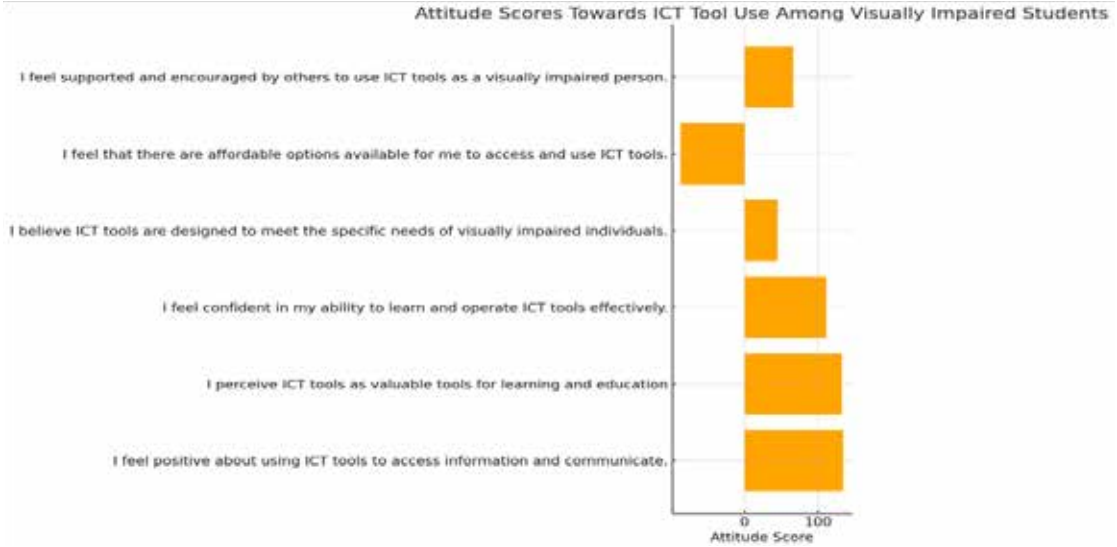
Awareness and Extent of Use
Screen readers, Braille displays, and OCR tools show the highest awareness and usage scores. Devices like electronic Braille notes, tactile graphics tools, and some advanced assistive devices (e.g., Digi player, Sunbot glasses) have lower scores, indicating lesser awareness and usage.

Availability
Screen readers and OCR tools again rank highly in availability, aligning with their high usage. Similar to the awareness scores, electronic Braille notes and tactile graphics tools have lower availability scores.

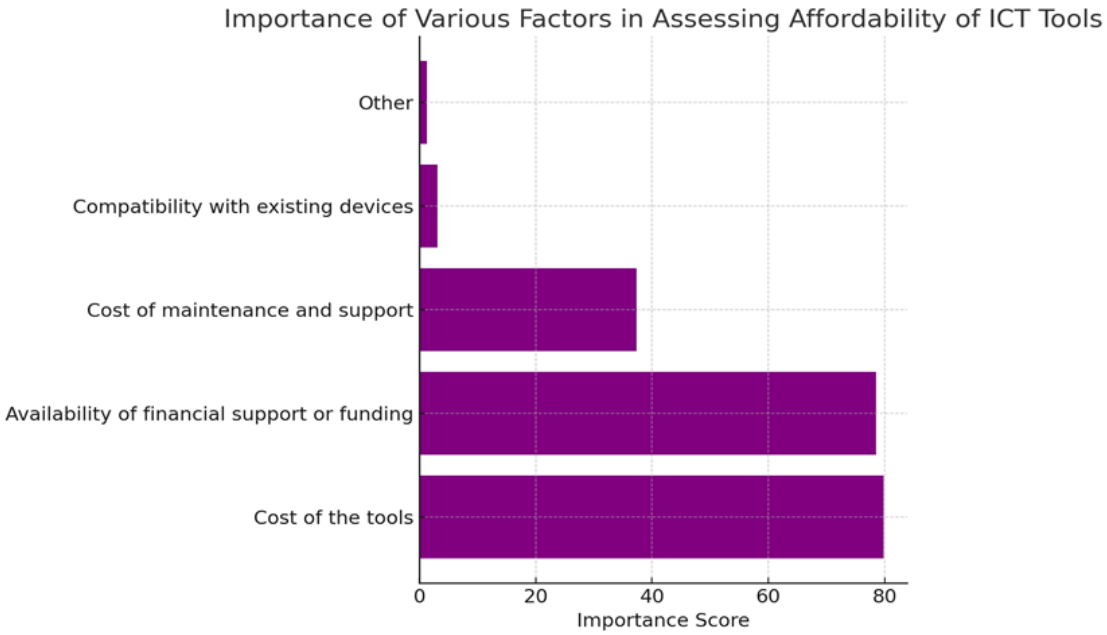
Accessibility
Screen readers and Braille displays score relatively high in accessibility, suggesting they are easier to use. Tools such as electronic Braille notes and tactile graphics tools score lower, indicating potential usability issues or lack of user-friendly features.

Affordability
Screen readers and OCR tools appear to be more affordable compared to other technologies. Advanced tools like electronic Braille notes and tactile graphics tools, which also have lower awareness and availability, score lower in affordability.

Challenges and attitude of visually impaired students to use ICT tools



Factors determining accessibility and affordability of ICT tools



ICT tools and unique needs of visually impaired students alongwith their pricing range and key manufacturers

Reading & Classroom Adoption
Offers tools like screen readers, Braille displays, and wearable AI devices, ranging from INR 7,000 to INR 4,00,000, with prominent manufacturers including Freedom Scientific and OrCam Technologies from the USA and Israel.

Writing & Classroom Adoption
Features devices such as digital Braille note takers and speech recognition software, priced between INR 3,000 and INR 7,00,000, mainly produced by companies like HumanWare in Canada and Nuance Communications in the USA.

Classroom Adoption
Includes educational software and accessible toys, costing INR 500 to INR 50,000, with diverse suppliers like Dolphin Computer Access from the UK.

Other Supporting Environment
Encompasses a wide range of tools from smart canes to accessible smartphones, with prices from INR 500 to INR 1,50,000, manufactured by global companies including Apple, Google, and Young Guru Academy.

Study Title:

Integrating AI, AR & VR in Learning Models and their Impact

Organization:

Indian Institute of Technology Hyderabad

1. Overview

Virtual reality (VR) technology is gaining attention in psychology and neuroscience for its potential to enhance memory recall. Unlike traditional verbal or written assessments, VR immerses individuals in realistic environments, offering a richer context for studying memory retrieval. Research aims to understand how VR can improve various aspects of memory recall by recreating real-life scenarios and eliciting emotional responses. Studies show that VR provides contextual cues and emotional stimuli that aid in memory consolidation and retrieval, offering promising applications in education and therapy. In education, VR can enhance retention and recall of material, while in therapy, it may help with trauma processing and cognitive rehabilitation. Current research focuses on using VR to aid memory recall among school children, aiming to transform traditional educational methods and improve how students remember information. Challenges like simulator sickness and the fidelity of virtual environments remain, but the potential benefits are significant.

2. Objectives

(i) Assessing memory recall accuracy; (ii) Examining memory retention; (iii) Exploring context-dependent memory; and (iv) Comparing VR to traditional methods.

3. Key Findings

Pre-test findings:

Followed by traditional teaching method the survey finding shows that 56 pupil performed well in terms of memory recall performance. They scored 7-8. Among the 56 pupil there are 14 pupil are performed with hight score 9-10. 27 pupil performed with medium score 4-6 and 17 people are low scorer they got 2-3.

Non-digitalized test method follows process of the test was oral question-answer method, writing on the black-bord and finding from the chat sheet. Overall study shows 14% of pupil are highest scorer and 54 % of pupil are good scorer. 27% pupil performed medium and 17% are not performed well in this study.

Post-test findings:

After VR intervention finding indicates an overwhelming percentage of respondents. The study effectively shows that 78 pupil are well performed while using the virtual reality devices, 7 pupil found eye sight difficulties while using VR devices and 15 people are found difficulties to understand and memorise the content while to using the VR devices and not well performed in the retention (Memory) measurement test.

Among the 78 pupil, 53 people are well performed (up to 8 - 10 score) on all the over the items such as recognizing, listing, describing, identifying, locating and finding. 25 pupil are finding difficulties (up to 6 - 8 score) while they are locating and finding the objects in the virtual environments.

OUTPUT

Data collection

The data has been collected from 100 (n = 100) number of participants. The study focused on the retention power of the students, followed by six key points of Remembering. Six key points contain twelve items. Each key point includes two items. Twelve items are measuring students mode of remembering. The 10-point rating scale is used to measure the student's performance.

Virtual reality content development

To design a virtual reality (VR) environment, the team considered several key elements and steps. Oculus Rift, VR platform was selected which is a cost-effective and good-performance user base and is compatible with our intended audience.

In the second stage, all the 3D models and 3D assets by using the 3D modelling software Blender, was created for the VR environment. Later stage, all the models and assets are exported to Unity software to develop the entire 3D environment. The VR experience developed under the study acquired smooth performance to avoid motion sickness and provide an immersive experience.

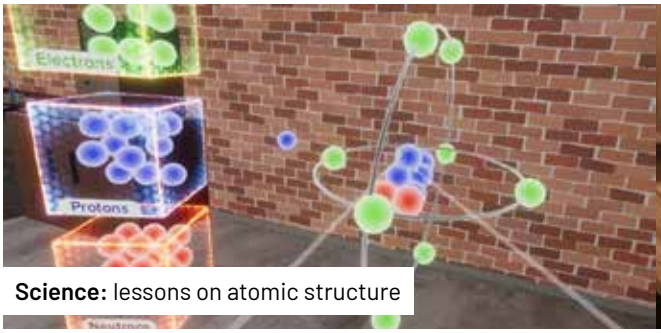
Overall, the study provides promising evidence that VR interventions can benefit memory retention in a significant portion of the student population (78%). However, addressing challenges related to specific VR functionalities, such as navigation, and content delivery is crucial for optimizing the learning experience for all students. Also the study reports significant drawbacks of useability factors of VR devices for weak eyes site person and some are not to accustomed with the virtual environment.

User interface visuals

Step 1: Inside room view

Step 2: Elements in lesson

Multiple view of the lesson structure



Science: lessons on atomic structure

Image 3: Intervention with student volunteer

Theme III: Adoption and Future of Digital Technologies


SEO

Study Title:

Qualitative study of technologies designed using Artificial Intelligence for improving healthcare services in the Indian context

Organization:

Centre for Development of Advanced Computing (CDAC), Mohali

1. Overview

As Artificial Intelligence has made its mark globally in recent times, various sectors are explored that can benefit from AI. In this study, the study of AI in the Indian healthcare sector is addressed, as India can be the best-chosen place for implementing AI in the healthcare sector for its reasonable and accessible amenities along with better opportunities for innovation. The healthcare sector can be a major beneficiary of this revolution because of the shortage of highly qualified healthcare professionals, facilities,

and low government expenditure which contradict the large Indian population. This report aims to summarize what has been achieved so far in AI healthcare, identify challenges, and recognize some of the promising ways for future healthcare in India, in terms of both applications and innovations.

Based on the recent examined review in healthcare, it is suggested that deep learning (DL) methods can be beneficial for transforming immense health data into better human health. The DL Algorithms ranging from convolution neural networks (CNN) and radial basis function (RBF) to variable auto-encoders are applied in countless applications in the field of medical image analysis in recent medical research such as detection, evaluation, facilitating treatment and prediction of various critical diseases. Essential steps to address clinical application problems, how the domain could be enriched further, and translate the finest emerging AI technology from research to real-time practice at the clinic are examined. However, this can be possible with (1) Robust clinical assessment (using defined criteria that are understandable for physicians and hopefully go beyond quantitative precision indicators to comprise patient care and other quality outcomes (2) appropriately validated & controlled AI-enabled healthcare management systems that can assist individual without any bias and error. If these targets can be met in the future, the results would undoubtedly be positive for patients.

2. Objectives

(i) AI Technologies in Healthcare and (ii) Facilitate collaboration among industries and startups in AI-Health to enhance healthcare services in India.

3. Key Findings

AI Technologies in Healthcare:

The study identified various AI algorithms used in healthcare, ranging from medical imaging analysis to assisting medical professionals.

Applications include:

- **Medical Imaging:** AI aids in analyzing medical images like X-rays, CT scans, etc., for diagnosis and disease detection.
- **Remote Patient Monitoring:** IoT (Internet of Things) technology is used for remote monitoring of patients, allowing for better care management.
- **Digital Platforms:** AI integrates with digital platforms to improve healthcare delivery and patient access.
- **Remote-Assisted Surgery:** Robotics technologies are being explored for remote surgical procedures.
- **Teleconsultations:** Machine learning facilitates virtual consultations with doctors.

Research and Development:

Researchers, doctors, and startups are actively involved in developing and deploying AI solutions for medical imaging.

The study reviewed recent research papers on AI-powered medical imaging, focusing on diagnosis, algorithms, and performance.

Collaboration for Improved Healthcare:

The study identified startups and Government-funded organizations working in AI-powered healthcare solutions. This includes a list of Startups, Research Institutes, Funding Agencies, Principal Investigators, Research Projects

Government initiatives promoting AI in healthcare were also reviewed. These include programs from NITI Aayog, National eHealth Authority (NeHA), Ministry of Health and Family Welfare, Ministry of Commerce and Industry (AI Task Force), Ministry of Electronics and Information Technology (Policy Group on AI), Department of Industrial Policy and Promotion (National IPR Policy), United States–India Science & Technology Endowment Fund (USISTEF), Department of Science & Technology (Cognitive Science Research Initiative - CSRI), Department of Biotechnology (Biotechnology Ignition Grant Scheme - BIG), Biotechnology Industry Research Assistance Council (BIRAC), Government of Karnataka (Centre of Excellence for Data Science and Artificial Intelligence - CoE-DS&AI)

Gaps and Opportunities:

The study identified gaps in healthcare delivery through questionnaires and expert opinions.

It also categorized existing AI-based technologies in healthcare, including Health Monitoring Devices, Surgical Procedure Equipment, Health Lab Report Analysis Systems, Hospital Patient Management Systems (PMS), Pharmacological Analysis and Prediction Systems, Healthcare Insurance Business Analytics Systems, Patient Profiling Systems, Early Disease Detection Systems

Study Title:

Developing a framework for assessing innovation readiness, research intensity and technology resilience of firms

Organization:

ABV-Indian Institute of Information Technology and Management (IIITM), Gwalior

1. Overview

Interconnected global economy necessitates dynamic technological solutions for sustainable product and service development. The imperative is continuous investment in research and development activities and development of partnerships for assimilation of new know-how for building competitiveness along product development life cycles. With this backdrop this study aims to understand possible relationship between constructs of innovation readiness, research intensity and technology resilience in the Indian manufacturing firms who are extensively using evolving digital technologies.

2. Objectives

(i) Understand theoretical constructs of innovation readiness, research intensity and technology resilience and developing measurement scales for them; and (ii) Development of an integrative framework representing structural relationship between theoretical constructs of innovation readiness, research intensity, technology resilience leading to production system excellence.

3. Key Findings

Research Framework:

A framework was developed based on a literature review to assess the interrelationships between these constructs.

Standardized measurement scales were identified from the literature review and validated using statistical procedures.

Structural Equation Modeling (SEM) methodology was employed to assess the framework's validity and the hypothesized relationships between the constructs.

Key Results:

The developed measurement scales were found to be valid and reliable based on statistical criteria.

The analysis revealed potential validity for the proposed framework, suggesting significant relationships among the studied constructs.

Path coefficients indicated that:

- The strongest positive relationship exists between innovation readiness and technology resilience.
- The weakest positive relationship exists between research intensity and production system quality.

Key Results:

This study offers a novel framework for understanding the interrelationships between innovation readiness, research intensity, technology resilience, and production system excellence.

The developed scales can be valuable tools for managers to:

- Assess their organization's strengths and weaknesses in these areas.
- Identify areas requiring improvement to enhance innovation and production capabilities.

Technology roadmaps can be created based on the framework to:

- Align technology development with product and service plans.
- Ensure alignment with business and customer needs.

Study Title:

Readiness and Interest of Organizations for Adopting Emerging Technologies like AI and ML

Organization:

Indian Institute of Technology, Indore

1. Overview

The smart grid is a modern electricity network that uses advanced technology to improve the distribution, generation, and transmission of electricity. Its main aim is to integrate renewable energy sources smoothly and manage their fluctuations efficiently. The smart grid includes digital sensing, smart metering, and automation instruments, allowing better communication between operators and consumers. The utilization of AI and machine learning algorithms enables rapid fault detection, resulting in reduced downtime and improved grid resilience. The study emphasizes the importance of Phasor Measurement Units (PMUs) for real-time monitoring. However, it also highlights limitations in current Transient Stability Assessment (TSA) techniques, underscoring the need for a robust real- time TSA solution.

This study's innovative approach involves creating a database of synchrophasor data from the IEEE 39 bus system, collected by PMUs at generator terminals under various operating conditions. It uses an intelligent AI/ML technique, the Long Short-Term Memory – Autoencoder (LSTM-AE), for more efficient and accurate Transient Stability Assessment (TSA). This study highlights the growing demand for real-time TSA and its advantages in enhancing the efficiency and reliability of power grid operations. It recognizes the industry's keen interest in AI/ML techniques, particularly in load forecasting and fault identification. However, the lack of practical expertise in handling AI/ML tools among human resources poses a barrier to their implementation. To address this, the proposed tool serves as a decision-making tool that minimizes the need for frequent training programs, reducing the overhead on industries.

2. Objectives

To create data analytics monitoring tools that utilize AI/ML techniques to extract information from synchronized measurements

3. Key Findings

Proposed Methodology Outcome:

Utilization of LSTM autoencoder for normalization and dimension reduction optimizes feature selection, resulting in reduced computational complexity.

The unsupervised LSTM-AE classifier achieved a remarkable test accuracy of 98.88%, surpassing the performance of PCA-based LSTM.

LSTM-AE exhibited earlier prediction of transient stability compared to PCA-based LSTM and TSI.

The LSTM-AE classifier achieved a perfect accuracy rate of 100% in predicting transient stability, outperforming the ROCOV-ΔV plan.

LSTM-AE leveraged direct synchrophasor data, eliminating the necessity for rotor angle estimation in transient stability prediction.

Online Questionnaire Survey Outcome:

a. **Strong Interest in AI/ML Adoption:** Figure A, illustrates that approximately 89.5% of power utilities express a high level of interest in utilizing AI/ML techniques, particularly in renewable generation forecasting, acknowledging their potential benefits to operations.

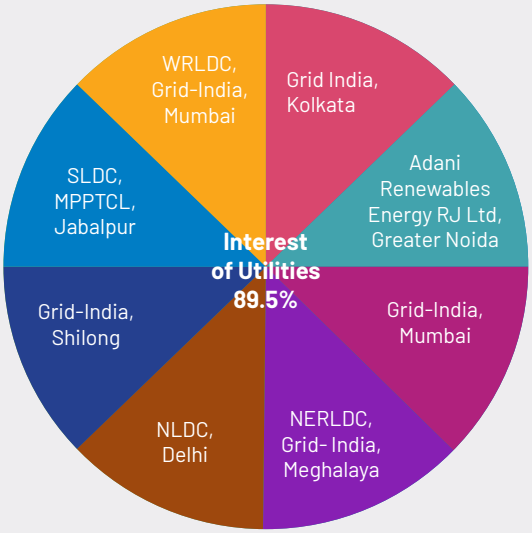


Fig A: Utilities' Readiness and Interest in AI/ML technique

b. **Decision-making Support:** Survey analysis indicates that utilities perceive AI/ML as valuable tools for making more accurate and informed decisions, especially in load forecasting and other operational aspects, as depicted in Figure B.

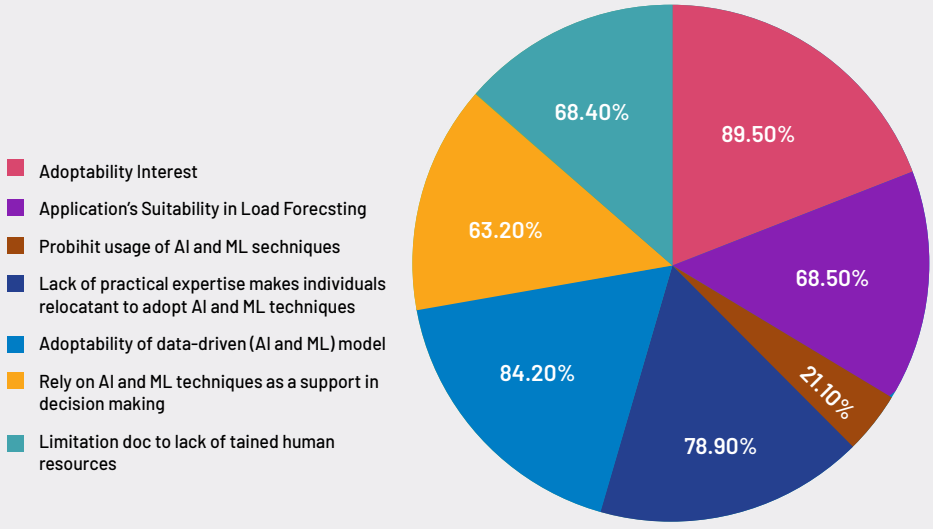


Fig B: Survey Analysis

c. **Willingness to Explore and Adopt:** Power utilities demonstrate a proactive approach by expressing openness to exploring AI/ML applications, showcasing their commitment to remaining competitive in the energy industry, as evidenced in Figure C. Some utilities have already initiated the implementation of AI/ML technologies, highlighting the practicality and feasibility of integrating these technologies into the sector.

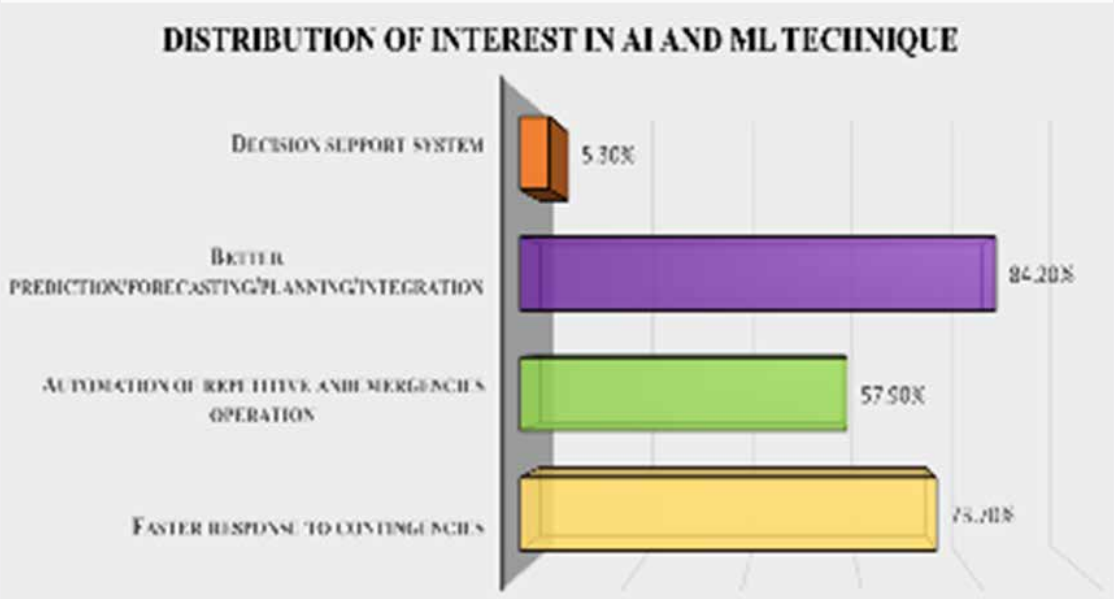


Fig C: Interest in Adoption of AI/ML through Different Means

Study Title:

AI-driven Load Forecasting Models for Indian Load Dispatch Centers

Organization:

Symbiosis Institute of Digital & Telecom Management (SIDTM), Pune

1. Overview

The project "AI-driven Load Forecasting Models for Indian Load Dispatch Centers" is a pioneering initiative aimed at harnessing the transformative potential of Artificial Intelligence (AI) in the realm of electricity grid management. Supported by DSIR, the project addresses the crucial challenge of accurately predicting electricity demand across diverse Indian regions – East (Odisha), West (Maharashtra), North (Delhi), and South (Telangana). Through the application of advanced machine learning techniques, the project aspires to develop precise load forecasting models that empower load dispatch centers with unprecedented efficiency and foresight.

2. Objectives

(i) To pre-process the gathered historical data for forecasting the load in long term basis; (ii) To develop improved energy demand forecasting models for load dispatch centers (LDCs) of Indian states at the long term i.e., yearly for 33/11 kV and 0.415kV substations with good accuracy; (iii) To develop a graphical user interface (GUI) based load forecasting models; (iv) To develop the efficient long term Load forecasting model for Load Dispatch Centres of India using Artificial Intelligent Techniques; and (v) Observe the model's uncertainty in a statistical framework

3. Key Findings

Enhanced Data Pre-Processing:

A robust data pre-processing framework was developed to effectively handle historical data and ensure its suitability for long-term load forecasting models. This cleaned and prepared data is crucial for building accurate forecasting models.

Advanced Load Forecasting Models:

New and improved energy demand forecasting models were created specifically for Local Distribution Companies (LDCs). These models leverage machine learning techniques like regression models, Artificial Neural Networks (ANN), and the innovative 1D CNN BI LSTM model. These models deliver highly accurate load forecasts for various substation types, catering to diverse needs within the power grid.

User-Friendly Interface for Decision-Making:

An intuitive Graphical User Interface (GUI) was designed and implemented. This user-friendly interface allows users to easily input their data and receive accurate load forecasts for the upcoming month. This empowers load dispatch centers with improved accessibility to forecasting information and facilitates informed decision-making.

AI-Powered Long-Term Forecasting Model:

A cutting-edge AI-based load forecasting model was developed, excelling in long-term predictions. This model is a valuable tool for optimizing energy distribution within load dispatch centers. By predicting future demand more accurately, this model can help minimize resource wastage and enhance operational efficiency within the power grid.

Uncertainty Analysis and Model Validation:

Rigorous uncertainty analysis was conducted using datasets representing various regions across India. The findings demonstrate that inherent uncertainties have minimal impact on the accuracy of the load forecasting models. This analysis validates the reliability of these models for decision-makers and stakeholders within the power grid.

Breakthrough Performance of 1D CNN BI LSTM Model:

Extensive testing identified the 1D CNN BI LSTM model as the superior performer across all regions. This model significantly outperforms other forecasting models, demonstrating exceptional predictive accuracy. This breakthrough not only validates the project's methodology but also paves the way for significant advancements in load forecasting practices throughout India's energy landscape.

Overall, this study presents a comprehensive set of advancements in long-term load forecasting for India's power grid. These findings hold great promise for optimizing energy management, improving decision-making, and ensuring a more efficient and reliable electricity supply for the nation.

Study Title:

Studies on air ventilation in central air-conditioning units in post-COVID-19 scenarios guided by artificial intelligence and machine learning techniques

Organization:

Indian Institute of Technology Delhi, New Delhi

1. Overview

The COVID-19 pandemic has led to significant human and economic losses, prompting developed countries to establish air ventilation guidelines to reduce indoor transmission. However, India lacks a dedicated policy for mitigating COVID-19 through HVAC ventilation. The project "Studies on air ventilation in central air-conditioning units in post-COVID-19 scenarios guided by artificial intelligence and machine learning techniques" addresses this gap. It aims to create an indigenous policy for preventing indoor transmission of COVID-like situations, considering India's diverse climate and air quality challenges. Existing HEPA filters are insufficient due

to high pressure drops, costs, and power consumption. This study evaluates current filter manufacturing technologies in India, identifies their limitations, and proposes advanced techniques to enhance filtration performance. Utilizing AI and ML, the project optimizes filter media and explores future applications for HVAC systems. It also reviews global HVAC policies, formulates recommendations with input from academia, research organizations, and industry, and outlines a roadmap for policy adoption to improve air filtration systems.

2. Objectives

(i) To prepare a detailed report comprising the national and international status of existing technologies, current gaps, and the capabilities of Indian manufacturers; (ii) To study high filtration efficiency filters to improve air filtration, explicitly focusing on the Indian market; (iii) To analyse the commercially available filters for their filtration efficiency, pressure drop, and dust-holding capacity; (iv) To study high filtration efficiency filters using artificial intelligence and machine learning models; (v) To propose the policies of air ventilation using high filtration efficiency filters in central air conditioning units that meet the requirements of the Indian situation; (vi) To propose a roadmap for adopting the technologies and policies for high filtration efficiency air filters based upon the requirements of the Indian market; and (vii) To propose a future scope of machine learning and artificial intelligence techniques in the context of healthy air ventilation/ air conditioning/air filtration/HVAC systems in the COVID-19 scenario.

3. Key Findings

State of High-Efficiency Filtration:

A comprehensive review identified current advancements and limitations in high-efficiency air filtration technologies, both globally and in India. The study also explored existing gaps in filtration technology regarding their effectiveness against COVID-19.

Performance Evaluation of Filters:

Commercially available filters were evaluated based on filtration efficiency (FE), dust-holding capacity (DHC), and pressure drop (ΔP) using advanced techniques. Analysis of a limited set of filter samples revealed significant variations in these key parameters. The study explored the influence of factors like particle size, air velocity through the filter, and filter media structure on performance.

AI/ML for Filter Optimization:

The research successfully employed machine learning (ML) and artificial intelligence (AI) models to analyze the complex relationship between filter media structure and filtration performance. This approach facilitated the simulation of high-efficiency filter performance.

Policy and Standards:

The importance of global standards like ISO 16890 for proper evaluation and implementation of high-efficiency filters was highlighted. A roadmap was developed to address industry challenges and enhance indoor air quality. This roadmap emphasizes balancing energy efficiency with improved air quality through a combined approach incorporating global standards.

Indian Filter Market Landscape:

The Indian market offers a diverse range of filtration technologies, including mechanical filters, HEPA filters, UVGI, PCO, and gas-phase filtration. These solutions cater to both general and specialized ventilation needs. However, the study observed a prevalence of MERV 8 and 11-rated filters, falling short of the MERV 13 and higher recommendations suggested by major organizations for the post-COVID era. This indicates that the Indian market may still rely on pre-pandemic filtration standards.

Policy Recommendations for Effective HVAC Systems:

The study emphasizes the need for robust HVAC system policies considering COVID-19. These policies should encompass Material selection for filters; Performance prediction models; Design optimization for enhanced filtration; Real-time monitoring of filter performance; Adaptive filtration strategies based on real-time data; Data-driven insights for continuous improvement; Customization options for diverse needs; Maintaining energy efficiency; and Continued research and development.

Consumer Awareness and Industry Adaptation:

Highlighting consumer awareness and industry adaptability in promoting high-efficiency air filters is crucial. This will ultimately contribute to reducing a borne virus transmission and promoting sustainability within the HVAC sector.

Study Title:

Role of Branding in Enhancing the Competitive Growth for MSME Sector

Organization:

All India Management Association (AIMA), New Delhi

1. Overview

India is emerging as one of the fastest-growing economies in the world, driven significantly by the Micro, Small, and Medium Enterprises (MSME) sector. Defined by the MSMED Act, 2006 based on investment in plant, machinery, or equipment, MSMEs are crucial for economic growth. With around 46 million establishments and employing about 106 million people, MSMEs contribute 29% to GDP, 45% to manufacturing output, and 40% to exports. They generate employment at lower capital costs, especially in rural areas, and support large industries as ancillary units. However, disparities in growth across sectors and regions persist. Effective branding strategies are essential for MSMEs to enhance competitiveness, overcome challenges, and sustain growth. Branding

helps MSMEs create unique identities, improve market reach, and increase customer loyalty, as seen with brands like Lijjat Papad and Chai Point. A well-defined branding strategy involves clear brand identity, personality, and communication, crucial for MSMEs to thrive in a competitive environment.

2. Objectives

(i) To study the role of branding in growth of MSME sector. (ii) To explore key branding strategies for MSMEs in India. (iii) To assess the acceptability of branding for MSMEs in India. (iv) To suggest the way forward for MSMEs to create their brand.

3. Key Findings

Factors Influencing Branding:

Branding strategy, importance, funding sources, perception, methods, modes, and Limited Liability Partnership (LLP) are crucial for MSME branding. All these factors are interconnected and require a holistic approach for successful implementation.

Regional Coverage:

The study covered all four regions viz. North, South, East, and West. A disproportionate distribution in gender and enterprise category was observed.

Model Refinement:

Statistical analysis identified some variables as less relevant and were removed. These excluded variables included branding's impact on quality creation, market sustenance, growth ability, trust building, and certain branding methods (training, association ties).

Impact of Branding Elements:

Brand identity, traits, communication methods, modes, and strategy were identified as dependent variables. Each dependent variable was significantly impacted by its corresponding independent variables. For example, logo, brand name, packaging, design, and tagline significantly influence brand identity. Similarly, specific methods (co-branding, events, partnerships, ambassadors) influence communication methods, and communication modes (website, advertising, networking, promotions, digital media, print) influence communication modes.

Enablers for Branding:

Government initiatives, funding availability, time management, branding awareness, LLP schemes, and comparisons with MNC branding were seen as enablers, not hurdles.

Competitive Advantage:

A majority of MSMEs believe branding provides a competitive edge. Increased return on investment, sales growth, and market expansion were identified as key metrics for competitive growth.

Theme IV: Smart Cities and Waste Management

Study Title:

Techno-commercially Optimized Waste Management System Based on SMART Trash Bin

Organization:

Academy of Technology, Aedconagar, Adisaptagram, Hooghly

1. Overview

Everyday waste is generated from residential or commercial buildings, industrial and institutional establishments such as hospitals, markets, etc. in urban as well as in large cities, including SMART cities. Solid waste management is quite important to maintain a safe, clean and green environment. Because of the mismanagement of waste, there remains a high risk of breeding of germs and spreading of infectious diseases. It is a challenging task to maintain the cleanliness of overpopulated urban areas more effectively in most countries, especially in India.

In India, most of the reliable existing smart

systems of waste management used in large cities, including in SMART cities are being imported, which are either highly costly or their technical know-how is the proprietary aspect of the manufacturer. Hence, the research work to develop cost-effective technology/instrumentation in waste management such as smart sensor based trash bins is important in residential buildings, especially in overpopulated urban areas if we consider the Indian scenario. A study on the development of a working prototype model focused on techno-commercially optimized waste management based on SMART trash bins is proposed in the present work. The proposed model is capable of collecting, monitoring, and facilitating the transfer of household waste from residential buildings for subsequent recycling and toxicity neutralization.

2. Objectives

(i) To develop a commercially viable, real-time solution for waste management.

3. Key Findings

Rapid Waste Generation:

The growing population and increasing urbanization lead to a proportional rise in municipal solid waste (MSW). This creates a strain on the existing waste management infrastructure.

Lack of Public Awareness:

There's a general insufficient public understanding of proper waste segregation and disposal practices. This leads to mixed waste streams, hindering recycling efforts.

Missing Municipal Plans:

Many municipalities lack comprehensive SWM plans that address waste collection, processing, and disposal across the city. This leads to a reactive rather than proactive approach to waste management.

Inadequate Infrastructure

The current waste collection, transportation, and processing infrastructure is insufficient to handle the growing volumes of waste. This results in overflowing landfills and improper waste disposal.

Limited Waste Data:

There's a lack of accurate data on the quantity, future growth patterns, and composition of waste. This makes it difficult to plan for future needs and invest in appropriate technologies.

Study Title:

Study on Development of High Strength and Durable Material which can be used as construction material by recycling the Plastic Waste

Organization:

Rajiv Gandhi University of Knowledge Technologies, Basar mandal, Nirmal district, Telangana

1. Overview

The project "Smart Waste Management - Development Of Cost Effective Technology Study On Development Of High Strength And Durable Material Which Can Be Used As Construction Material By Recycling The Waste Plastic" was a comprehensive effort aimed at pioneering innovative solutions for waste management. Its primary objective was to investigate the creation of construction materials with high strength and durability, derived from recycled waste plastic, thereby addressing environmental concerns while advancing construction practices.

Throughout the project, a series of experiments, methodological studies, and analyses were conducted to evaluate various properties of the recycled plastic material. These investigations focused on factors such as strength, durability, and resilience to assess its suitability as a construction material.

The research involved meticulous methodological studies to optimize the recycling process, ensuring the material met construction standards while remaining cost-effective. These studies aimed to refine the manufacturing process by considering variables such as plastic composition, treatment methods, and mixing ratios with other materials.

The properties of the resulting material underwent rigorous testing protocols to examine its structural integrity, load-bearing capacity, weather resistance, and ecological impact. These assessments were crucial in determining its suitability for diverse construction applications, thereby fostering the development of sustainable construction practices.

The project took a holistic approach, considering not only the technical aspects but also economic feasibility and environmental impact. By bridging the gap between waste management and the construction industry, it presented a viable and eco-friendly alternative for sustainable construction materials.

2. Objectives

(i) To conduct an extensive literature review, exploring technologies designed to transform plastic waste into construction materials suitable for a wide range of applications; (ii) To create a durable construction material by reusing waste plastic through experimentation with different compositions and types of base plastics; and (iii) To offer strategic guidance on maximizing the use of waste as construction material.

3. Key Findings

Increased PET Improves Strength:

Lab studies demonstrate that a higher percentage of PET in the mix leads to significantly improved compression strength, even without using bitumen or asphalt. This suggests the potential for complete bitumen replacement in some construction materials.

Lower Processing Temperatures:

Previously, processing temperatures for aggregate coating ranged from 130-180°C. Replacing bitumen with plastic allows for lower processing temperatures (120-220°C), potentially reducing energy consumption during construction.

High Strength Achieved:

The study successfully developed a composite material with high compressive strength (40 MPa) using only 40% PET as the base, combined with aggregates and sand, without asphalt/bitumen. This exceeds the strength achieved using 5% Wollastonite with HDPE plastic (24 MPa).

Alternative Replacement Strategies:

Other studies explored replacing a smaller portion (4-10%) of asphalt/bitumen binder and cement with plastic waste.

Detailed Analysis Conducted:

The research included a comprehensive methodological study and analysis of two approaches. (i) **Cement-Based Composites, where** plastic used as a filler material to replace fine or coarse aggregates in cement and (ii) **Plastic Waste with Byproducts where** plastic waste combined with fly ash, sand, and fine chips as aggregates.

Theme V: Empowering the Industrial Sector and MSMEs

Study Title:

Demand, Opportunities and Challenges for Development and Deployment of Ultra-Precision Machining Technology in India

Organization:

Central Manufacturing Technology Institute (CMTI), Bangalore

1. Overview

Ultra-Precision Machining (UPM) technology has its roots in diamond machining, which saw its initial development between the 1950s and 1970s. Originally, it was designed primarily for the precision machining of metal optics. Over the years, UPM has evolved to encompass a broader spectrum of technologies, including advancements in machinery, manufacturing processes, and metrology techniques. These collective advancements enable the production and functionality of components with surfaces and features that adhere to tolerances measured in nanometers. In India, the demand for ultra-precision technologies is not only substantial but also experiencing rapid growth. These technologies find

application across a wide array of sectors, ranging from defense and space to atomic energy, machine tools, and various strategic and non-strategic industries

One critical observation is that within India, there is a notable absence of domestic ultra-precision machine tool manufacturers.

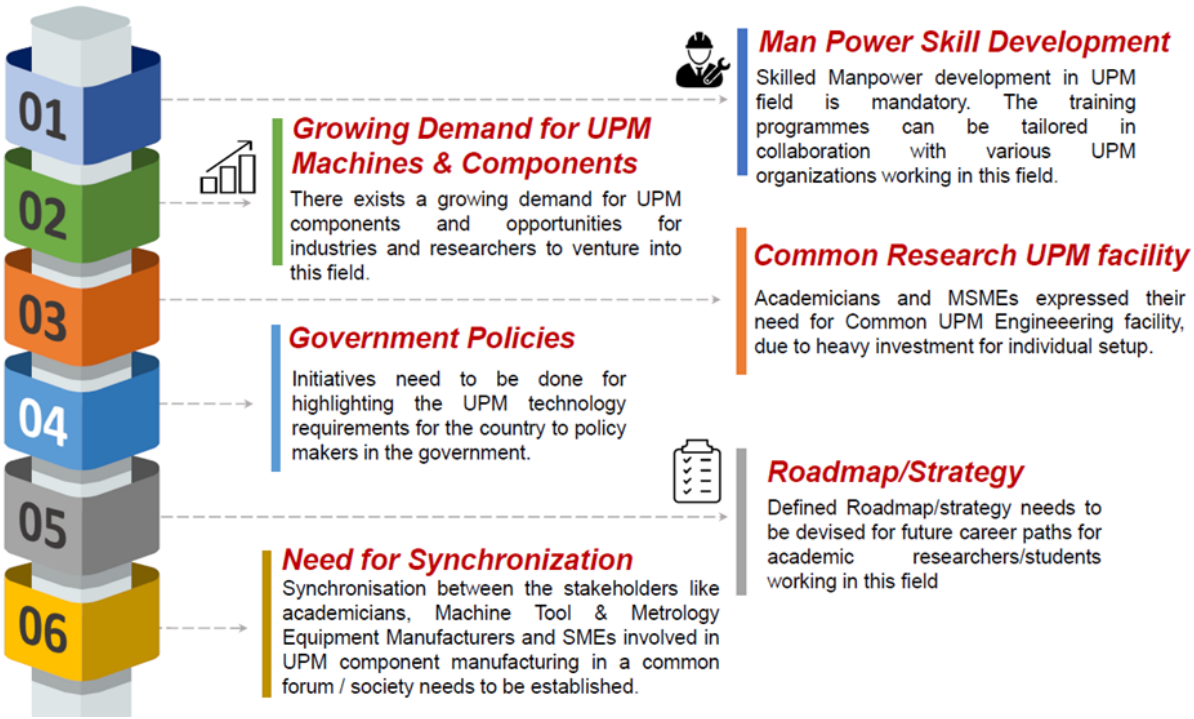
Furthermore, only a limited number of industries are involved in the indigenous fabrication of ultra-precision components. As a result, India faces a significant technological gap in its capability to produce high-precision components independently, which is particularly problematic given the current technological landscape.

2. Objectives

(i) To identify the specific technological demands and challenges related to the development and implementation of Ultra-Precision Machining Technology (UPM) in India. (ii) It aims to offer recommendations and suggestions for key stakeholders in this sector. (iii) To expedite the growth and adoption of UPM technology in India, positioning the nation alongside leading countries and communities worldwide.

3. Key Findings

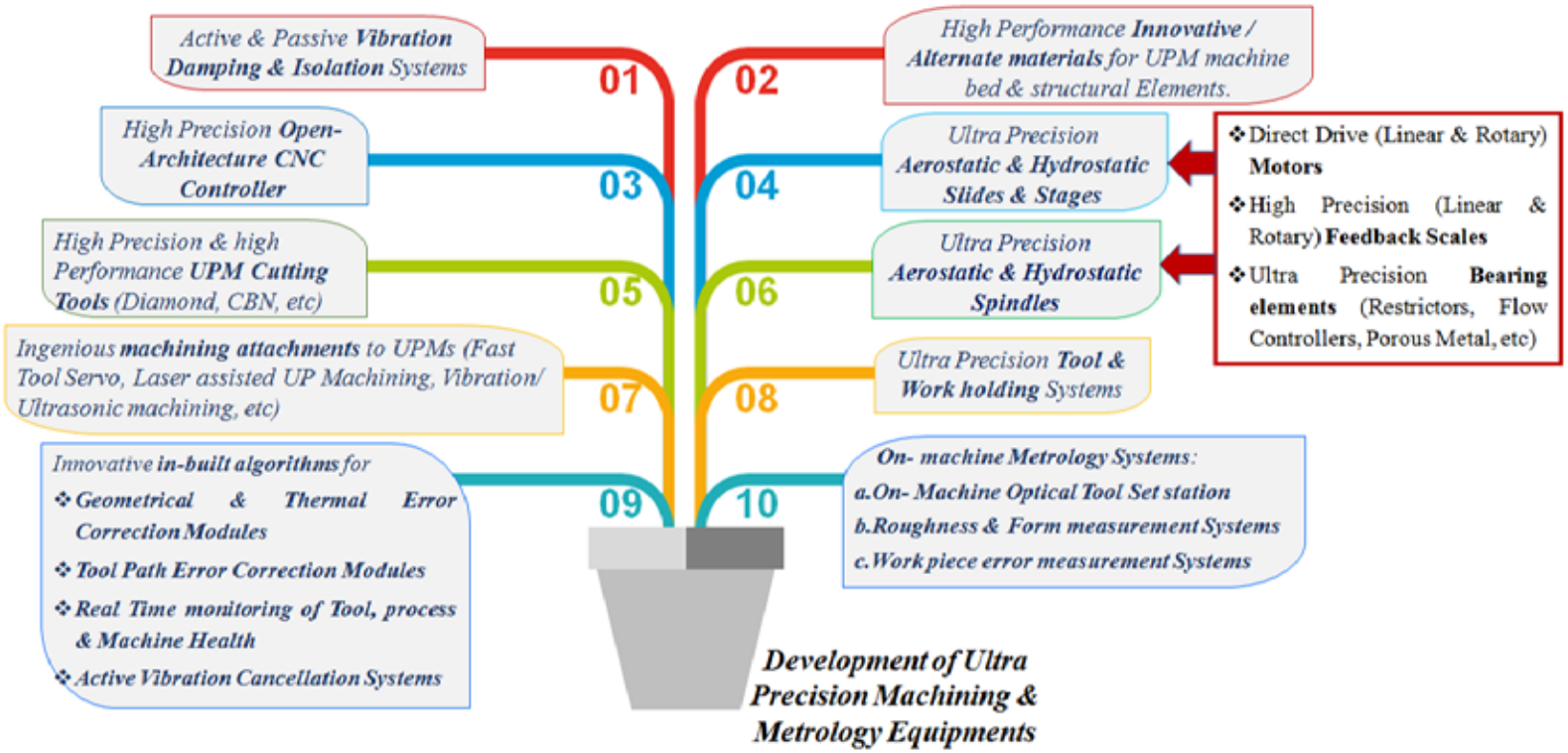
a. The broader study findings from the survey of 215 participants from various sectors regarding adoption of Ultra Precision Machining Technology (UPMT) on India are:



The study concluded with key outcomes and recommendations, including factors for setting up a UPM industry, a case study of CMTI in UPMT technology development, challenges and mitigation strategies, technological gaps, and an action plan roadmap for networking and advancing Indian UPMT technology and community.

In summary, the survey revealed a strong interest in adopting UPMT in India, with a focus on developing indigenous technology and addressing challenges through collaboration and government support. Recommendations included strengthening infrastructure, promoting education, and establishing Centers of Excellence to drive innovation and growth in the field of ultra-precision machining technology.

b. List of Identified Technological Gaps & Indigenous Developmental Requirements of UPM Elements/ Systems in India:



Study Title:

Forecast model to predict leather footwear trade data for the year 2030 using Artificial Intelligence Approach

Organization:

CSIR-Central Leather Research Institute (CLRI), Chennai

1. Overview

The Indian footwear sector holds a significant share, accounting for approximately 52% of the country's leather and leather products. Projections suggest its potential growth to reach 80 billion by the year 2030-31. In the fiscal year 2019-20, India exported close to 130 million pairs of leather footwear. Against this backdrop, the project team has proposed a predictive model using a Recurrent Neural Network (RNN) to forecast India's Leather Footwear Exports from 2022-23 to 2030-31 in terms of Quantity.

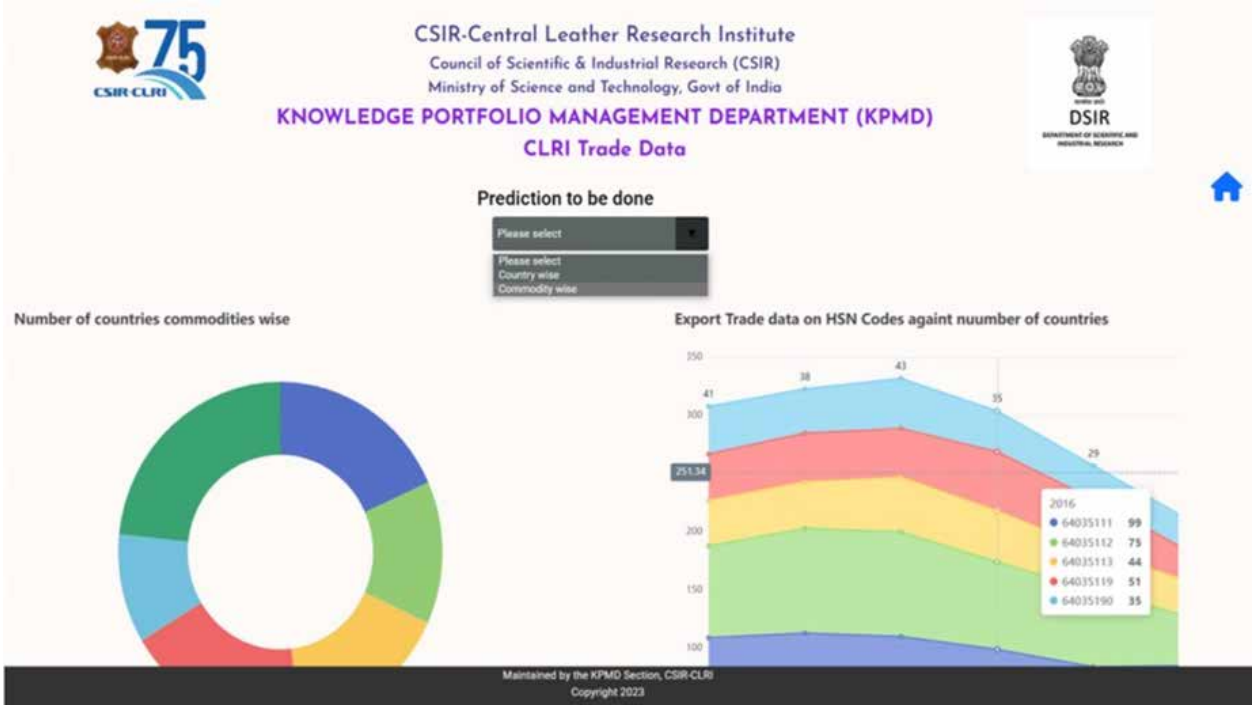
Furthermore, the developed AI forecast model was validated across various domains, including the Textile and Clothing industry, exchange rate fluctuations between USD and INR, and steel exports from the UK, USA, and India.

2. Objectives

To have the insights into the Trade data on India's Export of Leather Footwear and Prediction of Leather Footwear Trade for the year 2030.

3. Key Findings

A software copyright on "CSIR-CLRI Dashboard on Leather Footwear Trade Data using AI aproach" has been applied. CSIR-CLRI Trade Data: Dashboard illustrates the forecast results for every particular country and leather commodity for any particular year as desired by the user. It's a menu driven web based application consisting menus such as Leather Footwear Export Forecast, Year Wise Commodity Export, Estimation of Finished Leather, Year wise Footwear Export, Directory of Tanneries in India, World Footwear Yearbook Data and Functionalities such as Livestock Prediction, Country wise data etc.



The key findings from Trade data on India's Export of Leather Footwear and Prediction of Leather Footwear Trade for the year 2030 is as mentioned below:

Export Projections: India's Overall Leather Footwear export is expected to grow around 6.54% in terms of Quantity in the year 2030-31 in a period of nine years i.e., approximately from 130 million pairs to 139 million pairs.

Domestic vs. Export Production: There is a projected 68 to 77 million pair difference between production and export, indicating that 35% of leather footwear will be used domestically, with 65% exported in the coming years.

It can be observed that I**ndia might export around approximately 139 million leather footwear pairs in the year 2030-31** increasing from 127.9 million pairs from the year 2022-23.

Rising Commodity: Commodity 64031920 (Other Sport Footwear with Outer Soles of Rubber) climbed from 25th and 26th in 2017 and 2018 to second place in 2020 and 2021, exporting 15 to 24 million pairs with a 15% to 18% share of total exports.

Major Export Markets: The top five importers of Indian footwear (2009-2019) were the USA, UK, Germany, France, and Italy. The USA emerged as the leading importer, with India exporting $411 million worth of footwear in 2018.

Prediction Model: The results obtained shows that the ANN model has predicted significantly well with the error rates ranging between approximately 2 % to 6% of MAPE. Yet RNN-LSTM model has been implemented to 37 leather commodities comprising of 268 countries due to its strong memory calibre which adopts well for sequential data.

Study Title:

Emerging requirement of Nano coating in the fields of Automotive, Aerospace, Machine tool, Healthcare & sanitization sectors in the Country and the means to achieve it

Organization:

Central Manufacturing Technology Institute (CMTI), Bangalore

1. Overview

This report examines India's readiness to adopt and implement nano coatings at a commercial scale, based on a survey by the Central Manufacturing Technology Institute. Nanotechnology, including nano coatings, can enhance energy efficiency, clean the atmosphere, improve consumer goods, and address health issues, potentially increasing production performance while reducing costs. The survey indicates significant interest in nano coatings across various capital goods sectors in India. Successful adoption will

require collaboration among scientists, government, industry, and the public to guide nanotechnology's development. The report provides insights for stakeholders and highlights the views of experienced respondents on nanotechnology. While nano coating is not new, its importance has grown in the last five years, influencing industrial developments and product pricing. Several companies were consulted to identify challenges in adopting nano coatings.

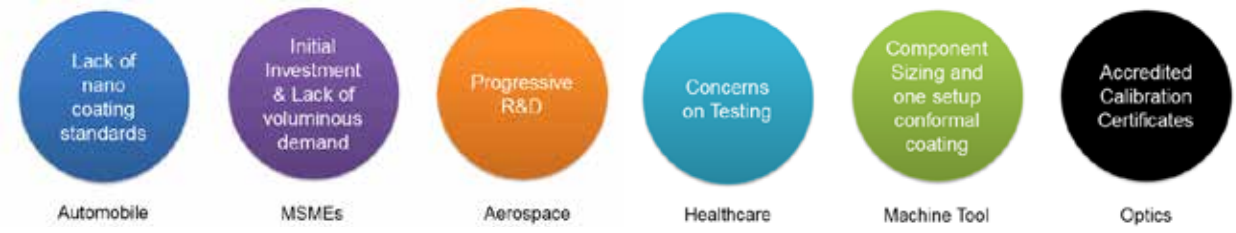
2. Objectives

(i) To understand the requirement of MSME in different sectors in Nano coatings; (ii) Visit industries to understand and note the problems faced due to current problems in existing coating techniques; (iii) Understand the technologies required for addressing various problems of coating by industries in country and find the availability of such facilities in public domain; (iv) Organize to demand aggregation workshops and allow industry personal to speak on the coating issues currently faced

3. Key Findings

The findings offer valuable insights into the current state of nano coating adoption in India. They highlight the challenges faced by industries, the demand across sectors, and the need for advancements in domestic equipment manufacturing and collaboration. The potential future investment indicates a growing interest in nano coatings, but addressing the identified barriers will be crucial for wider adoption and technological progress. The survey across all regions of India investigated the adoption of nano coating technologies in various industries.

a. Challenges for Industries:



R&D and Investment Hurdles
Continuous research and development (R&D) and high capital investments are identified as significant barriers to nano coating implementation.

Demand for Nano Coatings & Technology Development Gaps
The demand for nano coatings is relatively equal across all capital goods sectors, ranging from 16% to 20%.

Limited Equipment Manufacturers

The survey highlights a significant gap in domestic nano coating equipment manufacturers compared to countries like China and Korea.

Investment Timeframes

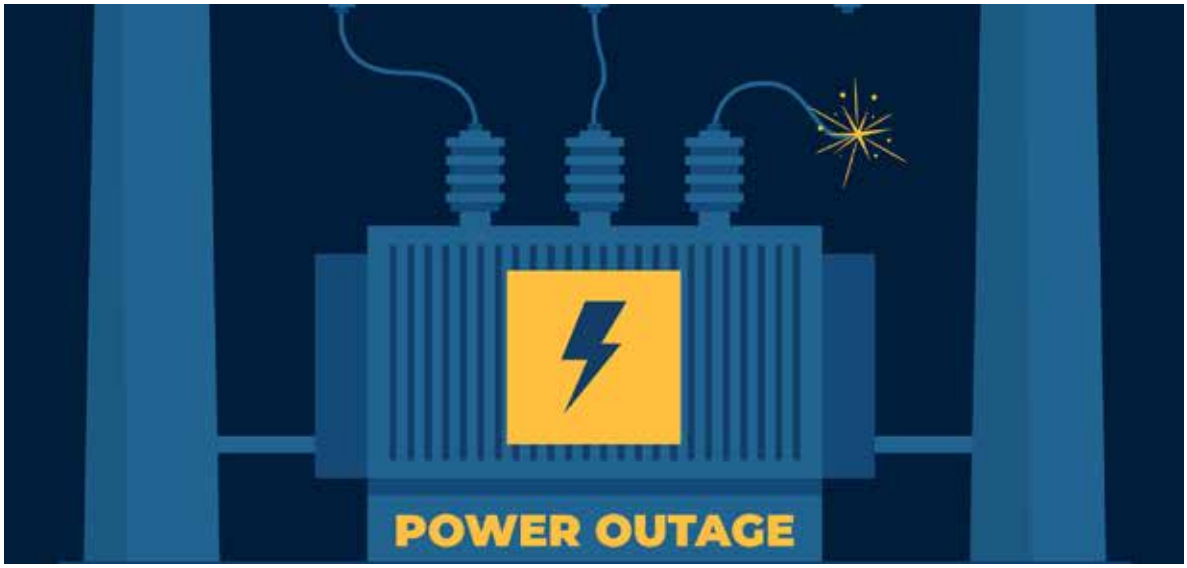
Organizations are taking a cautious approach to investment, with an average budget of Rs. 1-5 crore for production-scale nano coating facilities.

Study Title:

Study of specific areas registering high failure rate of distribution transformers to analyze the cause of failure and suggest a solution to overcome this problem by applying IT technology and integrating it with metering solutions

Organization:

PDPM-Indian Institute of Information Technology, Design and Manufacturing (IIITD&M), Jabalpur



1. Overview

Over the past two decades, electricity consumption has surged due to urbanization, energy-intensive agriculture, and the rise of electric vehicles. This has led to an overloaded distribution system, particularly stressing distribution transformers (DTRs), which suffer from heavy losses and high failure rates, especially in developing countries. DTRs, ranging from 25kVA to 1MVA, are deployed across varied regions, from urban centers to remote fields. Transformers under 150kVA are particularly vulnerable due to their remote

locations and lack of protection systems. High failure rates of DTRs in India result in revenue loss and customer dissatisfaction. This study investigates the causes of DTR failures, current practices for handling them, and recommends strategies to reduce failure rates. It also suggests cost-effective solutions for monitoring, alerting, and managing DTR data.

2. Objectives

(i) Data collection related to transformer failure within a distribution area (DISCOM); (ii) Data analysis and interpretation to discover the vital causes of transformer failure; (iii) Identification of key parameters for possible remedial solutions; and (iv) Development of an information technology-based solution for minimizing the transformer failure rate.

3. Key Findings

Challenges in DTR Management:

Lack of Preventive Maintenance: Most utilities neglect scheduled preventive maintenance due to limited awareness and insufficient manpower.

DTR Overload: The primary cause of DTR failure is overloading, especially in low-capacity transformers. This is often exacerbated by:

- Absence of proper protection/monitoring systems.
- Inappropriate methods used to bypass fuse protection (leading to ultimate failure).

Inadequate Data Management: Utilities lack proper data management systems, hindering data collection and analysis for informed decision-making. This is crucial for tasks like:

- DTR failure prediction
- Augmentation planning
- Preventive maintenance scheduling

Hardware Solutions:

- **Overload Monitoring System (OMS):** This cost-effective system utilizes the cable between the secondary bushing and distribution terminal box as a current sensor, eliminating the need for expensive current transformers. A microcontroller processes the signal to collect load data and trigger alarms upon overload conditions.

Proposed Solutions:

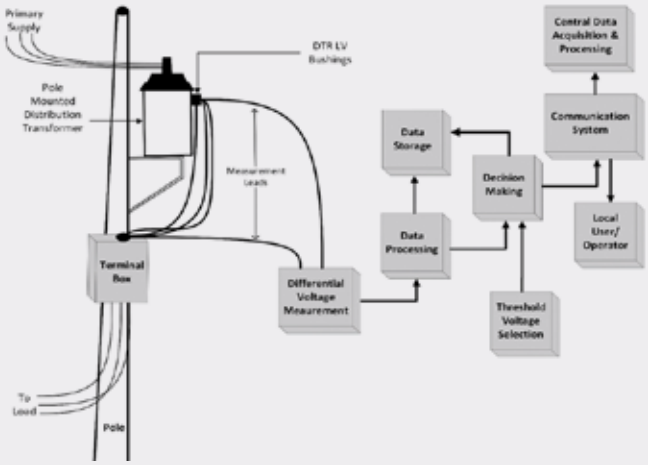


Fig: Conceptual block diagram of overload monitoring system.

– **Overload Protection System (OPS):** This builds upon the OMS by enhancing it with tamper-proof overload protection. It replaces traditional fuse systems, offering reliable protection. The system can be further expanded to include additional sensors (e.g., winding temperature, oil level) for comprehensive transformer protection.

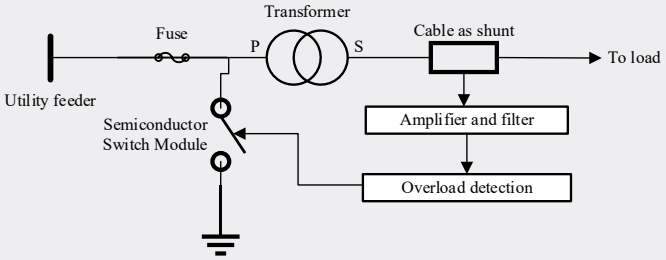


Fig: Overload Protection Scheme

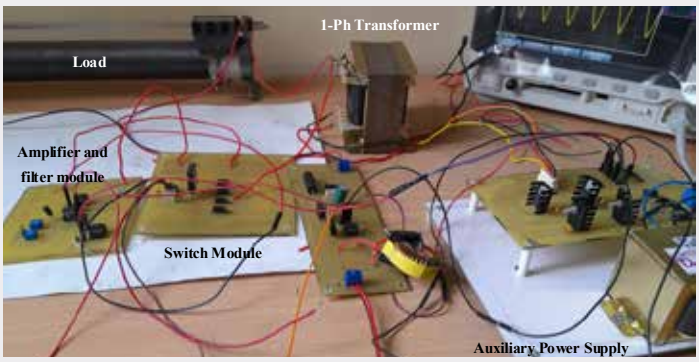


Fig: A single-phase, small-scale prototype of the novel protection scheme.

Software Solution:

— **DTR Management Software:** Data collected from utilities nationwide revealed a significant issue – extended replacement times for failed DTRs. This primarily stems from poor asset and inventory management practices at utility stores, substations, and repair centers. The project proposes a software solution framework, which could be implemented as a web or desktop application, to manage and record DTR databases across utilities, stores, substations, and repair centers. This solution would empower informed decision-making, such as scrapping failed DTRs or upgrading transformer capacity at specific locations. The framework includes software requirement specifications (SRS), Use Case diagrams, and ER diagrams for the required database. Software development teams can leverage this framework to implement the solution while adhering to the outlined functional and non-functional requirements.

Study Title:

Access To Energy Efficiency Technology Information For Indian Industries

Organization:

The Energy and Resources Institute (TERI), New Delhi

1. Overview

Post-liberalization, the Indian steel industry has transformed significantly in structure and technology, with new modern plants and the upgrade of existing ones boosting productivity, energy efficiency, and environmental sustainability. Despite efforts to promote energy savings, information on these initiatives is scattered, especially impacting secondary sector industries. A centralized repository is needed to provide insights into energy-efficient technologies, adoption rates, international benchmarks, and benefits in terms of energy consumption and CO2 emissions.

This study examines the process paths in Indian iron and steel industries, detailing technologies used in BF-BOF and EAF-EIF processes. While focusing on energy efficiency and CO_2 reduction, it also calls for separate research on pollution abatement

technologies. The pulp and paper sector, reliant on conventional technologies, sees high resource consumption and effluent generation. The study identifies energy-efficient processes and technologies in this sector, validated through plant visits and stakeholder meetings.

2. Objectives

The study aims to provide accessible technology information, particularly focusing on energy efficiency, via a web portal. It centers on two key Indian industry sub-sectors: (i) Iron and Steel, and (ii) Pulp and Paper. The objectives include consolidating, analyzing, and spotlighting energy-efficient technologies utilized in both sectors.

3. Key Findings

Iron & Steel:

Information on production technologies related to Iron & Steel section has been grouped based on both the primary and secondary steel making routes with each technology containing technology description, energy savings, environmental aspects, investment cost, and source details.

A total of 106 emerging and energy efficient technologies have been compiled and consolidated in the portal:

Classification of BF-BOF Process Routes
The BF-BOF process routes are classified into seven broad steps, covering Iron Ore Preparation, Coke making, Iron (Hot metal) making, BOF/LD converter steel making, Casting, and Rolling (Hot Rolling and Cold Rolling), as well as Processing/finishing operations.

Classification of DRI-EAF/EIF Routes
there are six broad steps, including Coal-based DRI making, Gas-based DRI making, EAF steel making, EIF steel making, Casting, and Rolling and Finishing lines.

Consolidation of Benefits
Benefits in terms of energy savings, CO_2 emissions reduction, and other factors have been consolidated for integrated steel plants (BFBOF Route) and gas-based DRI-EAF steel making routes. These consolidations are largely drawn from international and national literature, as well as consultations with domain experts and industry professionals.

Pulp & Paper:

Collection of Energy-Efficient Processes and Technologies in the Indian Paper Industry
A comprehensive collection of energy-efficient processes and technologies used in the Indian paper industry has been collated. This includes 52 main production process steps from raw material preparation to paper making. The data is gathered in consultation with domain experts and sourced from published literature.

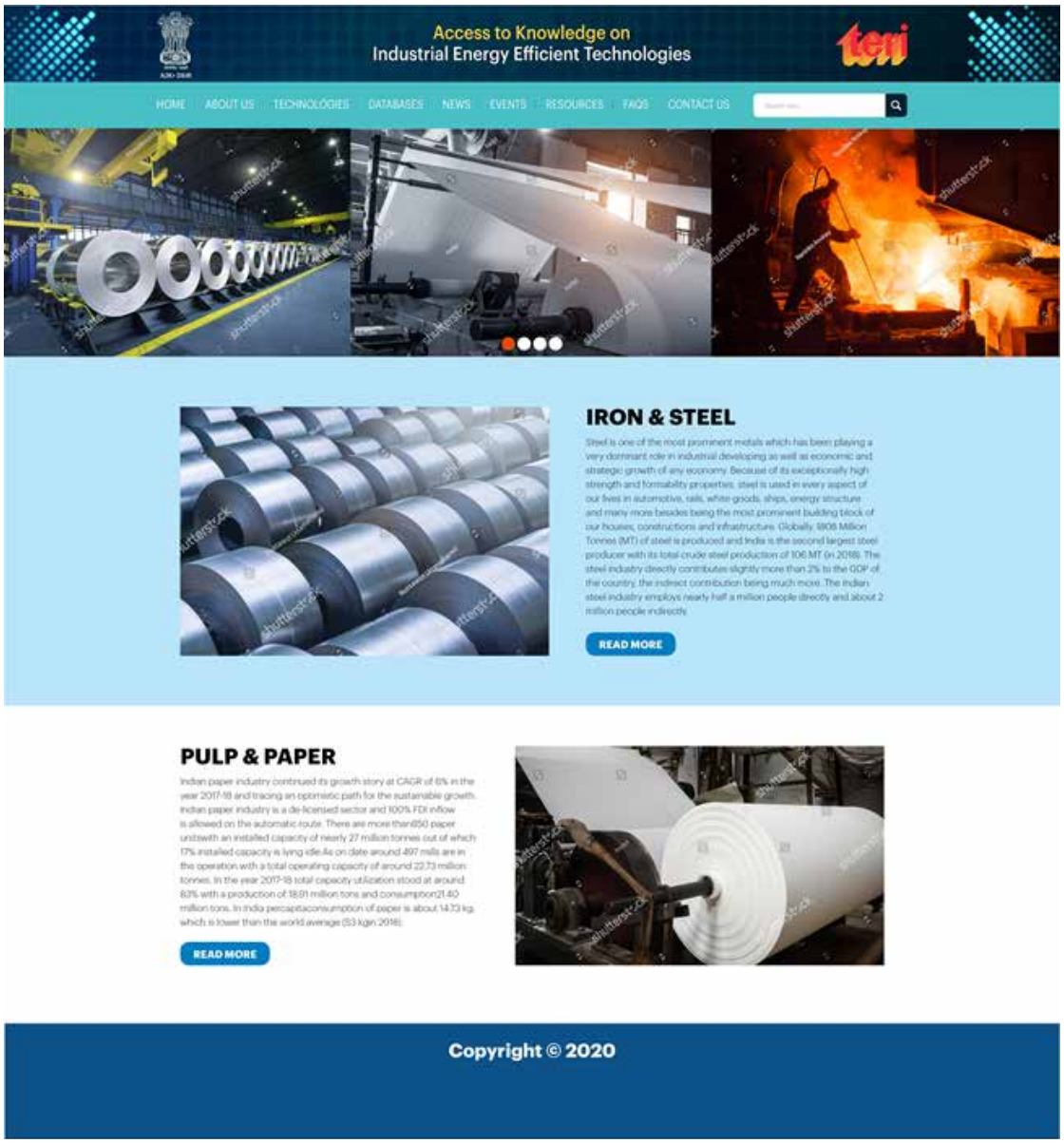
Classification Based on Raw Materials
The data is classified based on three types of raw materials: Wood-based, Agro-based, and Recycled Cellulose Fibre (RCF). Each process contains descriptions of technology, energy savings, environmental aspects, and information source details.

Wood-Based Production Process and Technologies
The Wood-based section presents 17 production processes and technologies, covering various stages from raw material preparation to paper production.

RCF Production Process and Technologies
There are 12 major production processes and technologies identified for RCF, including waste paper handling, pulping systems, bleaching, and paper machine operations.

Designing and development of web portal:

A dedicated web portal (https://ieetech.org/) has been designed and developed to serve as a central access point for information exchange and knowledge sharing. The portal allows users to discover relevant technologies and access resources. This web portal provides a comprehensive resource for stakeholders in the Indian paper industry seeking to improve energy efficiency and environmental sustainability and features an online forum for stakeholder interaction.


Access to Knowledge on
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IRON & STEEL
Steel is one of the most prominent metals which has been playing a very dominant role in industrial developing as well as economic and strategic growth of any economy. Because of its exceptionally high strength and formability properties, steel is used in every aspect of our lives in automotive, rails, white goods, ships, energy structure and many more besides being the most prominent building block of our houses, constructions and infrastructure. Globally 1808 Million Tonnes (MT) of steel is produced and India is the second largest steel producer with its total crude steel production of 106 MT (in 2018). The steel industry directly contributes slightly more than 2% to the GDP of the country, the indirect contribution being much more. The Indian steel industry employs nearly half a million people directly and about 2 million people indirectly.
READ MORE
PULP & PAPER
Indian paper industry continued its growth story at CAGR of 6% in the year 2017-18 and tracing an optimistic path for the sustainable growth. Indian paper industry is a de-licensed sector and 100% FDI inflow is allowed on the automatic route. There are more than 650 paper unitswith an installed capacity of nearly 27 million tonnes out of which 17% installed capacity is lying idle.As on date around 497 mills are in the operation with a total operating capacity of around 22.73 million tonnes. In the year 2017-18 total capacity utilization stood at around 83% with a production of 18.91 million tons and consumption(21.40 million tons. In India percapitaconsumption of paper is about 14.73 kg, which is lower than the world average (53 kgin 2018).
READ MORE
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Study Title:

Performance Evaluation of Advanced Dielectric Material in Transformers

Organization:

National Institute of Technology (NIT), Srinagar, J&K

1. Overview

Transformers stand as vital components within power transmission and distribution systems, their upkeep crucial for ensuring uninterrupted service. This task poses a significant challenge for utility engineers and owners alike, emphasizing the necessity of comprehending a transformer's functionality under critical conditions. Understanding the influence of both internal and external factors on transformer operation is imperative for effective maintenance. Advanced techniques for health assessment and fault diagnosis facilitate the management of numerous transformers, streamlining maintenance efforts.

In this regard, a systematic approach addressing transformer maintenance and challenges in cold climates is proposed. Examining the dielectric behavior of transformers across varying climatic

conditions, field surveys conducted in cold regions like Jammu and Kashmir and Himachal Pradesh shed light on temperature impacts. Notably, load fluctuations exhibit minimal effects on oil and winding temperatures in cold climates.

Further analysis of field studies and test data elucidates the stresses impacting transformer operation, unveiling specific issues prevalent in cold regions. Challenges such as reduced oil viscosity hindering effective cooling during energization and malfunctioning of oil pumps and flow meters during cold starts are identified. Solutions tailored to these issues are explored comprehensively.

Exploration of modern dielectric materials reveals Ester as a superior option for transformers in cold climates, supported by comparative tests highlighting its suitability. Performance data gathered from field and experimental studies aid experts in assessing transformer health, complemented by an examination of various health assessment methodologies.

Introducing a novel multi-criterion fuzzy logic method expands the repertoire of existing health assessment techniques, facilitating precise health index determination for transformers in cold climates. This holistic approach aims to enhance transformer maintenance strategies, ensuring reliable performance even in challenging environmental conditions.

2. Objectives

(i) To study the dielectric behaviour of various transformers installed in Kashmir Valley Region; (ii) To examine the influence of several working stresses on operating performance of transformers; (iii) To investigate the advancements in solid and liquid dielectrics of transformers; (iv) To study the recent advanced technologies to determine the health status as well as faults present in transformers; and (v) To develop a new and generalized algorithm for transformer health assessment based on the collected primary and secondary data.

3. Key Findings

Improved Performance in Cold Climates:

Ester Oil Advantage: Compared to mineral oil, ester-based transformers outperform in cold climates by addressing all the mentioned challenges.

Economic Viability: While the initial cost of ester oil is higher, its longer service life makes the overall cost comparable to mineral oil over an extended period.

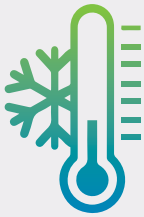
Climate Impact:

Distinct Behaviours: Transformers operate differently depending on the climate.

Hot Regions: High ambient temperatures challenge cooling mechanisms, potentially leading to overheating and insulation degradation.

Cold Regions: Rapid temperature swings can cause mechanical stress and insulation issues due to material contraction and expansion. However, cold temperatures generally enhance insulation strength.

Minimal Load Impact: Load variations have minimal effect on transformer temperatures in both hot and cold environments.



Cold Climate Challenges:

Decreased Oil Fluidity: Increased oil viscosity or freezing hinders heat transfer, leading to hot spots within the transformer.

Internal Temperature Rise: Reduced oil circulation traps heat, causing localized overheating.

Cooling System Issues: Extremely low external temperatures affect cooling efficiency.

Internal Pressure Fluctuations: Local freezing and heating create pressure variations, impacting pumps and flow meters.

Moisture Ingress: Snow and ice can introduce moisture, increasing the risk of electrical breakdown.

Advanced Health Assessment:

Deep Learning Techniques: This study identifies deep learning as a suitable method for assessing transformer health and predicting faults, offering improved performance and accuracy.

Cold Climate Health Model: A new health assessment model specifically designed for transformers operating in cold climates has been developed. This model utilizes diagnostic data to provide health indices, aiding utility managers in making informed decisions about transformer maintenance.

Acronyms

A2K+	Access to Knowledge for Technology Development and Dissemination
DSIR	Department of Scientific and Industrial Research
ICT	Information and Communication Technology
TRL	Technology Readiness Levels
MSMEs	Micro, Small, and Medium Enterprises
SDG	Sustainable Development Goals
STI	Science, Technology and Innovation
ML	Machine Learning
AI	Artificial Intelligence
IIT	Indian Institute of Technology
FIIT	Foundation for Innovation and Technology Transfer
TIFAC	Technology Information, Forecasting and Assessment Council
ICCW	Intrnational Centre for Clean Water
CSIR	Council of Scientific and Industrial Research
CSIO	Central Scientific Instruments Organisation
IHBT	Institute of Himalayan Bioresource Technology
AICRP	All India Coordinated Research Project
NARD	National Agricultural Research System
OER	Open Educational Resources
PFROs	Public Funded Research Organizations
VR	Virtual Reality
AR	Augmented Reality
NEP	National Education Policy
CSR	Corporate Social Responsibility
CUSAT	Cochin University of Science and Technology
SIMS	Symbiosis Institute of Management Studies,
MNIT	Malviya National Institute of Technology
CAGR	Compound Annual Growth Rate

IoT	Internet of Things
R&D	Research and Development
CDAC	Centre for Development of Advanced Computing
RGIPT	Rajiv Gandhi Institute of Petroleum Technology
AIMA	All India Management Association
SIDTM	The Symbiosis Institute of Digital and Telecom Management
ABV-IITM	Atal Bihari Vajpayee Indian Institute of Information Technology and Management
ICAR	Indian Council of Agricultural Research
CIAE	Central Institute of Agricultural Engineering
ICRIER	Indian Council for Research on International Economic Relations
CMTI	Central Manufacturing Technology Institute
NIT	National Institute of Technology
PDPM-IIITD&M	Pandit Dwarka Prasad Mishra Indian Institute of Information Technology, Design and Manufacturing
TERI	The Energy and Resources Institute
RFID	Radio Frequency Identification Detection
GPS	Global Positioning System
COVID-19	coronavirus disease 2019
IPRs	Intellectual Property Rights
UDL	Universal Design of Learning
UN	United Nations
HSS	Higher Secondary Schools
INR	The Indian rupee
USD	United States Dollars
CNN	Convolution Neural Networks
TSA	Transient Stability Assessment
LSTM-AE	Long Short-Term Memory – Autoencoder
IEEE	Institute of Electrical and Electronics Engineers
KV	Kilo Volts
LDCs	load dispatch centers
GUI	Graphical User Interface

HEPA	High Efficiency Particulate Air
MERV	Minimum Efficiency Reporting Value
HVAC	Heating, ventilation, and air conditioning
MSMED Act.	Micro, Small And Meduim Enterprises Development Act
GDP	Gross Domestic Product
LLP	Limited Liability Partnership
PET	Poly-Ethylene Terephthalate
HDPE	High Density Poly Ethylene
UPM	Ultra-Precision Machining
UPMT	Ultra Precision Machining Technology
RNN	Recurrent Neural Network
UK	United Kingdom
DTR	Distribution Transformers
OMS	Overload Monitoring System
OPS	Overload Protection System
BF-BOF	Blast Furnace-Basic Oxygen Furnace
RCF	Recycled Cellulose Fibre

Notes

Notes

About DSIR

The Department of Scientific and Industrial Research (DSIR), one of the Departments of the Ministry of Science and Technology, was set up through a Presidential Notification, dated 4th January, 1985 (74/2/1/8 Cab.). The mandate of DSIR includes promotion of industrial research for indigenous technology promotion, development, utilization and transfer.

The primary endeavour of DSIR is to promote R&D by the industries; support industrial units to develop state-of-the-art globally competitive technologies of high commercial potential; catalyse faster commercialization of laboratory-scale R&D; augment technology transfer capabilities; enhance the share of technology intensive exports in overall exports; strengthen industrial consultancy and establish a user-friendly information network to facilitate scientific and industrial research in the country.

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