# India: Green Outlook Report

Oxford Policy Management

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# List of abbreviations

| | |
|---|---|
| BIRAC | Biotechnology Industry Research Assistance Council |
| C-CAMP | Centre for Cellular and Molecular Platforms |
| CCMTs | Climate Change Mitigation Technologies |
| CII | Confederation of Indian Industry |
| CSE | Centre for Science and Environment |
| CSIR | Council of Scientific and Industrial Research |
| DAE | Department of Atomic Energy |
| DBT | Department of Biotechnology |
| DOS | Department of Space |
| DPIIT | Department for Promotion of Industry and Internal Trade |
| DRDO | Defence Research and Development Organisation |
| DST | Department of Science and Technology |
| EAC-PM | Economic Advisory Council to the Prime Minister |
| EVI | Electric Vehicle Initiative |
| EVs | Electric Vehicles |
| GHG | Greenhouse Gas |
| GoI | Government of India |
| ICAR | Indian Council of Agricultural Research |
| ICMR | Indian Council of Medical Research |
| IEA | International Energy Agency |
| IITs | Indian Institute of Technology |
| IMPRINT | Impacting Research and Innovation Technology |
| IPRs | Intellectual Property Rights |
| ISGF | India Smart Grid Forum |
| JUICE | Joint UK-India Clean Energy Centre |

| | |
|---|---|
| KIA | Karnataka Innovation Authority |
| KTDB | Karnataka Technology Development Board |
| MEITY | Ministry of Electronics and Information Technology |
| MHRD | Ministry of Human Resource Development |
| MNRE | Ministry of New and Renewable Energy |
| MoEFCC | Ministry of Environment, Forest and Climate Change |
| MoES | Ministry of Earth Sciences |
| MSW | Municipal Solid Waste |
| NITI Ayog | National Institution for Transforming India |
| OPIC | Overseas Private Investment Corporations |
| PM-STIAC | Prime Minister's Science, Technology and Innovation Advisory Council |
| PPP | Public Private Partnership |
| PSA | Principal Scientific Advisor |
| R&D | Research and Development |
| SAPCCs | State Action Plans on Climate Change |
| SDGs | Sustainable Development Goals |
| SERB | Science and Engineering Research Board |
| SPARC | Scheme for Promotion of Academic and Research Collaboration |
| SSS-NIBE | Sardar Swaran Singh National Institute of Bio-Energy |
| TCP | Technological Cooperation Programmme |
| USICEF | US-India Clean Energy Finance |
| VC | Venture Capital |

# Introduction

India’s green growth narrative over the last decade has been a function of reforms as well as wide-ranging interventions across sectors such as biotechnology, renewable energy, transportation, and sustainable agriculture. In its transition towards a low-carbon economy, India has built an ecosystem that works with and thrives on international technological collaboration including in areas where Denmark is an established player. Committed to meeting ambitious clean energy targets, India has deepened investments for accessing and deploying smart grids as well as waste-to-energy production units. India has continued to focus on promoting alternative sources of energy, including biofuels such as biogas through multi-ministerial schemes. It has heavily invested in new sectors such as artificial intelligence and quantum computing, with an expressed view to build strong international research-oriented partnerships. Moreover, India’s regulatory reforms, which have led to improvements in its World Bank Ease of Doing Business ranking, makes it an attractive destination for Danish entrepreneurs and established businesses alike. India and Denmark’s sustainable development synergies are reflected in the India-Denmark Green Strategic Partnership of 2020.

# 1. Political and organizational factors, regulation and financing

## India's commitment to green growth

With the ambition to promote green growth through renewable energy adoption, energy and resource efficiency, digital pathways, and effective waste-management, India has set up a range of technology-specific national 'missions' and schemes. There are several cross-sectoral flagship programmes (such as *Make in India*, *Skill India, Digital India,* and *Startup India*) that have a major bearing on green Research and Development (R&D) plans. India has also set ambitious emission reduction targets under the United Nations Framework Convention on Climate Change's Paris Agreement, which feed into India's green growth agenda. The government of India launched the National Action Plan on Climate Change in 2008 with the intention of combatting climate change through eight sectoral missions focused on mitigation and adaptation aspects. Three of these missions- on solar energy, afforestation and energy efficiency- seek to slow down India's emissions. Three others focus on agriculture, water and Himalayan eco-systems to develop mechanisms to adapt to the effects of climate change. Two are service missions that focus specifically on sustainable habitat and strategic knowledge development. Each of these missions and initiatives is tagged to a specific ministry and has elements of research and technological innovation. State Action Plans on Climate Change (SAPCCs) have also now been prepared for almost all states and union territories in India; these outline how the national framework will be implemented at the subnational level, taking into account vulnerabilities unique to specific geographies. SAPCCs are primarily concerned with adaptation, with a limited focus on mitigation of greenhouse gas (GHG) emissions – though some are accompanied by a GHG inventory and explore the potential of renewable energy and other clean technologies.

**India's Climate Commitments**

***Cancun Agreements (2010)***

India put forth its target to reduce its GDP's emission intensity by 20–25% below 2005 levels by 2020.

***Paris Agreement (2015)***

India stated its commitments to address climate change as part of its Nationally Determined Contributions, which was submitted for 2015–30. The key pledges stated:

- Share of non-fossil fuel in the total installed capacity to be 40% by 2030
- Emission intensity of GDP to reduce by 33–35% by 2030 from 2005 levels
- To create an additional carbon sink of 2.5–3 billion tonnes of $CO_2$ through additional forest cover by 2030 in India

## India's Science, Technology and Innovation (STI) Landscape

India's R&D activities specifically in the green technology space take place across a set of central government ministries through schemes/missions with in-built R&D components. Government expenditure on research and development is primarily undertaken by the central government.

STI interventions are organized using a top-heavy approach, with national priority topics largely determined with the approval of the Prime Minister's Office, and through deliberations with the National Institution for Transforming India (NITI Aayog), Ministry of Science and Technology, the Principal Scientific Advisor (PSA), Science Advisory Council to the Prime Minister. In addition to this, the Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) facilitates the PSA's Office to assess the status in science and technology domains, understand existing sectoral challenges in hand, formulate interventions, develop relevant roadmaps and advise the Prime Minister accordingly. India has a Science and Technology Innovation Policy (2013) in place- this sets a target for India to allocate 2% GDP towards R&D through enhancing the role of the private sector, increasing the role played by public-private partnerships, integrating agriculture R&D policy into the national research ecosystem. This policy is being revised to reflect updated thinking on sectoral priorities- this process is being steered by the Department of Science

and Technology (DST), and will be released in December, 2020.[1] The new policy (STI 2020) is being formulated in the wake of the COVID-19 crisis and is expected to be drawn up based on a new understanding of priorities, sectoral focus and strategies.[2] The core vision of the STI 2020 is the decentralization of policy designing by making it a bottom-up and inclusive process. Twenty-one focused thematic groups have been constituted for this purpose, including disruptive technology, agriculture, water and food security, and sustainable technologies.

**Expenditure on R&D by Major Scientific Agencies**

| Agency\ Year | 2017-18 (Rs Crore) |
|---|---|
| Defence Research & Development Organisation (DRDO) | 15,195.87 |
| Department of Space (DOS) | 9,130.57 |
| Indian Council of Agricultural Research (ICAR) | 5,355.57 |
| Department of Atomic Energy (DAE) | 5,208.01 |
| Council of Scientific & Industrial Research (CSIR) | 4,582.12 |
| Department of Science & Technology (DST) | 3,526.64 |
| Department of Biotechnology (DBT) | 1,771.65 |
| Indian Council of Medical Research (ICMR) | 1,468.70 |
| Ministry of Earth Sciences (MES) | 1,123.58 |
| Ministry of Electronics and Information Technology (MEITY) | 386.55 |
| Ministry of Environment, Forest and Climate Change | 260.87 |
| Ministry of New and Renewable Energy (MNRE) | 34.50 |
| **Total** | **48,044.63** |

Beyond this first level of centralized decision-making, the Finance Ministry allocates budgets STI and R&D to various ministries, and the next level of resource allocations for research is carried out by the nodal departments and science agencies that function under these ministries. Each of the ministries have their own 'international cooperation' divisions and engage bilaterally with countries on projects or schemes. Research funds in Higher Educational Institutions such as public or private universities and research institutions are allocated by the Ministry of Human Resource Development (MHRD) at the first level and then by the University Grants Commission at the second level.[3] Science and Technology Councils exist at the state level, where governments have institutionalised a ministry of science, technology and education, but their expenditure on R&D is quite limited. There are, however, many centrally sponsored schemes as well as incubation centres that operate at the state level and can be accessed by investors, researchers and innovators:

- Atal Innovation Mission Incubation Centres
- Biotechnology Industry Research Assistance Council (BIRAC) Regional Entrepreneurship Centres
- Centre for Cellular and Molecular Platforms (C-CAMP) in Bengaluru
- Department of Science and Technology Centres (such as the DST- IISc Energy Storage Platform on Supercapacitors, DST- NFTDC Energy Storage Platform on Hydrogen, DST- IIT Delhi Energy Storage Platform on Batteries, DST- IIT Bombay Energy Storage Platform on Hydrogen)
- Centres of Excellence at the Indian Institutes of Technology (such as DESMI Centre of Excellence on Waste to Wealth at IIT-Delhi), which can be sponsored by industry partners, the institute itself or externally funded projects[4]

[1] https://www.thehindubusinessline.com/economy/policy/new-policy-on-science-technology-innovation-being-framed-by-centre/article30585104.ece
[2] http://thesciencepolicyforum.org/initiatives/science-technology-and-innovation-policy-stip-2020/
[3] European Union Research and Innovation Observatory India Report (2015)- Available at: https://rio.jrc.ec.europa.eu/country-analysis/India/country-report
[4] http://www.iitd.ac.in/content/centres-excellence

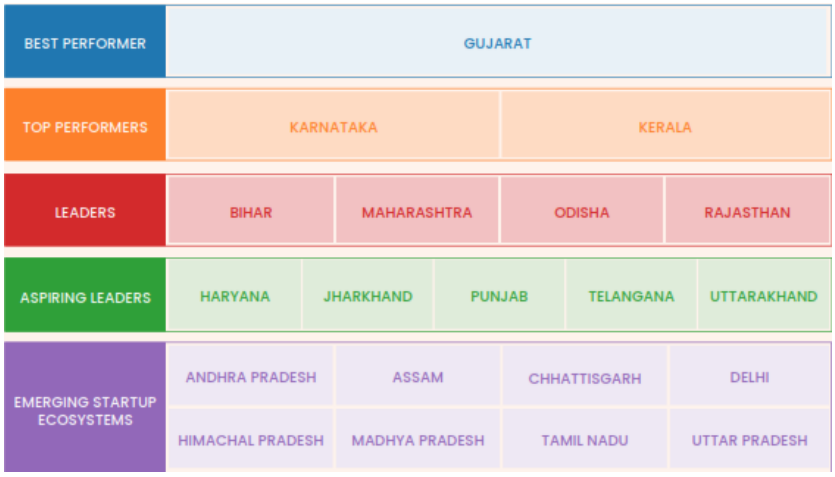
Multisectoral green technology incubators run independent of government interventions can be found in major clusters across India, such as in Bangalore, Chennai, and Hyderabad. [5]

## State Level Innovation

Some states been pro-active in complementing the STI policies of the central government, with several of them setting up their own policies and incubators. For instance, Karnataka has its own 'Startup Cell,' and is in the process of passing the Karnataka Innovation Authority (KIA) Bill, which proposes sandboxes that will exempt innovators from regulation. The EU-India incubators and accelerators network was launched in October 2018 in Bangalore. This pilot initiative aims at matchmaking cohorts of incubators and accelerators from India and the EU and foster cooperation between them such as exchange of startups, staff, mentoring, or best practices to facilitate internationalisation of startups. The 'Karnataka Technology Development Board' (KTDB) was also created to improve the R&D environment in the state, and a 'Talent Accelerator' to fast-track the development and career progress of tech talent across colleges of Karnataka.

Similarly, Maharashtra has its own State Innovation Society, which aims to foster innovative approaches and create conducive environment for innovative businesses to operate in Maharashtra. As per the India Innovation Index (2019), the top states (in order of excellence) are Karnataka, Tamil Nadu, Maharashtra, Telangana, Haryana, Kerala, Uttar Pradesh, West Bengal, Gujarat, and Andhra Pradesh. The capitals of these states that have strong innovation policy and regulatory frameworks have emerged as India's key STI hubs. These cities are Bengaluru, Chennai, Mumbai, Hyderabad, and the National Capital Region of Delhi.

**State 'Start up' Ecosystem Rankings**




The Government of India has also developed a flagship initiative called 'Startup India,'[6] with the goal to build a strong eco-system for nurturing innovation in the country. This includes an Action Plan (2016), that focuses on enhancing innovation through 1) Simplification and Handholding with respect to regulatory procedures 2) Funding support and incentives 3) Harnessing industry-academia partnerships. It also addresses specific aspects of the Startup ecosystem including:

- Focus and expansion of innovation across sectors ranging from digital/ technology sector to agriculture, manufacturing, social sector, healthcare, education.
- Increased innovation in Tier 1, 2 and 3 cities including semi-urban and rural areas across all states

[5] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1651598
[6] https://www.startupindia.gov.in/

# 2. India's Strength Positions

## India's Overarching R&D Funding Priorities

India's public expenditure on R&D, as a fraction of GDP, has remained stagnant between 0.6 - 0.7% over the past decade. The Defence Research and Development Organisation, Department of Space, and the Indian Council of Agricultural Research were the top three R&D spenders in 2017-18. With a total spend on R&D of Rs 192.5 billion (EUR 2.36 billion) by private multinationals in 2017-18, which amounts to approximately 0.2% of GDP, private investments in research have lagged behind public investments so far.[7]

## Green Technology Patent Trends

Indian patents across all technology fields has grown steadily between 2005 and 2016. Over the same period, Indian patenting specifically in Climate Change Mitigation Technologies (CCMTs) related to power, transport and buildings have more than tripled; Indian patenting in smart grids increased by eight times; CCMTs in manufacturing and computing have doubled.[8] International cooperation trends are reflected in patent patterns- according to analysis conducted by the International Energy Agency (IEA), *even though inventors residing in India are only responsible for approximately one percent of global CCMT inventions, they are significantly more likely to co- operate with foreign inventors, relative to those from other countries*. For instance, 76% of Indian patent applications are done jointly with an inventor residing in another country. Overall, the sectoral rates of co-invention in India rank among the highest globally, such as in CCMTs in the power sector and buildings (68% in India, relative to 13% and 12% for global applications in these sectors, respectively), in manufacturing (61% relative to 16%), Carbon Capture, Utilisation and Storage (58% relative to 21%) and smart grids (57% relative to 13%).[9]

**State-wise Waste Generation in Urban Areas under Municipal Solid Waste Management in India**

| States/UTs | Total waste Generation (In MT/D) | Total Waste Processing (%) |
|---|---|---|
| **Bihar** | 2389 | 43 |
| **Chhattisgarh** | 1649 | 84 |
| **Jharkhand** | 2126 | 52 |
| **Madhya Pradesh** | 6424 | 68 |
| **Odisha** | 2720 | 12 |
| **Rajasthan** | 6500 | 56 |
| **Uttar Pradesh** | 15500 | 57 |

MT/D: Metric Tonne/Day

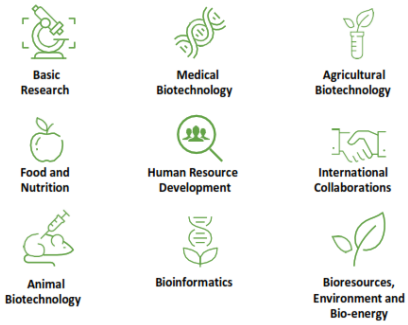
*Source: Lok Sabha (2019)*

## Continued Government Priority Sectors for R&D and Investment

The Indian government continues to promote efforts in the following sectors:

[7] Out this pool of R&D spend, 32% was undertaken by private multinational enterprises.
[8] International Energy Agency (2020). *Clean Energy Transitions: Accelerating Innovation Beyond 2020- Focus on India*
[9] ibid

**1) Biotechnology-** India is one of the first countries to have a department dedicated to Biotechnology. *As per the recent national budget (2020-21), the Department of Biotechnology (DBT) and the DST will be allocated 17% and 14% more funding respectively than the last fiscal year, indicating the government's continued focus on building up research in this sector.*[10] Biotechnology has been hailed as "the key driver for contributing to India's $ 5 Trillion economy target by 2024."[11] The DBT's strategy (2015-2020) is cross-sectoral, and has focused on four core missions- education, healthcare, food and nutrition, and clean energy. This led to the setup of the Regional Centre for Biotechnology in Gurgaon, Haryana. Other states have launched their own biotechnology policies- these include Andhra Pradesh, Gujarat, Rajasthan, Telangana, and Uttarakhand, all with the aim to attract new investments. Biotechnology has been given focus in cross-sectoral flagship programmes such as 'Make in India' and 'Startup India.'




DBT has set up BIRAC (Biotechnology Industry Research Assistance Council). This is a not-for-profit interface agency tasked with strengthening and empowering emerging biotechnology enterprises to undertake strategic research and innovation. Approximately 50 bio-incubators have been supported by BIRAC and established since 2014, with more planned across the country. See Appendix 5 for a snapshot of existing bio-incubators in India. DBT coordinates bilateral partnerships on various topics with over 20 countries. DBT also announced the launch of the first Indian Biological Data Centre in Faridabad, which is expected to be a national facility to store, manage, archive and distribute biological data.[12]

In terms of the bio-industry sector, there has been focus on biofuels- an announcement of a new policy on Biofuels (2018), which proposes an indicative target of 20% blending of ethanol in petrol and 5% blending of biodiesel in diesel by 2030. The DBT has been focusing its research and development especially on second generation biofuels.13 India's commitment to this sector is also demonstrated by the fact that it is the co-leader of Mission Innovation's Innovation Challenge #4 on Sustainable Biofuels, is a part of the Biofuture Platform's strategic leadership as well, and is a member of the IEA Bioenergy Technology Cooperation Programme.

Bio-Agriculture forms the third largest segment in the domestic biotech industry, and is an emerging area working on breeding nutritious, high-yielding and less resource input-demanding crops. This subsector includes sustainable methods of agriculture practices such as the use of improved crop varieties, as well as biological substitutes for fertilizers and pesticides. To supplement efforts in this direction, DBT established National Agri-Food Biotechnology Institute at Mohali, Punjab (in 2010) to undertake cross-cutting research activities encompassing the areas of Agriculture, Food and Nutrition biology.[14]

The biopharma subsector has picked up steam as well. The National Biopharma Mission's program, 'Innovate in India' was launched in 2017. This is a DBT program that aims to bring together industry and academia in order to promote entrepreneurship and indigenous manufacturing in the bio-pharma sector.

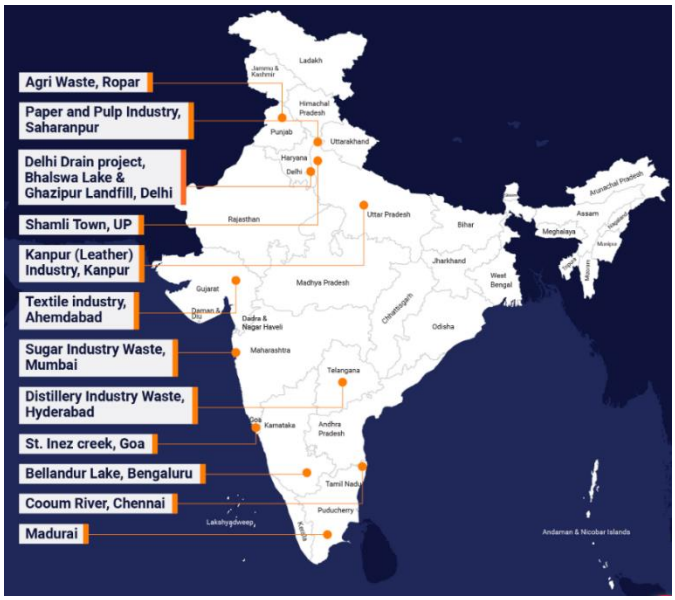
**2) Sustainable/'Climate-Smart' Agriculture-** India has committed to the goal of doubling farmers' incomes by 2022, and as such, agricultural R&D remains a focus. Agriculture research and education received a 6.6% in budgetary allocation in 2020-21- a portion of this is given to the Indian Council of Agricultural Research (ICAR) and the Central Research Institute for Dryland

[10] https://www.thehindu.com/business/budget/budget-2020-cheer-for-science-as-key-departments-get-a-raise/article30715689.ece
[11] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1658686
[12] https://www.rcb.res.in/index.php?param=newdetails/5024
[13] Bioethanol, biodiesel, advanced biofuels, drop-in fuels, and bio-CNG qualify as biofuels
[14] https://nabi.res.in/cms?slug=agricultural-biotechnology

Agriculture. The DBT and DST engage in developing joint research and calls with international parties as well Indian agricultural research institutes. While there is a broad range of research underway in this sector, there has been a surge in interest in introducing climate-smart and sustainable agricultural practices and boosting relevant technology adoption. This is reflected through the activities undertaken as part of the National Mission for Sustainable Agriculture. The Indian Council of Agriculture leads the National Initiative on Climate Resilience Agriculture, another government-led focusing on strategic research, technology demonstration and capacity building activities. Recent research focus areas have included biochar, and smart farming. Recent international collaborations have included the joint research funding[15] by DBT and the Dutch Research Council (NWO), inviting a range of research actors to focus on interdisciplinary research to develop climate smart agriculture. [16]

**3) Waste-management and Waste-to-Energy**- *The Indian government has reiterated its interest in this sector through funding allocations towards several specific missions and schemes run through partnerships between various ministries.* India's flagship scheme, *Swachh Bharat* (Clean India) received a budgetary allocation of Rs 123 billion (EUR 1.5 billion) in 2020-21, with the Finance Minister suggesting that the influx of funds would go towards solid waste collection, source segregation and processing.[17] The government approved a physical target of 257 megawatt (MW) for 2019-20, and granted Rs 4.8 billion (EUR 58.5 million) to the *Waste-to-Energy scheme* run by the Ministry of New and Renewable Energy (MNRE).[18] This specific central financial assistance is in the form of capital subsidy and grants-in-aid. The Ministry of Oil and Natural Gas, as part of the *Sustainable Alternative Towards Affordable Transportation initiative,* announced that the that an estimated 5,000 compressed biogas plants are to be built across the country by 2025 with a total anticipated investment of Rs 1.7 trillion (EUR 20.8 billion)- the ministry has already started invited tenders for setting up plants.[19]

**Figure 2: Waste to Wealth Mission- Sentinel Sites**




Most recently, **the PM-STIAC has set up the *Waste to Wealth Mission***, with the main motive to "identify, develop and deploy technologies to treat waste." This aims to leverage global technological capabilities by addressing the issues of waste disposal, deteriorating air quality and water pollution. A 'Project Management Unit' has been established in partnership with Invest India, which is India's National Investment Promotion and Facilitation Agency.[20] The Unit has already identified 14 'Sentinel Sites' for its pilot projects across the country. Each pilot project is expected to be managed by an implementing agency, with the goal of testing and learning from a range of techniques approaches.[21] This mission remains opportunity for Denmark in terms of both investment and

[15] Total funding of EUR 2,800,000 for two projects, with DBT providing EUR 700,000
[16] https://www.nwo.nl/en/funding/our-funding-instruments/wotro/merian-fund/cooperation-india-dbt---climate-smart-agriculture/cooperation-india-dbt---climate-smart-agriculture.html
[17] https://www.hindustantimes.com/india-news/in-budget-2020-21-pm-modi-s-swachh-bharat-scheme-gets-28-hike-in-allocation/story-MDQgVZhjd5hTc6UMme7WyI.html
[18] https://mnre.gov.in/img/documents/uploads/file_s-1584425847955.pdf
[19] https://www.bioenergy-news.com/news/india-to-build-5000-biogas-plants-by-2023/
[20] https://www.investindia.gov.in/swachh-bharat-unnat-bharat
[21] https://www.psa.gov.in/article/launch-waste-wealth-waste-wealth-mission-swachh-bharat-unnat-bharat/83

technology co- production and research. Past areas of international cooperation in this sector have included calls for demonstration projects; a centre for excellence at IIT Delhi has been set up.[22]

This sector will continue to remain a priority for India given that Urban India generates 145,000 tons per day of municipal solid waste (MSW) per day, out of which only about 23% of the total generated waste is being processed or treated.[23] Delhi, Mumbai, Kolkata, Chennai, Bengaluru and Hyderabad contribute to the maximum amounts of solid waste generation, which accounts to 21% of the waste generated in the country.[24]

**4) Energy Efficiency-** A World Bank study values India's Energy Efficiency market at INR 1.6 trillion (EUR 19.6 billion).[25] Given the government's pledge to reduce energy intensity across sectors (including industry, agriculture, and transport) by 2030, energy efficiency remains a key focus. In 2018-19, Energy savings (electrical + thermal), achieved in the energy consuming sectors have been approximately 16.54 Mtoe, which was 2.84 per cent of the net total energy consumption during the year.[26] Recent focus has been placed on reducing India's demands for cooling across sectors- the government is aiming at a 20-25% reduction in cooling demand and 25-40% cut in the energy requirement for cooling load by 2038.[27] Given this goal, the government launched the India Cooling Action Plan in March 2019, with a 20-year time horizon.

**5) Smart Grids-** As evidenced by the patent trends, there has been a strong push for R&D in smart grids- this has included technologies around storage integration, demand response, regional electricity highways, flexibility options, new grid architecture and control, power electronics. As part of the Smart Grids Mission (2015) run by the Ministry of Power, there are 11 smart grid pilots underway.[28] There are activities underway as part of Mission Innovation. Examples include the recently launched India-European Union Flagship Call on Integrated Local Energy Systems (2020),[29] as well as the DST and Swedish Energy Agency Industrial R&D programme (2020) focused on developing and commercializing smart grid technology.[30]

**6) Water and Wastewater Management-** *Indian Water Ministry plans to invest Rs 3.6 trillion (EUR 44.2 billion) over the next five years across multiple geographies in India through the Jal Jeevan Mission*.[31] States such as Gujarat, Jharkhand, Karnataka, Maharashtra and Punjab already have their state-specific policies in place, but lagging states will be asked to develop their State Action Plans. There have been developments towards setting up Public-Private-Partnership (PPP) models in this space, with the National Mission for Clean Ganga engaging the first ever-successful hybrid annuity PPP in sewage treatment in India.

In 2019, the Prime Minister of India announced that as part of the Jal Jeevan Mission, the target is to provide functional tap connections to every household by 2024. A technical committee under the chairmanship of the PSA has been constituted. The Technical Committee will work on a) inviting innovative technologies in drinking water, sanitation, grey water management and solid waste management sectors through relevant ministerial departments or the National Mission portal; b)

[22] https://pib.gov.in/Pressreleaseshare.aspx?PRID=1571509
[23] EY and ASSOCHAM (2019). *The big "W" impact: effective management solutions in India*
[24] ibid
[25] https://pib.gov.in/newsite/PrintRelease.aspx?relid=155458
[26] https://www.deccanherald.com/business/business-news/india-saves-rs-89122-cr-in-2018-19-by-energy-efficiency-834415.html
[27] https://energy.economictimes.indiatimes.com/news/power/india-plans-to-cut-cooling-energy-demand-40-per-cent-by-2038/74594897#:~:text=New%20Delhi%3A%20The%20government%20is,MoEFCC)%2C%20Babul%20Supriyo%20said.
[28] https://www.nsgm.gov.in/en/content/sg-pilot
[29] https://dst.gov.in/pressrelease/india-european-union-flagship-call-announced-integrated-local-energy-systems-india#:~:text=India%2DEuropean%20Union%20Flagship%20Call%20on%20Integrated%20Local%20Energy%20Systems,Ugo%20Astuto.
[30] https://dst.gov.in/pressrelease/sweden-and-india-announce-co-funding-multi-million-dollar-programme-smart-grids
[31] https://jalshakti-ddws.gov.in/sites/default/files/JJM_Operational_Guidelines.pdf

facilitating techno-economic appraisal of technologies and consider appraised technologies for acceptance; iii.) recommending any non-technological interventions needed to achieve scaling up the use of such technologies. An example of a relevant intervention is the government's requirement for states to pilot 'Sensor based Internet of Things solution' to monitor the regularity of water supply, quantity and quality of water.

Water infrastructure investments will remain a need. Several international companies have already invested in this sector- Xylem, a large American water technology provider has received an order of EUR 921,800 to supply advanced wastewater treatment technology to a sewage treatment plant in Madhya Pradesh.[32] The Centre for Science and Environment (CSE) has partnered with international fecal sludge, wastewater and environmental laboratories – Asian Institute of Technology Bangkok (Thailand), University of Kwa Zulu- Natal Durban (South Africa) and Columbia University (U.S.A) to upgrade existing Faecal Sludge and Wastewater Laboratories in the country and set up India first state of art referral facility on faecal sludge and wastewater at Alwar, Rajasthan.[33] Denmark and India have indicated, during discussions leading up to the Green Strategy Partnership (2020), their joint wish to enhance cooperation in the specific areas of water supply, water distribution, wastewater treatment, sewerage systems, re-use of treated wastewater, water management and energy optimisation in the water sector through the Indo-Danish Water Technology Alliance. Following this, the Gujarat Government (Gujarat Water Supply and Sewerage Board) has signed a MoU for five years with Denmark (Danish Water Forum) to set up the Indo-Danish Water Technology Alliance, with the goal to enhance technology exchange, training, capacity building, knowledge exchange, cooperation in water supply, wastewater treatment- reuse and water management between the two organizations.[34]

**7) Energy Storage and Hybrid Energy Systems-** The India Energy Storage Mission (2017) was set up with the expressed purpose of developing battery pack manufacturing capacity in India, establishing a multi-stakeholder research and development consortium, followed by a scale-up of the supply chain. Indian battery manufacturers and research institutes have started building up domestic capacity- for example, the Indian Institute of Technology Madras has a research and development centre devoted to new and advanced battery technology. Niti Ayog is working towards inviting investments for battery manufacturing and is expected to provide direct production-linked incentives to the tune of Rs. 18,000-crores.[35] The target is for India to have a manufacturing capacity of 50,000 MW in the country by 2026.

There is also continued interest in developing hybrid renewable projects and corresponding technology transfer, as evidenced by the MoU between India and Denmark on Wind-solar hybrid systems. Wind-solar hybrid models remain a viable new renewable energy option in India, with 15 GW of such hybrid power to come up over the next five years.[36]

**8) Electric Vehicles (EV)**- India is promoting electric vehicles in a big way through subsidy-oriented schemes such as FAME 2, which has a budget of Rs 100 billion (EUR 1.24 billion). The Indian automobile industry is the fourth largest in the world. Over 210 million cars, two-wheelers, three-wheelers and other vehicles currently ply the country's roads. India has demonstrated its commitment to transition to Electric Vehicles (EVs) and is part of the Electric Vehicle Initiative (EVI) under the global Clean Energy Ministerial. EVI member countries endorse the global 'EV@30' campaign, which sets the objective to reach a 30% sales share for EVs by 2030. India aims for an EV sales penetration of 30% for private cars, 70% for commercial cars, 40% for buses, and 80% for two- and three-wheelers by 2030. Transitioning to EVs could translate to savings of 846 million

[32] https://www.maiervidorno.com/indias-water-stress-pushing-for-a-revolution-in-the-water-waste-water-industry/
[33] ibid
[34] http://newsonair.com/Main-News-Details.aspx?id=401043
[35] https://www.cnbctv18.com/business/india-readies-plan-to-boost-battery-manufacturing-under-production-linked-incentive-scheme-6688651.htm
[36] https://www.thehindubusinessline.com/economy/wind-solar-hybrid-is-new-renewable-energy-option-in-india-crisil/article31794976.ece

tonnes of net $CO_2$ emissions over sold vehicles' lifetime.[37] A majority of states have already set their EV policies, with the expressed aim of attracting investment in both R&D and manufacturing across the EV value chain, including charging infrastructure, battery storage and automobile component manufacture.

## Areas of Increased Government Focus and Funding

Recent national level developments such as the *nine new Science and Technology Missions of 2019*, indicate themes of India's national scientific focus in the near term to midterm, as well as the mechanisms to take innovation from basic research to market delivery.[38] The Missions aim to catalyse collaborations across scientific ministries, research institutions and industry partners, through the PM-STIAC, to leverage cutting edge scientific research.[39] These missions build on prior sectoral developments and include: Electric vehicles (focusing on batteries, Electric Vehicle component R&D and manufacturing), Bioscience for human health (focusing on genomic study for improving healthcare delivery), Waste to Wealth (continued focus on developing and deploying technologies to treat waste to generate energy, recycle materials and extract worth- augmenting work undertaken by Swacch Bharat and Smart Cities projects), Artificial Intelligence (focusing on areas such as healthcare, education, agriculture, smart cities and infrastructure, smart mobility and transportation), AGNIi- Accelerating Growth Of New India's Innovations (focusing on bringing Indian innovations to market).[40] [41] Progress has been made in terms of implementing these missions- DST has sanctioned Rs 170 crores to IIT Delhi to develop a technology hub on Collaborative Robotics (Cobotics). This will include medical robotics, agriculture and disaster management, defence and smart manufacturing. More than 100 faculty members at IIT Delhi and from other universities abroad have already committed to this I-Hub Foundation for Cobotics (IHFC).[42] Similarly, the Emerging Technologies Initiative, which is a joint effort between the PSA, New Emerging & Strategic Technologies (NEST) division of the Ministry of External affairs and Science and Policy Forum (SPF), has started developing landscape reviews and technology roadmaps.[43]

[37] Rocky Mountain Institute; Niti Ayog (2019). *India's Electric Mobility Transformation: Progress to Date and Future Opportunities*
[38] Each of these missions aims to *engage international and national institutional partners, young scientists and industry*
[39] https://pib.gov.in/Pressreleaseshare.aspx?PRID=1567633
[40] http://pibphoto.nic.in/documents/rlink/2019/mar/p20193601.pdf
[41] Other missions are: Deep Ocean Mission, Teaching S&T in Indian languages, Quantum Frontier, Indian Biodiversity: characterization, preservation and sustainable use.
[42] https://www.livemint.com/education/news/iit-delhi-gets-rs-170-crore-from-dst-to-develop-collaborative-robotics-hub-11597404619952.html
[43] http://thesciencepolicyforum.org/initiatives/eti/

# 3. Actors

## Governmental institutions responsible for R&D fund allocation

The *Department of Science & Technology* is a major stakeholder in the R&D ecosystem. DST is responsible for science & technology policy and data compilation on R&D. Accordingly, it has a significant role to play, and engages in direct lines of cooperation with bilateral stakeholders. The other key player is the Department of Scientific & Industrial Research (DSIR), which operates a scheme for granting recognition and registration to in-house R&D units established by corporate enterprises. This is the only scheme in the entire government set-up for benchmarking industrial R&D. The government of India announces a number of fiscal incentives for research and development by industry from time to time and many of these incentives are implemented through DSIR. In-house R&D units are recognized by DSIR are eligible for these incentives as well as for receiving funds for R&D from other government departments and agencies such as the Department of Science and Technology, Department of Biotechnology, Ministry of Electronics and Information Technology, Ministry of Environment, Forests, and Climate Change, Ministry of New and Renewable Energy, Ministry of Food Processing Industries, Council of Scientific and Industrial Research, Indian Council of Medical Research, Ministry of Power (where recognition to the in-house R&D centre by DSIR is a requirement). Key government research institutes in the green technology sector that Danish counterparts can approach for bilateral partnerships include:

- National Institute of Wind Energy
- National Wind Technology Centre
- India Smart Grid Forum (ISGF)
- National Institute of Solar Energy (NISE)
- Sardar Swaran Singh National Institute of Bio- Energy (SSS-NIBE)
- Solar Energy Corporation of India (SECI)
- Indian Council of Agricultural Research (ICAR)
- Central Research Institute for Dryland Agriculture
- Biotechnology Industry Research Assistance Council (BIRAC)
- National Agro-Food Biotechnology Institute (DBT-NABI)
- Department of Science and Technology (DST)
    - DST- IISc Energy Storage Platform on Supercapacitors
    - DST- NFTDC Energy Storage Platform on Hydrogen
    - DST- IIT Delhi Energy Storage Platform on Batteries
    - DST- IIT Bombay Energy Storage Platform on Hydrogen
- Bureau of Energy Efficiency (BEE)
- Invest India

## Higher education institutes

Universities play a subsidiary role in terms of the research and innovation, but receive funding from government R&D funders such as DST, DBT and Ministry of Human Resource Development. The five institutions that spend the most on R&D are Indian Institutes of Technology (IITs). Though limited to the IITS, IIMs, IISc Bangalore, ISB, as well as a few other central public universities, higher education institutes have started serving as innovation hubs, and several serving as centres of excellence for specific technological development as well as hosting incubation centres and project sites. Similarly, run in collaboration by the Ministry of Science and Technology, and Ministry of Human Resource Development, the Impacting Research Innovation and Technology (IMPRINT)

programme involves 10 leading IITs and universities and focuses on healthcare, computer technology, advance materials, water, sustainable habitat, security and defence, manufacturing technology, nano technology hardware and environment and climate change. IIT Kharagpur hosts the Scheme for Promotion of Academic and Research Collaboration (SPARC), which focuses on improving the ecosystem of India's higher education institutions by facilitating academic and research collaborations between Indian institutions and institutions in 28 countries.

**Education Institutes Incurring Highest R&D Expenditure (in Rs Crores)**

| Institution | 2018-19 | 2016-19 |
|---|---|---|
| **IIT Madras** | 536.55 | 1002.66 |
| **IIT Bombay** | 250.93 | 815.29 |
| **IIT Kharagpur** | 138.76 | 522.55 |
| **IIT Delhi** | 154.24 | 488.12 |
| **IIT Kanpur** | 119.28 | 316.90 |

## Private organizations

Private sector R&D is still limited in India- the total expenditure (self-reported) on R&D incurred by them was Rs 87.2 billion (EUR 1 billion) 2018-19.[44] Though still limited, there are Venture Capital (VC) funders active in the clean tech space. However, both the number and volumes of deals have been rising.[45] There are only a small number of relevant clean energy deals each year, and most are in the range of EUR 1-1.8 million.[46] These were predominantly in solar technologies, with some in alternative fuels for transport.[47][48]

[44] https://www.business-standard.com/article/economy-policy/india-inc-spent-more-on-r-d-in-fy19-auto-and-pharma-leading-sectors-119103100062_1.html
[45] International Energy Agency (2020). *Clean Energy Transitions: Accelerating Innovation Beyond 2020- Focus on India*
[46] ibid
[47] ibid
[48] Some examples of VC deals in 2018-19 are: Ecozen Solutions(solar irrigation); Cygni Energy (solar systems); ZunRoof(solar services); Fourth Partner Energy(solar products); Tork Motorcycles (EV bike); ION Energy(storage); Swadha Energies (efficient HVAC); and ProKlean technologies (bioenergy, 2017). Growth equity and late-stage deals include: Punjab Renewables(bioenergy); CleanMax solar(solar products and services); and Husk Power Systems (rural utility)

# 4. International/multilateral cooperation

## India's Participation in Key International Consortiums

India works closely with multilateral agencies, participates in several international fora, and has engaged bilaterally with countries to meet its green growth aspirations. Some of India's key engagements are given below:

***International Solar Alliance-***The International Solar Alliance is an alliance of 121 countries initiated by India; India has pledged a target of installing 100GW of solar by 2022. The alliance has committed one trillion dollars as investment, and has sought the partnership of multilateral organisations like the World Bank to mobilize investments. Countries have signed up to support each other in research and development activities. Denmark has recently joined the International Solar Alliance.[49]

***Mission Innovation-*** India along with other member countries has agreed to double its investments in span of 5 years on development of clean energy technologies over the base investments of 2015.[50] India has been gradually increasing its engagement with the Mission Innovation initiative, co-leading the Analysis and Joint Research subgroup and three Innovation Challenges (Smart Grids, Off-grid Access to Electricity, and Sustainable Biofuels). These two platforms could facilitate greater R&I collaboration with member states. The Mission Innovation programme is coordinated by DBT, as a key nodal agency and facilitating national efforts in collaboration with concerned ministries to promote R&D efforts to accelerate clean energy innovations. In 2018, the DBT and BIRAC partnered with Tata Trusts to establish a Clean Energy International Incubation Centre near New Delhi. Mission Innovation was renewed in 2020 for five more years, though it is expected that countries might not be able to immediately commit to spending target given the impacts of COVID-19 on country finances.[51]

***Technology Cooperation Programmes under the International Energy Association-*** In the energy sector, India participates in a range of Technology Collaboration Programmes of the IEA, which it joined in 2017 as an Association Country. Topics include technology areas such as energy demand-side management, hydrogen, and bioenergy.

***Biofuture Platform-*** This is a twenty-country alliance to accelerate the sustainable low carbon bioeconomy for energy transition. India is a participant; other partner organizations and initiatives have included FAO, IRENA, UNIDO, IEA, IEA Bioenergy TCP; SE4ALL, GBEP; WBCSD, and REN21.

## Bilateral Cooperation Relationships

Indian has entered into formal agreements on technology development and exchange with countries such as the United States (for example, the Indo-U.S. Joint Clean Energy Research and Development Centre in smart grids and energy storage), the United Kingdom (for example, the Joint UK-India Virtual Clean Energy Centre, DST–Research Councils UK collaborative projects on energy efficiency, storage and energy systems), the European Union, and a number of its member countries including Denmark.[52] Memorandums of Understanding have been signed between countries and government entities such as the MNRE, MoP, DST, DBT. Examples of the modality of international cooperation that Denmark can emulate and/or build up on are:

[49] https://www.newindianexpress.com/nation/2020/sep/28/modi-virtual-summit-with-denmark-pm-mette-frederiksen-on-monday-2202809.html
[50] http://mission-innovation.net/our-members/india/plans-and-priorities/
[51] https://news.trust.org/item/20201002104424-bd06v/
[52] IEA, 2019

- **Co-funded research:** Innovation Fund Denmark has collaborated with the Department of Science and Technology and Department of Biotechnology to set up multi-million Euro funding for joint research projects in the clean energy and water sectors. The Joint UK-India Clean Energy Centre (JUICE) is helping to decarbonise energy, and has brought together leading energy researchers from ten UK universities with their counterparts across India to share experience and co-develop relevant technologies. The programme has been funded in the UK by the Engineering and Physical Sciences Research Council, and in India by the Department of Science and Technology.[53]
- **Technology Centres:** The Indo-German Science and Technology Centre was established to facilitate R&D networking. The centre runs schemes that bring Indian and German researchers and industry counterparts to work on a range of projects including in biomass, water management, and energy storage. India and Germany made a joint declaration of intent in 2019 to launch dedicated research cooperation on artificial intelligence (including cyber security) through this centre.
- **New sector-specific R&D units:** The National Agri-Food Biotechnology Institute and Centre of Innovative and Applied Bioprocessing signed a MOU in 2019 with Bioendev, a Swedish technology development company, to setup a pilot project on a torrefaction R&D unit for validation of biocoal production from rice-straw.
- **Project preparation support:** US-India Clean Energy Finance (USICEF) is a unique project that utilizes a combination of impact investment funds. This goal is to drive access to energy in underserved regions of India, by supporting early stage development of distributed solar power projects. This is a partnership between the Indian Ministry of New and Renewable Energy, the Overseas Private Investment Corporation (OPIC), and a consortium of private foundations who have 'impact investments' in India (such as the MacArthur Foundation). Here, USICEF provides project preparation support with the aim to catalyze long-term debt financing for distributed solar power from OPIC and other international financial institutions.[54]
- **Catalyzing Private Infrastructure Finance:** The UK government invested in (through the City of London) the National Infrastructure Investment Fund, which allocates funds towards clean technology sectors such as renewable energy, clean transportation, water treatment and waste management in low income states.

## Engagement with the European Union

The *'Elements for an EU Strategy on India'*, adopted by the EU in November 2018, set the scene for a reinforced EU-India strategic partnership in the next decade aiming at supporting India's sustainable modernisation process and addressing together the Sustainable Development Goals (SDGs). Research and Innovation is an integral part of this strategy and necessary to achieve the strategic objectives.[55] The India-EU Science and Technology Agreement has been renewed for another five years (2020-2025).[56] This extension would continue to build on cooperation activities between Indian and European research entities, and additional areas such as climate change, sustainable urban development, manufacturing, advanced materials, nanotechnologies and biotechnology, food processing, and ocean research may also be considered.[57]

In addition to sectoral dialogues where the importance of R&I is recognized (India-EU Water Partnership, the Joint declaration on Climate Change and Energy, and Joint declaration for a Partnership for Smart and Sustainable Urbanisation), ongoing cooperation projects include seven India-EU research projects on purification of water and waste water treatment for EUR 40 million,

[53] http://www.juice-centre.org.uk/#
[54] https://www.usicef.org/
[55] https://cdn2.euraxess.org/sites/default/files/eu-india_ri_cooperation_brochure.pdf
[56] https://www.outlookindia.com/newsscroll/eu-india-to-step-up-cooperation-in-research-and-innovation/1491054
[57] https://www.saurenergy.com/solar-energy-news/india-eu-renew-agreement-on-science-and-technological-cooperation

two for influenza and tuberculosis vaccines, one on polar sciences, clean energy and smart grids research and demonstration projects in partnership with businesses. A joint multimillion funding call co-funded by India's Department of Science & Technology and the European Commission's Innovation and Networks Executive Agency on smart and integrated local energy systems has opened recently. The focus of the call is to develop and demonstrate novel solutions that integrate energy vectors such as electricity, heating, cooling, water and waste, and realize interconnections with energy storage and electric vehicles.[58]

Similarly, the DBT has also recently agreed to co-fund successful Indian entities in five Green Deal call topics under the final Horizon 2020 Work programme. The call topic areas included clean and innovative energy, circular economy, farm to fork strategies, biodiversity and pollution management.[59]

Further, Indian researchers can access Marie Skłodowska-Curie Actions grants and an Implementing Arrangement is in place between the European Commission and the Indian Science and Engineering Research Board (SERB) for Indian scientists to join European Research Council teams in Europe. Under the *EU India Innovation Partnership*, the European Commission has launched the EU Innovation Platform in India and the EU-India Incubators and Accelerators Network, aimed at fostering innovation partnerships, knowledge exchange and co-creation between innovation and startup ecosystems in both regions.

[58] https://www.pv-magazine-india.com/2020/05/11/eu-india-invite-joint-research-proposals-on-integrated-local-energy-systems/

[59] Call open till January 26, 2020. Further information is available here: http://dbtindia.gov.in/sites/default/files/Final%20Webnoticice_INDIA-EU_Green%20Deal_22092020.pdf

# 5. Opportunities for Cooperation

Many of India's R&D priorities in green technology correspond with Danish sectoral strongholds- these include, but are not limited to, smart grid deployment, hybrid renewable energy systems, energy efficiency products, waste and water management, biotechnology and sustainable agriculture. India and Denmark, as part of the Green Strategic Partnership of 2020 have agreed to hold regular consultations and dialogue on a broad range of potential sectoral collaborations ranging from water, energy, sustainable cities to health and life sciences.[60] Additional indicative ways of enhancing these synergies are given below:

## Building on existing avenues of bilateral/multilateral government cooperation

**Engagement through EU-India platforms:**

- The current EU innovation Platform pilot phase ends in 2020. Denmark should continue to take forward its momentum and work on bilateral engagements, building on partnerships and networks that have developed over the last two years through meetings or initiatives for deepening innovation impact on the ground (for example, through panel discussions with angel investor networks, or linking with thematic business/ technology incubators that have been identifies).[61]
- Denmark can build on research and academic institution networks in the two regions that currently exist under the EU-India banner. For example, Horizons 2020 joint calls with the government of India (through entities such as the Department of Biotechnology, and the Ministry of Earth Sciences) facilitate research and academic exchanges on subjects of mutual interest. Denmark can build on specific topics that have gained traction by engaging with tried and tested members of the Indian research community. This could include topics such as sustainable agriculture.

**Mission Innovation-** India has been an active participant of Mission Innovation. Specifically, India has laid out plans to double clean energy R&D investment involve intensifying research efforts on setting up demonstration models/pilot plants for developed technologies, working with relevant stakeholders to translate research outputs for end-use deployment, and participating in demand-oriented mission programmes on clean energy technologies. Mission Innovation allows for Indo-Danish collaboration in priority sector challenges (such as the Smart Grids Innovation Challenge).

## Technological Cooperation Programme (TCP) under the aegis of the International Energy Agency (IEA)

In April 2019, the IEA Secretariat conducted a survey on ways to strengthen the role played by TCPs further, and to identify growth and engagement opportunities within the IEA's global network. Several avenues of cross-sectoral collaboration were identified. While the IEA doesn't provide direct financial support to TCPs through funding, it provides guidance and support by playing the role of a conduit, and by providing legal advice. This overarching network provides room for countries to cooperation across a range of technological modalities including the advancing research, development, and commercialisation of energy technologies. Such TCPs could be a

[60] https://www.mea.gov.in/bilateral-documents.htm?dtl/33069/Joint_Statement_for_IndiaDenmark_Green_Strategic_Partnership#:~:text=The%20two%20Prime%20Ministers%20confirmed,energy%20transition%20and%20climate%20change.&text=India%20and%20Denmark%20agree%20to,global%20fight%20against%20climate%20change.

[61] https://startupeuropeindia.net/eiip/

good avenue for Indo-Danish cooperation in sectors that align with both their technological development priorities.

### Partnering with or leveraging existing platforms

- **Participate in the Global Innovation & Technology Alliance (GITA) programme:** The GITA programme is a Public Private Partnership (PPP) program promoted by the Technology Development Board, Department of Science & Technology (DST), Government of India (GoI) and the Confederation of Indian Industry (CII). This is an innovative platform that encourages industrial investments in deployable technology solutions. This platform connects industrial and institutional partners, and provides participants opportunities for funding, capacity Building, deployment, and strengthening of the innovation Eco-System. The projects are evaluated in a transparent manner, and the disbursal process is managed with efficiency. So far, funding mechanisms have included loans, and grants. Participating countries include Canada, Finland, Israel, Italy, Republic of Korea, Spain, Sweden, United Kingdom along with the INNO-Indigo and Enterprise Europe Network. Sectors of engagement include automotive, agriculture, biotechnology, chemicals, artificial intelligence, cleantech, affordable healthcare, and robotics and automation. A recent development under GITA has been the India-Israel Industrial R&D and Technological Innovation Fund (I4F), which is a cooperation platform between the Department of Science and Technology (DST), Government of India, and the Israel Innovation Authority (IIA), Government of Israel, to promote facilitate and support joint Industrial R&D projects between companies from India and Israel, which would lead to successful commercialization.[62]
- **Smart Grid Forums:** Denmark participated in the third India-EU smart grid workshop in 2016, where the focus of the workshop was on the upscaling and deployment of smart grid demonstrations in India. Denmark has engaged bilaterally with India to co-fund research in this sector as well. Given India's continued interest in this sector, similar demonstration events and co-funded research projects in this sector can be held more regularly and perhaps under the framework of the EU's Horizon 2020 programme.
- **Promote Energy Efficiency Investments:** Danish businesses' experience in energy efficiency and energy conservation across industry and building sectors gives them a competitive advantage to work in the sector in India. For instance, Danfoss, a Danish multinational company, has recently expanded the India-based production of cooling, industrial refrigeration and drives, and has acquired the India-based hydraulics division of another company (Eaton Corporation).

### Potential New Sector of Cooperation- Artificial Intelligence and Quantum Computing

Interventions in this sector could lead India's efforts in sectors like healthcare, agriculture, education, smart cities, infrastructure, smart mobility and transportation. It could add immense value in developing intelligent automation to estimate and control pollution levels, predict meteorological events such as cyclones, floods and natural disasters.[63] Given the increase India's budgetary allocations to this sector (to the tune of EUR 978 million in 2020-21), this is an immense opportunity for industry leaders and the scientific community to co-produce technology and/or to work towards its deployment. Education institutes in India have already started forging strategic partners with global entities- Bosch recently invested 2.5 million euros in the Robert Bosch Center

[62] Sectors of cooperation include Agriculture, Energy, Healthcare, Information & Communication Technologies and Water: https://www.gita.org.in/OnlineRfp/ProgramInfo.aspx?GITA=kZdo4yRVS4gRExygXA1GyqVbyWB3io23meK0IVIdjpY=

[63] https://www.investindia.gov.in/team-india-blogs/national-artificial-intelligence-mission

for Data Science and Artificial Intelligence located at IIT Madras.[64] The Indo-Danish call for joint projects Cyber physical systems is a step in the right direction.

## New Route for Entry-Participation in Incubators

The startup ecosystem across India is in the clean technology space is very vibrant. While many incubators are supported and promoted by government entities, there are several being run by civil society organizations as well as not-for-profit enterprises. For example, the World Wildlife Fund's Climate Solver initiative is a platform that annually awards cleantech innovations of Small and Medium Enterprises and individuals as well as connects them to investors and business incubators for scaling up. Similarly, the Confederation of Indian Industry and the Federation of Indian Chambers of Commerce & Industry's startup promotion accelerators focus on multi-sectoral networking and business-development opportunities. Denmark could engage with such incubators through increased exposure to Danish green technology investors, mentors, and entrepreneurs seeking opportunities in new markets. While the government allows 100% foreign direct investment in green technology sectors such as renewable energy (including waste-to-energy) and biotechnology, government sponsored grants for startups often require entities to be registered in India, with 51% (or more) stake in the entity.

Some other examples of leading incubators are given below:

| Incubator | Details |
|---|---|
| **NASSCOM's 10,000 Startup Warehouse (2013)** | NASSCOM |
| **Kerala Startup Mission (2006)** | In collaboration with the Department of Science and Technology |
| **Society for Innovation and Entrepreneurship (2004)** | IIT Mumbai |
| **Dlabs (2014)** | Indian School of Business |
| **Centre for Innovation, Incubation and Entrepreneurship (2007)** | Indian Institute of Management Ahmedabad |
| **Technology-Hub (2015)** | Helix Model- public/private partnership between IIIT, ISB, government of Telangana, National Academy of Legal Studies and Research |
| **Indian Angel Network (2010)** | Angel network based in Delhi; promotes strategic tie-ups with other Department of Science And Technology supported incubators |
| **Bio-incubators by BIRAC (2018)** | In 41 locations across India; set up by BIRAC |
| **Amity Technology Incubator (2008)** | Supported by the Department of Science and Technology |

[64] https://analyticsindiamag.com/bosch-unveils-its-new-%e2%82%b920-crore-ai-and-data-science-centre-at-iit-madras/

# Appendix 1: Key Science, Technology and Innovation Roadmaps

| Key Science, Technology and Innovation Roadmaps |
| --- |
| **India Cooling Action Plan (2019)**: By Ministry of Environment, Forest and Climate Change (MoEF&CC) |
| **Action Plan for Secure & Sustainable Agriculture (2019)**: By Office of the Principal Scientific Advisor |
| **Implementation of India's National Biodiversity Action Plan: An Overview (2019)**: Ministry of Environment, Forest and Climate Change (MoEF&CC) |
| **R&D Expenditure Ecosystem (2019): Current Status & Way Forward:** Economy Advisory Council to the Prime Minister (EAC-PM) |
| **Strategy for New India @75:** NITI Aayog |
| **Technology Vision 2035:** Department of Science & Technology |
| **Vision for 2030:** Ministry of Earth Sciences (MoES) |
| **Strategic Plan and Agenda 2030:** Indian Council of Medical Research (ICMR) |
| **The Bioenergy Roadmap Vision 2020:** Department of Biotechnology |
| **Agriculture Vision 2020:** Indian Agricultural Research Institute |
| **National Biotechnology Development Strategy 2015-2020:** Department of Biotechnology |
| **Three Year Action Agenda:** NITI Aayog |
| **Innovation Action Plan:** Ministry of Heavy Industries |

# Appendix 2: International Energy Agency Technology Collaboration Programmes

| Technology Collaboration Programme on… | Participant from India |
|---|---|
| **Advanced Motor Fuels (AMF TCP)** | MoPNG |
| **Bioenergy (Bioenergy TCP)** | MoPNG |
| **Clean Coal Centre (CCC TCP)** | Bharat Heavy Electricals Ltd. (BHEL) |
| **Tokamak Programmes (CTP TCP)** | Institute for Plasma Research (IPR) |
| **Demand-side Management (DSM TCP)** | MoP, Bureau of Energy Efficiency (BEE) |
| **Fusion Materials (FM TCP)** | Institute for Plasma Research (IPR) |
| **Greenhouse Gas R&D** | The Energy and Resources Institute (TERI) |
| **Hydrogen (Hydrogen TCP)** | Reliance Industries Limited (RIL) |
| **Smart Grids (ISGAN TCP)** | Ministry of Power (MoP) |
| **Nuclear Technology Fusion Reactors (NTFR TCP)** | Institute for Plasma Research (IPR) |
| **Ocean Energy Systems (OES TCP)** | National Institute of Ocean Technology (NIOT) |

*Source: International Energy Agency*

# Appendix 3: India's Mission Innovation Plans and Priorities

**Research and Development Plans**

**Promoting India-centric innovation for clean energy proliferation**

**National, bilateral, and multilateral joint virtual centres on clean energy themes**

**Setting up of technology platforms led by industry for clean energy technologies**

**Scaled-up funding to academic and R&D institutions as well as R&D units in industry for research on identified topics relevant to clean energy**

**National, bilateral, and multilateral capacity building programs in clean energy**

**Demand-oriented mission programs on clean energy technologies**

**Developing models for last mile connectivity for technology leads obtained through R&D**

**Setting up demonstration models/pilot plants for developed technologies**

**Working with all stakeholders to translate research outputs for end-use deployment**

**Research Focus Areas**

**Energy efficiency (industry; residential and commercial buildings, appliances and equipment; transport)**

**Renewable energy sources (solar energy, on-shore wind energy, off-shore wind energy, ocean energy, biofuels, geothermal energy, hydroelectricity, other renewable energy sources)**

**Hydrogen and fuel cells; other power and storage technologies (electric power generation including advanced but non-renewable; electricity transmission and distribution**

**Energy storage; non-transport applications; smart grids)**

**Cleaner fossil energy (clean coal technology, clean fuels e.g. methanol)**

**Other cross-cutting** technologies in Carbon Capture, Utilisation and Storage or research (energy system analysis, basic energy **research that cannot be allocated to a specific category).**

*Source: Mission Innovation*

# Appendix 4: Key Missions and Schemes Relevant to Green Technology Development

| Missions | Participating Ministries/Departments |
|---|---|
| ***National Action Plan on Climate Change Missions*** | |
| **National Solar Mission (2010)** | Ministry of New and Renewable Energy |
| **National Mission on Enhanced Energy Efficiency (2008)** | Bureau of Energy Efficiency/Ministry of Power |
| **National Mission on Sustainable Habitat (2010)** | Ministry of Housing and Urban Affairs |
| **National Water Mission (2009)** | Ministry of Jal Shakti |
| **National Misison for Sustaining the Himalayan Ecosystem (2010)** | Department of Science and Technology, Ministry of Science and Technology |
| **National Mission for Green India (2010)** | Ministry of Environment, Forest and Climate Change |
| **National Mission for Sustainable Agriculture (2010)** | Department of Agriculture, Cooperation, and Farmers Welfare |
| **National Mission on Strategic Knowledge for Climate Change** | Department of Science and Technology, Ministry of Science and Technology |
| ***Prime Minister's Science, Technology and Innovation Advisory Council Missions (2019)*** | |
| **Natural Language Translation** | Ministry of Electronics and Information Technology |
| | Ministry of Human Resource Development |
| | Department of Science and Technology |
| **Quantum Frontier** | Department of Science and Technology |
| | Department of Space |
| | Department of Atomic Energy |
| | Defence Research and Development Organisation |
| | Ministry of Electronic and Information Technology |

| Missions | Participating Ministries/Departments |
|---|---|
| **Artificial Intelligence** | Niti Ayog |
| | Department of Science and Technology |
| | Ministry of Electronics and Information Technology |
| | Department of Biotechnology |
| | Department of Biotechnology |
| **National Biodiversity Mission** | Ministry of Environment, Forests and Climate Change |
| | Department of Biotechnology |
| **Electric Vehicles** | Department of Science and Technology |
| | Department of Heavy Industries |
| | Ministry of New and Renewable Energy |
| | Ministry of Power |
| | Niti Ayog |
| **BioScience for Human Health** | Department of Biotechnology |
| | Department of Health Research |
| | Department of Health |
| | Department of Science and Technology |
| | Department of Atomic Energy |
| **Waste to Wealth** | Department of Biotechnology |
| | Department of Science and Technology |
| | Ministry of Electronics and Information Technology |
| | Ministry of Urban Development |
| | Swachh Bharat Abhiyan |
| | Ministry of Earth Sciences |

| Missions | Participating Ministries/Departments |
|---|---|
| **Deep Ocean Exploration** | Department of Biotechnology |
| | Department of Space |
| | Ministry of New and Renewable Energy |
| | Oil and Natural Gas Corporation |
| | Defence Research and Development Organisation |
| | Geological Survey of India |
| | National Hydrographic Office |
| | National Biodiversity Authority |
| **Accelerating Growth of New India's Innovations (AGNIi)** | Invest India |
| ***Ministry of New and Renewable Energy Missions*** | |
| **National Solar Mission (2010)** | |
| **National Electric Mobility Mission (2012)** | |
| **National Smart Grid Mission (2015)** | |
| **National Energy Storage Mission (2018)** | |
| ***Cross-Cutting Initiatives focused on improving competitiveness*** | |
| **Make in India (2014)** | |
| **Skill India (2015)** | Ministry of Electronics and Information Technology |
| **Digital India (2015)** | Ministry of Commerce and Industry; Department for Promotion of Industry and Internal Trade |
| **Startup India (2015)** | Ministry of Commerce and Industry |
| **Atal Innovation Mission (2018)** | Niti Ayog |
| ***Other Relevant Schemes/Missions*** | |
| **Swacch Bharat Abhiyan (Clean India Mission)** | Ministry of Drinking Water and Sanitation; Ministry of Housing and Urban Affairs |

| Missions | Participating Ministries/Departments |
|---|---|
| **UJALA** | Ministry of Power |
| **INSPIRE Programme** | Ministry of Water Resources |
| **Namami Gange Programme** | Ministry of Housing and Urban Affairs |
| **Smart Cities Mission** | Ministry of Housing and Urban Affairs |
| **Atal Mission for Rejuvenation and Urban Transformation** | Ministry of Housing and Urban Affairs |

## Appendix 5: BIRAC Incubators